THE PROCEEDINGS OF

Vietnam International Water Conference (VIWC 2022)

19-21 Sept 2022 Online; 09-11 Nov, Onsite, HCM, Vietnam

Ngoc T. NGUYEN, Anh Q. NGUYEN, Toan. D. VU, Phi Q. NGUYEN, Tien L.T. DU,
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SOUTHEAST ASIA UNION FOR WATER, ENVIRONMENT AND GEOSCIENCES (SEAGU)

THE JOINT INNITIATIVE BY ASEAN & US SCIENCES AND TECHNOLOGY FELLOWSHIP & INTERNATIONAL SOCIETY OF GROUNDWATER FOR SUSTAINABLE DEVELOPMENT (ISGSD)

Vietnam International WATER Conference

19-21 Sept 2022 - Online
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Disclaimer:

PREFACE

On behalf of the Organizing Committee, I warmly welcome you to the 12th edition of the VIETWATER 2022 and Vietnam International Water Conference (VIWC 2022) in the most dynamic city of Vietnam, Ho Chi Minh City.

Having a dense river network with more than 2,300 rivers, Vietnam has more than 800 billion cubic meters each year. However, two thirds of the surface water resources originate from outside of the country. More than 70% of the water is generated in less than four months of the wet season. Urban populations have increased more than 80% from 1990 to 2020, making up almost 40% of the total populations. Rising demands, rapid urbanization, increasing pollution, outdated water technologies and infrastructures, and unequal access to safe water and sanitation can severely jeopardize the sustainable development of this world top growing country.

"Too much, too little and too dirty" water problems have further been exacerbated by the evident climate crisis. Record temperatures, wildfires, droughts and floods have been broken around the world. The most recent catastrophic floods submerged a third of the entire Pakistan country. It is the wake-up call for the world to act as the U.N. Secretary-General Antonio Gutteres has said, "Today, it's Pakistan. Tomorrow, it could be your country". At the 2021 United Nations Climate Change Conference (COP26) in Glasgow, Vietnam's Prime Minister Pham Minh Chinh stated that Vietnam will reach its net-zero carbon emission target by 2050 and called for fairness and justice in climate change issues. Furthermore, Political Bureau of the Party Central Committee of Vietnam have issued the Politburo's Conclusion 36-KL/TW for ensuring national water security, reservoir and dam safety till 2030 with vision 2045.

The collaboration between countries and between stakeholders is thus imperative to develop and implement the latest technologies and innovations in the water industry. I thus strongly believe that VIETWATER 2022 is an excellent platform that can bring the world leading technologies, innovations, minds, and related stakeholders to tailor the solutions addressing the local problems in your countries, cities, neighborhoods, and your backyards.

At this occassion, you are heartily welcome to enjoy the only close-up experience in Vietnam of the cutting-edge VIETWATER Expo in water supply, sanitation, and purification technologies, the leading WETV Expo in waste and environment technologies, and the innovative PROPAK Expo in processing and packaging solutions. In parallel with the expo, you are warmly invited to meet the world leading scientists and experts in water, environment, and geosciences at VIWC2022 to customize the global solutions to your local issues where sciences, technology and innovation meet to build the future of localities.

Best regards,

Sci. Dpl. Glenn Banaguas

Chairman, US-ASEAN Fellows for Science and Technology
Chairman, ASEAN Science Diplomats
United Nations (UN) Sasakawa Award Winner 2022

PART I: RESEARCH BRIEFS

OS2: Remote Sensing of Water and Inundation

Date and time: 90mins 10:00am - 11:30am 19 Sept, Mon (**Houston Time/GMT-6**),
Meeting Link:
Meeting ID

Time	Content
Chair	**Assoc. Prof. Hyongki Lee**
10:00 – 10:05	**Opening** *Assoc. Prof. Hyongki Lee*
10:05 – 10:20	**A Novel Rapid Inundation Forecasting Technique: Forecasting Inundation Extents using Rotated empirical orthogonal function analysis (FIER) and Its Economic Benefits to Lower Mekong** *Chi-Hung Chang, University of Houston, Houston, TX, USA*
10:20 - 10:35	**CERES – A Citizen Science Approach Monitoring Reservoir Operation from Space for Poorly Gauged Reservoirs** *Tien L T Du, University of Houston, Houston, TX, USA*
10:35 – 10:50	**A cloud-based application for groundwater monitoring from satellite observations** *Ngoc Nguyen, University of Houston, Houston, TX, USA*
10:50-11:05	**Developing Operational Web Application for Flood Inundation Forecasting for Lower Mekong River Basin** *Son Do, University of Houston, Houston, TX, USA*
11:05 – 11:30	**Discussion, Q & A and Closing** *Assoc. Prof. Hyongki Lee*

A Novel Rapid Inundation Forecasting Technique: Forecasting Inundation Extents using Rotated empirical orthogonal function analysis (FIER) and Its Economic Benefits to Lower Mekong

Hyongki Lee, Chi-Hung Chang, Son K. Do, Tien Du, Faisal Hossain, Kel Markert, Thanapon Piman, Chinaporn Meechaiya

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Chi-Hung is currently Postdoctoral Researcher at University of Houston

We introduce a novel inundation forecasting system named "Forecasting Inundation Extents using Rotational empirical orthogonal function analysis (FIER)." The system is data-driven that forecasts the inundation extents based on the correlation between historical inundations observed from satellite images and river levels (or streamflow) and is computationally efficient, yet skillful, and highly scalable. Here, we present daily forecasted inundation extents over the Lower Mekong floodplains up to 18-day lead times, using forecasted river levels available from our in-house VIC-altimetry-based forecasting system. The results are validated using observed inundation extents from available satellite images. We also assess the economic benefits that our FIER-Mekong inundation forecasting system can contribute by delineating mature rice paddies in Lower Mekong which could have been saved from flood damages during the wet season harvest time by taking early actions, such as advising farmers when and where to reap the rice crops, using forecasted inundation depths derived from our forecasted inundation extents and a terrain model. Finally, we present a web application tool of FIER-Mekong (https://share.streamlit.io/skd862/fier_mekong/main/demo.py) which can facilitate its use in decision-making by end-users with hindcasted, nowcasted, and forecasted inundation extents, and inundation depths.

Keywords: Mekong River**,** Remote Sensing, Inundation Forecast, Flood Damage Prevention

CERES – A CITIZEN SCIENCE APPROACH MONITORING

RESERVOIR OPERATION FROM SPACE FOR POORLY GAUGED RESERVOIRS

Tien L.T. Du, Hyongki Lee, Duong D. Bui, Son K. Do, Ngoc T. Nguyen, Thao P. Bui, Nuong T. Bui, Tra T.T. Nguyen

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Tien is currently Postdoctoral Researcher at University of Houston. My research interests are change detection, attribution, optimization, forecasting and policy recommendation for sustainable (transboundary) water management through modeling and data-driven approaches. She is an Alumni of the Young Southeast Asian Leaders Initiative and Australian Endeavour Leadership Program.

Water resources management for sustainable development is highly challenging in the poorly gauged regions. Lack of infrastructure investment, declining monitoring networks or restricted data access due to national security concerns could be main reasons for significantly limited availability and access of the essential water information in these regions. To overcome the main hurdles of hydrology community in data availability and access to reservoir data in the poorly gauged regions, this study creatively employs a well-known citizen science approach to constantly further improve our satellite based reservoir operation monitoring (CERES) tool, enhance end-users' trust, acceptance and uptake of the tool and consequently support water resources decision making processes for users. Our CERES is a cloud-based interactive web app with freely available datasets for non-commercial uses based on multi-mission satellite datasets, including Sentinel-1 C-band Synthetic Aperture Radar Ground Range Detected (SAR GRD), Shuttle Radar Topography Mission (SRTM) Digital Elevation Models (DEM), Advanced Land Observing Satellite (ALOS) and Multi-Error-Removed Improved-Terrain (MERIT) DEM. Its graphical user interface design allows non-programming users to interact with maps, generate results, evaluate them with provided templates and optionally email performance metrics and figures back to developers for further improvement without granting developers of access to the local observed data.

Keywords: monitoring, remote sensing, citizen science, reservoirs, poorly-gauged

A cloud-based application for groundwater monitoring from satellite observations

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Master at the Incheon National University, Republic of Korea (2021).

Ngoc is currently PhD student in University of Houston. My PhD research topic is linking multi satellite missions and hydrological modelling for supporting water resources management in the data sparse regions.

Groundwater (GW) plays an important role in regional and global water cycles. However, GW recently is challenging to monitor because of limited access to the in-situ observations. In this study, satellite observations are used to estimate GW changes using Gravity Recovery and Climate Experiment (GRACE) and Global Land Data Assimilation System (GLDAS) – NOAH product data. Using cloud computing platform of Google Earth Engine, an application is developed to allow users to assess groundwater change across a target region. Since GRACE has low resolutions, the current version can only provide insights about groundwater changes in large river basin than 10,000 km^2. Future down sampling methods can be integrated into the app for extracting more groundwater signals for smaller basins.

Keywords: groundwater, monitoring, remote sensing, GRACE, GLDAS, Google Earth Engine

Developing Operational Web Application for Flood Inundation Forecasting for Lower Mekong River Basin

Son K. Do, Chi-Hung Chang, Hyongki Lee, Tien L.T. Du

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Son Do is a Master student in Geosensing Systems Engineering from the University of Houston. He focuses on applying remote sensing on flood forecasting and reservoir operation in the Mekong area.

Floods are among the world's most costly and deadly natural disasters. For relief planning, support rescue, and damage recovery decisions during flood events, inundation mapping is extremely vital. Yet, there is no rapid operational inundation forecasting system that can help decision-makers proactively mitigate flood damages in Lower Mekong River Basin. Here, we integrated the so-called Forecasting Inundation Extents using Rotated empirical orthogonal function analysis (FIER) framework with an altimetry-based operational Mekong River level forecasting system to produce accurate inundation extent forecasts for the region. To inform and assist end-users we built an operational web application that generates inundation forecasts with up to 18-day lead times in about 20 seconds on a daily basis with a promising skill (> 70% of critical success index). We use an open-source platform called Streamlit which gained popularity recently among data scientists and engineers to build and host web applications using only Python without intense front-end design knowledge. We also utilize Google Earth Engine and Floodwater Depth Estimation Tool (FwDET) to generate flood depth estimation maps. The wesb application FIER-Mekong can be accessed at https://skd862-fier-mekong-demo-vlobm9.streamlitapp.com/).

Keywords: monitoring, remote sensing, flood forecasting, web-application

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PhD at Ohio State University, USA (2008).
Dr. Lee specializes in using spaceborne and airborne geodetic instruments including satellite altimetry, SAR/InSAR, and GRACE to better understand earth system sciences. His primary research focus includes quantifying and characterizing terrestrial water dynamics towards applications for water resources management.

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OS3: Water, Environment and Ecosystems

Date and Time: 90mins 10:00am - 11:30am 19 Sept, Mon (**Hanoi Time/ GMT+7**),
Meeting Link: MS Team Link

Time	Content
Chair	**Nguyen Minh Phuong**
10:00 – 10:05	**Opening** *Nguyen Minh Phuong*
10:05 – 10:20	**Study the application of vetiver grass in radioactive contaminated water treatment** *Anh Thi Lan VU, VNU University of Science, Vietnam*
10:20 - 10:35	**Da river water management issues** *Tuan Canh Le, Ha noi University of Natural Resources and Enviroment, Vietnam*
10:35 – 10:50	**Assessment of Watersheds Vulnerability to Flood Risks Along North Western Coast of Egypt Using Remote Sensing and GIS Techniques** *Hamed El Asfoury, Fayoum University, Egypt*
10:50-11:05	**Multivariate Statistical Analysis of Groundwater Quality in Tan Thanh district, Ba Ria - Vung Tau province, Vietnam** *Hai Au NGUYEN, Vietnam National University, Vietnam*
11:05 – 11:20	**Potential of Sentinel-1 SAR observations to monitor floods in the north Vietnam** *Binh PHAM-DUC, University of Science and Technology of Hanoi (USTH), Vietnam*
11:20-11:30	**Concentration of Radon of spring waters near radioactive mine regions from the Middle to North of Vietnam** *Van-Hao DUONG, Hanoi University of Mining and Geology, Vietnam*

Study the application of vetiver grass in radioactive contaminated water treatment

Anh Thi Lan VU

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Nowadays, metallic mining activities also produce large amounts of radioactive waste. Radionuclide contaminants pose serious problems to biological systems, due to chemical toxicity and radiological effects. Hence, it is essential to achieve effective reclamation of contaminated. The research results of the article show that there are currently several methods of treating radioactive pollution such as: isolating radioactive wastes in artificial synthetic stones and then burying them beneath the bed. soil, using nano ceramic materials ... In particular, the use of vetiver grass has the effect of stabilizing soil texture, handling radioactive contaminated soil, saving costs, and economic efficiency is necessary. Vetiver grass is a highly developed root plant that grows very fast and eats very deep, and sticks to the ground. They have good drought and water resistance properties. Their roots can penetrate into the ground up to 3.6m on good ground. Very large and long root system is a good condition for the growth and growth of bacteria and fungi, helping the process of decomposition and absorption of organic matter, nitrogen, phosphorus, heavy metals, and radioactive contamination.

Keywords: vetiver grass, radioactive, water treatment

Da River Water Management Issues

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Water is a very important resource, especially for human life. The incident that occurred on October 9, 2019, is a serious warning about water security. The unconscious of some people, pouring waste oil into the Dam Bai lake area. Accordingly, waste oil mixed into water sources, polluting clean water sources, affecting hundreds of thousands of people in Hanoi. The awkwardness of managers when having water pollution. Especially inexperienced in dealing with incidents. Practical survey results, combined with topographic analysis of Dam Bai lake area (Phu Minh commune, Ky Son district, Hoa Binh province), where the Song Da water plant takes water directly to process into clean water for about 250,000,000 people of Hanoi Capital. The author concludes: There is no way to separate the spring water sources with Da river water. The water safety corridor is compromised. The problem of waste oil polluting the Tram spring stream flowing into Dam Bai lake, polluting the Da river water source, is a warning sign for many incidents of water source insecurity that are likely to occur in the future.

Keywords: Da river, Đam Bai lake, water pollution

Assessment of Watersheds Vulnerability to Flood Risks Along North Western Coast of Egypt

Hamed El Asfoury

Hamed El Asfoury

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Lecturer of Climatology. PhD and MA, Cairo University, in climate impact on human activities and floods. Over 20 years of experience in teaching climate and environmental hazards in Egypt and Saudi Arabia.

Egypt is characterized by its arid condition. In the last few years, attention has been devoted to the North-Western coast of Egypt due to the large urbanization activities in it. The government spares no effort to develop it. Many comprehensive planning studies have been conducted and many luxurious tourist spots have been built. Thus, flood management and analysis of this area has become a must.

Intense stream networks distinguish the desert geomorphology, which is subjected to harsh climatic conditions, and extreme water scarcity. However, different stream networks, especially along the sea coasts and the Red Sea Mountains, are subjected to extreme precipitation events in the form of flash floods, where a considerable amount of rainfall occurs, suddenly, for a short duration, and with a relatively long time period. Flood management has mainly two objectives: (1) benefiting from the available flood water during water scarce period, and (2) mitigation actions to minimize the damage caused by flash floods.

A methodology for flood prediction, risk assessment, and vulnerability estimation is extremely important. The using of GIS techniques has allowed us to read and comment on all the resulting maps. We have also discovered that the impact risk will not be calculated if any of the following factors is verified, i.e. high rate of rain falls in short time span, existence of any strategic buildings, projects, or external and mature drainage networks .

Keywords: flash floods, remote sensing, flood management, flood prediction

Multivariate Statistical Analysis of Groundwater Quality in Tan Thanh district, Ba Ria - Vung Tau province, Vietnam

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PhD in Water Resources, Institute of Environment and Resources - Vietnam National University Ho Chi Minh City, Ho Chi Minh, Vietnam (2017). Over 15 years of experience in doing research and teaching on water resource in Vietnam.

This research applied the groundwater quality index (GWQI), principal component analysis (PCA) and cluster analysis (CA) for assessing pollution levels and factors effecting groundwater quality in Tan Thanh district, Ba Ria – Vung Tau province. Seventeen monitoring wells of Pleistocene aquifer were collected in April (dry season) and October (rainy season) during 5 years (2012-2017). Nine parameters of water (pH, total dissolved solid, total hardness, Chloride, Fluor, Nitrate, Sulfate, Cooper and Iron) were determined. According to GWQI, 17 monitoring sites have been classified as from good to very good. Two factors including (i) interaction of chemical components in aquatic sediments and (ii) character of aquifer and anthropogenic, affected to the quality of groundwater in the study area. In addition, CA divided data into 2 different groups, group 1 embrace wells with fresh water, group 2 consist of wells that tend to be saline intrusion, similar to groundwater quality in the group has high GWQI index, respectively. The study result provided specific information, and the useful tools in order to deal with the complicated databases, as well as zone the groundwater quality in the study area. This further help the authorities to plan suitable strategy for groundwater quality management.

Keywords: Groundwater; groundwater quality index; principal component analysis; cluster analysis

Potential of Sentinel-1 SAR observations to monitor floods in the north Vietnam

Binh PHAM-DUC, Trung TRAN

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PhD in Environmental Science from Sorbonne University, Paris, France.
His work focuses on applications of satellite remote sensing data for studying the variation of the environment, and effects of climate change on the water cycle at regional scale.

As one of the countries affected the most by global warming and climate change, the frequency and intensity of extreme weather events occurring recently in Vietnam are increasing. Floods, among others, are one of the most damage disasters in Vietnam. In this paper, we illustrate how satellite data (especially free SAR data from the Sentinel-1 satellite) can be used to monitor floods, at 30 m spatial resolution, in the north Vietnam where the cloud cover is very high. Although there is no reference inundated map at the same spatial and temporal resolutions for comparison, SAR-derived permanent surface water map is in good agreement with free-cloud Landsat-derived surface water map. This study shows strong potential of SAR satellite observations for monitoring and forecasting applications over highly cloud-covered environments like the tropical regions.
Keywords: SAR, Sentinel-1, Landat-8, Flood detection, North Vietnam

Seasonal Variation of Groundwater Level and Quality in Xuan Mai, Hanoi, Vietnam

Thanh Kim Thi DO, Quynh Thuy KIEU, Dung Xuan BUI

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Groundwater distrubted almost everywhere beneath on the surface of Earth, it is the major source for different uses such as domestic, agricultural and industrial purposes. Nowadays, there are so many factors influencing to groundwater such as variation rainfall, insufficient water surface, human factors impact to the quality of groundwater. The present investigation is aimed at evaluation of spatial and temporal groundwater level, assessing some chemical indicators about groundwater quality and groundwater quality index (GWQI) for applying interpolation map by IDW methods in Xuan Mai town. This study has been carried out by measuring groundwater depth in four drillwells by Rugget Water Level Tape 200 and taking 12 samples of 9 hamlets, then compared with the Vietnam standard 09:2015/Ministry of Natural Resources and Environment (QCVN 09: 2015/BTNMT). For computing GWQI, nine parameters viz., pH, Fe, NO2-,NH4+, NO3-, CaCO3, TDS, Mn2+, Cl-, have been considered. The study was conducted from 10th October, 2018 to 10th October, 2019 with dry season from 03/2017 and 02/2019 to 05/2019, rainy reason from 06/2019 to 08/2019.
The main results of this study is: (1) Groundwater depth experienced a decline trend in dry season with the exception of drillwells 11. (2) Groundwater quality had the fluctuations in both dry and rainy seasons. While the TDS, NH4+, NO3- and Mn2+ indicators witnessed a marked increase in rainy season, the concentrations of Cl-, Fe, NO2- decreased slightly. CaCO3 and pH concentration remain unchanged in safe levels. With NO3-, 8/12 drillwells were polluted in the dry season, especially drillwell 1, exceed 6.5 times. During the rainy season from June to August, NH4+ concentration plummeted, only 4 drillwells exceeded the standard. There are 5 drill-wells polltued of Mn2+, however, in dry seasons, the concentration decreased significantly. (3) Assessment of water quality in Xuan Mai according to the GWQI index for each point, all 12 drill-well was “good” and “excellent” and suitable for eating and living.

Keywords: Drill-well, groundwater, GWQI, seasonal fuctuation, Xuan Mai

Concentration of Radon of spring waters near radioactive mine regions from the Middle to North of Vietnam

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PhD in Geophysics, AGH University of Science and Technology (2018), He deal with monitor and assessment of natural radioactivity; Isotope analyst: Determine ^{238}U, ^{234}U, ^{228}Ra, ^{226}Ra, ^{224}Ra, ^{222}Rn, ^{220}Rn, ^{210}Pb, ^{210}Po, ^{230}Th, ^{232}Th, ^{40}K isotopes in environmental samples (with low concentration); Isotope application in geology, hydrogeology, environment and agriculture. Now he work as lecturer in Geophysics Department in HUMG

In North and Midle of Vietnam, there are many radioactive mines including Uranium-type and Rare-Earth-Element-type that are being explored and mined. The mine of radioactive ores is result into exposure radioactivity to environment, especially natural waters. To access an impact of exposure radioactive mine to natural waters, we conducted monitoring radioactive levels of surround mine areas by determination of concentration of Radon in spring water. The concentration of Radon was determined by RAD-7 radon detector.

Spring waters near locality of 15 radioactive mines from the Middle to North of Vietnam are analyzed for the concentration of Radon to examine the effect of high radioactive regions which released to water environment during 2018. Our preliminary result showed that concentration of Radon in spring waters varies from 70 Bq/m^3 to 35000 Bq/m^3 for 14 monitored stations, except for that of Muong Hum monitored station, which is reached to 89900 Bq/m^3. The highest concentration of Rn measured in Muong Hum monitored station is probably due to enrichment of Uranium during weathering. We also found that variation of the concentration of Radon in spring waters is depend on amount of rainfall of season. The concentration of Radon is higher in dry season and lower in rainy season. This result is explained because of Radon in spring waters leaching from near radioactive mines. The low concentration of Radon in rainy season is due to dilution of Radon by meoteric water. Further investigation is the need to understand a rule of disintergration of radioactive elements and scatter of Radon in natural waters. Based on the results, the natural radiological hazard was assessed also.

Keywords: radioactive mines, spring waters, Radon, monitor

Solutions in order to prevent the radioactive pollution on the water source in the rare earth ore mining and processing

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Over 20 years of experience in doing research and teaching on mining and environmental protection in Vietnam, about 10 years studying and cooperative research with German partners. He has published 12 special books and textbooks and over 40 inter- and national papers.

Water source is one of environmental components effected very strongly by mineral mining and processing. Most of the mineral mining released the acid mine drainage (AMD) and mineral beneficiation has been maintaining an amount volume of wastewater from the mineral concentration and hydrometallurgical processing. Along with various heavy metals, sometimes AMD contains different radioactive materials from rare earth ore mining and processing, because of most rare earth deposits content the radionuclides in Uranium (^{238}U) and Thorium (^{232}Th) decay series and radioactive potassium isotope (^{40}K) which mostly originate naturally from rocks and soil. Mining and using rare earth elements (REEs) become essential demand and very rivalry in the Industry Revolution 4.0 and rare earth ore resources play a strategy role for the modern technologies of the industry countries. Unfortunately, rare earth ore mining and processing procedures constitute destructions on the earth's land and destabilize soil and water ecosystems. Otherwise, the technological mining of ion-absorption clay (solution mining) may be low REE recovery (up to 5%), groundwater contamination, an increase in soil and water pH, and nutrient pollution of downstream rivers. Alarmingly, some of these human health and environmental impacts are irreversible and persistent even after reclamation of the mine site.
Vietnam is a country having abundant potential resource of rare earth ore in the world. The geological exploration projects of rare earth mineral have been implemented since 60th decade last century in Vietnam. In recent years, some rare earth ore mining projects were studied and prepared to extract and use REEs. The pre-mining projects of rare earth deposit have concerned particularly to environmental protection issue. In addition to the presenting an overview of methods to prevent radioactive pollution, this study presents some initiate experimental results of U and Th separation and radioactive wastewater treatment in Vietnam.

Keywords: radioactive wastewater treatment, rare earth mining, radioactive pollution, radionuclides extraction.

Mapping Surface Water Bodies based Water Indices Extracted from Sentinel 2 Images

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Remote sensing technology has taken many advantages in water and hydrological systems management, such as: accurately determining water bodies; or providing up-to-date spatiotemporal changes of stream flows, water quantity, and water quality. Theoretically, based on the significant spectral signature of water in the visible to shortwave infrared wavelengths, it is feasible to distinguish water bodies from other phenomena on satellite images like vegetation, bare soils, clouds, or even shadows. However, due to restrictions of spatial resolutions and capabilities of satellite sensors, establishing threshold values to separate water bodies from the background may be challenging. To minimized the effects of environmental background noises, there are some indices investigated in extracting information about water resources such as the Normalized Difference Water Index (NDWI), the Normalized Difference Vegetation Index (NDVI), the Land Surface Water Index (LSWI), the Modified Normalized Difference Water Index (MNDWI), etc. This study examines performances of some widely used water indices derived from a freely remotely sensed data – the Sentinel 2 for mapping water bodies. Results are expected to support a process of automatic extraction water bodies from imagery scenes by comparing and recommending possible threshold values and indices in a particular case study.

Keywords: hydrological systems management, remote sensing, mapping, Sentinel 2.

Effects of Tam Phuoc-Phuoc Tan Stone Mine Area to Buong River's Water Quality, Bien Hoa Tity, Dong Nai Province

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Master's degree in environmental science at Ho Chi Minh City University of natural sciences (2011). She is a lecturer on environmental geology at the University of Natural Resources and Environment in Ho Chi Minh City. Her works focus on environmental issues in mining; environmental rehabilitation and restoration in mineral activities; apply GIS and remote sensing in geological hazard assessment.

Tam Phuoc - Phuoc Tan mine cluster has a planned area of over 400ha. Currently, the area has 10 exploiting stone mines with an area of 354.18 ha (8 on the left bank and the others on the right). The distance from the edge of the mine to the river bank is at least 50m, the cote of exploitation is -80m. Buong River has a total length of 53km, the section running through the Tam Phuoc-Phuoc Tan mine cluster is the middle part of the river, about 6.6 km long, the stream is zigzag in the general direction from the Northeast to the Southeast. All operating mines have prepared environmental impact assessment reports but individually, there has been no overall impact assessment of the mine clusters on the Buong River.

This study focuses on assessing the impact of the mine cluster on the water quality of the Buong River through the collection of measurement data of the water quality of the Buong River and the quality of wastewater of mines in 10 years (2008-2018). The results show that the water quality of the Buong River is declining and in the future, it is no longer able to receive wastewater from the mine cluster.

Keywords: Buong River, water quality, Tam Phuoc-Phuoc Tan, stone mine

Assessment of water quality in an urban lake and canal system in Cantho city, Vietnam

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A PhD in Hydrological and Environmental Engineering, Tokyo University of Agriculture and Technology (2017).
Over 20 years of experience in doing teaching and research on the science-based linkages between the hydrological environment engineering, environmental impacts assessment, and society in order to promote sustainable management of water resources.

XangThoi's Lake and canal system in urban of CanTho city is an important interface between recreational purpose and ecology, which demands environmentally responsive strategies, urban flooding control and water quality. The study attempts to investigate the water quality and hydrological interventions. Water quality assessment of the lake and interlinked canals was carried out. A total of 12 points and samples were collected and observed during post-monsoon, pre-monsoon and were subjected to physical, chemical and bacteriological analysis. Besides the domestic and international standards were applied to evaluate the degree of pollution, the spatial and temporal variability of surface water pollution were conducted by the estimated water quality index. It was concluded that experimental plans like linking of lake and canals have considerable impacts on the water quality on lake and disrupt the balance of not only lake ecosystems but also polluted receiving waters. The specific hydrological impact assessment and cumulative impact assessment framework should be explored with respect to local context.

Keywords: water quality, urban lake-canal, assessment

The curious case of UPGRADING OF THE TAN HOA LO GOM CANAL in Ho Chi Minh City, Vietnam

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Nguyen is the architect in urban planning, finished MSc in Urban Environmental Management (Asian Institute of Technology), and PhD in Urban Planning&Real Estate Development in Radboud University. From 2015, Thanh is a lecturer at Ho Chi Minh City Open University. Currently, he is working on projects about Land Property Rights in Vietnam. His interest are land use, globalization, real estate, and GIS

This study presents a case study about a successful flooding control and urban upgrading project. Vietnam is a sample of rising stars in Southeast Asian, attended by uplifting millions of families out of poverty. Many canals are in the Ho Chi Minh City, one known as Tan Hoa – Lo Gom canal appeared to be the most heavily polluted.

This article aims to evaluate the impact of interventions to improve living conditions in the case of the Tan Hoa-Lo Gom Canal Sanitation, implemented in Ho Chi Minh City from 2000 to 2015. The main concern is about the willingness of the poor, especially in supporting them to maintain and develop their livelihood through socio-economic support programs provided for households who were affected by slum clearance and participation of communities.

This research figured out that the bottom-up approach makes better project implementation and management. This way not only sets the poor resident in the central platform but also is helps the poor deal with daily life difficulties. We found that the project has given a significant improvement to the people and stakeholders: - The resettlement program allowed people to progress from being slum dwellers with virtually no legal status to official home-owning residents. - A social housing project developed a mechanism to finance the operation and maintenance of the buildings in a sustainable way. Residents run and maintain the apartment blocks themselves, with their management board and regulations.

Besides, the study debates that despite remarkable successes of the project, gradual replacement of the poor at the post-project is unavoidable if there is no suitable strategy in restoration and generation income from local government and other stakeholders.

Keywords: canal pollution, urban upgrading, Ho Chi Minh City, sustainable, slump

Potential impact of global warming by effect of temperature on toxicity of Pb on aquatic life

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PhD in Applied Biological Science in the Ghent University, Belgium. She has many years of experiences working with limnology, especially with eutrophication phenomenon in aquatic bodies. Her most recent research focus on ecological toxicology of heavy metals and other toxic substances on aquatic biota in Hanoi Lakes.

Lakes in the Hanoi urban area have been facing many environmental problems, such as 1) lack of water; 2) high turbidity from organic materials and garbage; 3) pollution from heavy metals and artificial organic chemicals; 4) algae blooms; and 5) biodiversity degradation.
Heavy metal pollution in urban lakes of Hanoi has become one of the major environmental issues in the last decades. Lead (Pb) is a heavy metal found in significant concentrations in the waters of Hanoi lakes and accumulates in the aquatic animals. Research on the toxicity of Pb is necessary due to the extent of its harm to aquatic ecosystems. The toxicity of Pb to aquatic organisms (determined through EC50 values) depends on different environmental conditions. The study was conducted to evaluate the effect of temperature on the toxicity of Pb on the test organism Moina Dubia, which is indigenous to the lake in Hanoi. Moina Dubia was cultured under laboratory conditions and has been used to conduct EC50 determination for Pb. Moina Dubia belongs to the Cladocera group (Cladocera) which is an indigenous creature collected at Lake Hanoi. The research process shows that Moina Dubia grows and develops well in the laboratory and is suitable as a test organism in toxicological studies. A survey of 24OC and 28OC temperature conditions shows that when the temperature increases, the EC50 value decreases, so higher water temperature is a factor that increases the toxicity level of Pb on Moina Dubia
Due to global climate change, the trend of increasing the ambient temperature is in red River Delta had been reported. As the consequence, the increase of water temperature in aquatic bodies can be observed. Clear impact of water temperature on toxicity of heavy metal as Pb showed that global warming may lead to the increase of toxicity of the heavy metal of aquatic bodies.
Results of this study strongly recommend for comprehensive approaches to improve environmental conditions in urban lakes of Hanoi.

Keywords: Lead toxicity, metal pollutants, temperature increase

Assessment of Metal Enrichment in Water and Sediment of Salichaung Hot Spring, Momauk Township, Kachin State, Myanmar

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The main focus is to investigate the water chemical analysis and heavy metal enrichment in sediments of Salichaung Hot Spring, Momauk Township. Water sample were examined with Public Health Laboratory to determine the water quality parameters. Sediment samples were analyzed by using EDXRF method. The water in the Salichaung Hot Spring is chemically potable for the twelve water quality posts of measurements. The concentrations of elements in bottom part sediment S (B) are higher than top part sediment S (T). The enrichment factors (EF) of Fe and Zn have no enrichment in top and bottom sediment. The enrichment factors (EF) of Al and K are minimal enrichment in top and bottom sediment. The enrichment factors (EF) of Mn in top and bottom sediment are moderate. The enrichment factors (EF) of Sr is significant in top sediment and moderate in bottom sediment. The enrichment factors (EF) of Th is significant in top and bottom sediment. The enrichment factors of seven heavy metals are not in very severe range.

Keywords: Salichaung Hot Spring, water quality parameters, enrichment fact

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She has experience in scientific research in various fields including water quality. During her Master's Program of Climate Change and Delta Management - Can Tho University, she was also involved in the project "Saline changes, groundwater reserves and development of salinity maps in Vinh Chau, Soc Trang province" to create practical data on groundwater quality and data raw salt in the area .

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PhD student in the School of Environmental Science and Technology, HUST. Ms. Hong's research is focusing on the relationship between the environment and health of communities living in the contaminated area as well as on solution for mitigating pollution impact on human health. She is currently working on PhD project on ecological toxicology of heavy metals and other toxic substances on aquatic biota in Hanoi Lakes.

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Ha Le has graduated undergraduated program on Environmental Engineering. She is currently a Master student in Environmental Engineering, HUST. Ms. Ha's research is focusing on the effect of certain water characteristics on toxicity of pollutants, especially heavy metals.

Tran Thi Vinh

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Vinh Tran has graduated Bachelor of Environmental Science. She is currently a Master student in Environmental and Resource Management, HUST. Ms. Vinh's research is focusing on the risk assessment of heavy metal contamination on aquatic biota in Hanoi Lakes.

OS4: Water quality and Aquaculture

Date and time: 10:00 a.m – 11:30 a.m Monday, September 19th, 2022;

Meeting link: https://meet.google.com/egn-btky-onr?pli=1&authuser=0

Meeting ID:

Times	Content
Chair	**Prof. Vu Duc Toan**
10:00 – 10:05	**Section opening** *Prof. Vu Duc Toan (Chair)* *Assoc.Prof. Nguyen Thi Lan Huong (Co-chair)* *Faculty of Chemistry and Environment, Thuyloi Univeristy, Vietnam*
10:05 – 10:20	**Adsorptive removal of heavy metals from water using thermally treated laterite: an approach for purification of rainwater** *Assoc.Prof. Tran Dinh Trinh*
10:20 - 10:35	**Superior removal of Methylene Blue by mesoporous g-C_3N_4@WO_3 nanocomposite: equilibrium and kinetic study.** *Assoc.Prof. Tran Dinh Trinh*
10:35 – 10:50	**Research on Sterols pollution in the water of Kim Nguu River, Ha Noi** *MSc. To Xuan Quynh*
10:50 – 11:05	**Residue and ecological risk assessment of Polybromine diphenyl ethers (PBDEs) in the surface water of West Lake, Hanoi** *MSc. Vu Thu Huyen*
11:05 – 11:20	**Assess the current state of the environment in brackish-water shrimp-farming areas in Nam Dinh province proposing measures to improve efficiency.** *BSc. Pham Truong Thao Nguyen*
11:20 - 11:30	**Conference summary** *Prof. Vu Duc Toan*

Adsorptive removal of heavy metals from water using thermal treated laterite: an approach for purification of rain water

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Many people presently do not have access to clean water, especially in rural/coastal areas. In such areas in Vietnam, rainwater is partly utilized along with groundwater, which risks of being contaminated by heavy metals, especially arsenic in some areas. Besides, rapid industrialization and urbanization may result in lots of pollutants ended up with rainwater. Therefore, the pollutant must be safely removed from rainwater for living purposes. In this study, we modify natural laterite by thermal process to improve its adsorption capacity and mechanical properties. The modified laterite was used to study the adsorption of heavy metals in water medium and purify rainwater.
The treatment process led to removal of impurities and decrease in surface area of laterites. The adsorption of of Cu2+ (10 mg/L) and Ni2+ (10 mg/L) reached equilibrium at 35 min, with removal efficiencies of 99% (for Cu2+) and 95% (for Ni2+). The optimal pH was pH 7.0, being linked with the electrostatic interactions. The maximum uptakes of modified laterite were 0.820 mg/g and 1.027 mg/g for Ni2+ and Cu2+, respectively. Rainwater quality at 100 households in Hai Dong coastal commune, Hai Hau district, Nam Dinh province varied from household to household, mainly respecting the national regulation on domestic water quality (QCVN 02: 2009/BYT), with some exceeding values. Fe2+ and Mn2+ contents in some samples exceeded national regulation due to mixture of rainwater with groundwater. The application of modified laterites combined with sands and biochar significantly improved the water quality that could be used for different domestic purposes.

Keywords: rainwater quality, heavy metal, bacteria, adsorption, water purification, drinking water

Synthesis of g-C3N4@WO3 nanocomposites and its application for the removal of methylene blue: equilibrium and kinetics study

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Dr. Tran's research interest is focused on water and waste water treatment processes. He published over 50 ISI/Scopus articles with high IF and more than 20 oral presentations in international conferences in the related domain. He has also served as a frequent reviewer of several high ranked peer-reviewed journals.

In this research, the g-C3N4@WO3 nanocomposites were synthesized from Na2WO4 and g-C3N4 via the hydrothermal method in a strong acid medium. The g-C3N4 content is 0, 0.5, 1, 3 and 5 wt%). The characterization of the g-C3N4@WO3 nanocomposites was measured by XRD, Raman, FT-IR, FESEM, and UV-vis spectra. The results show that g-C3N4@WO3 nanocomposites are hexagonal structural with an average crystal size of about 15.4 to 20.7 nm. The adsorption ability of the g-C3N4@WO3 nanocomposites was evaluated through the methylene blue dye absorption process. The optimal conditions of the MB adsorption process on the g-C3N4@WO3 nanocomposites were investigated. Moreover, equilibrium and kinetic modelling of the adsorption process also was studied and discussed.

Keywords: graphite carbon nitride (g-C3N4), nanocomposite, hydrothermal method, adsorption, synthetic dyes, equilibrium and kinetic modelling

Research on pollution of Sterols in Kimnguu River water, Hanoi

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As the world's population continues to grow, water pollution is one of the greatest challenges worldwide. More wastewater is produced and the demand for clean water is increasing. Make sure Human and environmental safety and health, efficient wastewater treatment systems. And there is a need for reliable assessments of water quality and pollution. Sterols are a group of compounds that indicate water pollution. Sterols are often present in high concentrations in untreated domestic wastewater and they have a high potential for bioaccumulation in sediments. Sterols have been extensively studied in surface water, wastewater before and after treatment systems, and sediments. In particular, coprostanol is an indicator of waste contamination (human and animal feces) in the environment, and analysis of the ratio of coprostanol/cholesterol indicates the source of sterols in wastewater. Kim Nguu River is Hanoi's wastewater drainage river, the composition of pollutants in the river is quite complicated, the study of sterol pollution in river water can help to learn more about the origin of pollutants in the water.

Residue and ecological risk assessment of Polybromine diphenyl ethers (PBDEs) in the surface water of West Lake, Hanoi

Huyen Thu VU, Toan Duc VU

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PBDEs are a group of persistent organic pollutants used as flame retardants in polymeric materials such as plastics, plastics, and rubber. From these materials, PBDEs are found in many consumer products, especially electrical and electronic equipment, household plastic products, furniture, transportation vehicles, and workwear. The toxicity of PBDEs is relatively low, but they have the potential to bioaccumulate and cause negative effects in humans. The main effects include endocrine disorders, affecting the human brain, liver, and kidneys. PBDE can enter the environment by evaporation from plastic products, from dust from electronic waste, from exhaust fumes from municipal solid waste incinerators, and then enter the food chain (accumulation). in food such as fish, beef...) and then into the human body (eating, breathing, skin contact). The concentrations of PBDEs in all biological samples ranged from 2.38 to 1632 ng/g dry weight with an average value of 425 ng/g. They persist in the environment for a long time, are hydrophobic, bioaccumulative and highly contagious. Many studies show that PBDE has accumulated in blood, human milk and environmental components such as air, soil, and sediment in many countries around the world.

Keywords: PBDEs, benthich animals

Assess the Current State of The Environment in Brackish-Water Shrimp-Farming Areas in Nam Dinh Province and Proposing Measures to Improve Efficiency

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Student Thao Nguyen focuses on environmental engineering. She has participated in implementing 03 state-level projects and had 1 article published in foreign journals, is now a 2nd year Master student majoring in integrated water resources management, *TH Koln University of Applied Sciences - Thuyloi University (TLU)*

In the context of the increasing trend of marine environmental pollution, the role of marine environmental monitoring for aquatic product production is increasing. Environmental incidents appear more and more often, red tides, diseases, accumulation of toxins, and mass deaths of aquatic animals occur more and more frequently. The reason is due to the increase in environmental pressure from economic activities. Aquaculture plays an important role in our country's economy. Annually, aquaculture production reaches millions of tons, of which shrimp farming accounts for the majority with about 1 million tons per year. However, due to the above reasons, shrimp farmers are facing a number of problems such as disease and environmental control. Therefore, it is necessary to assess the environmental status of brackish water shrimp farming areas to give timely warnings and solutions to improve water quality, reduce the risk of disease spread, and limit damage to farmers.

Keywords: aquaculture, shrimp farming

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Prof.Dr. Toan Vu Duc focuses on environmental toxicology, environmental chemistry and environmental engineering (applied to persistent organic pollutants, plastic waste, risk assessment, soil and wastewater treatment). He has established a strong research group in these areas and have published 45 journal articles (including 16 ISI journal articles), 6 book/chapter book. He was recently project leader of 2 big project from NAFOSTED funding. He is the senior lecturer and member of the Scientific Committee of Department of Chemistry and Environment, Thuyloi University, Vietnam. He has cooperated as reviewer for several ISI-index journals and as Associated Editor of Pollution Research (Scopus Journal). He has worked as a members for more than 50 councils for acceptance of projects, doctoral and master theses. He has completed the principle supervision of 2 PhD students and 25 MSc students. Currently, He is working as Vice Head of Division of Environmental Engineering with 3 PhD students (2 as principle supervisor and 1 as co-supervisor).

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OS5: Water-efficient Agriculture for Climate change Resilience:

Date and time: 90mins: 20;00-21:30 pm, 20 Sept, Tue (Hanoi Time/ GMT+7),
Meeting Link: https://meet.google.com/cpc-vryv-izj
Meeting ID: cpc-vryv-izj (Google Meet)

Time	Contents
Chair	**Dr. Tanh Nguyen**
20:00-20:05	**Reception** *Dr. Tanh Nguyen and Dr. Do Thi Xuan*
20:05-20:20	**Drought research in Vietnam: A review and recommendations; Q&A** *Nguyen Ngoc Bich Phuong and Prof. Dr. Phan Van Tan, Vietnam National University-Ha Noi/University of Sciences, Vietnam*
20:20-20:35	**Simulation of maize biomass and yield in An Giang province, Viet nam and under climate change; Q&A** *Mr. Le Huu Phuoc, Andalas University & An Giang University*
20:35-20:50	**Food security as a landscape study problem** *Dr. Tanh Nguyen, An Giang University/Vietnam National University-Ho Chi Minh City and AgMIP-Vietnam*
20:50-21:05	**Microbial community structures related to beneficial microorganisms inhabiting paddy soils under global climate change** *Dr. Do Thi Xuan, Can Tho University*
21:05-21:15	**AgMIP-Vietnam directions** *Dr. Tanh Nguyen, An Giang University*
21:15-21:20	**Close up** *Dr. Do Thi Xuan, Can Tho University*

Drought research in Vietnam: A review and recommendations

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Drought is one of the natural phenomena, often recurring on the mainland, and often leaving serious consequences for production, environment, socio-economic life and terrestrial ecosystems in general. Drought is a state of temporary water shortages compared to climate averages, which are unusual or climate anomalies. Therefore, drought can occur anywhere (not only in arid areas) and at any time of the year (even during the rainy months). In Vietnam, drought is one of the most concerned issues, especially in the directions of drought forecast and drought assessment. In this study, the drought researches since late 1990s to present have been overviewed. The advantages and limitations in previous studies have been discussed. Based on that, some recommendations on the drought research in Vietnam in future have been proposed.

Keywords: drought, climate change, drought forecast, drought assessment

Simulation of maize biomass and yield in A Giang province, Viet nam and under climate change

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At the present time, climate change causing increasing temperature, dryness and CO2 has exposed negative impacts on crops. In this study, four independent chambers were built to establish the expectation of different temperatures between the chambers. The experiment was carried out from January to March 2021 at An Giang University experimental area. Corn variety "Gold 58" was grown in 42 pots (34x28x28cm) in a chamber, 2 plants/pot. Temperature and CO2 were hourly recorded. Plant height, leaf number, stover biomass were measured every 10 days period. The results showed that days to maturity in 4 chambers ranged from 62 to 67 days and accumulated temperature from transplanting or sowing to maturity (Tsum) varied from 1976 to 2077 0C d. The average of CO2 concentration of 10 days period in the chambers varied from 527.5 to 558.3 ppm at daytime and 626.1 to 744.4 ppm at night-time (highest in chamber 1). Plant height at harvest in chamber 1 was 306.7 ± 11.5 cm, while it was decreased by 6.1%; 11.7% in chambers 3 and 4. Total biomass above the ground in chamber 2, 3, 4 also significantly declined by 25.2%; 31.6% and 36.4% at harvest, respectively. Fruit yield also reduced by 14.3%, 34.9% and 34.1% respectively compared to chamber 1. Observed versus simulated comparison by our crop-model (based on R language programing) resulted in RRMSE value less than 8.2%. NSE index (Nash Sutcliffe Efficiency) of the models greater than 0.75 show that the models have high reliability.

Keywords: biomass, CO2, corn, crop model, Vietnam Mekong Delta, yield

Food security as a landscape study problem

Tanh T. N. Nguyen

Dr. Tanh T. N. Nguyen

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Dr. Tanh Nguyen is the scholar on crop and greenhouse gases modeling at Institute of Meteorology and Climate Research Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Germany. Dr. Nguyen is also a tenured faculty at An Giang University (AGU), Vietnam National University-Ho Chi Minh City (VNU-HCM), with leadership roles as Dean of Engineering, Technology, and Environment, Chair of Biochemical Engineering Department, and to-be Director of Climate Change Institute. Dr. Nguyen is the AgMIP-Vietnam+ Lead who supports crop study collaborations in the region of Vietnam+.

Food security is the global concern. However, addressing its problems is difficult since it is related to many factors, particularly climate change and human crisis. Thus, this study developed a framework of food security analysis using a landscape approach. The approach was designed for problem identification of food security. The study also developed a procedure to study the food security. By placing the food security in landscape, its issues have been easily revealed and assessed. This approach can promisingly assist studying food security issues, which can be applicable worldwide.

Keywords: food security, landscape, modeling, spatial approach

Microbial community structures related to beneficial microorganisms inhabiting paddy soils under global climate change

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PhD in Biology- Soil microbiology, Swedish University of Agricultural Sciences (2012).

More than 10 years of experience in doing research and teaching on soil bacterial community structures, PGPR and arbuscular mycorrhizal fungi in Vietnam.

Soils are the most popular habitat for microbial growth on Earth. They play an important role in ecological agriculture system, such as plant growth promotion, soil structure preservation and soil nutrients metabolism. However, they are easily to receive impact from agricultural practices and changes in soil conditions. Among them, soil salinity is usually caused either by nature or by human activities which negatively affects plant growth including rice on agriculture sites, especially Mekong Delta, a major agriculture site supporting both food export and supply for Vietnamese. Rice loses grain yield under salt condition. Not only rice development, but also soil microbial diversity such as bacterial and arbuscular mycorrhizal communities are also under influence of soil salinity.

I am interested in understanding how anthropogenic activities as well as saline intrusion that affect on soil microbial diversity of beneficial bacterial and arbuscular mycorrhizal community structures, greenhouse gas emission and rice yield in an intensive rice cultivation, rice crop rotation and a rice-shrimp rotational cropping systems in the Mekong delta, Vietnam.

Keywords: microbial community structures, arbuscular mycorrhizal community, PGPR, sustainable, ecosystem services

OS6: Smart Water Grid: Artificial Intelligence for Water Applications

Date and time: 90mins 10:00am - 11:30am, 20 Sept, Tue (Seoul Time/GMT+9),
Meeting link:
Meeting ID: Passcode:

Time	Content
Chair	**Prof. Gyewoon Choi**
10:00-10:05	**Opening and Introduction** *Prof. Gyewoon Choi , Incheon National University, Korea* *CEO of K-water (2013-2016)*
10:05 – 10:20	**Enhancement of Satellite DEM Accuracy using Machine Learning and Remote Sensing data for Flood Mapping** *DongEon Kim, Head researcher, HANCOM inSPACE, Korea*
10:20-10:35	**Smart Water Grid Technologies and its application plan to Municipalities in Nepal** *Dongwoo Jang, Assistant Professor, Incheon National University, Korea*
10:35-10:50	**Prediction of WWTP Influent and Effluent Characteristics using Machine Learning** *Seongjoon Byeon, Senior Research Engineer, ICUH, Korea (Co-author Joohee Park)*
10:50-11:15	**Analysis of Water Use Patterns Based on Big Data and Neural Networks** *Seul-gi Kang, Research Engineer, ICUH, Korea (Co-author Youngkyu Kim)*
11:15-11:30	**LSTM for prediction of water level in the Red river, Vietnam** *Nguyen Tra. Researcher, Advanced Solutions, Vietnam*
11:30 – 12:00	***Q&A and Discusion***

Enhancement of Satellite DEM Accuracy using Machine Learning and Remote Sensing data for Flood Mapping

Dong Eon KIM

Dong Eon KIM
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The digital elevation model (DEM) is crucial for various applications, such as land management and flood planning, as it reflects the actual topographic characteristic on the Earth's surface. However, it is quite a challenge to acquire the high-quality DEM, as it is very time-consuming, costly, and often confidential. This research explores a satellite DEM enhancement scheme using a machine learning (ML) that could improve the German Aerospace's TanDEM-X (12 m resolution). The ML was first trained in Nice, France, with a high spatial resolution surveyed DEM (1 m) and then applied on a faraway city, Singapore, for validation. In the training, Sentinel-2 and TanDEM-X data of the Nice area were used as the input data, while the ground truth observation data of Nice were used as the target data. The applicability of enhanced DEM was finally conducted at a different site in Singapore. The enhanced DEM shows a significant reduction in the root mean square error of 43.6% in Singapore. This research also demonstrated the application of the trained ML on Ho Chi Minh City, Vietnam, where the ground truth data are not available; for cases such as this, a visual comparison with Google satellite imagery was then utilized. The enhanced DEM with 10 m resolution shows much clearer land shapes (particularly the roads and buildings).

Keywords: Machine Learning, Digital Elevation Model, Flood Mapping, Remote Sensing

Smart Water Grid Technologies and its application plan to Municipalities in Nepal

Dongwoo Jang

Dongwoo Jang
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PhD in Hydraulics, water engineering, Dept. of Civil & Environmental Eng. Incheon National University, Incheon, Rep. of Korea (2017). Over 10 years of experience in doing research and teaching on hydraulics, water supply systems in Korea. Research fields are water supply and sewerage systems, hydroinformatics, smart water grid and river engineering.

In the case of small towns in Nepal located in mountainous areas, the water quality is clean as there is a water intake source using spring water from the top of the mountain. But the water supply pipe connected to the water treatment plant is not buried underground and it is exposed to the outside, so it is vulnerable to the accident as landslide in flood condition. Due to the nature of the mountainous area, frequent rockfalls damage to the water supply pipeline. So the non-revenue water rate is very high comparing with urban distribution network.

Smart water grid technology was developed with the goal of water security, safety, and efficiency. In this study, smart water management technology was classified and technology applicable to small towns in Nepal were suggested. A solution was proposed for water treatment, water quantity and water quality monitoring in water facilities and distribution network. Based on the results of field visits to major small towns in Nepal, essential technologies for water supply and management were selected according to short-term, medium-term, and long-term plans.

Keywords: smart water grid, small town, water supply systems, water facilities

Prediction of WWTP Influent and Effluent Characteristics using Machine Learning

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PhD in Information, Communication Sciences and Technology, University of Nice Sophia Antipolis, France (2015). Currently serving as a position of senior research engineer in ICUH and an adjunct professor in Incheon National University, Korea.

The operation of a wastewater treatment plant (WWTP) is a complex task which requires to consider several aspects: adapting to always changing influent composition and volume, ensuring treated effluents quality complies with local regulations, ensuring dissolved oxygen levels in biological reaction tanks are sufficient to avoid anoxic conditions etc. all of it while minimizing usage of chemical and power consumption. The traditional way of managing WWTPs consists in having employees on the field measure various parameters and make decisions based on their judgment and experience which holds various concerns such as the low frequency of data, errors in measurement and difficulty to analyze historical data to propose optimal solutions.

There is a need to develop technologies which would allow forecasting both influent and effluent flow as well as main water quality parameters (such as BOD, COD, pH, TN, TP etc.). In this study, forecast of WWTP influent and effluent characteristics was carried out using programs based on ARIMA, ARIMAX and Neural Network algorithms. Influent and effluent flow and quality data was obtained from currently operating WWTP and analyzed to identify temporal trends (daily, weekly, seasonal) as well as correlation between several variables. Then the performance of each one of the three methods was compared: ARIMA studies past variations of a single variable to forecast future values, ARIMAX includes exogenous variables correlated with the variable to forecast as predictors and Neural Network also includes exogenous variables while using a hidden layer of neurons to perform predictions. Each method performance is analyzed using several indices (Pearson Correlation Coefficient, Root Mean-Squared Error or Mean Average Percentage Error) and global results are discussed.

Keywords: Wastewater Treatment, Automation, Machine Learning, Forecast, ARIMA, Neural Ne twork

Acknowledgements

The authors acknowledge funding from Ministry of Environment with the support of the Korea Institute of Environmental Industry and Technology's water and sewage innovation technology development project. (2020002700010)

Analysis of Water Use Patterns Based on Big Data and Neural Networks

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Demand for water wellness technology is increasing due to the continuous occurrence of water accidents, interest in water quality. Currently, various studies on water supply as welfare are being conducted, and it is connected to interest in indoor water quality and water use patterns in the exis ting water supply system.
This study constructed data based on past water usage data and reviewed water usage patterns for each purpose of use compared to total water usage by applying external factors that can affect the total water usage and water usage patterns through machine learning. The purpose of use was anal yzed by dividing it into toilet water, sink, washing machine, and kitchen sink, and the analysis tec hnique was analyzed by applying a neural network-based algorithm that is easy for various statisti cal analysis and big data analysis.
As a result, it seems that it is sufficiently predictable with a coefficient value of 0.7 or higher, it intends to develop a program that the direction of improving the model in a predictable form by c ollecting data directly. In addition, it will be applied to the actual area in the form of living labs to derive the direction of improvement.

Keywords: Water wellness, Big data, Analysis of water use patterns, Living lab

Acknowledgements

The authors acknowledge funding from Ministry of Environment with the support of the Korea Insti tute of Environmental Industry and Technology's water and sewage innovation technology develop ment project. (2020002700004)

Application of Machine Learning Model in predicting Hanoi Water Level

Tra Thi Thu Nguyen[1], Ngoc Thi Nguyen[2], Duong Du Bui[3], Thao Thi Phuong Bui[4], ,
Giang Thi Tra Tran[1], Linh Khanh Bui[5]

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Bachelor at Hanoi University of Natural Resources and Environment, Vietnam (2022). Tra is a trained hydrologist. Her research interests are groundwater and surface exchanges and human impacts on water resources management.

The lower portions of the Red River and Thai Binh River in the North are where Hanoi, the capital of Vietnam, which is important to the socioeconomic development of the nation, is situated (Red River Delta or Northern Delta). Therefore, accurate flood forecasting, specifically the water level, in Hanoi will be crucial to preventing flooding, protecting public safety, and promoting social and economic improvement. For predicting water levels in Hanoi, authors have developed the Long Short-Term Memory Neural Networks (LSTM) model, a special type of Regression Neural Network (RNN). The average daily water level at three stations in Son Tay, Hanoi, and Ba Lat from 1962 to 2019 and the average daily traffic at two stations in Son Tay and Hanoi from 1962 to 2019 are the input data for the forecast model. Forecasting value accuracy evaluation is carried out by using the Coefficient Nash Sutcliffe Efficiency (NSE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). The findings reveal a similar trend between the anticipated and actual values. The best forecast values are for one day; the Nash coefficient was 0.93, MSE at 0.13, and RMSE was 0.37; this indicates that the forecast's quality is satisfactory. As a result, this model has the ability to estimate Hanoi's water levels, providing a foundation for future research.
Keywords: ANN, RNN, LSTM, Red River Delta, Water Level Forecast, Ha Noi

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OS7: Implementation plan for Integrated Water Res. Management in Vietnam

Date & Time: 8:30 to 13:30, September 21, 2022. (Hanoi Time GMT+7)

Meeting Link

Meeting ID: Passcode

Time	Content
Chair	**Dr. Le Van Minh**
8:30 - 8:45	**Opening remarks** *Dr. Le Van Minh - Chairman of VNWP*
8:45 - 8:55	**Formulas in water resources management in Vietnam** *Dr. Le Hung Nam, Head of Water Resources and Agriculture Department, General Department of Irrigation*
8:45 – 8:55	**IWRM for sustainable ecological system** *Dr. Bui Du Duong - Head of Water Resources Monitoring Department, National Center for Planning and Investigation of Water Resources*
8:55 – 9:15	**IWRM for Disaster Risk Reduction** *Dr. Ha Hai Duong - Head of Water Resources and Climate Change, Institute of Water, Irrigation and Environment*
9:15 – 9:35	**IWRM for Domestic Water Supply** *MSc. Nguyen Thi Nguyet - Head of Training and International Cooperation, Institute of Water, Irrigation and Environment*
9:35 – 9: 45	**Mechanism to private participation in disaster prevention** *Deputy Director of Disaster Policy Center, Vietnam Disaster Management Authority*
9:45 – 9: 55	**Application of Toolbox to IWRM in Vietnam** *Dr. Le Thi Cuc, Former Director of Science and International Cooperation, General Department of Water Resources*
9: 55 – 10:25	**Tea Break**
10:25 – 11:30	**Q&A and Disscusion** *Dr. Doan Doan Tuan - Coordinator, VNWP*
11: 30 – 11: 45	**Closing remarks** *Dr. Le Van Minh - Chairman of VNWP*

Challenges on integrated water resources management and water resources security in Vietnam

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Vietnam is considered as a country with abundant water resources, but uneven distributed across the regions and seasons. In addition, most of Vietnam's water originates outside its borders, be beyond to vulnerability due to water exploitation and use of upstream. These main factors shall lead to difficulties in water resources management and exploitation of the country, especially in the context of climate change and sea level rise, posing many challenges in ensuring water resources security in the future. The study shall provide the overview of current state of water resources in Viet Nam, results achieved of water resources management and exploitation as well as causes, challenges, difficulties for ensuring goal of water resources security and safety of dams and reservoirs to 2030, and vision to 2045.

Keywords: water resources management and exploitation, water resources security, safety of dam and reservoir, water governance.

Ecosystem approach in Integrated Water Resources Management (IWRM) in Vietnam

Phuong Thao5, Duong Bui1, Tra Nguyen2, Giang Tran2, Ngoc Nguyen3, Tien Du3, Linh Bui4, Dan Bui2

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The integrated water resource management method, which is based on ecosystems, has been widely used globally to manage natural resources in general and integrated water resources in particular. With the aim to create policies for the implementation of integrated ecosystem-based water resources management in Vietnam, with a current emphasis on coastal ecosystems; Creating and sharing information with key stakeholders in regions where ecosystems and river basins need to be managed about integrated management of water resources based on ecosystems; Applying integrated ecosystem-based water resources management as a pilot project in at least three places that represent the North, Central, and South regions, after which other river basins can adopt the strategy; and making legal recommendations for the integration of ecosystem-based integrated water resource management into documents related to water resource management, biological conservation, and green growth plan. This study applies the Ecosystem Approach in Integrated Water Resources Management (IWRM) specifically Ecosystem Approach (EA); Ecosystem-Based Approach (EBA) and Ecosystem-Based Management (EBM) to the ecosystem in Vietnam. Combining with desk study, in-depth interviews, and multistakeholder consultations workshops to validate the proposed draft action plan. Results from this research will be public in the e-IWRM Multistakeholder Action plan under the Global Water Partnership (GWP) SEA Website and Integrated Water Security Open Program Platform (developed and uploaded by GWP SEA).

Keyword: Vietnam, Integrated Water Resources Management (IWRM), Ecosystem approach

Assessment of climate risks and water-related disasters to irrigation and disaster prevention systems in the South-Central region. (Pilot in Ninh Thuan province).

Duong Hai HA

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Head of Department for Water Resources and Climate Change

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According to the report of IPCC (2017), Vietnam was identified as one of the ten countries most likely to be affected by climate change, due to the location is in the path of many storms and the coastline is long with large deltas. The South-Central region is affected by several natural disasters as storms, flood, and drought, in which, Ninh Thuan province is severely affected by drought. In the period of 2021-2025, there have been many investment proposals of irrigation infrastructure to connect existing reservoirs and transfer water for socio-economic development and drought prevention. However, the issue of climate risks has not been considered thoroughly from the beginning of the infrastructure management and investment planning process. This is due to the lack of access and utilization of climate information, and the lack of guidelines, policies as well as short-term orientation in planning.

According to the Global Risk Report (2019), the costs of disaster recovery are nearly nine times higher than the costs of prevention. Therefore, climate risks need to be holistically considered and managed appropriately at the planning stage of infrastructure investment projects. Infrastructure investment decisions within climate change considerations are one of the key factors for the country's sustainable development. Collaboration and joint efforts among climate experts, infrastructure design and operations engineers will assist policymakers and investors to identify and allocate funding needed for adaptation measures.

Keywords: adaptation measures, climate change, climate risks, infrastructures investment, Ninh Thuan province

The status of water security and orientations to ensure water security in the Mekong Delta.

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Vietnam has two major rivers, the Red River in the North and the Mekong River in the South, but Vietnam is located downstream of these rivers. Although the water potential is 830 billion m3, however, up to 63% is exogenous water (from China, Myanmar, Thailand, Laos, and Cambodia). Therefore, Vietnam faces many challenges and potential factors that greatly affect water security. According to the assessment of the Asian Development Bank (ADB), in 2013 Vietnam had the National Water Security Index ranked 26/49 in the region and belonged to the group of high risk of water insecurity. In 2016, the National Water Security Index dropped to 28/49 and ranked above some countries in the region such as Thailand, Laos, Cambodia, and Myanmar. In 2020, the national Water Security Index improved, especially with the indicators of urban water security, environment, and resilience to water-related disasters. The WB assesses that the threats from water to Vietnam will have an overall impact on GDP, estimated to decrease by 5.96% annually if no timely solutions are taken to ensure water security.

In the face of such challenges, it is necessary to have a new, comprehensive breakthrough approach to water security to further improve the efficiency of water exploitation and use to meet the requirements of present and future living. To achieve that, it is necessary to carry out the studies on the basic contents of water security and long-term orientations and strategies on water security with radical solutions to meet the requirements of sustainable socio-economic development of Vietnam, especially in the Mekong delta.

Keywords: Mekong delta, sustainable development, water security index

IWRM Multistakeholders Action Plan – Water for people

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Nguyen Thi Nguyet

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MSc. Nguyen Thi Nguyet, Institute for Water and Environment (IWE), Hanoi, Vietnam (2004).
Over 20 years of experience in doing research in water resources management in Vietnam. Since 2007, she has been working with Global Water Partnership (GWP) through Vietnam Water Partnership (VNWP) and Global Water Partnership Southeast Asia (GWP-SEA) to bring IWRM concepts to Vietnam and put into practices.

In 2017, Vietnam committed to achieve the sustainable development goal (SDG) "all people can use clean water meeting National Standards by 2030". The Government is making efforts to improve people's quality of life through strategies and plans to promote economic and social development; in which clean water and sanitation are essential needs reflecting the quality of life of each family and each country. The Constitution of the Socialist Republic of Vietnam in 2013 stipulates that citizens have the rights to social security and live in a healthy environment and the obligation to protect the environment. Resolution No. 20-NQ/TW dated October 25, 2017 on "strengthening the protection, care and improvement of people's health in the new situation", sets out one of the tasks and solutions to mobilise resources for construction and upgrading of water supply and drainage systems and environmental sanitation. The national action plan to implement the 2030 Agenda for Sustainable Development approved in Decision No. 622/QD-TTg dated May 10, 2017 identifies: By 2030, ensure accessibility adequate and equitable access to safe and potable drinking water and affordable for all.

Socio-economic development and population growth is creating the pressure to water resources, especially during industrialization and modernization process have been increasing water demand and creating conflicts in the use of water sources for different purposes. In addition, over exploitation of related resources such as land and forests causes the negative impacts on water resources such as changing the natural flow regime, increasing flood flows, reducing water dry flows, increasing the level of basin erosion, river-bed sedimentation, etc. Besides, the wasteful use of water and lack of control over surface and underground water resources cause depletion and scarcity of water resources; The lack of knowledge and necessary pollution prevention measures have made water resources degrade more qualitatively, sometimes water availability but cannot use due to pollution, the water environment is seriously degraded. On the other hand, climate change is also posing many threats to water resources.

The Integrated Water Resource Management (IWRM) approach has been introduced and implementing in water resource management in Vietnam and also applied in water supply and sanitation sector. To address above challenges, an IWRM Multistakeholders Action Plan focuses on Water for people developed will contribute to implement IWRM in Vietnam and promote the implementation of Goal 6.5.1 of the Millennium Development Goals (MDGs).

Keywords: IWRM, Action plan, water and sanitation, SDG.

Action plan for development of mechanism for private enterprise participation in disaster risk management in vietnam

Huy Quang Bui

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Master of Coastal zone engineering, Asian Institute of Technology, Bangkok, Thailand, (1999)
Over 20 years of experience in doing research and teaching on disaster risk management in Vietnam.

In the context of climate change, natural disasters in the world in general and Vietnam in particular have been taking place increasingly extreme and difficult to predict. In Vietnam, every year, natural disasters cause a lot of damage to people, property, living environment and socio-economic. In particular, businesses have also suffered significant losses due to natural disasters.
In addition to the objective causes due to the increasing frequency and intensity of natural disasters due to climate change and unsustainable socio-economic development, the subjectivity on the part of businesses and business leaders due to insufficient awareness, lack of force, experience; The lack of national mechanisms and policies to support enterprises to participate in disaster prevention activities has also contributed to the damage of enterprises themselves.
Vietnam Government has promulgated the Law on Natural Disaster Prevention and Control, the National Strategy on Natural Disaster Prevention and Control to 2030, with a vision to 2050, which encourages and identifies the role of the business community in activities of disaster prevention and control. To be able to clearly see the current situation of capacity building and the role of enterprises in disaster prevention, the proposed study focuses on analyzing the current state of capacity of enterprises, mechanisms and policies of the State towards enterprises in disaster prevention and develop an action plan to promote capacity building and the role of enterprises in disaster prevention in Vietnam.
Keywords: mechanism, policy, business community, disaster prevention and control

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OS8: Modeling and Simulation for interdisciplinary applications on water management issues

Date and time: 08:30am - 11:30am 20 Sept, Tue (**Hanoi time GMT+7**)

Meeting Link

Meeting ID: Passcode

Time	Content
08:30 – 09:00	Reception
Chair	**Asso. Prof. Nguyen Ngoc Doanh**
09:00 – 09:20	**A serious agent-based simulation game to drive discussions about waste management in Vietnam** *Prof. Alexis Drogoul, ACROSS IRD/France & TLU/ Vietnam*
09:20 – 09:40	**Assessment effect of system of rice intensification (sri) adapt to climate change at Cho Moi District, Bac Kan Province, Viet Nam** *Dr. Dinh Thi Hai Van, VNUA/Vietnam*
09:40 – 10:00	**Towards a new set of high-resolution climate scenarios for Vietnam** *Asso. Prof. Ngo Duc Thanh, USTH/ Vietnam*
10:00 – 10:15	*Coffee break*
Chair	**Prof. Alexis Drogoul**
10:15 – 10:35	**Modelling and Interactive Simulation for Water Management in the Bac Hung Hai Irrigation System** *Asso. Prof. Nguyen Ngoc Doanh, ACROSS IRD/France & TLU/ Vietnam*
10:35-10:55	**Using agent-based simulation to address agricultural water issues** *Asso. Prof. Patrick Taillandier, INREA/France*
10:55-11:15	**Prediction of water level in irrigation system using the hydraulic and data-driven models: an application in the Bac Hung Hai irrigation System** *Asso. Prof. Pham Van Chien, UMMISCO IRD/France & TLU/ Vietnam*
11:15-11:35	**An Agent-Based Co-modeling Approach to Simulate the Evacuation of a Population in the Context of a Realistic Flooding Event: A Case Study in Hanoi (Vietnam)** *Dr. Arthur Brugiere, ACROSS IRD/France & TLU/ Vietnam*
11:35 – 14:00	*Lunch*

A serious agent-based simulation game to drive discussions about waste management in Vietnam

Alexis Drogoul

Alexis Drogoul
Co-director of International Joint Laboratory ACROSS
Advanced Center of Excellence for Computational Research on Sustainability Science
5th floor, building A1, 175 Tay Son, Dong Da, Hanoi, Vietnam

Alexis Drogoul holds a Ph.D. in Computer Science. He is a Senior Researcher at IRD and his work concerns the development of software tools (such as GAMA, http://gama-platform.org) for modeling and simulating socio-environmental systems for environmental decision support, particularly in Vietnam, where he has been working since 1999 with numerous partners.

Background. Waste management is a big problem in Vietnam, especially in irrigation systems, where waste has a profound impact on agriculture, which also provides a significant portion of wastewater production. While residents and decision-makers are becoming increasingly concerned, the implementation of collective solutions to these problems is almost non-existent.

Aim. The challenge is then to propose a serious game allowing to open the dialogue on this subject and allowing to envision shared and sustainable solutions of waste management. Achieving such an objective also requires taking into account the realities of power relations between stakeholders, which a serious game can highlight.

Method. In order to open the dialogue about waste management in rural areas in Vietnam, we propose RÁC, an agent-based serious game using a concrete case study which is exemplary in terms of risk management: the waste management in the Bắc Hưng Hải irrigation system (Vietnam). RÁC places the players (stakeholders, but also students) in the role of a village leader, who must ensure a sufficient level of agricultural production while minimizing both solid and wastewater pollution in order to maintain a quality label that is essential for selling agricultural products in the national market. The model was fully implemented with the GAMA open-source agent-based simulation platform.

Results. RÁC was played in two contexts: with students (middle and high school) from the *Lycée Français Alexandre Yersin* in Hanoi, and with farmers and village leaders in the Bắc Hưng Hải irrigation system. The first series of games with students, which was mainly used to calibrate and improve the game, showed the importance of the emergence of leaders amongst the players to ensure the coordination of the decisions made and thus the efficiency of the policy chosen. The second series of experiments with farmers and village leaders, in addition to participating to put in debate the management of wastes in their territory, allowed to highlight the importance of the local leaders (village leaders) in the coordination of decisions.

Conclusions. The results showed that the game achieved a first objective regarding its potential to highlight the power games existing between players. It also allowed the players to discuss the subject of waste management, a subject that can only be discussed collectively. Future work in the short term will focus on continuing to organize game workshops to better assess the impact of the game on waste management coordination. Longer-term prospects include several improvements to the model and interface and improving the accessibility of the game to allow teachers and stakeholders to directly use the game independently.

Keywords: serious game, agent-based simulation, waste management, irrigation system, Vietnam

Assessment effect of system of rice intensification (sri) adapt to climate change at Cho Moi district, Bac Kan province, Vietnam

Dinh Thi Hai Van

Dinh Thi Hai Van has experience in Environmantal Management and climate change. As a head of Department of Environmental Management, Viet Nam National Unviersity of Agriculture, She has forcused on the Environmatal management in Agriculture Aspect and Rurral areas, Climate change. Some recent interest research topics are Waste Management in Agriculture; effects of climate change effects on agriculture; and adaptation of farmers to climate change.

Vietnam is among the top 10 countries in the world most vulnerable to climate change. It is the most important factors threatening agricultural production for the poor farmers who are leaving the mountain areas in Vietnam. Currently, the Government of Vietnam and the Ministry of Agriculture and Rural Development have been making many efforts to respond to climate change such as applying System of Rice Intensification (SRI) in the context of water shortage and climate change.

Yen Cu commune, Cho Moi district, Bac Kan province located in the North of Viet Nam, which is the most areas affected by extreme weather and climate change such as drought, landslides, heat, especially changing in rainfall have caused affect in agriculture production, therefor, local authorities have asked farmers of Cho Moi district applied the System of Rice Intensification (SRI) to cope with climate change.

After 5 years of application SRI, this study evaluates the effectiveness of the SRI model to respond to climate change here in terms of economy, society and environment aspect, the opportunities and challenges of applying the SRI model also is presented and identified by local farmers that can be a lesson learnt for other mountain areas in the North of Viet Nam in the context of climate change and water shortage.

Towards a new set of high-resolution climate scenarios for Vietnam

Thanh NGO-DUC

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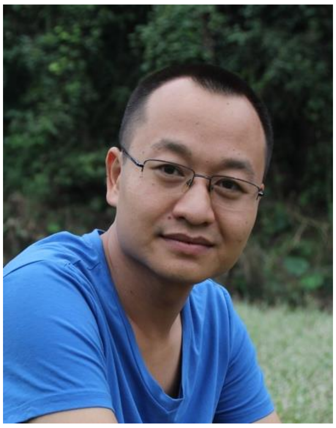
Dr. Thanh Ngo-Duc obtained his Ph.D. in Meteorology from the University of Paris VI in 2005. He is currently Co-Director of the Department of Space and Applications, and Co-Director of the International Joint Laboratory LOTUS (http://lotus.usth.edu.vn) at the University of Science and Technology of Hanoi (USTH). He is also a member of the Scientific Committee in Earth and Environmental Sciences of the Vietnam National Foundation for Science and Technology Development (NAFOSTED). Using modeling and remote sensing tools, his research focuses on the topics of natural disasters and climate change. Dr. Thanh is also a lead author of the latest Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), published in August 2021.

The latest downscaling activities in Vietnam have been mainly based on the dynamical approach for a limited number of Global Climate Models (GCMs) of the Coupled Model Intercomparison Project Phase 3 (CMIP3) and Phase 5 (CMIP5). To date, no attempt to downscale the latest GCMs of the CMIP Phase 6 (CMIP6) has been done in Viet Nam. Here, we first apply the Bias Corrected Spatial Disaggregation (BCSD) statistical method to downscale the outputs of 31 CMIP5 and 35 CMIP6 GCMs for inland Viet Nam. The new sets of data, including four variables: daily precipitation, daily average, and maximum and minimum temperatures, are at 10-km spatial resolution and respectively called CMIP5-VN and CMIP6-VN. CMIP5-VN and CMIP6-VN cover the historical period of 1980–2005 and 1980–2014, and the future projection period until 2100 with four Representative Concentration Pathways (RCPs; RCP2.6, 4.5, 6.0, and 8.5) and seven Shared Socioeconomic Pathways (SSPs; SSPs 1-1.9, 1-2.6, 2-4.5, 3-7.0, 4-3.4, 4-6.0, and 5-8.5) scenarios, respectively. Then, we establish the joint probability density functions (PDFs) of temperature and precipitation change over the 21st century for every region in Viet Nam using the surrogate/model mixed ensemble (SMME) method. The new SMME data facilitates the assessments of local and regional climate change risks, including tail risks, which are known to have low probability but severe consequences. The newly built CMIP5-VN, CMIP6-VN, SMME-CMIP5, and SMME-CMIP6 datasets have been made online available and free of charge. We recommend the use of these datasets for studies on climate change assessment, as well as into climate change impacts on socio-economic activities in Viet Nam.

Keywords: statistical downscaling, dynamical downscaling, CMIP6, climate scenarios

Modelling and Interactive Simulation for Water Management in the Bac Hung Hai Irrigation System

Doanh Nguyen-Ngoc



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A/Prof in Computer Science from the University of Paris in 2010. His research area is Modeling and simulation of complex systems with applications focusing on sustainable development such as environmental pollution, smart/sustainable cities and agriculture/rural development, etc. Currently, he is the co-director of international joint laboratory ACROSS (Advanced Center of Excellence for Computational Research on Sustainability Science) and is a collaborator of the International Center for Research and Postgraduate Training in Mathematics under the auspices of UNESCO, the Institute of Mathematics, the Vietnam Academy of Science and Technology, and he is also Director of UMMISCO - the international research network on mathematical modeling and computer modeling, Institute of Research for Development (IRD), France.

Irrigation systems contribute worldwide to the provision of a wide range of services on which the survival and well- being of humanity depends. They are of primary importance in Vietnam where about 90% of the water used is for irrigation and aquaculture and where agriculture is the largest employer and a major contributor to the national GDP and to the income of the low-salary households. Nevertheless, irrigation systems have recently been subjected to several issues including increasing demand, pollution, under-investment, depletion of sources or environmental changes. Any mitigation measure against these issues needs to be sustainable with respect to the very diverse uses of the water, the changing conditions upstream and downstream, and the somewhat conflicting objectives carried out by land- use/agricultural planning on one hand and urbanization and society well-being on the other. This need of sustainability requires the design of innovative tools to tackle these issues. This work aims at exploring the usage of Agent-Based modeling coupled with a tangible and interactive interface in order to enhance interactions between stakeholders and support the evaluation of various alternatives of the management of the Bac Hung Hai irrigation system.

Keywords: Agent-Based Model, GAMA platform, modelling, interactive simulation, Bac Hung Hai, irrigation system

Using agent-based simulation to address agricultural water issues

PATRICK TAILLANDIER

Patrick Taillandier
Senior researcher, National Research Institute for Agriculture, Food and the Environment (INRAE)

Patrick Taillandier is a senior researcher in computer science in the unit of Mathematics and Applied Computer Science of Toulouse (MIAT) of the National Research Institute for Agriculture, Food and the Environment (INRAE). He spent five years at the University of Rouen, where he was an Associate Professor. Since October 2020, he is invited researchers at IRD (UMI UMMISCO - ACROSS lab). His research focuses on agent-based simulation and he has been particularly interested in recent years in the integration of the spatial dimension in simulation and on the modelling of human behaviour.

In many agricultural regions, the lack of water poses many problems that tend to multiply with climate change. It is therefore important to be able to continue to ensure an important agricultural production while consuming less water. In this presentation, we explore how agent-based simulation can contribute to the reflection on this topic. In particular, two projects aiming at using agent-based simulation to address water issues in agriculture will be presented. The first project, centered on the MAELIA platform, concerns the use of agent-based simulation to evaluate water management alternatives on an agricultural territory. The objective here is to use computer simulation to help in the decision making process, both at the level of the decision-makers and at the level of the farmers themselves to bring them to discuss together possible solutions. The second project concerns the use of agent-based simulation to study the diffusion of agricultural technology and focuses on communicating water meters. The objective here is to better understand what are the barriers to the adoption of such technology and how to help remove them.

Prediction of water level in irrigation system using the hydraulic and data-driven models: an application in the Bac Hung Hai irrigation System

Chien PHAM VAN

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Chien Pham Van performed his Ph.D degree in hydrodynamics and sediment transport. His research is mainly focusing on both developing and applying numerical models, software, and tools such as hydrological models, hydraulic models, tracer and sediment transport models, and data-driven models for simulating the quantities of interest in water bodies as well as in land-sea continuums. Currently, he is a member of the international joint laboratory ACROSS (Advanced Center of Excellence for Computational Research on Sustainability Science).

In the irrigation system, the water level is an important indicator because of its role in various purposes such as the operation of different structures like culverts, sluice gates, and pumps as well as water management, and water supply for different water–consuming sectors. Accurate estimations and predictions of water levels in agricultural irrigation systems are pre-requisite for the successful implementation of water resources planning and management tools. In this context, one-dimensional hydraulic (i.e., MIKE 11) and data-driven models (consisting of a traditional multiple linear regression and a recurrent long – short term memory) are implemented together for predicting the water level in irrigation systems. Different statistical metrics including the root mean square error (RMSE), mean absolute error (MAE), mean error (ME), Nash–Sutcliffe efficiency (NSE), Pearson's correlation coefficient (r), and Willmott's index are implemented for quantitatively assessing the agreement between estimated and observed water levels at various locations in the period from 2000 to 2021 (with an interval time of 6 hours). The Bac Hung Hai irrigation system (BHHIS) is used to demonstrate the capability of models. The results showed that both hydraulic and data-driven models can estimate water levels with high accuracy. The latter is strongly believed to provide a better understanding of water resources in the system as well as to support decision-making in water resources planning and management under the effects of climate change, urbanization, and human activities.

Keywords: Hydraulic model, LSTM, water level, Bac Hung Hai, irrigation system

An Agent-Based Co-modeling Approach to Simulate the Evacuation of a Population in the Context of a Realistic Flooding Event: A Case Study in Hanoi (Vietnam)

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Arthur Brugière holds a double master degree in Computer Science and is currently a Ph.D. student in cotutelle at Sorbonne University and Thuyloi University working on Multi-Level Agent-Based Models (ML-ABM) since 2021. He has been working on modeling and simulating complex socio-environmental systems' project at the IRD Vietnam since 2019.

According to recent studies, Vietnam is one of the twenty countries most affected by natural disasters in the world, and particularly by floods either on the low elevation coastal zones (risk of submersion) or along the Red River and the Mekong River (risk of flooding). In this context, dams are both means of mitigation but also threats given the possible failures and ruptures. The authorities must, therefore, prepare warning systems and evacuation plans for the downstream population to avoid loss of life. Agent-based models are now the approach of choice to support such preparedness by considering the system as a whole and integrating dynamics of different natures: hydrology, population behavior, evacuation, crisis management, etc. To design such a decision-support tool, modelers generally need to couple different formalisms, such as diffusion equations when considering the hydrodynamic part, and agent-based modeling when considering inhabitants' behaviors. This is the goal of the ESCAPE project, which uses agent-based simulations to explore evacuation strategies and contribute to the development and evaluation of evacuation plans. In this study, to improve the ESCAPE framework, we propose to combine a hydraulic dam failure model with an agent-based evacuation model using the GAMA platform. We focus on the evacuation of a Hanoi city (Vietnam) district, threatened by flooding due to the failure of the Hoa Binh dam located more than 80 km upstream of the city. We demonstrate how to methodologically and operationally couple a hydrodynamic water diffusion model (implemented using the HEC-RAS software) and a multi-paradigm evacuation model (using the ESCAPE framework). Our goal is to extend and enrich this population evacuation model by coupling it with flood simulation.

OS9: Reducing CO2 Emissions: Experiences from ASEAN Countries

Date and time: 120mins 10:00am - 12:00am 20 Sept, Tue (Hanoi Time GMT+7)
Meeting link:
Meeting ID: Passcode:

Time	Content
Chair	**Dr. Glenn Banaguas**
10:00-10:05	**Opening remarks** *Dr. Glenn Banaguas, Chairman of US-ASEAN Fellows for Science and Technology*
10:05 – 10:20	**S&T Policies toward achieve net-zero carbon emissions in Vietnam** *Dr. Nguyen Quynh Anh, S&T Policy Institue, MOST, Vietnam*
10:20-10:35	**Innovative solutions on aquatic and fisheries resources of Mekong River in Myanmar regarding SDGs** *Dr. Mie Mie, Myanmar Researcher of US-ASEAN S&T Fellow Association*
10:35-10:50	**GHG Inventories for Vietnam Cement Industry"** *Dr. DANG Vu Tung, "Hanoi University of Science and Technology, Hanoi Vietnam*
10:50-11:15	**Water Security in era of climate change (TBC**) *Dr. ZAINURA BINTI ZAINON NOOR, A/Professor and Director, Centre for Environmental Sustainability and Water Security, Universiti Teknologi Malaysia*
11:15-11:30	**Seasonal comparison of groundwater level and quality in the catchment of the Tonle Sap Lake, Cambodia (TBC)"** *Dr. Kong CHHUON, Dean of Faculty of Hydrology and Water Resources Engin at Institute of Technology of Cambodia*
11:30-11:45	**Mitigation of forest fire through the use of Internet of Things (IoT) TBC"** *Dr Wida Susanty binti Haji Suhaili, A/Professor & Deputy Director for Centre of Innovative Engineering, the School of Computing and Informatics, the Universiti Teknologi Brunei (UTB).*
11:45-12:00	***Q&A and Discusion:*** *Dr. Glenn Banaguas & Dr Quynh Anh*

Innovative solutions on aquatic and fisheries resources of Mekong River in Myanmar regarding SDGs

Mie Mie Kyaw, Myat Mon Kyaw, Khin San Htay

Mie Mie Kyaw

Senior Lecturer

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Senior Lecturer, Department of Zoology, University of Mandalay, Myanmar. ASEAN- U.S. Science and Technology Fellow (2014); Research fellow of University Academics and Scientists; DAAD Scholarship Program (Germany), Department of Hydrology and Water Resources Management, Kiel University, Germany, (2015); ASEAN Science Diplomat (2017); Research Fellow; MIF (The Matsumae International Foundation), (Japan), Department of Environmental Engineering, Kyoto University, Japan (2018). Over 18 years of experience in doing research and teaching on Environmental Studies, Ecology, Fisheries, Water resources, Socioeconomic developments regarding SDGs in Universities in Myanmar. Prior to her current position, she was Assistant Lecturer of Department of Zoology, University of Yangon, Yangon, Myanmar.

OS10: Policy Dialogue on Water in Vietnam

Date and time: 90 mins; 10:00-11:30am on September 20 (Tuesday) Paris Time GMT+2
Meeting Link:
Meeting ID:

Time	Content
Chair	**Delia Sanchez**
10:00-10:05	**Openings** *Delia Sanchez, OECD*
10:05 – 10:20	**Introduction "National Dialogue on Water in Asian contries"** *Jewon LEE, Asia Water Council, Korea*
10:20-10:35	**National Dialogue on Water in Thailand: Outcomes and lessons learn from Thailand** *Mr. Chumlarp Tejasen, The Office of the National Water Resources (ONWR), Thailand*
10:35-10:50	**National Dialogue on Water in Vietnam** *Delia Sanchez, Project manager, OECD*
10:50-11:15	**National Dialogue on Water in Vietnam: Prioities for water security and Workplan** *Nguyen Chi Nghia, Duong Du Bui, Nguyen Ngoc Ha; NAWAPI, MONRE*
11:15-11:30	***Q&A and Discussion:*** *Delia Sanchez, Project manager, OECD & NAWAPI*

The National Dialogue on Water for Asian countries

Jewon LEE, Asia Water Council

Jewon LEE
Project Director
Asia Water Council (AWC)
200, Sintanjin-ro, Daedeok-gu, Daejeon, Republic of Korea

Project Director of AWC, Senior Manager of Korea Water Resources Corporation(K-water).

Over 14 years, expert in managing large scale overseas projects, including responsibility of all pre and post-contract commercial/contractual aspects on projects such as procurement, contract preparation and finalization, financial control and reporting and dispute resolution on the basis of experiences. As a Project Manager of AWC, managing technical projects, contributing to solve water related issues in Asian countries.

The Asia Water Council (AWC) is a leading water platform that aims to provide tangible solutions to resolve water issues in Asia and beyond, and support achieving sustainable development with clean and sufficient water. AWC consists of 147 members from 27 countries, and actively cooperating with water-related organizations including governments, academic and research institutions, non-governmental organizations and civil society.

AWC is closely working together with Ministry of Environment of the Republic of Korea (MoE) and the Organisation for Economic Co-operation and Development (OECD) under the name of "National Dialogue on Water", targeting to accelerating investments to water security and sustainable development in Asian countries. AWC is taking a role to provide technical advice on water related issues in Asian countries.

Throughout the Dialogue, AWC will concentrate on providing innovative solutions to resolve water-related issues and strengthen technical capacity of the Vietnam's water sector. Technological solutions could be related to:

1. Securing sustainable water resources to manage increasing water demand from economic development;
2. Development of technologies on water resources monitoring of the drought situation associated with climate variavility and climate change, especially targeting on Mekong delta, Huong basin etc.;
3. Leakage management on water supply to reduce water shortage;
4. Water quality management for both surface and ground water.

These suggestions are part of the areas that we could consider as a technical contribution throughout National Dialogue on Water in Vietnam. Further discussion with relevant government agencies of Vietnam will be needed to set more specific and focused goals to ensure water security in Vietnam.

Keywords: technical solution, water issue, water resources, water monitoring leakage management, water quality

The National Dialogue on Water in Vietnam

Delia Sanchez Trancon, Xavier Leflaive, Taehoon Kim

Delia Sanchez Trancon

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Junior Environmental Economist, Water Team, Environment, Transitions and Resilience Division, Environment Directorate, OECD.

Delia works on water and adaptation, in particular economic and regulatory instruments. Recently, she led the National Dialogue in Thailand and provided policy recommendations to the Hungarian and Brazilian government on water security as well as facilitating the implementation of the economic pillar of the Water Framework Directive for the European Commission. Prior to joining OECD, she worked as an international consultant providing advisory services to public, private and international organisations to improve water resources management and sanitation services. She studied Agricultural Engineering at Master level at Grande Ecole d'Ingenieurs de Montpellier, France.

As part of a five-year collaboration aimed at supporting to achieve the water-related Sustainable Development Goals (SDGs) in Asia, the Ministry of Environment of the Republic of Korea (MoE), the Asia Water Council (AWC) and the Organisation for Economic Co-operation and Development (OECD) propose to work with the Government of Vietnam to hold a National Dialogue on Water ("Dialogue") in 2023.

The Dialogue will aim to support key water policy reforms, building on the agenda that Vietnam is embarking, in particular the reform of the Water Law. As indicated by NAWAPI, water security is a key priority for the Vietnamese government; therefore, the general orientation could be on policies and economic instruments to enhance water security in the context of adaptation to climate change in Vietnam. This dialogue would focus on the priority areas identified by the Vietnamese government during the Vietnam Water Week for example water river basin management planning, economic instruments, water allocation or technologies strategies for water security. The dialogue would include country-specific analyses and exchanges of experience from countries in the region such as Thailand and Korea and beyond, depending on Vietnam's interest.

Keywords: policy reform, economic instruments, water resources management, water security

The National Dialogue on Water in Thailand

Chumlarp Tejasen
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Mr. Chumlarp Tejasen is the director of Foreign Affairs Division of the Office of the National Water Resources (ONWR), Thailand. Being as a director higher level, he is responsible for supervising, monitoring, integrating plans and projects in accordance with the Government's policy and strategy on the national water resources management, as well as representing the Royal Thai Government in international conferences relating water resources management, and maintaining and promoting the Thailand's national interest in bilateral, and multilateral fora between Thailand and other countries. With over 27 years of experiences, his work covers Hydraulic Structure Design, Irrigation System Design, Dam Design, as well as the international cooperation projects with many countries and international organizations in Asia, Europe, America, and Australia. Mr. Chumlarp has a Master's Degree in Engineering and Applied Geology from Asian Institute of Technology, Thailand and Bachelor's Degree in Civil Engineering from King Mongkut's University of Technology Thonburi, Thailand.

As part of a five-year collaboration aimed at supporting to achieve the water-related Sustainable Development Goals (SDGs) in Asia, the Ministry of Environment of the Republic of Korea (MoE), the Asia Water Council (AWC) and the Organisation for Economic Co-operation and Development (OECD) worked with the Government of Thailand to hold a National Dialogue on Water ("Dialogue") in 2021/22.

The Kingdom of Thailand has achieved remarkable economic development and it aspires to become a high-income economy by 2037. Water security and disaster risk management are requisites for this ambition to materialise. However, several water challenges coexist such as competitive increase in water demand in agriculture, industry and service sector; deterioration of water quality due to increasing pollutants; deepening damage from floods and droughts due to climate change. The dialogue focused on two sets of issues: managing water demand in the Eastern Economic Corridor (EEC) and financing water supply and sanitation. The first one is essential to support rapid economic growth in the region. The second contributes to better livelihoods and increased water quality nation-wide. Success in both areas can build on recent developments, but also require significant adjustments in water policies and policies that affect water availability and demand.

The dialogue highlighted that enhanced water security in the EEC would benefit from supplementing water supply augmentation (already locked in development plans) by a range of measures, combining robust water allocation regimes, stimulating demand for reclaimed water and fair compensation for provinces which water is diverted to augment supply in the EEC. The diffusion of a range of smart water technologies would seem appropriate in that context.

The dialogue highlighted that additional investment is required to collect and treat wastewater and to address further cost drivers, including population growth and urbanisation, economic growth

(and raising social expectations) and the need to adapt to a changing climate. The dialogue identified number of requisites required. The first is operational efficiency of existing services, a condition to efficient allocation of (public and private) funding, willingness to pay of domestic water users, and minimising financing needs in the future (avoiding rapid decay of existing assets). Economic regulation has a role to play: systematic benchmarking of the performance of service providers can be the basis of tailored incentives towards operational efficiency. International experience can inspire the selection of performance indicators and the design of incentives, including through performance-based contracting. Smart water technologies can support such an endeavour. When the enabling conditions are in place, blended finance can play a critical role in mobilising the commercial finance required as well as strengthening the financing systems upon which water–related investments rely.

Keywords: policy reform, economic instruments, water resources management, water security

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Delia works on water and adaptation, in particular economic and regulatory instruments. Recently, she led the National Dialogue in Thailand and provided policy recommendations to the Hungarian and Brazilian government on water security as well as facilitating the implementation of the economic pillar of the Water Framework Directive for the European Commission. Prior to joining OECD, she worked as an international consultant providing advisory services to public, private and international organisations to improve water resources management and sanitation services. She studied Agricultural Engineering at Master level at Grande Ecole d'Ingenieurs de Montpellier, France.

Xavier Leflaive

Head of the Water Team

OECD, 46 Quai Alphonse le Gallo, 92100 Boulogne-Billancourt

Xavier Leflaive leads the Water Team in the OECD Environment Directorate. He promotes poli cies that contribute to water security and sustainable development. His work covers issues relate d to pricing and financing; innovation in water management and water services; the reform of w ater allocation regimes; diffuse water pollution. Most recently, Xavier Leflaive coordinated the Recommendation of the OECD Council on water, which captures main policy guidance from th e OECD on water. He spearheads the Roundtable on Financing Water, which endeavors to bridg ing the financing gap in the water sector. He has facilitated water policy reforms, in Brazil, Irela nd, Korea, the Netherlands, the Caucasus and Central Asia. Xavier Leflaive studied business ad ministration and social and political sciences in France, Canada and the UK. He holds a PhD in Social and Political Sciences from the University of Cambridge, UK, under the supervision of A nthony Giddens.

Taehoon Kim

Policy Analyst

OECD, 46 Quai Alphonse le Gallo, 92100 Boulogne-Billancourt

Taehoon works on the trilateral cooperative project among OECD, South Korean government and Asia Water Council(AWC) for enhancing water security in East Asian countries.

Before he joins OECD, he has worked in Asia Water Council(AWC), the biggest water management cooperation platform in Asia, as the Operation Director. He was in charge of overall operation of the Secretariat of the Asia Water Council and held several important meetings and events of AWC including the 3rd General Assembly, four times Board of Council meetings. And he was leading planning and preparation of the 2nd Asia International Water Week(AIWW) held in Indonesia March 2022.

Furthermore, he worked as the Water Advisor of the Ministry of Foreign Affairs, Republic of Korea. He reviewed several important global water agendas including Global Water Architecture, OECD Consolidated Recommendation on Water and drafted official stance of Korean Government on those issues. Also he participated international water meetings and conferences including OECD Round Table on Financing Water, Working Party on Biodiversity, Water as Korean Delegation. Also, He worked as Finance Manager, Overseas Business Department of Korea Water Resources Corporation(K-water). Bridge Financing of $436 Million for M&A deal of Angat Hydropower Plant in the Philippines is one of his remarkable achievements. He has a Master's Degree in Economics and a Bachelor's Degree in Political Science from Sungkyunkwan University, Republic of Korea.

OS11: Groundwater, Soil and Surface Water Exchange

Date and time: 8:00am - 10:05 am, 21 Sept, Wed (Michigan Time: GMT-4)
Meeting link:
Meeting ID: Passcode:

Time	Content
Chair	**Dr. Yadu Pokhrel, A/Professor, Michigan State University, USA**
8:00-8:05	**Opening and Introduction** *Dr. Yadu Pokhrel, Associate Professor, Department of Civil and Environmental Engineering, Michigan State University, USA*
8:05 – 8:20	**Modeling coupled surface water-groundwater systems in the Lower Mekong River basin** *Dr. Yadu Pokhrel, Associate Professor, Department of Civil and Environmental Engineering, Michigan State University, USA*
8:20-8:35	**Groundwater Dynamics in the Mekong River Basin: Response to Climate and Human Activities** *Tamanna Kabir, PhD Candidate, Department of Civil and Environmental Engineering, Michigan State University, USA*
8:35-8:50	**Synthesis of multi-source dataset for transdisciplinary research in the Lower Mekong River basin** *Tanjila Akhter, PhD Student, Department of Civil and Environmental Engineering, Michigan State University, USA*
9:50-9:15	**Rapid hydropower development in the Mekong Basin and their impacts toward the downstream hydrodynamics** *Huy Dang, PhD Student, Department of Civil and Environmental Engineering, Michigan State University, USA*
9:15-9:30	**Sustainability Assessment of urban groundwater systems** *Dr. Nuong Bui, Faculty of Environment, Hanoi University of Natural Res and Environment, Vietnam*
9:30-9:45	**Social Approach of Groundwater Management** *Daniel Kramer Professor at Michigan State University*
9:45-10:05	***Q&A and Discussion***

OS12: Urban Water-Related Problems in Asian Megacities

Date and time: 105mins 10:00am - 11:45am 21 Sept, Wed (Tokyo Time GMT+9),
Meeting Link:
https://zoom.us/j/91926564024?pwd=Ri9hWDlVWlRiczV1MHFFYmt4RE1Pdz09
Meeting ID: 919 2656 4024; Passcode: 230539

Time	Content
Chair	**Dr. Akira Kawamura**
10:00-10:05	**Introduction and Session Remark** *Dr. Akira Kawamura, Professor Emeritus of Tokyo Metropolitan University, Japan*
10:05 – 10:20	**Novel Method to Identify the Source of Groundwater Nitrate Pollution in Intensive Agricultural and Livestock Areas in Japan** *Dr. Kei Nakagawa, Professor of Nagasaki University, Japan*
10:20-10:35	**The effect of urbanization on temperature indices in the Philippines** *Mr. John Asaula Manalo, Ph.D. Student, Tokyo Metropolitan University, Japan*
10:35-10:50	**Climatological intraseasonal variation in aerosols and their impact on extreme rainfall over India** *Ms. Anu Gupta, Ph. D Student, Tokyo Metropolitan University, Japan*
10:50-11:15	**Effects of inhomogeneous wind and topography on surface mass transport in a shallow lake** *Mr. Ngoc Hieu LE, PhD Student, Tokyo Metropolitan University, Japan*
11:15-11:30	**Analysis of dissolved oxygen during overturn period of selective withdrawal operation in a water supply reservoir** *Mr. Ronnel Pabalan, Master Student, Tokyo Metropolitan University, Japan*
11:30-11:45	**Current challenges in sustainable management of the water supply system in Hanoi, Vietnam** *Dr. Nuong Thi BUI, Hanoi University of Natural Resources and Environment (HUNRE)*

Novel Method to Identify the Source of Groundwater Nitrate Pollution in Intensive Agricultural and Livestock Areas in Japan

Kei Nakagawa

Kei Nakagawa
Professor
Nagasaki University
1-14 Bunkyo-machi, Nagasaki 852-8521, Japan

Kei Nakagawa is a Professor of Environmental Groundwater Science with 28 years of research experience. He was appointed as an Assistant Professor in Soil Science at the Department of Agricultural Chemistry in 1999 at Kyushu University and promoted to Associate Professor in Water Use Engineering at the Department of Agricultural Engineering in 2002 at Kagoshima University. In April 2011, he was appointed as a Full Professor at the Graduate School of Fisheries and Environmental Sciences of Nagasaki University.

Groundwater pollution by nitrate is a common problem in many parts of the world. The agriculturally important Shimabara area in Nagasaki, Japan, is experiencing this problem. The general source of drinking water in the study area is groundwater and consequently, nitrate pollution is a significant problem.
Investigating contaminant sources is indispensable to developing effective countermeasures against nitrate pollution in groundwater. Major nitrogen sources are chemical fertilizer, livestock waste, and domestic wastewater. The scatter diagram of $\delta^{18}O$ and $\delta^{15}N$ of NO_3^- (Kendall, 1998) has been used to identify pollution sources. However, it can be difficult to distinguish sources because of the overlapping $\delta^{18}O$ and $\delta^{15}N$ ranges of chemical fertilizer and livestock waste sources. In this study, we propose the use of coprostanol as a method to identify the source of the pollution. Coprostanol has been used as a fecal contamination indicator because it is one of the major fecal sterols formed by the conversion of cholesterol by intestinal bacteria in the gut of higher animals. The proposed method was applied to a case of nitrate contamination in Shimabara City, Nagasaki Prefecture, and its applicability was discussed.

Keywords: groundwater, nitrate pollution, fecal sterols, coprostanol

The effect of urbanization on temperature indices in the Philippines

John A. Manalo, Jun Matsumoto, Hiroshi G. Takahashi, Marcelino Q. Villafuerte, Lyndon Mark P. Olaguera, Guoyu Ren, Thelma A. Cinco

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Ph.D. in Science (student), Department of Geography, Tokyo Metropolitan University (2019–present). Also affiliated at the Philippines Atmospheric Geophysical and Astronomical Services Administration of the Department of Science and Technology (PAGASA-DOST), Philippines.

This study presents a comprehensive analysis of the effect of urbanization on the surface air temperature (SAT) from 1951 to 2018 in the Philippines. The daily minimum temperature (Tmin) and daily maximum temperature (Tmax) records from 34 meteorological stations were used to derive extreme temperature indices. These stations were then classified as urban or rural based on satellite night-lights. The results showed a significant difference in the SAT trends between urban and rural stations, indicative of the effect of urbanization in the country. Larger and more significant warming trends were observed in indices related to Tmin than those related to Tmax. In particular, the effects of urbanization were significant in the annual index series of Tmin, diurnal temperature range, minimum Tmin, percentage of days when Tmin was less than the 10th percentile (TN10p), percentage of days when Tmin was greater than 90th percentile (TN90p), and the number of coldest nights. The effects of urbanization were not as clear on the index series of maximum Tmax (TXx), minimum Tmax (TXn), percentage of days when Tmax was less than 10th percentile (TX10p), and the number of hottest days. The effects of urbanization on the annual series of extreme temperature indices were statistically significant at the 95% confidence level, with the exception of Tmax, TXn, TXx, TX10p, and the number of hottest days. Further analysis revealed that the effect of urbanization was the greatest during the DJF (December–January–February) season.

Keywords: urbanization, surface air temperature, satellite night-light, extreme temperature indices, the Philippines

Climatological intraseasonal variation in aerosols and their impact on extreme rainfall over India

Anu Gupta, Jun Matsumoto

Anu Gupta
Ph. D Student
Tokyo Metropolitan University, Tokyo

I am a researcher in climatology with mathematical background. I am interested in the real-world applications of mathematics, specifically pertaining to climate studies and artificial intelligence. Exposure in understanding the climate with mathematical perspective motivates me to understand the gaps in the research. In addition, it gives me an insight into how different fields apply different branches of mathematics and makes me a better researcher.

The aerosol distribution are interrelated with the intraseasonal variations in Asian summer monsoon winds. Due to the intraseasonal variations in winds, the spatial distribution of aerosol over India changes. These climatological features are analyzed using the MODIS satellite observation and CAMS reanalysis datasets. Eight phases of MISO (Monsoon Intraseasonal Oscillations) are computed using the MISO index. The differences in distribution of aerosols in eight MISO phases influence the incoming solar radiation, cloud properties, and convection processes. These features are analyzed over the Central region of India which is known as the monsoon core region of India. Reduction in incoming solar radiation, influences the convection processes and suppresses the strength of convection and hence reduces the occurrence of extreme rainfall events (EREs) over Central India.

To understand the impact of MISO-related variation of aerosols on EREs, we analyzed it in the high and low aerosol scenarios during the phases of MISO. We found that in the MISO phases of low (high) aerosols, frequency of extreme rainfall is found more (less). However, the MISO-related variation of mean rainfall was different. It was found to have a peak during the transition phases corresponding to low and high aerosols. Interestingly, the fraction of clouds was found to be more (less) in the high (less) aerosol phases. Thus, we analyzed the combined direct and indirect effects of aerosols and their influence on the extreme rainfall events over Central India.

Keywords: climatology, aerosols, monsoon intraseasonal oscillations, extreme rainfall events

Effects of Inhomogeneous Wind and Topography on Surface Mass Transport in a Shallow Lake

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Ngoc Hieu LE

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He received his Bachelor's Degree in Thuyloi University (2017) and Master's Degree in Water Engineering and Management at Asian Institute of Technology – Thailand (2019). His research interests include the hydrodynamic modeling, numerical simulation, and artificial neural network (ANN)

Wind-induced surface mass transport was investigated under spatially inhomogeneous wind field and different bathymetry gradients in a hypothetical round shape lake. The simple lake was created on top of Lake Kasumigaura to disregard the effect of the shape providing a very first look at horizontal circulation driving changes in surface mass transport. The study utilized the Weather Research and Forecasting model coupled with the Large Eddy Simulation (WRF-LES) to recreate the spatial variation of wind over the shallow Lake Kasumigaura, Japan. Furthermore, this study carried out an integrated method of quantification to identify inhomogeneity levels of the spatial wind field based on a 2D mean filter coupled with the coefficient of variance (C_v). After that, each classified snapshot of the wind field was applied to the hypothetical lake with different bathymetry gradients using the hydrodynamic model Fantom-Refined 3D to numerically track floating particles. Based on the numerical results obtained, the effects of inhomogeneous wind field were noticeable under flat topography with strong wind. Interestingly, sloping boundary tended to accumulate the particles in the leeward direction, so that the difference between uniform and non-uniform wind cases was minor.

Keywords: inhomogeneous wind, numerical simulation, bathymetry gradients, mass transport

Analysis of Dissolved Oxygen during Overturn period of Selective Withdrawal Operation in a Water Supply Reservoir

Ronnel PABALAN, Katsuhide YOKOYAMA, Maurice DUKA

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Dissolved Oxygen (DO) and Manganese (Mn) have a significant role in indicating the quality of drinking water. In general, low DO causes a reduction of particle Mn to dissolved Mn and high DO helps in the oxidation of dissolved Mn. Mn concentration can cause aesthetic problem (0.1 mg/L), issues for piped water supply system (0.2 mg/L) and toxicity (over 0.4 mg/L). Understanding the DO and Mn cycle is important to help the management of a water supply reservoir because of the effect of DO level in the oxidation and reduction process of Mn.

This study aims to examine the water quality condition of Ogouchi Reservoir in Tokyo, Japan which underwent a Selective Withdrawal (SW) operation from 1992 to 2001. Initial investigation shows that the reservoir exhibited similar thermal structures annually but displayed variation in DO and Mn. Annual DO increase and Mn upwelling at the bottom during winter overturn (Dec-Mar) occurred during 1992-1996 and 2000-2001. But, from 1997 to 1999, the continuous low concentration of DO at the bottom resulted in an increase in Mn. Therefore, the next part of the study focused on winter overturn to examine DO changes in order to understand the process of Mn.

Thermal gradient (TG), the difference in surface and bottom temperature over depth, and Schmidt Stability Index (SSI), the resistance of water column to mixing are used to explain DO changes. The relationship of the winter average of DO with TG and SSI shows an R^2 of 0.76 and 0.71, respectively. These results indicate that TG and SSI can partially explain DO behavior but they appear to be insufficient to determine the timing of the increase. The TG and SSI of the years with DO increases drop to 0.0035 ºC/m and 30 J/m^2, respectively. These values are the possible threshold value causing the change in DO. However, the TG and SSI of 1999 also dropped below the thresholds but DO remained low. Upon examining the week in DO change happened, it was found that the accumulated wind power during the time when DO remained low (37 to 77 W/m^2) is lower than during that when DO increased (92-198 W/m^2). Based on this, wind can be the driving factor of DO change. Therefore, if TG is at most 0.0035 ºC/m and SSI decreases to 30 J/m^2, DO increase can happen given the presence of approximately 90 W/m^2 accumulated wind power during that time.

Keywords: Dissolved Oxygen, Dissolved Manganese, Water Supply Reservoir, Thermal Gradient, Schmidt Stability Index, Wind Power

Current Challenges in Sustainable Management of the Water Supply System in Hanoi, Vietnam

Nuong Thi BUI, Tu Linh HOANG, Phuong Thanh VU, Trang Quynh VU, Mai Ngoc TRAN, Thanh Tien NGUYEN, Duong Du BUI

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Dr. Nuong Thi BUI an environmental specialist whose researches focus on sustainable water reso urces management, multicriterial decision making approaches, system dynamic, applied math and computer programming in environmental and natural resources valuation and management. After receiving her Doctoral Degree of Civil and Environmental Engineering from Tokyo Metropolitan University, Japan, she continued her work as a lecturer at the Environment Faculty of Hanoi Univ ersity of Natural Resources and Environment, Vietnam. She has also completed her postdoctoral r esearch internship program of University of Southampton, United Kingdom. She is PI and Co-PI of several national and international projects in Vietnam, Mekong and ASEAN regions. She has d one extensive research and impressive publication record of more than 10 peer- reviewed papers i n Asia and Vietnam for over a decade.

Hanoi, the socio-economic center of Vietnam, where the demand for water supply usage is always the highest compared to other cities in the country. This paper presents the current view of existing sustainability challenges in water supply system management for Hanoi (HUDWSS). First, we employed the concept of a wide-range-application-on-water- management approach, which provides a framework for integrating the disparate physical, socio-economic and political system, system dynamic (SD), to analyze the complexity of the water resources components related water stakeholders and sectors in Hanoi. We then built up a list of mathematic equations explaining the inter-relationships and interactions among those components. We also tested the simulation effectiveness by comparing the simulated results to the historical data in duration of 2017-2020. Secondly, we investigated 206 usable samples in April 2022 in the target study area to see how changes in the water use behaviors of Hanoi communities in the current circumstance of both preventing the spread of Covid-19 pandemic and developing the local economic system. The analysis results showed that the main changes in the domestic water use behaviors of Hanoi communities were consisted of hand washing, bathing/personal hygiene, house cleaning, clothes washing. During the pandemic, 77% of the respondents had a habit of washing their hands for 30 seconds as recommended by the Ministry of Health, the number of hand-washing times a day increased 5-7 times before the pandemic broke out. The rate of housing cleaning increased by 33% compared to before the pandemic, besides the high frequency of people also increased by an average of 3.5 times per week. The average frequency of clothes washing is also changed from 2.43 times / week to 4.61 times / week. The total estimated average water uses per person increased by 1.41% compared to its before the pandemic. Therefore, based on the total population of Hanoi city, the amount of domestic water increased by 471,457 m^3/day compared to its before the pandemic. This study finally analyzing the sustainability of HUDSS via several Covid-19 related water development scenarios to propose several recommendations for sustainable development of Hanoi urban water supply system.

Keywords: Urban water management, Sustainability, System dynamic, Covid-19, Hanoi.

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OS13: Groundwater for Sustainable Development

Date and time: 90mins 10:00am - 11:30am, 21 Sept, Wed (**Swedish Time GMT+2**),

Meeting Link & ID: https://kth-se.zoom.us/j/68515535823

Time	Content
Chair	**Prof. Prosun bhattacharya**
10:00 – 10:05	**Opening** *Prof. Prosun bhattacharya*
10:05 – 10:30	**Groundwater polution, data analysis and digital transrmation for sate drinking water services** *Prof. Prosun bhattacharya, KTH Royal Institute of Technology. President of International Society of Groundwater for Sustainable Development (ISGSD), Sweden*
10:30 – 11:00	**New perspectives on data analysis: the importance of considering the spatial aspects of the data in scientific research** *Dr. Julian Ijumulana, College of Engineering and Technology, University of Dar es Salaam, Tanzania. TH Royal Institute of Technology, SE-100 44, Stockholm, Sweden*
11:00 – 11:30	**Development of Power BI dashboard accurate reporting of Arsenic risk in Bangladesh for improved decision making** *Sanjeev Sharma, the CEO and Co-founder of ExcelDots, Sweden*

GROUNDWATER POLLUTION, DATA ANALYSIS AND DIGITAL TRANSFORMATION FOR SAFE DRINKING WATER SERVICES

Prosun Bhattacharya, K. Matin Ahmed, Sanjeev Sharma, Mattias von Brömssen, Nargis Akter, Md. Jahid Alam, Rajabu Hamisi, M. Tahmidul Islam, Morshedul Hasin, Md. Saifur Rahman, E.H. Russel Khan

Prosun Bhattacharya

Professor, Department of Sustainable Development, Environmental Science and Engineering, KTH Royal Institute of Technology,, Sweden

Prosun Bhattacharya is a Professor of Groundwater Chemistry at KTH Royal Institute of Technology, Stockholm, Sweden and Affiliate Scientist at KWR Watercycle Research Institute, Niewegein, The Netherlands. He is engaged with research on groundwater contamination especially focusing on geogenic contaminants – arsenic and fluoride and leading international projects with UNICEF-Bangladesh and Sida in Bangladesh, Bolivia and Tanzania.

The presence of geogenic arsenic (As) in groundwater has brought millions of people under severe health risk across the world. A population of nearly 28 million in Bangladesh are still exposed to As through drinking water sources above the WHO guideline (10 µg/L). Understanding the specific hotspots and real-time human exposure risks of As from groundwater sources can play a vital role to enhance equitable access to safe drinking water. Monitoring of groundwater levels and water quality parameters in the drinking water wells over the past decades have allowed us to map and characterize the spatial variability in groundwater quality. Recent monitoring of water quality in nested piezometric wells indicated consistent variation in the concentration of As within a very narrow band of oscillation within the individual groups of piezometer nest wells at shallow, intermediate deep and deep wells. Groundwaters abstracted from manually drilled shallow wells in relatively oxidized aquifers comprising red and off -white sands in south-central part of Bangladesh with As-safe water. The deep aquifers are identified as sources for safe water supplies in different parts of Bangladesh, the intermediate deep aquifers were also found to be a suitable drinking water source, safe from As and manganese over the time. These aquifers at intermediate depth are hydraulically separated from As contaminated shallow aquifers through interbedded aquitards. Identification of safe aquifers by the water sector professionals and the community based tube well drillers has been a challenge for the provision of safe drinking water supplies. Our ongoing project in Bangladesh brings priorities of training of local well drillers to identify safe aquifers as well as technocrats for their registration and certification. Integrating digitalization enabled by the ASMITAS tool and the data loggers, real-time hydrogeological data is captured at source for the screening well depth, groundwater level and well As concentration. Digital data management platform will also benefit the UNICEF-DPHE adopted Arsenic Safe Union (ASU) approach where the main concept is to assess the exposure of As concentration to the entire population of a village rather than individual water points, considering both technical and social issues for evidence-based decision making and provisions of safe drinking water in the affected communities. The approaches and findings generated in this study provide the local drillers and technocrats the value and evidence-based planning tools for the selection of safe arsenic aquifer and prioritizing the areas for arsenic risk reduction in Bangladesh.

Keywords: Groundwater pollution, arsenic, ASMITAS tool, digitalization, data, safe aquifers

NEW PERSPECTIVES ON DATA ANALYSIS: THE IMPORTANCE OF CONSIDERING THE SPATIAL ASPECTS OF THE DATA IN SCIENTIFIC RESEARCH

Julian Ijumulana & Prosun Bhattacharya

Julian Ijumulana

Postdoctoral Researcher and Assistant Professor
UDSM-DAFWAT Research Group, Department of Transportation and Geotechnical Engineering, College of Engineering and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania

Julian Ijumulana is a Doctor in Land and Water Resources Engineering at the University of Dar es Salaam (UDSM), Dar es Salaam Tanzania. Dr. Julian is also an affiliate member of the Department of Water Resources Engineering at UDSM teaching, consulting, and researching in spatial data sciences and technologies. His research activities focus on the spatial aspects of the data in land and water sectors. In his research, he works under the slogan of "letting the data speak by themselves for wise decisions in resource management".

Increasing advances in information technology and improved computational capabilities in hardware and software have necessitated new perspectives in data analysis. In this study, we present new perspectives on data analysis in which the two aspects of the observed event were considered. These aspects involved evaluation of the observed event in attribute and geographical space. In attribute space, the methods used were both graphical and inferential statistical models. These methods were used to evaluate the normality and homogeneity in concentrations of health concern water quality parameters. In geographical space, the methods combine the observed event value and location to determine the spatial processes controlling the behavior of the variable under investigation. In this study, we considered the location of each water sample by imposing the structure defined through the contiguity weight function. Using the univariate global and local Moran's I statistics, the latter revealed the spatial clustering process in most water quality parameters whereas the former identified and mapped the potential spatial patterns. These potential spatial patterns included high and low fluoride and arsenic concentration drinking water sources clustered in the same neighborhood. In addition, the univariate local Moran's I statistic mapped spatial outliers that included drinking water sources with low or high concentrations occurring in the neighborhood of high or low concentrations. This new perspective on data analysis provides new insights into the known facts as is the case in Tanzania, particularly in the fluorotic regions in the East African Rift Valley and the gold mining areas of northwestern Tanzania.

Keywords: Drinking water contamination, spatial analysis, arsenic, fluoride, northern Tanzania

DEVELOPMENT OF POWER BI DASHBOARD FOR ACCURATE REPORTING OF ARSENIC RISK IN BANGLADESH FOR IMPROVED DECISION MAKING

Sanjeev Sharma, Prosun Bhattacharya, Mattias von Brömssen, Kazi Matin Ahmed, Rajabu Hamisi, Nargis Akter, , Md. Jahid Alam

Sanjeev Sharma
CEO and Co-Founder of ExcelDots AB
Bromma Sweden

Sanjeev Sharma is the CEO of ExcelDots AB, a technology consulting company, headquartered in Stockholm, Sweden. The company was founded with a vision to build a better tomorrow by fusing sustainability practices with digital technologies, while working at the crossroads of science, technology and public policies. By leveraging the power of digital technologies and deep domain knowledge backed by scientific research, the ambition is to develop partnerships with government agencies and communities to re-imagine our relationship with nature. Sanjeev has been involved in applied research for end-to-end IOT, AI solutions for sustainability initiatives and working with some leading university and other partner companies to offer digital transformation in water sector.

Arsenic contamination in drinking water is inevitable issue in Bangladesh. Several major programs were rolled out for arsenic screening of tube wells which were intended to understand the arsenic risks and provide holistic approach for mitigation. Often handling millions of such data is a cumbersome process and lacks effective visualization technique. ASMITAS, a digital water platform, was introduced in Bangladesh, which is intended for arsenic risk mitigation in drinking water. The platform consists of a mobile application for new well characterization and an intuitive dashboard for arsenic screening, geological and hydrogeological information. Microsoft Power BI tool is one of the powerful visualization tools, which has been used in several industries for real time decision making. Integration of arsenic screening data from various tubewells into Power BI tool was demonstrated recently. SASMIT methodology was developed at KTH Sweden for systemic arsenic risk mitigation. It was further evolved during ongoing Sida-DPHE-Unicef-KTH supported project ‘Enhancing private sector capacity (EPSC), which aims at building capacity of local drillers and communities by targeting safe groundwater through Arsenic Safe Union (ASU) and SASMIT methods together. The dashboard has been successfully used for dissemination of groundwater hydrochemistry information to various stakeholders.

Keywords: Groundwater Sustainability, Digital Platform, Power BI, Arsenic Screening

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Kazi Matin Ahmed

Professor

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Professor Dr. Kazi Matin Ahmed of the Department of Geology, University of Dhaka is a leading researcher on groundwater in Bangladesh with focuses on impacts of urbanization on groundwater; microbiological contamination of groundwater from onsite sanitation; occurrence and mitigation arsenic contamination in groundwater; occurrence and mitigation of salinity in groundwater.

Sanjeev Sharma

CEO and Co-Founder of ExcelDots AB

Bromma Sweden

Sanjeev Sharma is the CEO of ExcelDots AB, a technology consulting company, headquartered in Stockholm, Sweden. The company was founded with a vision to build a better tomorrow by fusing sustainability practices with digital technologies, while working at the crossroads of science, technology and public policies. By leveraging the power of digital technologies and deep domain knowledge backed by scientific research, the ambition is to develop partnerships with government agencies and communities to re-imagine our relationship with nature. Sanjeev has been involved in applied research for end-to-end IOT, AI solutions for sustainability initiatives and working with some leading university and other partner companies to offer digital transformation in water sector.

Mattias von Brömssen

Head of Department of Water Resources, Ramböll Sweden

Mattias von Brömssen completed his Ph.D. at the Royal Institute of Technology (KTH), Sweden in 2012. Presently, he is working as project manager and expert within the fields of hydrogeology, water resources management, water quality assessments and contaminated soil and water. He has more than 19 years of national and international professional experience of projects including management and protection of water- and groundwater resources. His expertise include environmental impact assessments (EIA:s), hydrogeological surveys, environmental risk assessments, action plans for remediation and technical assistance at the environmental court etc. He has worked period wise in Bangladesh on high arsenic groundwater and options for safe drinking water, carried out through a co-operation between Ramböll, KTH, University of Dhaka and NGO Forum for Drinking Water Supply and Sanitation

Nargis Akhter

WASH Project Officer, UNICEF
UNICEF-Bangladesh, Dhaka, Bangladesh

Nargis Akter is Water Supply, Sanitation and Hygiene specialist with 13 years of experience, Civil and Environmental engineer by training, working in severely arsenic prone areas, hard to reach rural areas and challenging urban areas. Specialized on water quality and context specific WASH technologies design, implementation and monitoring. Competent in program planning, management (financial and program) and monitoring of Water, Sanitation and Hygiene projects with excellent track records of delivering results.

Md. Jahid Alam

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Jahid Alam holds a M.Sc. degree in Earth and Environmental Sciences from Department of Geology, University of Dhaka. He is currently working as WASH National Consultant Water Supply at UNICEF Bangladesh. He has worked as the Project Manager at University of Dhaka/Royal Institute of Technology, Sweden and Assistant Hydrogeologist at JICA Bangladesh. He has also a long experience of working with Institute of Water Modelling (IWM) and Assistant Hydrogeologist at JICA Bangladesh

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Rajabu Hamisi is a Land and water resources engineer working on new challenges in water and wastewater treatment, hydrogeology, geochemical modelling and development of innovative technology for sustainable water quality management. a Professor of Groundwater Chemistry at KTH Royal Institute of Technology, Stockholm. He is presently working as the Manager of the KTH-Unicef project Enhancing Private Sector Capacity and digital data management .The Netherlands. He is engaged with research on groundwater contamination especially focusing on geogenic contaminants – arsenic and fluoride and leading international projects with UNICEF-Bangladesh and Sida in Bangladesh, Boli

OS14: Climate change impacts and SEA lakes ecosystems

Date and time: 90mins 10:00am - 11:30am, 21 Sept, Wed (**Bangkok Time GMT+7**),

Meeting Link: https://ait-ac-th.zoom.us/j/97836023849

Meeting ID: 978 3602 3849

Time	Content
Chair	**Dr. Salvatore G.P. Virdis**
10:00-10:05	**Introduction/Opening remark** *Prof. Sangam Shrestha, Asian Institute of Technology, Thailand*
10:05 – 10:20	**Long-Term Spatiotemporal Analysis of Lake Surface Water area changes in Southeast Asia** *Ms. Tatsaneewan Phoesri, Asian Institute of Technology, Thailand*
10:20-10:35	**Assessment of surface runoff historical changes in main South East Asia river basins** *Ms. Nongrat Sukarasuta, Asian Institute of Technology, Thailand*
10:35-10:50	**Modelling Lake Surface Water Temperature (LSWT) in Southeast Asia** *Mr. Siwat Kongwarakom, Asian Institute of Technology, Thailand*
10:50-11:15	**Analysis of Lake Surface Water Temperature Spatial Trend in Tonlé Sap using MODIS** *Dr. Salvatore G.P. Virdis, Asian Institute of Technology, Thailand*
11:15-11:30	**Assessment of land use and lad cover changes in main South East Asia river basins** *Mr. Aung Chit Moe, Asian Institute of Technology, Thailand*
11:30-11:45	***Q&A and Discussion:*** *Dr. Salvatore G.P. Virdis*

Long-Term Spatiotemporal Analysis of Lake Surface Water for Southeast Asia based on Global Surface Water Dataset

Tatsaneewan Phoesri, Sangam Shrestha, Bachisio Mario Padedda, Pratyush Kumas Das, Nitin K. Tripathi, Salvatore G.P. Virdis,

Tatsaneewan Phoesri

Ph.D. research scholar & CCRASEAL Project Member
Remote Sensing and Geographic Information Systems, School of Engineering and Technology, Asian Institute of Technology

Ms. Tatsaneewan Phoesri is currently a Ph.D. student and Project Member of the Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project. She has experience in the multi-scale definition of residential neighborhoods using automated zone design and a background in hydrological modeling using GIS. Her current research interests are long-term multi-temporal analysis of surface water in Southeast Asia.

Southeast Asia (SEA) hosts a large number of lakes that are crucial for providing essential ecosystem services such as water supply, agriculture, tourism, and recreation. Both direct and indirect factors, such as anthropogenic activities and climate variability and change, have had severe impacts on lakes' surface water and their extent. This research aims to monitor change in lake surface water areas across the whole SEA by delineating and analyzing multi-resolution long-term satellite imagery.

A methodology has been set up to track and delineate surface water areas over more than 20 years using Landsat-derived datasets. Map generalization methods were applied to ensure spatial and temporal consistency of data. Preliminary results reveal spatial and temporal patterns of surface water extent dynamics, essential for understanding the relative impacts of changing climate and land uses.

Keywords: Monitoring, freshwater lake, surface water, remote sensing, temporal pattern

Assessment of historical and projected changes of surface runoff in Mainland South East Asia

Nongrat Sukarasuta, Siwat Kongwarakom, Sangam Shrestha, Salvatore G.P. Virdis

Nongrat Sukarasuta

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Bachelor of Science in Geology, Chulalongkorn University, Bangkok, Thailand (2020). Currently, she is master student in Remote Sensing and Geography Infromation System (RS&GIS), Asian Instistute of Technology (AIT), Pathumthani, Thailand.

Predicting and estimating surface runoff in Mainland Southeast Asia (MSEA) is essential for the assessment of water receiving potential of a watershed and for an appropriate planning of soil and water conservation measures. Due to MSEA rapid development, industrial, urban and population growth cause land degradation across the whole region.

Even if several research have highlighted the need for long-term catchment studies to guide future proper runoff measures and management policies, runoff knowledge in the tropical region of Southeast Asia is still insufficient. In particular comprehensive studies having a regional focus at the multi-basins scale have not been addressed before in MSEA.

This work aims at setting up an empirical model for the surface runoff estimation at the multi basins scale in the Mainland Southeast Asia. We present preliminary results of annual and monthly estimations of surface runoff distribution using the SCS-CN model approach from 2000 to 2020

Keywords: rainfall, runoff, Mainland Southeast Asia, remote sensing, SCS-CN method, curve number

Modeling Lake Surface Water Temperature (LSWT) in Southeast Asia

Salvatore G.P. Virdis, Siwat Kongwarakom, Liew Ju Neng, Sangam Shrestha

Salvatore G.P Virdis

Assistant Professor & CCRASEAL Project Leader
Remote Sensing and Geographic Information Systems, School of Engineering and Technology, Asian Institute of Technology

Assistant Professor at Remote Sensing and Geographic Information Systems at Asian Institute of Technology, Thailand. Formal background is in applied geological sciences and remote sensing. Currently, researching focus on Geo-Information and Earth Observation Science to monitor and evaluate existing and future anthropogenic changes and their effects on natural and non-natural physical/ human environments. He uses field-based, remote/ proximal sensing and advanced geospatial modeling on seasonal to decadal scales. He also severally published in high-impact international journals and having over 18 years of teaching experience. He mentors Master's and PhD students at AIT, and he is also a project leader of Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project

The impact of climate variability/change in Southeast Asian lakes is expected to exacerbate as business-as-usual anthropogenic emissions continue. This posed multiple threats to hundreds of millions of people relying on their ecosystem services. Therefore, it is important to quantify the severity of such impact on these lakes in order to develop a suitable mitigation and adaptation strategy. Lake surface water temperature (LSWT) among many is an important parameter for the physical and biochemical processes occurring within water as well as in air-water interactions because temperature regulates physical, chemical, and biological processes in water. Therefore LSWT is an important indicator to be measured in impact studies, however, this information is often lacking in Southeast Asia region.
This study presents preliminary results of LSWT predictive modelling exercise built from ERA5 reanalysis climate data and LSWT from MODIS products using various machine learning and deep learning algorithms. Predictive models have been applied on historical and projected climate data from different GCM-RCMs to predict LSWT time series for the past and future scenarios. Lake-wise trends have been detected and measured. Additionally, evaluation on model performances and accuracy of calculated trends are also provided.

Keywords: Lake surface water temperature, modeling, machine learning, risk map, climate change

Analysis of Lake Surface Water Temperature Spatial Trend in Tonlé Sap using MODIS

Siwat Kongwarakom, Liew Ju Neng, Sangam Shrestha, Salvatore G.P. Virdis

Siwat Kongwarakom

Research Scientist & CCRASEAL Project Manager
Remote Sensing and Geographic Information Systems, School of Engineering and Technology, Asian Institute of Technology

Mr Siwat Kongwarakom is a Research Assistant and a Project Manager of Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project. His expertise is within the field of geomatics and geoinformatics engineering. He has more than six years of experience collecting, managing, processing, and analyzing geospatial data by applying surveying, remote sensing, and geographic information system technologies. His current research interests focus on spatiotemporal analysis and modelling of climate variables.

Tonlé Sap lake is the largest and the most productive freshwater lake in Southeast Asia, providing food for millions of people residing in and around the lake. Thus, monitoring the lake is a crucial task, as the impact of climate change in the future could disrupt its ecosystem services. Lake surface water temperature (LSWT) is considered as an essential climate variable and an important indicator for lake management. In contrast, the number of available monitoring stations, especially for LSWT, is limited and poorly distributed in proportion to the size and shape of the lake. For this reason, analysis solely based on the observations from the stations is not sufficient to capture spatial and temporal trends exhibited locally.

In recent decades, remote sensing data has become a cost-effective input for researchers and decision makers to detect changes due to its spatiotemporal coverage and accessibility. By leveraging the satellite observation data, this study provides a spatial and temporal trend analysis of LSWT and land surface temperature (LST) in Tonlé Sap floodplain and surrounding area using MODIS product. In addition, other climate variables such as air temperature and wind were also examined to quantify their influences on LSWT.

Keywords: Tonlé Sap lake, water temperature, spatial trend, remote sensing, management

Analysis of Change Detection and Zonal Statistics of Land Use Land Cover on Mainland Southeast Asian Lake Basins utilizing MODIS and CCI Land Cover Datasets

Aung Chit Moe, Sangam Shrestha, Siwat Kongwarakom, Salvatore G.P. Viridis

Aung Chit Moe
Master Student
Remote Sensing and Geographic Information Systems, School of Engineering and Technology, Asian Institute of Technology

A Master Student (August 2021 Candidate), pursuing Remote Sensing and Geographic Information Systems at Asian Institute of Technology, Thailand. Graduated Bachelor of Science (Hons:) in Geology from University of Yangon, Myanmar in 2018. Currently, studying second year of master's degree by conducting Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project.

Lakes in Southeast Asia provide wide range of ecosystem services and are a vital natural resource for a variety of uses, including water supply, manufacturing, farming, transportation, aquaculture, and recreational activities. It has been shown that they are extremely susceptible to the risk posed by environmental and climate change. The Southeast Asian region has already been severely affected by the impact of climate change, and those effects will only increase and worse as the rate of climate change accelerates. Studies conducted within the Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project, are attempting to measure current and future climatic patterns, evaluate spatial and temporal lake changes and link that to threats, estimate climate change risk in lakes and other areas in the future, and improve multi-threat approach in climate change impact assessment on mainland Southeast Asian lakes into decision making processes.

With relation to these perspectives, land use and land cover change detection analysis becomes crucial in establishing a quantitative and analytical framework for the anthropogenic impact assessment coupled with current and projected climate on mainland Southeast Asian lakes.
In this study we present preliminary analysis on major LULC changes occurred in main lake river basin across whole Southeast Asia. The assessment is conducted by using and comparing different LULC time series dataset.

Keywords: climate change effects, Southeast Asia, lake basins, remote sensing, land use land cover, change detection, zonal statistics, global datasets

Using a Neural Network Based Model to Retrieve the Inland Water Bodies' Water Quality Parameters from Remote Sensing Data in Thailand

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M.E in Remote Sensing and GIS, Asian Institute of Technology, Thailand (2022).

Currently working as a research associate in CCREASEAL project and have been working on remote sensing data from past three years for water quality monitoring. Earlier have a Bachelor of Technology in computer science department and worked in web development projects.

Freshwater is vital for human wellbeing and the ecosystem in general. Inland water bodies are the primary sources of freshwater, and they are both directly and indirectly impacted by climate change and anthropogenic activities. Constant monitoring of water bodies is essential in understanding the dynamic nature of the water column as well as its properties for the long-term goal of fresh water and sanitization in such a situation. There are conventional methods for retrieving the water quality indicators, but in the monitoring of large surfaces waterbodies, combining remote sensing data with its high temporal, geographical, and spectral characteristic capabilities will provide a wide range of information to comprehend and estimate the patterns of the waterbodies. Several techniques for extracting active water quality indicators from images, as a proxy for phytoplankton and sediments in the water column, have become available with the development of machine learning and deep learning over the last few decades.

Considering the above-mentioned advancements, the main aim of this study was to apply spatially and temporally validated NN-based Case-2 Regional Coast Color (C2RCC) processor and to extract Water Quality Parameter (WPQ) in tropical inland and riverine waters of Thailand using in situ observation and permanent water quality datasets. C2RCC was indeed used to retrieve and estimate the concentration of chlorophyll, total suspended matter and turbidity using high spatial and temporal Earth observation data from Sentinel-2 MSI and Landsat 8 OLI. The satellite-based estimates have been compared to conventional field observations and the accuracy assessed.

Keywords: remote sensing, C2RCC, inland waterbodies, Sentinel-2 MSI, Landsat 8 OLI, chlorophyll, total suspended matter

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Ph.D. in Integrated River Basin Management (IRBM), University of Yamanashi, Japan. At Asian Institute of Technology, he serves as professor and program chair for the water engineering and management program. In addition, he is a Visiting Faculty at the National University of Laos, the University of Yamanashi in Japan, and the Institute for Global Environmental Strategies (IGES) in Japan. His interests in the study of hydrology and water resources include groundwater evaluation and management, integrated water resource management, and the assessment and adaptation to climate change in the water sector.

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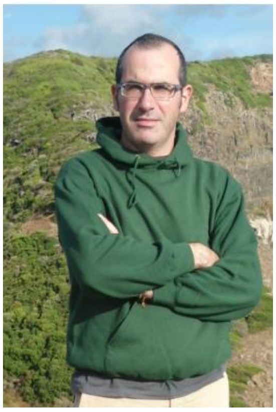

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Researcher in Ecology at the University of Sassari. He holds a Ph.D. in Analysis and Management of Natural Ecosystems and an MSc in Environmental Sciences. His work experience and current and previous research interests are in the field of studies on the structure and functioning of lake and coastal lagoon ecosystems. He specifically focuses on ecological responses to eutrophication and biogeochemistry, ecology of phytoplankton, and water pollution assessment and control, and his research is based on the ecosystemic approach linking river basin management and water ecosystems. He is also an author of over 70 peer-reviewed articles, book chapters, conference proceedings, and over 90 conference contributions as well as a member of the European Infrastructure for Biodiversity and Ecosystem Research (LifeWatch) and coordinator of the site Lake Ecosystems of Sardinia of Long-Term Ecological Research (LTER) network.

Pratyush Kumar Das

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Doctoral research scholar in Remote Sensing and GIS at Asian Institute of Technology. His primary background is in civil engineering and remote sensing. He has experience in remote sensing for agriculture, precision farming, UAV application for crop monitoring, and WebGIS. His current interest focuses on machine learning and deep learning application for crop classification using multi-temporal satellite images.

Sangam Shrestha

Professor
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Professor and Chair of Water Engineering and Management Program at the Asian Institute of Technology (AIT), Thailand. He is also a Visiting Faculty of the University of Yamanashi, Japan, National University of Laos, and a Research Fellow of the Institute for Global Environmental Strategies (IGES), Japan. His research interests are within the field of hydrology and water resources including, climate change impact assessment and adaptation in the water, integrated water resources management, and groundwater assessment and management.

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Mr Siwat Kongwarakom is a Research Assistant and a Project Manager of Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project. His expertise is within the field of geomatics and geoinformatics engineering. He has more than six years of experience collecting, managing, processing, and analyzing geospatial data by applying surveying, remote sensing, and geographic information system technologies. His current research interests focus on spatiotemporal analysis and modelling of climate variables.

Liew Juneng

Associate Professor
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Dr Liew Ju Neng is currently an Associate Professor at the Department of Earth Science and Environment, Universiti Kebangsaan Malaysia. His research interests encompass various aspects of regional climate dynamics over the Southeast Asia region with a specific focus on interannual and long-term climate change time scales. In addition, he is also interested in the issue of regional air quality and its association with regional meteorology.

OS15: Integrated flood and sediment management (FSmart)

Date and time: 180mins 9:00am - 12:00am, 22 Sept, Thu (**Japan time/GMT+9**),

Meeting Link: Click here: https://kyoto-u-edu.zoom.us/j/83775904137?pwd=TUFXRUdYb3ZnZ3VUblIwTDdsU3NiUT09

Meeting ID: 837 7590 4137, Passcode: 023578

Time	Content
Chair	**Prof. Tetsuya Sumi**
10:00-10:05	**Introduction/Opening remark** *Prof. Tetsuya Sumi, Kyoto University, Japan*
10:05 – 10:20	**Summary and outcomes of integrated flood and sediment project** *Dr. Sameh Kantoush, Kyoto University, Japan*
10:20-10:35	**Summary of the stakeholder's forum on integrated flood risk in the Cagayan river basin** *Prof. Orlando F. Balderama, Isabela State University ISU, the Philippines*
10:35-10:50	**Flood susceptibility mapping and prediction for extreme flood in Vu Gia Thu Bon River Basin** *Dr. Mohamed Saber, Kyoto University, Japan*
10:50-11:05	**Integrated flood and water resources management in the Cagayan river** basin *Dr Lanie Alejandro, Isabela State University ISU, Philippines*
11:05-11:20	**Impacts of dams and sand mining on flow regime and sediment morphology changes in the Vu Gia Thu Bon River basin** *Eng. Quang Binh, Vietnam University, Japan and the University of Danang – University of Science and Technology (DUT), Vietnam*
11:20-11:35	**Evolution of bank erosion and morphological changes in the Vietnamese Mekong Delta** *Dr. Doan Van Binh, Vietnamese German University*
11:35-12:00	***Q&A and Discussion:*** *Prof. Orlando F. Balderama, Isabela State University ISU, the Philippines* *Co-Chair by Dr. Mohamed Saber, Kyoto University, Japan*

Summary and outcomes of integrated flood and sediment management project

Sameh A. KANTOUSH

Sameh A. KANTOUSH
Associate Professor
Kyoto University
Disaster Prevention Research Institute (DPRI), Kyoto University
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Ph.D. at the Swiss Federal Institute of Technology Lausanne (EPFL) in Switzerland.
Dr. Kantoush specialties are river and dam engineering. His research interests span the fundamentals of river engineering and sediment transport, flash floods, hydropower and dams, reservoir sustainability, Ecohydraulics, dam impacts, and sediment management techniques. Dr. Kantoush served as a guest editor for Springer, Urban water, and Water journals.

Climate change poses great threats from disastrous floods and drought to the world, of which Japan, Vietnam and Philippines are among the most affected countries. Human interventions such as deforestation, dam constructions, and expansion of irrigation system have magnified the impacts of climate change. The project aims at assessing the impacts of climate change and human interventions on reservoir sedimentation, flood inundation, agricultural practices, and river and coastal erosion in the Vu Gia-Thu Bon and Cagayan river basins. Then, we establish integrated flood and sediment management schemes for sustainable development. The ultimate goal of the proposed project is to transfer the projects results to the stakeholders and policy-decision makers to implement into the national laws. We also organize some training courses, seminars and workshops to train young researchers, stakeholders, policy makers, local communities and to expand our collaborative network with other ASIAN countries and global change programmes.
The detailed objectives of this proposed project are to assess climate change/climate variability and its impacts on the rainfall-runoff and sediment yield in the Vu Gia-Thu Bon and Cagayan river basins; to quantify the consequences of changing climate on floods, droughts, agriculture activities, and river and coastal erosion; then to propose appropriate countermeasures; to investigate, analyze, and evaluate reservoir sedimentation in the Vu Gia-Thu Bon (e.g., Song Tranh 2 dam) and Cagayan (e.g., Magat dam) river basins. Then, to develop an indicator for reservoir classification based on sedimentation rate and reservoir longevity; to propose potential technical solutions for removing accumulated sediment in reservoirs (a case study in Song Tranh 2, Vietnam, and Magat dam, Philippines); to develop an integrated flood and sediment management for sustainable development; and to establish an association where the results from cooperation among scientists, stakeholders, decision makers, local communities, and private sectors can be transferred to the central government in implementing “integrated river basin management”.

Summary of the Stakeholders Forum on Integrated Flood Risk Management in Cagayan River Basin

Dr. Orlando F. Balderama
Vice President
Research and Development, Extension and Training
Isabela State University, Echague, Isabela

A/Prof., PhD in Water Resource Engineering, University of Tokyo, Japan. A Professor, R&D administrator, and consultant in the fields of agriculture and irrigation engineering/ management, water resources, river basin, climate change and disaster risk management.

The stakeholders forum generally aimed to enhance the capacities of policymakers, managers, and practitioners of river basin organizations on flood management through knowledge sharing of new approaches, techniques, methodologies, and good practices from partners here and abroad to help achieve effective implementation of integrated flood risk management as a component of integrated water resources management through stakeholders' collaboration and consultation. Considering the designed series of activities, the forum highlighted the partnership of the Japan Water Agency and the Cagayan River Basin Management Council, a multipartite information exchange among the Philippine government agencies' dignitaries, political leaders and legislators, and Japanese stakeholders, and the update reports conveyed by numerous Philippine government agencies as well as their collaborative workshop engagement to scale up international community linkages. It also underscored the inauguration of the International Organization on Climate Change Adaptation and Disaster Risk Reduction Management Office, stakeholders' collaboration for technology transfer and knowledge-sharing activities at NIA stations, and the newly forged partnership between JWA and City of Santiago to promote UN-SDG 6 and water security. By and large, as the event accentuated the need to mainstream knowledge sharing and communication in integrated flood risk management to strengthen effective IWRM practices, it then served as a channel that bridged what the government agencies and organizations know about flood and sedimentation management and what the community partners need to understand to revitalize science-community-government-academe collaboration.

Keywords: *knowledge sharing, technology transfer, water security, integrated water resources management, flood and sedimentation management*

Flood susceptibility mapping and prediction for extreme flood in Vu Gia Thu Bon River Basin

*Mohamed Saber[1, *], Tayeb Boulmaiz[2], Mawloud Guermoui[3], Karim I. Abdrabo[4], Sameh A. Kantoush[1], Tetsuya Sumi[1], Hamouda Boutaghane[5], Doan Van Binh[6], Binh Quang Nguyen[1,7], Thao T. P. Bui[1], Ngoc Duong Vo[7], Emad Mabrouk[8,9]*

Mohamed SABER

Water Resource Center, Disaster Prevention Research Institute (DPRI), Kyoto University
Kyoto 611-0011, Japan

Mohamed Saber is currently working as a specially Appointed Associate Professor at the Disaster Prevention Research Institute (DPRI), Kyoto University. He has a Ph.D. in Hydrology from Kyoto University, Japan. Mohamed has experience working and holding different positions in Japan; Turkey; USA; and Egypt. His research interests are mainly focused on flood forecasting and risk management, hydrometeorological analysis and climate change, water resources management, reservoir sedimentation management, and remote sensing and GIS applications, Machine Learning.

Flooding in humid regions have been increasing recently and can have devastating effects. Therefore, predicting flood-prone areas is essential for proactive disaster management. However, with limited data due to the scarcity of flood observation stations and the lack of monitoring systems, such predictions through physical hydrological models are challenging to accurately obtain. This study aims to evaluate two new boosting machine learning models, namely, LightGBM and CatBoost, for the first time in the prediction of flooding susceptibility (FS) in Humid Region (VGTB River basin in Vietnam). Then, the performance of these models is compared with that of the common random forest (RF) method, and also compared with the rainfll-runoff modeing. Fourteen independent factors that influence FFS in the study area, including elevation, slope, plan curvature, aspect, vertical and horizontal distance from main streams, hillshade, flow accumulation, the topographic wetness index (TWI), rainfall, land use (LU), lithology, the normalized difference vegetation index (NDVI), and the sediment transport index (STI), were assessed. Approximately 445 flash flood sites were identified through field visits and records of historical flood events. Accordingly, the dataset was divided into two groups for training (70%) and testing (30%) through a random selection scheme. The results show that the area under the curve (AUC) values of the receiver operating curve (ROC) were above 97% for all tested models, which indicates excellent accuracy. The FS mapping (FSM) results showed that downstream areas that are highly populated are prone to flooding and are characterized by high and very high levels of susceptibility. The results also compared with the 2D Rainfall Runoff Model showing acceptable agreement in terms of flood extend. The study verified that the newly employed algorithms (LightGBM and CatBoost) can be used for FFS prediction in other similar arid environments with reasonable accuracy. The outcomes of this study can be used by planners and officials for flash flood risk reduction.

Keywords: *Machine algorithms, LightGBM, CatBoost, Random forest, Flash flood susceptibility Mapping, different climatic environments*

Integrated flood and Water Resources Management, Research and Development in the Cagayan River basin

Lanie A. Alejo
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Water Research and Development Center
Isabela State University, Echague, Isabela

Flooding and sedimentation are two of the most catastrophic hazards to river ecosystems that have had a significant influence on the Philippines' Cagayan River Basin (CRB). Improper reservoir management could worsen flooding in downstream areas. The majority of the catchment's intake of silt is trapped by the Magat Dam in CRB, significantly reducing the reservoir's capacity for flood control and water supply. One of the 18 significant river basins in the Philippines is the CRB. As the economic engine and lifeline of the Philippines, these basins must be maintained responsibly. To handle several issues, including watershed conservation and rehabilitation, flood mitigation, a reliable source of clean water, as well as local livelihood and economic prospects, an integrated river basin management approach must be implemented. Therefore, basin-scale integrated flood and sediment control are crucial for the sustainability of river basins.

Distinguished researchers from Japan, Vietnam, and the Philippines have been teaming with the Water Research and Development Center at Isabela State University in the Philippines to develop cutting-edge methods and strategies for integrated flood, sediment, and water resources management. Additionally, the collaborative projects offer research-based techniques to lessen the effects of floods, sedimentation, and droughts brought on by climate change. The findings of the research projects under the center have been used to strengthen intervention proposals and build strategies to deal with pressing concerns in watershed and dam operations. Overall, the collaboration's objective is to transfer project results to decision-makers and stakeholders for incorporation into national laws through training seminars and workshops to educate young researchers, decision-makers, and local communities, as well as to broaden our network of partnerships with other ASIAN nations and global change initiatives.

Impacts of dams and sand mining on flow regime and sediment morphology changes in the Vu Gia Thu Bon River basin

Binh Quang NGUYEN, Sameh A. KANTOUSH, DOAN Van Binh, Mohamed SABER, Duong Ngoc VO, Tetsuya SUMI

Binh Quang NGUYEN

Water Resource Center, Disaster Prevention Research Institute (DPRI), Kyoto University
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54 Nguyen Luong Bang, Danang, Vietnam

Binh is a Ph.D student in Urban Management, Kyoto University, Kyoto, Japan from 2021. He is e xperienced in hydro-sediment-morpho dynamic numerical modeling (TELEMAC) and hydrology (SWAT). The research interest spans are the impact of dams, sediment transport, and morphologi cal evolution.

The Vu Gia Thu Bon (VGTB) River basin plays an important role in water resources in the Central region of Vietnam. However, over the recent decades, dam construction and other anthropogenic activities have increasingly profound effects on the flow regime and sediment budget. Understanding these impacts is critical for the foundation of sustainable hydrogeomorphology management. In this study, the long-term discharge and sediment load were spatiotemporally assessed from 1996 to 2020. The river bathymetric data (in 2010 and 2021) were also analyzed to further clarify the effects of upstream sediment changes and sand mining on morphological evolution. The mean annual sediment in Vu Gia and Thu Bon Rivers decreased by 36% and 47.2%, respectively, in the post-dam period compared with the pre-dam period. The volume of sand mining is approximately 453 Mm^3 from 1990 to 2018. Comparison of the effect of dam construction and sand mining shows that sand mining has the most influence on the reduction in sediment. The total incision volume during the period of 2010–2021 in our concerned river sector (-63.25 Mm^3, averaging at -5.27 Mm^3/yr) with a rate of incision depth of -0.14 m/yr. Results of the study provided useful insights into the effects of anthropogenic activities on the sediment budget. These changes of riverbed incision on hydrological processes invested to better understand water level changes and saline intrusion.

Keywords: Dam, Sand mining, Bathymetry, Flow regime, Sediment budget, Vu Gia Thu Bon.

Evolution of bank erosion and morphological changes in the Vietnamese Mekong Delta

Doan Van BINH, Nguyen Hao QUANG, Ha Nam THANG, Sameh A. KANTOUSH, Le Van QUYEN, Nguyen Luyen Phuong DOAN, Luc Anh TUAN, Tam Van NGUYEN, Tetsuya SUMI

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The Vietnamese Mekong Delta (VMD) is shrinking and sinking, thus is drowning. It has recently changed from depositional to erosional phase as a consequence of a reduction in sediment supply from the Mekong mainstem and an increase in sand mining. Studies quantifying morphological changes in the VMD were largely at local scales due to limited data availability, thus morphological evolution in the entire VMD remains little known. In this study, we attempt to quantify long-term riverbed and riverbank evolution in the main rivers of the entire VMD using remote sensing techniques and extensive field-surveyed data covering a total riverbank length of about 1200 km. Riverbanks extracted from remote sensing are validated using georeferenced coordinates of the riverbanks recorded during a field survey in February 2022. The results from this study provide a quantitative understanding of how sediment in the VMD has been lost or gained over the past three decades. Such results are useful in policymaking and sustainable development of the delta.

Keywords: remote sensing, morphological change, Vietnamese Mekong Delta, bank erosion

Watershed hydrological model for discharge and sediment simulation in Vu Gia Thu Bon river basin using HYPE model

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Vietnam has experienced several problems with its water resources, particularly floods, which have been a major worry for farmers for many years. Vietnam is one of the most flood-prone and climate change-affected countries, with more than 3,200 kilometers of coastline and 80% of the people residing there (Dasgupta S. et al., 2007). The most obvious human activities that affect Vietnam's water quality and quantity are watershed deforestations and the building of hydroelectric power facilities. Excessive flood episodes, which can result in poor water quality or inundation in the downstream communities, are one of the most important problems caused by these human activities. One of Vietnam's greatest internal drainage systems is the Vu Gia Thu Bon (VGTB) river basins in Central. Two significant rivers, the Vu Gia and the Thu Bon, together make up the VGTB river system (Firoz. et al., 2018). Regarding water, food, energy, as well as cultural and recreational activities, the VGTB river basin has a significant impact on the way of life of the locals.

By applying the Hydrological Predictions for the Environment (HYPE) model, conducting the discharge and suspended sediment concentration (SSC) simulation for the VGTB river basin in two cases with and without reservoir to see the change of streamflow and SSC in case of reservoir presence.

NSE values for Nong Son and Thanh My stations with daily scale for model performance in "natural" (without reservoirs, before 2010) conditions in the VGTB river basin were 0.78 and 0.46, respectively. The KGE values for the VGTB river basin's model performance under-regulated (with reservoirs, after 2009) conditions are 0.513 for the daily scale and 0.516 for the monthly scale.

Therefore, the HYPE model shows potential results with the Nong Son and Thanh My hydrology station within the VGTB river basin. With the goal of providing more realistic simulations for reservoir operation of managers and flood control plans, HYPE will be continuing to finalize in VGTB by integrating the reservoir operation.

Keywords: Watershed hydrological model (HYPE model), discharge, suspended sediment concentration, Vu Gia Thu Bon river basin.

Spatio-temporal impacts of climate change over the Cagayan River Basin, Philippines

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The Philippines is experiencing more frequent heavy precipitation events and severe droughts as a result of climate change and a greater degree of fluctuation in precipitation and temperature. And, the Cagayan River Basin (CRB) in the Philippines is the major basin, covering a total land area of 27,493.49 km^2, presently facing critical issues of rapid climate variability and frequent occurrences of flood, drought, and become the most significant constraints that somehow prevent further development in CRB. Addressing the effects and occurrence of these disasters is always a significant challenge in the Philippines, particularly in the CRB, due to the increasing population and the effects of climate change. One approach to addressing this challenge is to make better use of climate data and tailor it to better predict the likelihood of occurrences and associated risk for such disasters before they occur. Hence, this study is being conducted to support in addressing these problems by considering the Spatio-temporal assessment of climate change impacts on extreme climate events using the MRI-AGCM3.2S data, and the Mann Kendall's test to analyze the relative changes over space and time to investigate the variability and magnitude of change in climate variables and extreme climate indices over historical and future time periods.

The results showed that intra-annual rainfall is increasing in the future, with a higher fluctuation rate in minimum and maximum annual rainfall. A consistent rise in temperature and precipitation is expected to bring prolonged dry spells and wet spells, likely to result in droughts and severe flooding in the Cagayan River Basin. However, the risk of climate change will not be uniform; some sub-basins will be more vulnerable than others. Therefore, spatiotemporal modeling is important for determining changes in space and time across river basins and for the effective implementation of adaptation strategies.

Keywords: Climate Risk, Climate Change Adaptation, Spatio-temporal Impacts, Drought, flood

Hydrodynamic modelling of Magat Dam and Reservoir during extreme conditions using Telemac 2D

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Dams and reservoirs have become useful tools in managing existing water resources and have opened the possibility to effectively utilize them for irrigation, power generation and disaster mitigation. However, as to be expected when the natural course of a river is altered, these reservoirs are exposed to degradation and loss of effective operation due to natural sedimentation. In the case of Magat dam and reservoir, an improper or even the lack of sediment management at all would inevitably lead to the obstruction of the intake pipes and discontinued operation of the Magat Hydroelectric Power Plant. Moreover, the expected significant storage capacity loss will also indefinitely affect the agricultural production under the areas serviced by the said reservoir. This is in addition to the communities that depend on the reservoir for their domestic uses.

Based on the accumulated sediment volume for the past five (5) years, the remaining storage capacity for the Magat Reservoir is now at around 577.68 MCM. with 30.52 MCM and 547.17 MCM for the dead and active storage capacities, respectively. With these data, the reservoir can now only hold approximately 570 MCM of water and is only expected to get worse if no effective sediment management is employed. The Telemac 2D solves the Saint-Venant or shallow water equations and was used to conduct modeling that provides the water depth and the average vertical velocity at each point of the resolution mesh. In terms of outflow volume, the calibration results for the Typhoon Ulysses showed a close agreement between the simulated and actual observed flows. On the other hand, free surface calibration results showed a very close curve and trends between the observed and simulated free surface values. The TELEMAC 2D model can now be used to estimate the impacts of parameters changes on hydrodynamic processes in Magat Dam.

Keywords: hydrodynamic modeling, dams, reservoirs

The stabilization of "squeezed" vegetated channels

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A vegetated channel is a feature of river morphology commonly found in natural rivers and estuaries. River channels usually consist of floodplains, a transition area, and the main channel. In the right conditions, vegetation often grows in the floodplain region, creating vegetated areas. These river channels were termed vegetated floodplain or vegetated compound channels. In a vegetated channel, vegetation adds to friction and drag forces, damping the flow and boosting the magnitude of the gradient of the mean streamwise velocity at the vegetation edge. Consequently, a mixing layer develops between the vegetation and the main channel region. The parallel shear flow between the vegetation and open channel region can trigger the Kelvin-Helmholtz instability, pulling slow flow at the channel-vegetation interface toward faster flow in the main channel region. These kinds of water motions induce the flow to arise a kind of large quasi-two-dimensional turbulence structures in the mixing layer. These turbulence structures contribute up to 90% of the amount of transverse momentum exchange between the vegetated region and the open channel areas.

Nevertheless, the remaining vegetation areas have been squeezed into narrow strips due to human activities. As a result, riverbanks at those locations are usually suffering from erosion. In order to obtain more insight into this issue, in this study, experimental data were presented on the instantaneous flow field inside the vegetation region in different scenarios of vegetation widths. The results suggest that the large quasi-two-dimensional turbulence structures in squeeze conditions occur more frequently but less regularly. The transverse exchange of mass and momentum induced by these large vortex structures are larger, while the space and time for sediment to be deposited are reduced. Moreover, the experimental results also reveal that if the width of the vegetation region reduces, the bed shear stress in the transition region increases significantly. In this context, the increased applied bed shear stresses on the transition slope may cause the instability of the vegetated floodplain region.

Keywords: vegetation, river bank, erosion, turbulence flow, squeeze condition.

Proposed mitigation for salinity intrusion in the Vietnamese Mekong Delta

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The Vietnamese Mekong Delta plays an extremely important and central role in the country's food security. Due to the influences of the upstream dam's development, sea level rise and complicated tidal regime in the dry season that have caused barriers and constraints for local agricultural activities. Once these causes combined climate change, the salinity intensity is more severe and the length of salinity intrusion is likely further in Hau River and Co Chien Rivers. This paper aims to propose mitigation and adaptation measures of drought and salinity intrusion for a sustainable agricultural development in the Mekong' estuary areas. In order to achieve these purposes, the numerical model is used to simulate scenarios of salinity changes for the drought years and medium water years and mitigation scenarios. The results of salinity concentration from numerical model may be an important information for an appropriate land use planning or crop plants corresponding to various salt tolerance thresholds. Besides, the location of salinity monitoring stations as well as the kinds of salinity control works are also discussed to serve the operation of saline control works on the basis of analysis of field measurement data. The study will be very meaningful for local farmers to develop agriculture sustainably, especially, the farmers can select crops which are suitable for the salt concentrations or change land use and cultivation models for higher yields. That means agricultural productions increase the efficiency toward a sustainable agriculture-based economy.

Keywords: salinity intrusion, Upstream dams, Sea level rise, tidal regime, Hau River, Vietnamese Mekong Delta.

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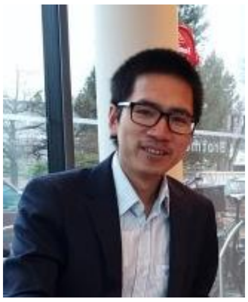

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PART II: SELECTED FULL PAPERS

Assessment of environmetntal pollution levels and forecast of changes in some heavy metals and grease in sediment of Nam Cau Trang Port cluster - Quang Ninh Province

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1. Introduction

The study area has many valuable natural resources, including Ha Long Bay, Bai Tu Long National Park, many estuaries, and deep-water bays. Sea encroachment to expand land fund, planning industrial zones, seaports, factories, urban areas, transportation, and mineral exploitation is the main cause of seawater quality degradation and depression, coastal area. Aquaculture activities, fishing activities, fishing activities, fisheries services, and tourism activities are also sources of water and sediment pollution in NCT Port Cluster.

Population growth and industrial, urban, and tourism growth have significantly increased pollution emissions, causing direct pressure on the natural environment and a significant impact on biodiversity and porcelain, healthy community, including NCT Port Cluster area.

Therefore, the assessing the current situation and forecasting environmental changes; The focus is on heavy metal and oil elements in seawater and coastal sediments in Quang Ninh province in general and NCT Port Cluster area in particular, is necessary and important in the orientation of economic - society, ensuring sustainable development goals.

The article introduces several research results on the assessment of the current state and forecasts of environmental changes in the sediments of NCT Port Cluster on the basis of the combined application of statistical models and key factor analysis methods; thereby proposing solutions to prevent and minimize negative impacts from human activities on the environment and measures to improve the efficiency of environmental state management in the NCT Port Cluster, Quang Ninh Province.

2. Materials and methods

2.1. Materials and scope of study

NCT Port Cluster is located in Hong Ha Ward. Its topography is mainly hilly, limestone mountains (Nui Dam), and earth hills in the North of the ward. The region's topography is high in the north and lowers in the south. Due to socio-economic development requirements, a part of the wetlands and tidal flats in the south of the ward have gradually been converted to use purposes into new urban areas.

Population growth and industrial development (including mining activities), and urbanization have been putting direct and increasing pressure on the coastal water and sediment environments. Quang Ninh province in general, NCT port cluster in particular.

The risk of pollution of the quality of seawater and coastal sediments is also due to the operation of fishing villages on the sea as well as wastewater and domestic waste from coastal residential areas that have not been thoroughly controlled.

Pollutants discharged into the study area are often in two main ways, due to the washing of the pollution sources on the mainland through the river, stream, creek system, tide to the bay and directly from the domestic wastewater, coastal residents, tourists, aquaculture, water transport activities, etc.

2.2. Research Methods

2.2.1. Outdoor method

Field survey, collecting documents on the current state of water, soil and air environment at some points in the area of the NCT port cluster in Quang Ninh. The locations of samples collected in sediments NCT Port Cluster, Quang Ninh Province with the analysis results of heavy metals and grease used in the paper are shown in Figure 1.

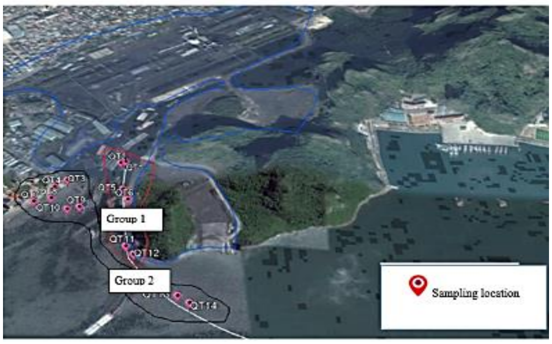

Figure 1. Sampling location

2.2.2. Collection and synthesis of documents

Collecting and synthesizing documents collected from previous works [2,4]; selecting documents to ensure reliability to handle in order to improve the effectiveness of the assessment of the current environmental situation and forecast the sediment environment fluctuations.

2.2.3. Document handling

a. Statistical method

- *One-way statistical method:* One-dimensional statistical model allows to describe of the statistical distribution law of certain environmental parameters (indicators).

- *Two-dimensional statistical method*: The content of heavy metals and grease in sediments often varies greatly by location, possibly close to the natural content or thousands of times higher, depending on the location taken sample and source of pollution. The concentration of heavy metals tends to decrease gradually from shore to sea, from inside the channel to the waterway transport route.

Correlation coefficient reflects the relationship between two environmental parameters (criteria) x, y, denoted by R_{xy} and is determined by the formula:

$$R_{xy} = \frac{\sum_{i=1}^{n} x_i y_i - \frac{1}{N}\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left[\sum_{i=1}^{n} x_i^2 - \frac{1}{N}\left(\sum_{i=1}^{n} x_i\right)^2\right]\left[\sum_{i=1}^{n} y_i^2 - \frac{1}{N}\left(\sum_{i=1}^{n} y_i\right)^2\right]}} \quad (1)$$

In which: x_i; y_i is the value of parameter x and y in the ith sample (monitoring point); n is the number of samples (points) studied. For highly reliable prediction, the correlation coefficient needs to be large ($R_{xy} \geq 0.7$).

b. Main ingredient analysis method

Assuming each research object (soil, water, air), we only need to consider two main components Y and Z, characteristic of some pollution level out of the *m* indicator, is enough, i.e. The original document match ($T_{n \times m}$) only needs two columns and n rows corresponding to *n* objects (sampling point). Then, if we represent the object on the correlation field with X and Y axis, we can imagine the uniformity level of the object of study. To evaluate the uniformity of the sample set and search for the most important indicators among the m indicators, people often use the analysis of main factors [Nguyen Phuong, Nguyen Quoc Phi (2018)].

Assuming the base matrix T has m columns, that is, there are m symbols x_1, x_2,... x_m and are all centered with a covariance matrix $[Sij]_{mxm}$, then we find a new variable Y is a linear combination of m initial variables x_1, x_2,..., x_n in the form of the following general equation:

$$Y = \sum_{i=1}^{m} b_i x_i \qquad (2)$$

The requirement is to determine the b_i coefficients such that variable Y contains the most initial information. In addition, for the variable Y to be unique, the following conditions must be met: $\sum_{i=1}^{m} b_i^2 = 1$ (3)

If the symbol p is a vector with components (b_1, b_2,..., b_m), then the vector to be found is called the eigenvector corresponding to the maximum *p* value of the covariance matrix $[Sij]_{mxm}$, determined by the equation: $(S- \lambda l)p = 0$ (4)

Similarly, we consider adding a new variable Z which is a linear combination of the original variables in the form of an equation: $Z = \sum_{i=1}^{m} c_i x_i$ (5)

Equation 5 must satisfy the following conditions: It contains many parameters about the original data and satisfies the condition that is the only variable: $\sum_{i=1}^{m} c_i^2 = 1$ (6)

The component variable Z must satisfy the orthogonal condition with component Y.

Let γ be the eigenvectors of the components (c_1, c_2,..., c_m), then the vector is also the eigenvector corresponding to the second eigenvalue of the covariance matrix $[Sij]_{mxm}$, i.e. was:

$$(S- \lambda l)\gamma = 0 \qquad (7)$$

In general, if the random variable X has m dimensional, the expectation is 0, then the covariance matrix $[Sij]_{mxm}$ has an orthogonal transformation: $U = p'X$ (8)

Such that the variance matrix of U is diagonal with the molecules λ_i is the solution of Equation 8. The $U_k = p_k{}'X$ component is orthogonal and is called the main factor. In addition, the random variable U received through the orthogonal transformation will preserve the variance, that is: $\sigma^2_y + \sigma^2_z = \sigma^2_x + \sigma^2_y = const$ (9)

Thus, the determinant of the corresponding covariance matrix U is also |S|.

3. Results and discussion

3.1. Statistical distribution characteristics and correlation relationship between metallic elements and grease in sediments in the NCT area, Quang Ninh Province

The results of the treatment of the statistical characteristics of the content of heavy metals and oil elements in the sediments of NCT port cluster are summarized in Table 1.

Table 1. The statistical characteristic parameters of the content of heavy metal elements and oil and grease in the sediments of the NCT port cluster

Element	Content ($mg.kg^{-1}$)			Variance (σ^2)	Coefficient of variation (V%)	QCVN 43:2017 /BTNMT
	Min	Max	Average			
As	16.8	39.6	25.8	89.38	36.6	41.60
Hg	1.3	2.7	1.9	0.24	26.1	0.70
Pb	113.5	289.2	169.9	3612.9	35.4	112.00
Cd	0.06	0.26	0.15	0.0058	54.6	4.20
Grease	65	461	205.9	17141.7	63.6	-

Based on the original document (analytical results), calculate the Z values for all samples and the results summarized in Table 2, 3.

Table 2. Results of calculation of rated component (t) of elements **Table 3. Results of Z value calculation for the Main ingredient**

N^0	As	Hg	Pb	Cd	Grease	As	Hg	Pb	Cd	Grease
	t_1	t_2	t_3	t_4	t_5	t_1	t_2	t_3	t_4	t_5
1	0.909	0.393	2.027	1.433	0.498	2.301	1.382	0.352	-0.266	0.036
2	0.640	1.128	2.120	1.298	0.527	2.499	1.329	-0.123	0.356	-0.009
3	-0.872	-1.075	-0.762	-0.721	-0.690	-1.845	-0.008	0.248	-0.127	-0.137
4	-0.914	-0.708	-0.790	-0.856	-0.617	-1.738	-0.155	0.025	0.151	-0.079
5	1.427	1.311	0.533	0.894	0.936	2.311	-0.434	-0.339	-0.148	0.233
6	1.230	1.495	0.409	1.164	0.805	2.323	-0.418	-0.549	-0.102	-0.129
7	-0.872	-0.892	-0.706	-0.991	-0.741	-1.887	-0.024	0.079	0.056	0.080
8	-0.810	-1.075	-0.681	-0.856	-0.719	-1.860	0.033	0.230	-0.111	0.026
9	-0.769	-0.525	-0.639	-0.721	-0.814	-1.550	0.014	-0.222	0.061	-0.062
10	-0.644	-0.708	-0.566	-0.856	-0.836	-1.620	0.069	-0.109	-0.054	0.141
11	1.220	1.128	0.141	1.029	1.752	2.397	-1.027	0.296	0.055	-0.098
12	1.137	0.944	0.288	0.760	1.716	2.191	-0.882	0.425	0.138	0.116

13	-0.872	-0.892	-0.722	-0.721	-0.887	-1.832	0.079	-0.009	-0.099	-0.132
14	-0.810	-0.525	-0.651	-0.856	-0.931	-1.689	-0.549	-0.559	-1.658	1.493
□						4.423	0.455	0.084	0.025	0.012

Based on Table 3, determine the distribution of sediment sampling points according to the new coordinate system, ie according to the two main criteria identified above, namely As and Hg (Figure 2).

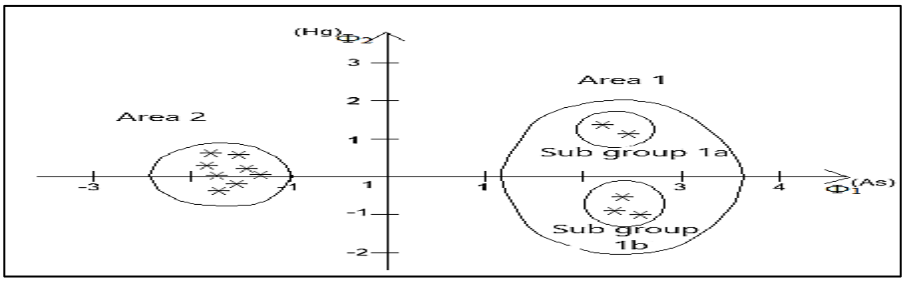

Figure 2. Position of sampling points on the new coordinate system identified by 2 main components (main indicator) As and Hg

In Figure 2, sampling points are divided into 2 Areas (2 groups) (Figure 1):

- The content of the elements As, Hg, Pb, Cd and grease in area 1 (group 01 - along the waterway) is 1.6 (Pb) to 3.8 times higher (grease). Compared with the average content of samples in area 2 (group 2) and the average content of elements Hg, Pb and grease all exceed the National Technical Regulation on Sediment Quality Standards (QCVN 43:2017/BTNMT) from 1.8 to 3.5 times.

- The average content of As, Hg, Pb, Cd and grease in area 2 (group 2) is lower than group 1, but the average content of Hg and Pb also exceeds the Sediment Quality Standards (QCVN43:2017/BTNMT).

3.3. Solutions to prevent and minimize environmental impacts

To ensure sustainability in the operation of the NCT Port cluster, Quang Ninh Province, according to the author, some solutions should be concentrated as follows:

- Strengthen periodic environmental monitoring, analysis and research and export batch; for indicators of grease and heavy metals, the monitoring frequency should be once a month.

- Constructing works to prevent surface washout, landslide of landfill sites in mineral exploitation areas, coal export ports. Enterprises are required to invest in the installation of advanced waste treatment systems, in order to limit the load and ensure the concentration of waste must be below the permitted level before being discharged into the environment.

4. Conclusion

The area of the NCT port cluster has environmental characteristics typical of the bay area, with a complicated coastline direction and many impacts from human activities. Most of the drainage systems to the study area in particular, Ha Long Bay in general, flow through industrial zones, ports, and residential areas.

The pollution of heavy metals and grease in the bottom sediments of NCT port cluster at the time of the study is tending to increase and is complicated by the emission sources have not been thoroughly controlled. At the time of assessment, the average content of Hg, Pb and grease in NCT port cluster sediments all exceeded the permitted norms (QCVN 43:2017/BTNMT).

The results of grouping based on the analysis of the main components of the study area are divided into 2 areas with specific characteristics.

NCT port cluster area is adjacent to Ha Long Bay; at the time of research, the bottom sediments have been and are being polluted with mineral oil and some heavy metals content (As, Hg, Pb). To ensure sustainable development, in the short term, it is necessary to focus on a number of overall solutions on environmental policies and management, combining solutions to socialize environmental protection with instrumental solutions, providing economic support to harmonize benefits between mineral exploitation, water transport with other activities that are effective and sustainable development.

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Assessment of surface water quality in Cao Bang city using Vietnam water quality index (VN_WQI)

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1. Introduction

Water, although renewable, is a finite and irreplaceable resource. Currently, the surface water quality of rivers, streams, and lakes is often affected and changed by human activities. Many studies have shown that: the impact of human activities has been clearly affecting the nature of water resources, especially surface water in urban areas, that have a high concentration of population [2]. In addition to artificial factors, extreme weather events also affect the properties of surface water.

Cao Bang city is a new economic development area in the northern mountainous region of Vietnam with a high economic growth rate, with large industrial, business, and service activities. However, economic development has not been synchronized with the technical infrastructure conditions on the environment; many handicraft production establishments have not yet been invested in a centralized wastewater treatment system [1]. Along with the socio-economic development, the surface water quality is increasingly declining due to receiving domestic and industrial wastewater and agriculture in the area. Domestic and industrial wastewater might contain hazardous substances that could exist in runoff and flow into surface water. Especially, the surface water of Cao Bang city has been exposed to many risks of water pollution in the Hien river, Bang river, and Cun stream. Therefore, it is necessary to regular water quality monitoring in areas affected by socio-economic development activities. Monitoring water quality not only helps assess and predict pollution but also provides information for planning the sustainable use of water resources [6]. This study applied the Vietnam water quality index (VN_WQI) to analyze surface water quality fluctuations using data from 5 monitoring locations at the rivers in Cao Bang city. The research results could provide useful information for the Cao Bang province environmental management agency in reviewing and reevaluating the effective monitoring system of surface water quality.

2. Materials and methods

2.1. Water sampling and analysis

Cao Bang city, located in the center of Cao Bang province, is one of the driving forces of the Northeast Vietnamese mountain's core economic zone. Monitoring of surface water quality was carried out at 5 locations including Bang river (2 locations, NM01-NM02), Cun stream (1 location, NM03), Hien river (1 location, NM04), and Na Di stream (1 location, NM05). The sampling location is shown in Figure 1 and Table 1. Water samples were collected monthly from January to December in 2020 (three times per year) using 18 parameters to assess the water quality. Water samples were collected and preserved according to the instructions in Vietnamese standards (TCVN 6663 Water quality-Sampling). The temperature, electrical conductivity (EC), pH, dissolved oxygen (DO), and total dissolved solids (TDS) were measured on-site using multiparameter Hanna HI98130 and HI9142 (USA). The turbidity and suspendid solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonium nitrogen (N-NH_4^+), nitrite nitrogen (N-NO_2^-), nitrate nitrogen (N-NO_3^-), phosphate (P-PO_4^{3-}), total Coliform, zinc (Zn), iron (Fe), copper (Cu), lead (Pb), and mercury (Hg) were measured in the laboratory using standard methods, in which the heavy metal was analyzed by Atomic Absorption Spectrophotometer.

Monitoring results are evaluated using national technical regulations on surface water quality (QCVN 08-MT:2015/BTNMT), column A_2 [2].

Table 1. Details of the Investigated suface water Sampling Locations.

No.	River	Location	Symbol	Coordinates	
				X	Y
1	Bang river	Mang river bridge	NM01	2510337	546418
		Hoang Nga bridge	NM02	2506236	553169
2	Cun stream	Temporary bridge	NM03	2507419	552520
3	Hien river	Hien river bridge	NM04	2507429	551660
4	Na Di stream	Chu Trinh commune	NM05	2501376	556629

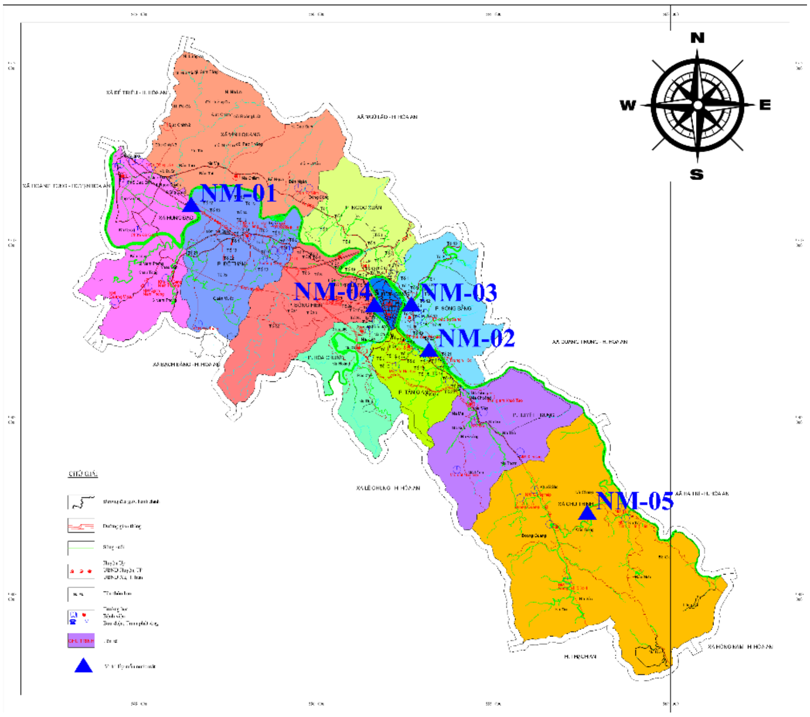

Figure 1. The study sites with sampling locations.

2.2. VN_WQI Calculation

From the multiple water quality parameters, the VN_WQI is utilized to classify the surface water quality of Cao Bang city. This index was calculated based on the Decision 1460/QD-TCMT and comparing the water quality assessment as shown in Table 2. VN_WQI was calculated from five groups of parameters including (Group I) pH index; (Group II) Crop protection agent; (Group III) heavy metal parameters; (Group IV) organic and nutrient parameters; and (Group V) microorganism parameters [5].

To calculate the WQI, it is necessary to select at least three out of five specified groups (from Group I to Group V), of which three parameters from Group IV are required. Therefore, this study chooses to calculate seven criteria: pH (group I); Zn, Cu, Pb, Hg (group III); DO, BOD_5, COD, NH_4^+, NO_3^-, PO_4^{3-} (group IV); and total Coliform (group V). The summary formula of VN-WQI is shown as equation 1.

$$\mathrm{WQI} = \frac{\mathrm{WQI_I}}{100} \times \frac{\left(\prod_{i=1}^{n} \mathrm{WQI_{II}}\right)^{1/n}}{100} \times \frac{\left(\prod_{i=1}^{m} \mathrm{WQI_{III}}\right)^{1/m}}{100} \times \left[\left(\frac{1}{k}\sum_{i=1}^{k} \mathrm{WQI_{IV}}\right)^{2} \times \frac{1}{l}\sum_{i=1}^{l} \mathrm{WQI_{V}}\right]^{1/3}, \quad (1)$$

where WQI_I, WQI_{II}, WQI_{III}, WQI_{IV}, and WQI_V are the results of WQI by groups I to V, respectively.

Table 2. Surface water quality classified by VN-WQI.

WQI value range	Water quality	Utilization purpose	Color
91 – 100	Very good	Good use for domestic water supply purposes.	Blue
76 – 90	Good	Used for domestic water supply purposes but need appropriate treatment measures.	Green
51 – 75	Average	Use for irrigation purposes and other similar purposes.	Yellow
26 – 50	Poor	Use for waterway transport and other similar purposes.	Orange
10 – 25	Very poor	Heavily polluted water, needing treatment measures in the future.	Red
<10	Heavily polluted	Toxic water, need to take measures to overcome and treat.	Brown

3. Results and discussions

3.1. Evaluating surface water quality in Cao Bang city

Descriptive statistics of the parameters are given in Figure 2. On the basis of the averages of the measured parameters, their changes during the year were examined. According to these results, the pH values showed a downward trend until August then entered a period to rise until the time of the last sampling. This may be related to the increased activity of photosynthetic organisms. However, the pH values were all within the safe limit (6.0–8.5).

The DO values fluctuated greatly by months and sampling sites in the range of 6.47÷8.92 mg/l (Figure 2a). It showed an increase in the period between August and November because in cold seasons due to the fact that low temperatures increase oxygen solubility and living organisms reduce a large number of their activities that require oxygen consumption.

TSS at sites and months fluctuated from 8 to 196 mg/l (Figure 2b). TSS at most locations exceeded the allowable limit (30 mg/l). TSS has seasonal variation in which the rainy season is usually higher than that of the dry season. Although high TSS values are associated with household waste, waste disposal, industrial sewage from agricultural fields, and stock farming activities, the increases observed in the summer are thought to be the result of floods and sand mining activities.

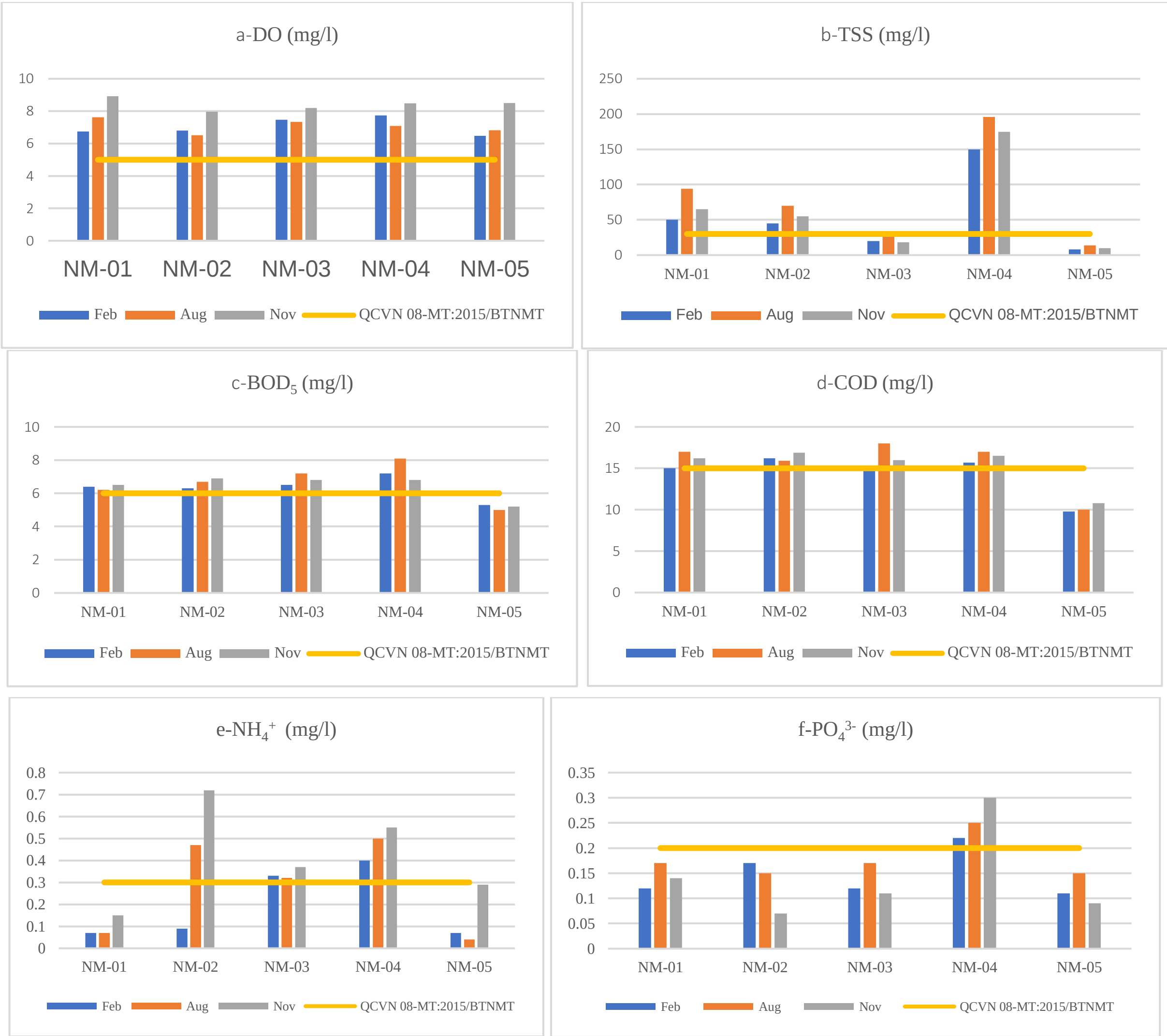

Figure 2. Changes in values of parameters over 1 year.

The BOD at the sampling periods and locations fluctuated from 5.0 to 8.1 mg/l. BOD in the rainy season month (August) fluctuated more than that in the dry season months (Figure 2c). BOD at most locations exceeded the allowable limit of 6 mg/l. Similarly, COD between months and sampling sites ranged from 9.8 to 18.0 mg/l (Figure 2d). The COD has exceeded the allowable limit (15 mg/l) of QCVN 08-MT:2015/ BTNMT, column A2. This increase in the summer months can be explained by increased primary production. COD is widely used to determine domestic, industrial and agricultural waste concentrations. Inorganic chemicals that consume oxygen during degradation cause increasing COD levels, whereas high BOD values are based on anthropogenic activities associated with aquaculture and domestic wastes. Thus, surface water in Cao Bang city is mainly contaminated with organic matter from daily activities. Values also tend to be high at monitoring locations on the Bang river, Hien river and Cun stream, which are densely populated. The concentration of NH_4^+ between sampling months and sampling sites ranged from 0.04 to 0.72 mg/l (Figure 2e). The NH_4^+ in the study area has significant spatiotemporal fluctuations, at positions NM02, NM03, and NM04 higher than the allowed limit from 1.1÷2.4 times. According to QCVN 08-MT:2015/BTNMT column A2, the limit value of NH_4^+ is 0.3 mg/l. The PO_4^{3-} in water fluctuated in space and time with concentrations of 0.07÷0.30 mg/l (Figure 2f). In locations with high concentrations of NH_4^+, the PO_4^{3-} concentration accumulated and exceeded the allowable limit of 0.2 mg/l as at point NM04.

In addition, surface water sources in Cao Bang city have not shown signs of pollution by heavy metals and coliforms. Zn, Fe, Cu, Pb, and Hg at all locations through the sampling sessions were within the allowable limits. Similarly, the total Coliforms in the study areas ranged from 700 to 2,400 MPN/100ml, also it was within the allowable limit of 5,000 MPN/100ml.

3.2. General surface water quality assessment by VN_WQI

To have a general assessment for the surface water quality, the VN_WQI was conducted and its result was classified according to the Decision 1460/QD-TCMT approved by Vietnam Environment Administration mentioned in the above VN-WQI in the above section [5]. The calculation results of VN_WQI in the study area are presented in Figure 3. VN_WQI in NM01 (81-90), NM02 (75-89), NM03 (87-89), NM04 (82-85), and NM05 (96-98) indicated that the surface water quality in Cao Bang city was classified from good to very good. In general, statistical results showed that there are two VN-WQI levels detected in the study area and have an uneven distribution. Water quality in the downtown area was classified as good, with VN_WQI ranged from 75 to 89 (NM02, NM03 and NM04). Meanwhile, surface water quality in downstream area was classified very good (VN_WQI NM05 =96-98).

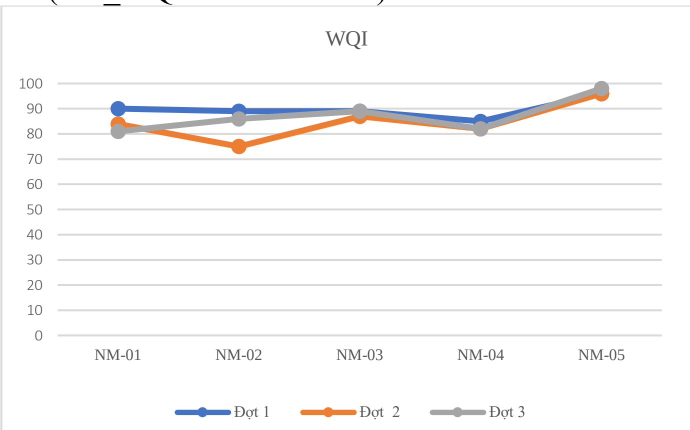

Figure 3. Change in VN_WQI values over 1 year at the monitoring locations.

One of the reasons to explain this situation is that the wastewater comes from industrial production establishments, services in the downtown area (wood processing facilities, building materials, and markets) that generate a lot of odors, exhaust gas, polluted wastewater. There is no centralized wastewater treatment system. The majority of the manufacturing facilities are near the river, and many of the dumping locations are beneath riverbank dwellings, making it difficult to regulate the discharge. Moreover, in residential areas, domestic wastewater and leachate from spontaneous landfills are discharged directly into rivers and streams of this city, also causing serious surface water pollution.

4. Conclusion

The results present that the surface water quality varies greatly according to the sampling locations, and the most polluted locations are in the downtown area where there are many industrial production establishments, services and densely populated. DO, TSS, BOD, COD, NH_4^+, and PO_4^{3-} have seasonal fluctuations. The surface water quality was contaminated with organic (high TSS, BOD, and COD), and nutrients (mainly NH_4^+). Heavy metals such as Zn, Fe, Cu, Pb, and Hg are within the allowable limits of QCVN 08-MT:2015/BTNMT, column A2.

The VN_WQI shows that surface water quality in Cao Bang city is classified from good to very good (WQI = 75-98), in which very good water quality is concentrated in the downstream area. Meanwhile, the good water quality is concentrated in the downtown area. At the time of the study, the surface water quality in Cao Bang city is mostly good. However, the downtown area still has many risks of causing environmental pollution, including the surface water environment.

In conclusion, the method of evaluating surface water quality by Vietnam water quality index is feasible, and the obtained results are highly accurate and are a reliable reference for other methods such as water quality assessment by multivariate statistical analyses. However, this method still has some limitations, such as depending on the quantity and accuracy of the actual measured data.

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Signs of Acid Mine Drainage and Distribution of Heavy Metal into The Environment at Ban Phuc Nickel Mine

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Abstract

Ban Phuc Nickel Mine, Son La Province is one of the typical nickel sulfide mines in Vietnam. Solid waste dumps, ore dumps or tailings of mines can be sources of environmental pollution by generating acid mine drainage (AMD). Research methods in the field and in the laboratory show that Ban Phuc Nickel mine has mineral compositions of sulfides such as chalcopyrite, pyrotin, penlandite, ... so there is a potential for generating acid mine drainage (AMD) and dispersion of heavy metals into the environment. Research results on soil environment and surface water environment have shown that Ban Phuc Nickel mine has a low pH and high concentrations of metals (Cu, Ni, Fe, As, Cd).

Keywords: acid mine drainage, heavy metal pollution, Ban Phuc Nickel mine

1. Introduction

Environmental pollution in mineral mines is a very serious problem, in which metallic mineral deposits have mineral compositions including sulfides, which, when oxidized, will form acid mine drainage and disperse metals, seriously pollute the environment. Mineral activities are the main cause of the formation of acid mine drainage and the dispersion of heavy metals into the environment [3,4,5]. The way to disperse heavy metals into the environment is mainly surface water, then into the soil environment, groundwater environment. The process of polluting can take place for hundreds of years, it does not only take place during mining but after the end of mining. Ban Phuc nickel mine is one of the typical nickel sulfide mines in Vietnam, the main mineral compositions are: pyrotin, chalcopyrite, penlandite, ... the mine has many potential risks forming acid mine drainage waste streams and metal heavy on the environment. However, Ban Phuc nickel mine has done a good job of protecting the environment, so the pollution is effectively controlled.

2. Research methods

2.1. Methods of synthesizing and analyzing documents

Research documents on geology, geochemistry and related environment are synthesized, analyzed, and selected by the authors as a basis and research orientation. The research works of many authors are important sources of literature. In this work, the author has collected materials on geology, lithology, geochemistry, environmental impact assessment reports, environmental monitoring documents at Ban Phuc Nickel mine area.

2.2. Field survey method

Field survey is a very effective and indispensable method when studying geology and geochemistry of the environment. During the research process, the authors conducted field surveys to collect information about factors that can affect the environment and signs of environmental pollution in the study area. During the fieldwork, samples of primary and secondary ores, surrounding rock samples, bottom mud samples, water samples, tail ore samples will be taken, and environmental indicators such as pH, Eh, and temperature will be measured. to assess the environmental quality of mineral deposits and surrounding areas.

2.3. Atomic absorption method AAS

Atomic Absorption Spectrophotometric (AAS) method is a very sensitive analytical technique to measure the concentration and content of elements. Atoms are in a free state in the form of clouds of atomic vapors, where they absorb and radiate energy. Each atom absorbs only certain radiations that correspond to the radiations they can give off during their emission. When atoms receive energy, they move to a higher energy level called an excited state. That process is called the process of absorbing the energy of a free atom in the vapor state and generating the spectrum of that atom. The spectrum produced in this process is called the atomic absorption spectrum. The AAS atomic absorption spectroscopy method allows the determination of almost all the major elements (except P) that can be determined and the detection limits of Na, K and Ca are extremely low. In this study, we use atomic adsorption method to determine the content of heavy metal elements present in water and soil environment. The samples were conducted at the Center for Analysis of Geological Experiments using a PinAAcle 900T atomic absorption spectrometer, manufactured by PerkinElmer of the US in 2019.

3. Results and discussion

3.1. Overview of Ban Phuc Nickel Mine

Ban Phuc Nickel Mine is located in Muong Khoa Commune, Bac Yen District, Son La Province. The mine is located right next to Highway 37 and about 2km from the Da River. The terrain is high, steep, strongly dissected, and dangerous. The lowest altitude is 100m, the highest is 1969m, usually +700m. In the Ban Phuc Nickel mine, there is Phuc stream flowing through the selection plant area and Dam stream flowing through the tailings lake area, these two streams flow into Khoa stream before flowing into the Da river. Mineral composition mainly includes pyrotin: 66 - 90%, pentlandite: 3 - 35%, chalcopyrite: 5 - 16%. Chemical composition of sulphide Nickel ore - Condensed copper with an average content of 1.44% Ni; 0.69% Cu; 0.05% Co; 25 ppb Au; 64 ppb Pt; 30 ppb Pd; 14.42% S; 2.28% Mg; 26.7% Fe [1,2].

Ban Phuc nickel mine has finished exploiting the dense ore body and is conducting exploration to exploit the diffuse ore body. In the mine area, has been built factory nickel ore flotation

3.2. Environmental characteristics of surface water

Pollution of surface water is one of the common signs appearing in mineral deposits. For nickel-copper sulphide mineral deposits, the surface water environment often has low pH and high heavy metal content. To assess the current state of the surface water environment of the Ban Phuc nickel mine, we took water samples from streams and quickly measured environmental indicators, sent for analysis to determine the content of heavy metals.

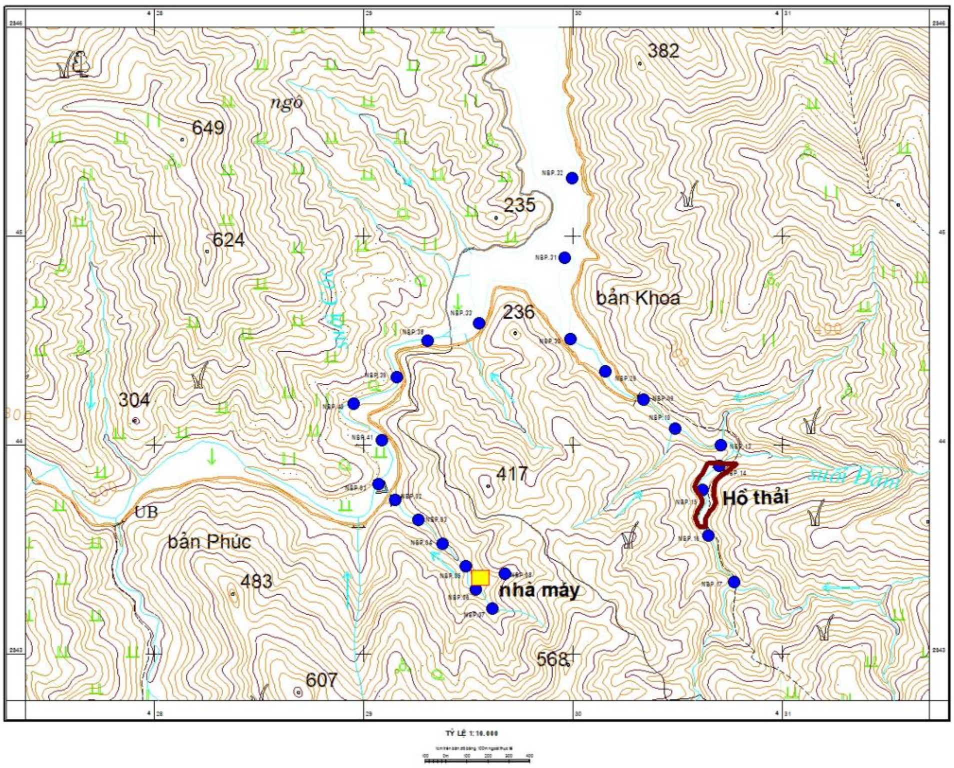

Figure 1: Water sampling map of Ban Phuc Nickel mine area.

Table 1. Analytical results of surface water samples at Ban Phuc nickel mine area

No	Model number	Coordinate system VN2000		Thành phần (mg/l)									
		X	Y	pH	Eh (mV)	T	Cu	Ni	Fe	As	Cd	Total
1	NBP.01	2343814	429071	4,2	450	32	1,223	1,578	5,4	0,0106	0,0032	8,2148
2	NBP.02	2343738	429151	3,9	560	32	1,425	1,778	5,2	0,0102	0,0034	8,4166
3	NBP.03	2343642	429262	4,1	475	32	1,235	1,678	5,6	0,011	0,0031	8,5271
4	NBP.04	2343526	429376	4,3	482	32	1,239	1,612	5,2	0,0116	0,0035	8,0661
5	NBP.05	2343420	429487	4,2	467	32	1,258	1,571	5,8	0,0112	0,0034	8,6436
6	NBP.06	2343309	429537	4,1	454	32	1,346	1,672	5,2	0,0104	0,0036	8,232
7	NBP.07	2343219	429614	4,4	485	32	1,313	1,634	5,3	0,0126	0,0033	8,2629
8	NBP.08	2343386	429675	3,8	538	31	1,449	1,598	5,3	0,0112	0,0032	8,3614
9	NBP.09	2344219	430338	3,6	547	31	1,623	1,545	5,6	0,0102	0,0023	8,7805
10	NBP.10	2344079	430487	3,7	638	31	1,682	1,605	5,5	0,0112	0,0031	8,8013
11	NBP.11	2343873	430370	4,6	372	31	1,92	1,705	5,8	0,0114	0,0034	9,4398
12	NBP.12	2343693	430148	4,9	335	30	1,97	1,813	5,7	0,0102	0,0035	9,4967
13	NBP.13	2344002	430706	3,8	645	31	1,98	1,856	5,4	0,011	0,0037	9,2507
14	NBP.14	2343902	430698	4,1	678	30	1,87	1,801	4,5	0,0048	0,0019	8,1777
15	NBP.15	2343785	430619	4,2	656	30	0,612	0,836	3,3	0,0024	0,0014	4,7518
16	NBP.16	2343568	430648	4,1	634	30	1,523	1,645	4,3	0,0048	0,0021	7,4749
17	NBP.17	2343346	430772	5,2	435	30	1,282	1,405	4,2	0,0058	0,0011	6,8939
18	NBP.29	2344354	430156	3,8	537	34	0,262	0,246	1,2	0,0004	0,0003	1,7087
19	NBP.30	2344507	429989	3,9	538	30	0,122	0,143	1,5	0,0002	0,0006	1,7658

20	NBP.31	2344896	429960	6,7	255	30	1,082	1,105	3,2	0,0072	0,0014	5,3956
21	NBP.32	2345277	429995	6,7	213	30	1,082	1,105	3,4	0,0064	0,0024	5,5958
22	NBP.33	2344584	429550	4,3	521	30	0,736	0,846	3,7	0,0054	0,0017	5,2891
23	NBP.38	2344502	429307	3,9	542	30	0,687	0,812	3,5	0,0042	0,0013	5,0045
24	NBP.39	2344328	429159	4,5	322	30	0,723	0,887	3,5	0,0044	0,0015	5,1159
25	NBP.40	2344198	428952	5,4	298	30	1,223	1,578	5,4	0,0106	0,0032	8,2148
26	NBP.41	2344023	429087	5,1	308	30	1,425	1,778	5,2	0,0102	0,0034	8,4166
QCVN 08-MT:2015/BTNMT cột B1				**5,5 - 9**			**0,5**	**0,1**	**1,5**	**0,05**	**0,01**	

Measurement results of pH, Eh and analysis of heavy metal content showed that surface water in Ban Phuc nickel mine area showed signs of pollution, namely low pH, high content of heavy metals. To simulate the results of measuring pH and content of heavy metals in surface water of Ban Phuc nickel mine, we use simulation software acrgis as follows:

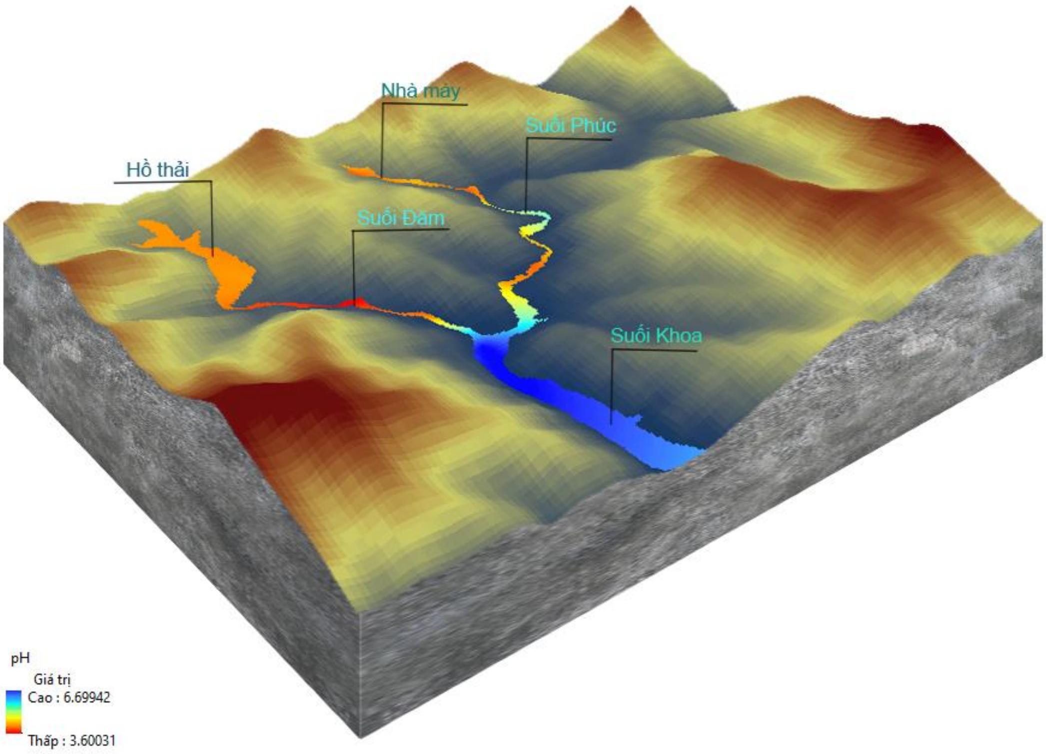

Figure 2: Simulation diagram of pH on streams in Ban Phuc nickel mine area

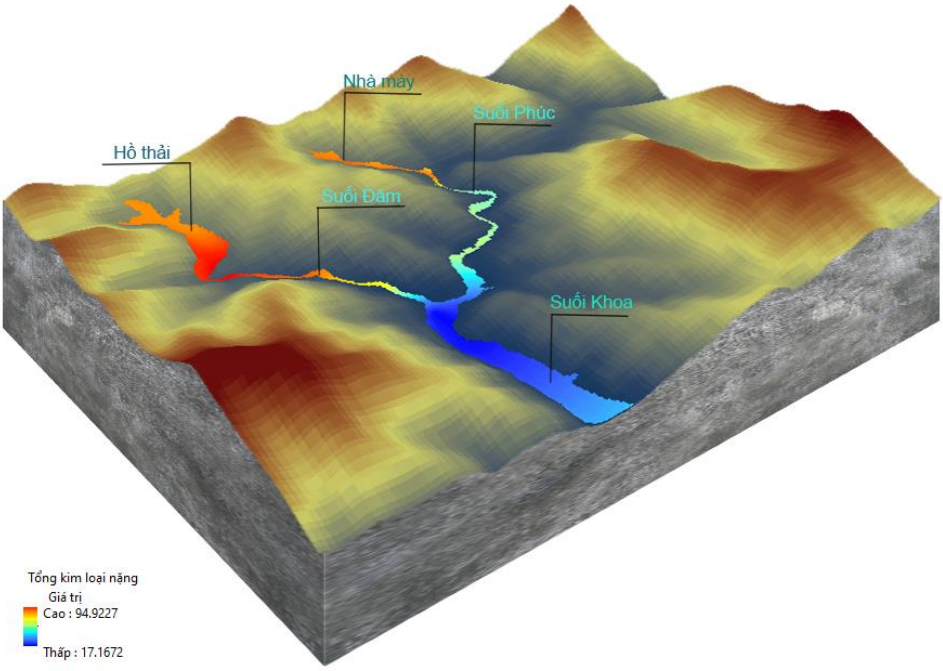

Figure 3: Simulation diagram of heavy metal concentrations in surface water Ban Phuc nickel mine

3.2. Environmental characteristics of soils

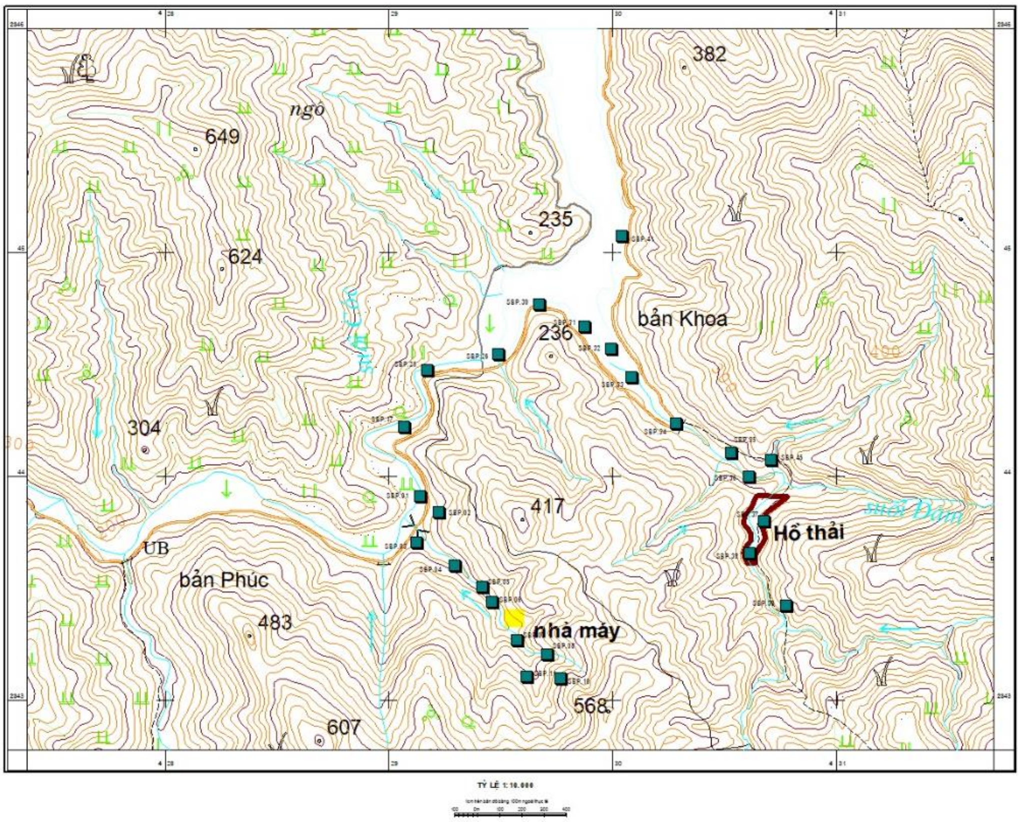

Figure 4: Soil sampling map of Ban Phuc Nickel mine area

Table 2. Analysis results of soil samples in Ban Phuc Nickel mine area

No	Model number	Coordinate system VN2000		Ingredients (mg/kg dry soil)					
		X	Y	Cu	Ni	Fe	As	Cd	Total
1	SBP.01	429140	2343910	142	187	34514	8,5	1,72	34853,22
2	SBP.02	429225	2343836	133	202	36842	6,4	1,04	37184,44
3	SBP.03	429129	2343697	145	231	42047	9,2	1,56	42433,76
4	SBP.04	429298	2343599	153	214	40232	9,7	1,94	40610,64
5	SBP.05	429420	2343504	189	223	41824	8,1	1,87	42245,97
6	SBP.06	429461	2343437	217	243	42124	11,1	1,76	42596,86
7	SBP.07	429574	2343264	223	256	45678	10,3	2,12	46169,42
8	SBP.08	429709	2343203	236	253	44389	10,5	2,23	44890,73
9	SBP.10	429769	2343095	242	261	43945	11,2	2,23	44461,43
10	SBP.11	429618	2343103	259	267	44715	11,8	2,18	45254,98
11	SBP.17	429069	2344219	143	166	36114	6,4	1,05	36430,45
12	SBP.25	429172	2344470	143	164	37245	6,4	1,05	37559,45
13	SBP.26	429489	2344544	152	167	37376	6,7	1,02	37702,72
14	SBP.30	429672	2344764	156	172	37745	6,5	1,04	38080,54
15	SBP.31	429876	2344666	174	183	38912	6,2	1,12	39276,32
16	SBP.32	429994	2344566	194	213	40125	9,3	2,12	40543,42
17	SBP.33	430086	2344441	213	242	45641	9,8	2,23	46108,03
18	SBP.34	430283	2344236	245	276	47463	11,3	2,25	47997,55
19	SBP.35	430531	2344103	248	281	47852	11,6	2,31	48394,91
20	SBP.36	430609	2343994	253	286	48212	11,8	2,26	48765,06
21	SBP.37	430676	2343796	264	282	47642	11,1	2,14	48201,24
22	SBP.38	430613	2343655	275	292	48523	12,1	2,34	49104,44
23	SBP.39	430777	2343420	242	283	47878	11,7	2,33	48417,03
24	SBP.41	430042	2345073	184	189	38945	6,2	1,12	39325,32
25	SBP.42	430346	2344581	111	117	29263	5,5	1,03	29497,53
26	SBP.45	430710	2344071	216	251	45647	9,8	2,23	46126,03
QCVN 03-MT:2015/BTNMT				**150**	**-**	**-**	**20**	**3**	

From the research results on the content of heavy metal elements in the soil environment of Ban Phuc nickel mine area, heavy metal elements are found in the areas of tailing ore waste lake, ore storage yard, high industrial yard. To simulate the dispersion of heavy metals into the soil environment, we use arcgis software as follows:

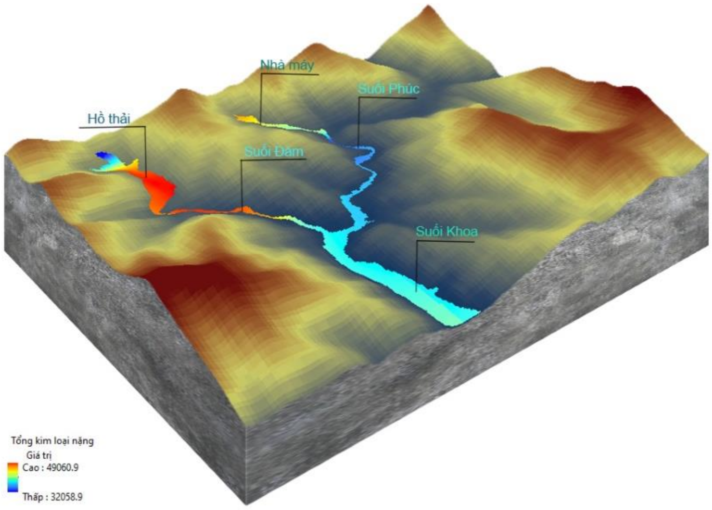

Figure 5. Simulation diagram of heavy metal content in soil environment
Ban Phuc nickel mine

3.3. Forecast of potential environmental problems

3.3.1. Environmental pollution due to tailing ore discharge lake

The tailing ore waste lake is an area of tailed ore that has a lot of potential for environmental pollution because the composition of tail ore contains secondary sulfide minerals, so it will be oxidized to form mine acid discharge and disperse metals heavy.

Figure 6. Ban Phuc nickel mine tailings tailings pond

3.3.2. Pollution due to solid waste

In the areas of waste dumps, dumps, and industrial yards, there is always the potential for environmental pollution because the composition of the waste rock contains sulfide minerals, ores left in the dumps and industrial yards. Sulfide minerals will be oxidized and produce mine acids and heavy metals. Rainwater runoff will carry heavy metals into the environment.

3.4 Proposing solutions to reduce environmental pollution

Stemming from the causes of environmental pollution and potential risks of environmental pollution in the future, we propose some solutions to reduce environmental pollution at Ban Phuc nickel mine as follows:

For tailings ore tailing ponds, the dam must first be kept safe to avoid dam failure by regularly checking the dam's safety. Carrying out pumping to cover the surface of mud after mining. Periodic monitoring of the waste lake environment to monitor the environment.

For underground wastewater, rainwater flowing through industrial yards, intra-mine transportation roads, ore storage yards, it is necessary to build water collection systems to concentrate treatment before being discharged into the environment.

- For solid waste in the form of piles generated in the process of mining, it is necessary to plan and design the landfill to be built with walls of acid-neutralizing materials.

Figure 7. Ban Phuc nickel mine waste rock

Figure 8. Oxidized ore at the old storage yard of Ban Phuc nickel mine

4. Conclude

The research results in surface water and soil in the Ban Phuc nickel mine area showed that the pH in surface water was low, the content of heavy metals was high, and in some samples exceeded the permissible standards. The sulfide minerals in the tailing ore, solid waste, when weathered, will produce acid mine discharge and disperse heavy metals into the environment. To minimize environmental pollution, it is necessary to carry out synchronous solutions to prevent mine acid discharge and collect and treat before discharging into the environment.

5. Thank you

We would like to thank the management of the project "Research and build models of heavy metal dispersion in the environment in areas with sulfur minerals", code: TNMT.2021.562.01 of the "Development Program" basic science in the field of Earth Science according to Decision No. 562/QD-TTg dated April 25, 2017 of the Prime Minister. Program number: 562" provided us with the research data.

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Remote sensing-based indices for mapping of water quality in Thai Binh river at Hai Duong province

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Abstract

This research explored the potential of remote sensing to estimate the relationship between sattelite spectrals and riverine environments, especially during extreme events when routine in-situ measurements are not available. Water quality parameters of Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Amoni concentration, Chlorophyll-a and the Trophic state index (TSI) were calculated using the Landsat 8 data and were correlated to the near in-situ measurements using regression equations for quantitative estimation of water quality in the session of Thai Binh River at Hai Duong province. This technique, using the obtained coefficients was applied to map the water quality in the Thai Binh River during the seasons of Sep. 2016, Nov. 2019 and Jun. 2020, and found in a good general agreement with the field measurements. The preliminary results indicate that (1) Spectral bands from Landsat images have the potential to map the spatial distribution of water quality in river environments, (2) Remote sensing data can be used for quantitative estimation of water quality parameters in river environments when coupled with linear regression equations, and (3) the same approach can be used to estimate water quality in rivers within reasonable error limits. Acquisition of more in-situ measurements of are on going to derive more general regression coefficients and achieve more validation results.

Keywords: RS-based indices, water quality mapping, Thai Binh river, Hai Duong province

1. Introduction

Water quality is one of the most important factors for riverine ecosystems. Water quality parameters of Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Amoni concentration, Chlorophyll-a and the Trophic state index (TSI) in the water affect the river habitats strongly. These parameters reflect the physical and chemical property of water. They influence the total primary productivity by affecting the transmission of light in water, as well as the transition of heavy metal and the micro-pollutant. Suspended sediment concentration and biochemical parameters are spatially inhomogeneous and their spatial distribution are difficult to measure with the routine in-situ monitoring method. Remote sensing is an efficient method, which can provide realistic water quality data with large spatial distributions for water resource study. In this study, remote sensing techniques are used for mapping of water quality in the Thai Binh River at Hai

Duong province. Previous developed indices such as Turbidity Index, Chlorophyll-a Index (Frohn and Autrey, 2007; Bee, 2008), Normalized Difference Suspended Sediment Index (NDSSI) (Hossain và nnk, 2006) and Normalized Suspended Material Index - NSMI (Montalvo, 2010) were also used to test the applicability in the study area. The study finds that the use of previous approaches can be used with consideration of measurement data. The regression equations from remote sensing data are effective approaches to estimate the water quality in study area and they all have reasonable agreements with in-situ measurements.

Estimation of water quality from optical satellite data using regression equation was studied in many regions over the world. The available techniques can be categorized in four general groups: (1) simple regression (correlation between single band and in-situ measurements) (Williams and Grabau, 1973), (2) spectral unmixing techniques (Gomez et al., 1997), (3) Band ratio technique using two and more bands (Lathrop, 1992; Populus et al., 1995; Wang et al., 2000), and (4) multiple regressions (using multiple bands and in-situ measurements) (Binding et al., 2005).

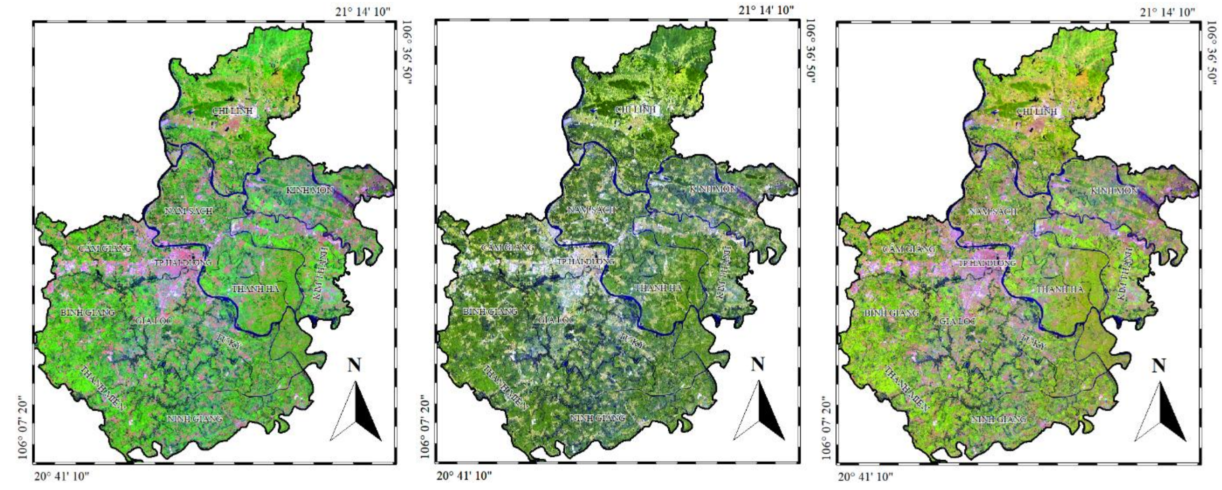
Usually when suspended sediment concentrations are high, the backscatter/reflectivity of water is high. There are three matters dominate the reflectance of inland water, which are yellow substance, suspended sediment and phytoplankton. Yellow substance is a soluble matter, which has no scatter capability, but it has a strong absorption effect on short-wave bands that highly reduce the underwater downwelling irradiance. Therefore, when the absorption of water itself and yellow substance is small, actual suspended sediment information could be obtained (Wang et al., 2003).

In this research, various band math equations have been developed to determine many components of water quality, aiming to discover new mathematical relationship to identify and discriminate the suspended materials and biochemical concentrations in river water. The linear regression shows that the vast majority of image-estimated parameters are closely correlated with the in-situ measurements. It has been observed that although remote sensing has been considered as a proven technique for water quality estimation, all the developed models and algorithms are applicable for specific areas and environments. To address this issue in this research we attempted to explore the potential of remote sensing to develop regression equations that can be used in regional riverine environments like study area, especially during extreme events when routine in-situ measurements are not available.

2. Materials and methods

2.1. Data used

The data used for this study is mosaic images of the remotely sensed data of Landsat 8 (OLI). The system is designed to collect 15m resolution panchromatic data and different bands of data in the visible, NIR, and MIR (Middle Infra Red) spectral regions at a resolution of 30m and 60/100m resolution data at Thermal Infra Red (TIR) band. Total 16 Landsat 8 OLI imagery from 2016 to 2020 were collected and the images acquired in 30/9/2016, 10/11/2019 and 21/6/2020 were used for further analysis. Figure below shows the nature of Landsat imagery prepared acquired over above 3 time periods.



a b c

Figure 1. Landsat 8 images of study area on 9/2016 (a), 11/2019 (b) and 6/2020 (c)

To remove the systematic errors and improve the quality, DN values of Landsat image were converted to radiance. The conversion of DN values to radiance is based on a calibration curve of DN (Chander and Markham 2003; Negi et al. 2009). All the images were projected to the Universal Traverse Mercator (UTM) coordinates zone 48. The spheroid and datum was also referenced to WSG84. Enhancement of the images using histogram equalization techniques was later performed on all the images.

It has been proven that the satellite data and the ground measurement data should be taken almost simultaneously. Very fortunately, 23 of the measurements are found very close to the dates of the available Landsat 8 images of study area. Normally only the images within a 10-day overlap with the in situ data can be selected. There are a total of 23 ground sampling stations distributed on the river system.

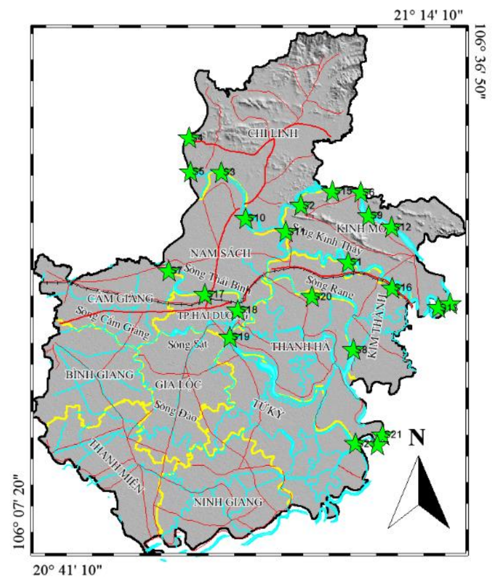


Figure 2. Location of 23 collect samples

2.2. Satellite-based water quality parameters

Landsat 8 OLI imagery were used to determine spatial distribution of the relative variation of water quality in the river environment. The water quality parameters of Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Amoni concentration, Chlorophyll-a and the Trophic state index (TSI) values were correlated to in-situ measurements to estimate their concentration quantitatively.

Table 1. Part of the in-situ measurements database

KẾT QUẢ PHÂN TÍCH NƯỚC SÔNG TỰ NHIÊN- HỆ THỐNG SÔNG THÁI BÌNH

KH	Vị trí quan trắc	Tọa độ X	Tọa độ Y	Lưu lượng m^3/s	Nhiệt độ	pH	Độ dẫn µS/cm	Độ đục NTU	TDS mg/l	Muối 0/00	DO mg/l	F^- mg/l
S1	Sông Thương, cách ngã ba sông Lục Nam và sông Thương 500m về phía thượng lưu	21°16'13"	106°31'85"	385,20	26,8	7,00	196	60	98	0,10	6,49	<0,30
S2	Sông Lục Nam, cách ngã ba sông Lục Nam và sông Thương 500m về phía thượng lưu	21°16'14"	106°32'10"	424,32	26,4	7,20	202	66	101	0,10	5,72	<0,30
S3	Sông Thương, cạnh đền Kiếp Bạc,	21°14'66"	106°32'46"	375,90	27,7	7,30	196	57	98	0,10	5,85	<0,30
S4	Sông Cầu, cách điểm nối giữa sông Cầu và sông Thương 500m về phía thượng lưu,	21°07'31"	106°17'46"	277,20	31,8	6,92	174	65	87	0,08	4,00	0,32
S5	Sông Đuống, cách điểm nối giữa sông Đuống và sông Thương 500m về phía thượng lưu,	21°06'28"	106°16'56"	789,25	29,8	7,28	178	64	89	0,09	6,23	<0,30
S6	Sông Thái Bình tại xã Nhân Huệ, cách ngã ba sông Thái Bình và sông Kinh Thầy 500m về phía thượng lưu,	21°30'10"	106°21'36"	396,50	29,2	7,20	190	47	95	0,10	5,74	<0,30
S7	Sông Thái Bình tại xã Thái Tân huyện Nam Sách	20°59'4"	106°16'39"	182,40	31,7	7,20	162	49	81	0,08	5,93	0,34
S8	Sông Thái Bình tại xã An Bình, huyện Nam Sách (sông Kinh Thầy)	21°35'00"	106°22'3"	936,00	28,2	7,15	160	134	80	0,08	5,48	<0,30
S9	Sông Đông Mai tại phường Văn Đức, TP. Chí Linh	21°07'85"	106°44'07"	34,50	30,6	7,02	162	126	81	0,08	4,85	<0,30
S10	Sông Đá Vách, xóm Trại khu Tử Lạc (gần khu vực chế biến than)	21°22'20"	106°35'47"	272,40	29,3	7,6	254	65	127	0,13	5,83	<0,30
S11	Sông Đá Vách, gần trạm cấp nước Tân Dân, Kinh Môn	21°33'10"	106°34'41"	402,48	30,8	7	212	72	106	0,11	5,79	<0,30
QCVN 08-MT:2015/BTNMT (Mức B1)				-	-	**5,5-9**	-	-	-	-	**≥4**	**1,5**

It has been observed for Landsat OLI imagery that Blue band and Near-infrared band are most sensitive to water and water transparency (turbidity). These bands usually gives the highest and lowest reflectance values respectively for water. These characteristics have been observed for water with different levels of turbidity. Biochemical parameters were also sensitive to the Blue, Green, Red and Near infrared bands. According to Nguyen et al., (2016) for any vegetation band 5 (near-infrared) and band 4 (red) of Landsat 8 OLI data always gives the highest and lowest reflectance respectively.

Near real time of the corresponding image acquisition dates in-situ measurements of water quality in the Thai Binh River were obtained from 23 stations. To determine the most suitable coefficients to estimate water quality in the river water using remote sensing data, the obtained values were plotted against the corresponding near real time in-situ measurements. The relationship between calculated values and in-situ measurements were interpreted using different numerical equations including linear, exponential, logarithmic, polynomial and power function. The coefficients associated with the equation that achieved highest correlation coefficient (R^2) value were considered suitable to use water quality estimation in the study area. Accordingly the polynomial equations was found to have R^2 values of over 0.8 and considered the most suitable equations initially. After a careful observation it was noticed that the polynomial equations have a potential to provide accurate estimation of TSS and TDS concentrations in low turbid and high turbid water because they have the best fit. However, the curves are very flat in the low turbid region and seem not to be capable of detect variation in the estimation. More importantly, the trend of increase in concentration at high turbidity values may result in unphysical predictions. The linear equations, although posses lower R^2 values than the polynomial equations, they show the potential to detect the variability in suspended materials and biochemical concentrations in both low and high turbid water. Therefore, the power equations were considered to be the most suitable approach to estimate the suspended materials and biochemical concentrations in the study area.

3. Results and discussion

3.1. Regression analysis

Landsat 8 spectral bands were converted to DN and then, these values are combined and calculated based on Equation (1), which is the general predictive equation for water quality parameter, and then are compared with the ground measurements.

$$y = ax + b \quad (1)$$

Where, x is the DN values and y stands for the individual water quality parameter.

a and b are the coefficients fitting to the in-situ data by the regression analysis.

Different models are used for the estimations of 8 water quality parameters by utilizing linear regression analysis. Comparisons are conducted for individual band or band ratio, while the combinations of reflectance value are more complex which include TM3*TM4 (Chen et al., 1996), TM3*TM4/lnTM1(Li et al., 2007), TM3*TM4/ln(TM1+TM2) (Li et al., 2007), TM3/TM4, (TM4-TM3)/(TM4+TM3), TM4/TM1, TM1/TM2 (Dwivedi and Narain, 1987), ln(TM1/TM2) (Li et al., 2007), and (TM1-TM3)/(TM2-TM3). Once the correlation coefficient R^2 is considered as high enough, a regression equation will be calculated and this equation can be used for the whole image and generates a water quality maps.

By applying the regression equations to each of the images in the database, the spatial patterns, as well as the temporal trends of 8 water quality parameters, can be investigated.

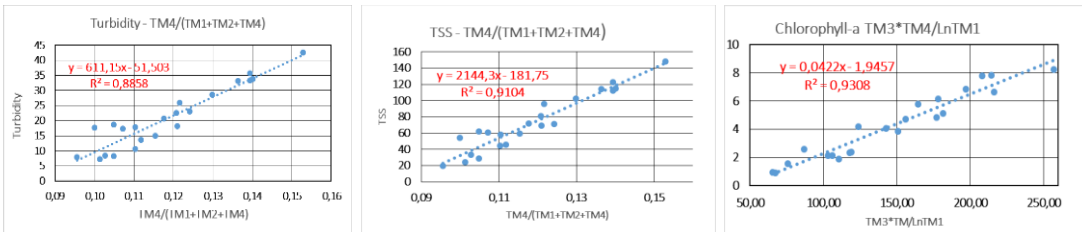
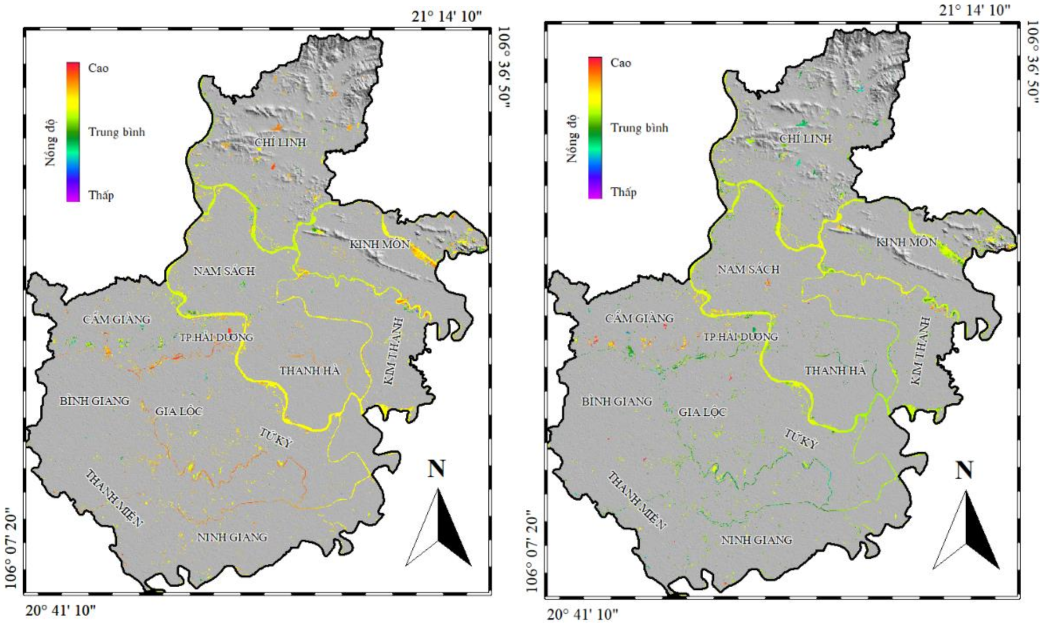


Figure 3. Scatter plots comparisons for water quality estimations

The comparison results for the estimated values and in-situ measurements of different parameters. The prediction made by the linear models have a very good relationship with the suspended materials and biochemical data, and the scatter points on the plots seem to be close to the line, which means their relationships are probably linear. All the datasets show good agreements, with the R^2 over 0.5. Therefore, it can be concluded that the Landsat 8 OLI images are reliable enough to predict the water quality in Thai Binh river system at Hai Duong province.

3.2. Spatial and temporal analysis

The seasonal patterns and temporal trends of water quality in Lake Simcoe are both analyzed in this study, as the available data for Thai Binh river system have a long time span of 4 years from 2016 to 2020. The spatial patterns of all 8 parameters are displayed in terms of the concentration maps.



a b

Figure 4. Turbidity (a) and TSS (b) maps in September 2016

From the above maps, it is obvious that the upper and lower sections of the river is normally clearer than the middle area, and the turbid area is concentrated near the Hai Duong city as well as industrial zones (An Phat, Viet Hoa - Kenmark, Nam Sach, Dai An, Lai Vu, Lai Cach, etc.)

The BOD_5, COD, NO_3^- are clearly show both the effects population density at major cities and towns in ther northern part and agricultural activities in the southern part of study area. The amount of fetilize is derived from the land use, which is predominately agricultural land, and in addition, the vegetation lands occupy about 67% of the terrestrial area. Hai Duong is one of the provinces with a very high urbanization rate in recent years. About 15% of the land area is urban, where the population has doubled in the past twenty years.

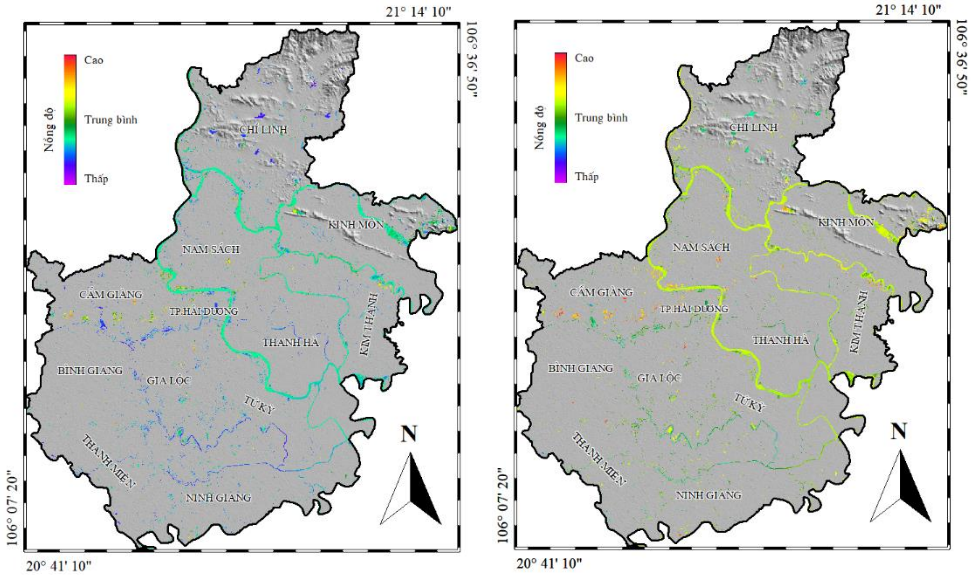


Figure 5. Calculation results of BOD_5 content in September 2016 (a) and November 2019 (b)

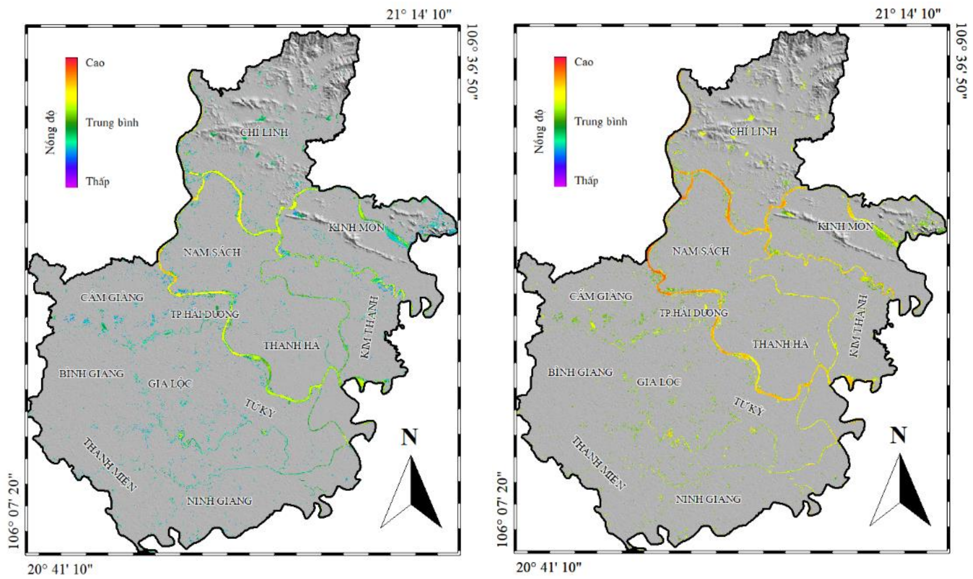


Figure 6. Calculation results of COD content in September 2016 (a) and November 2019 (b)

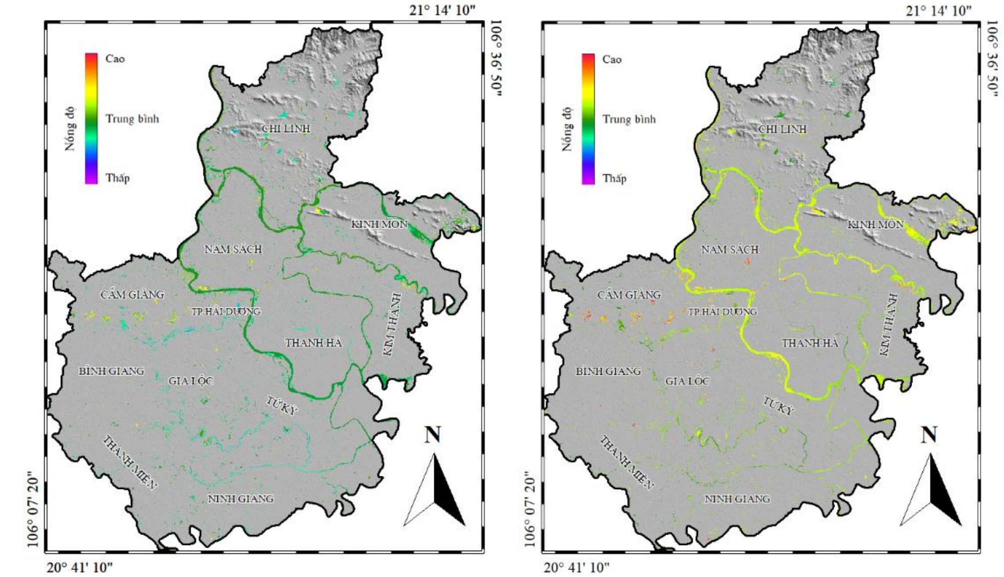
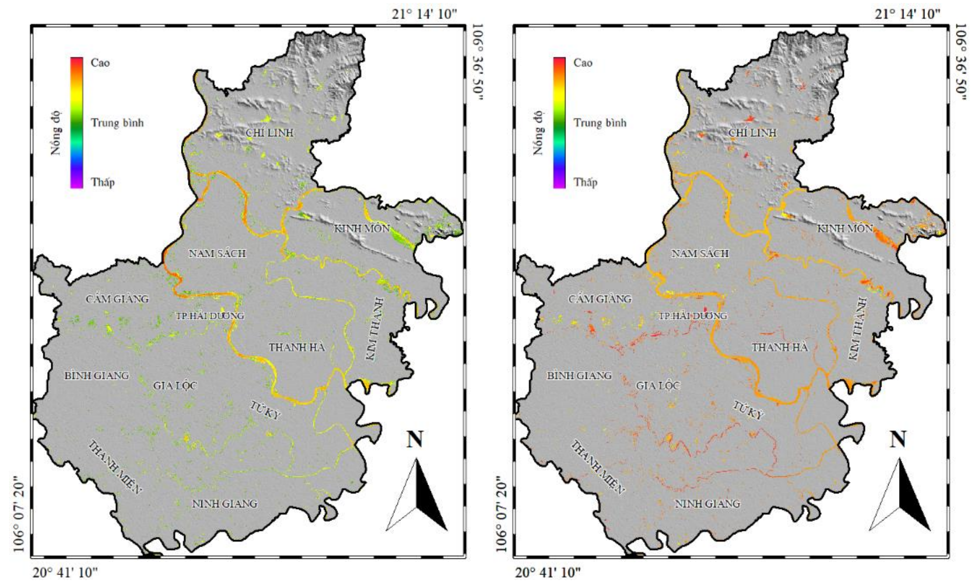


Figure 7. Calculation results of NO_3^- content in September 2016 (a) and November 2019 (b)

Correlation coefficients of BOD_5, COD and NO_3^- are somehow lower than the parameters of suspended materials, with the values of 0.348, 0.439 and 0.679, respectively. The distribution of population, industrial activities, the landforms and land uses in the area significantly influence the water flowing to the Thai Binh river system, and thus the water quality of the water. All of these factors can contribute to the instability of river water and the low agreements between the satellite-estimated parameters and the in-situ measurements.

For the parameters of suspended materials (turbidity, TSS and TDS), it clearly shows that in the late-summer period, the river usually has its worst water clarity, there are more lights and signals reflected to the remote sensor. Therefore, the relationships between the reflectance values and in-situ data become stronger.



a b

Figure 8. Calculation results of TDS content in September 2016 (a) and November 2019 (b)

There might be some other components in the water such as the garbage left by the residents. The eroded soil will make the water turbid as well.

In the scale of the whole province, the northwest part of the study area has worse water quality than the southeast part. This indicates that the northwest part is suffering from a more severe water quality problem than the southeast part. It can also be found that the water quality is turning bad gradually following the direction from southwest to northeast.

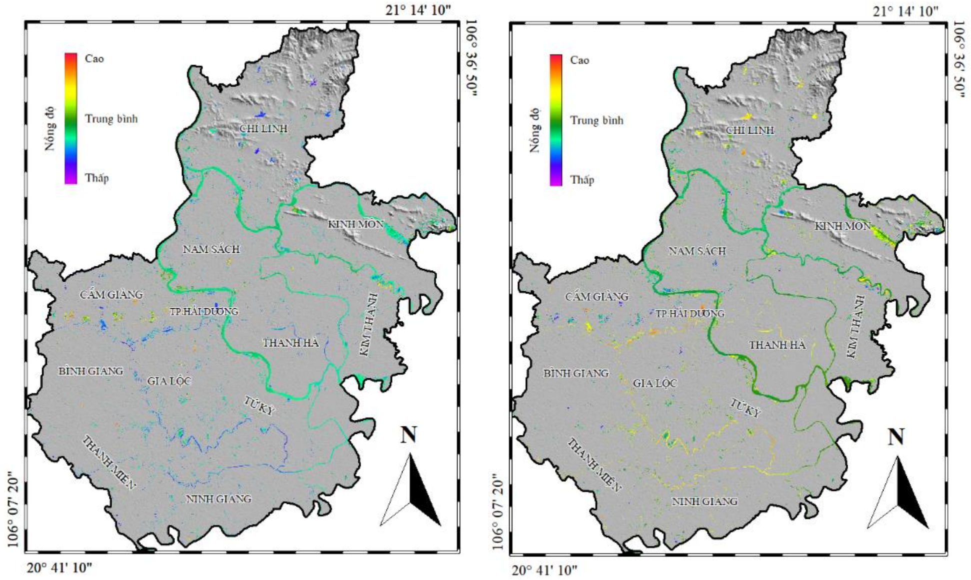


Figure 9. Calculation results of Chlorophyll-a (a) and Trophic State Index (b) in study area

The study area is also suffering from the most severe environmental problem with agricultural activities. The concentration map estimated by the regression equations can indicate the spatial distribution of the eutrophic areas. The contribution of TP, TN and chl-a are relatively high in drainage water pumped from the intensively cultivated land. However, the trophic state is still not too high in the river compare to the lakes in the area. The Carlson's modified tropic state index (TSI_m) is applied in this study, as it only uses the chl-a concentration to represent the trophic state index of both the river system and inland lakes in the area. The trophic state on Thai Binh river system show oligotrophic state, it generally host very little or no aquatic vegetation and are relatively clear, while eutrophic lakes tend to have large quantities of organisms, including algal blooms. In some cases, the algal biomass in lakes reaches too high and massive fish die-offs occured as decomposing biomass deoxygenates the water.

The colour in the water can increase the absorption of light and therefore decrease the signal back to the remote sensors. The atmospheric conditions (e.g., haze and water vapor content) clearly affect the light reflected by land and water surfaces as it travels back toward the satellite sensors.

The trends of all suspended sediment concentration and biochemical parameters imply that the water quality of the entire area has worsen, especially the water quality in the northern area where the population density is high and the concentration of industrial zones, and more attention needs to be paid to this area.

4. Conclusion

Parameters of suspended materials and biochemical concentrations were calculated using the Landsat 8 OLI imagery to map the spatial distribution water quality in the Thai Binh River at different time periods. This study builds the empirical relationships between the Landsat 8 images and the in-situ water quality data. Obtained values from regression equations were correlated with the near real-time in-situ measurements and the relationship between them were expressed by linear equations were found most suitable for quantitative estimation of water quality in the Thai Binh River. Obtained regression coefficients were applied to map the 8 water quality parameters in study area. The results were compared by the near real time measurement data and found in good general agreement qualitatively and quantitatively.

This research is still evolving and these initial results indicate that remote sensing based data has the potential to estimate relative variation of water quality and map the spatial distribution of suspended materials and biochemical concentrations in river environments in study area. Acquisition of more in-situ measurements of water parameters are on going to derive more general regression coefficients and achieve more validation results. However, there are usually a confusion of the pixels in satellite imagery between the water and soil if the spatial resolution of the satellite images is not high enough. Sometimes even if the stations are located perfectly on the imagery, it still may turn out that the DN values of soil rather than water are extracted. All of these reasons may more or less affect the results of estimation.

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Researching the Potential Impact of Industrial Stacks of the Bright International Vietnam Company on the Ambient Environment

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Abstract

Air pollution due to stacks emission is the biggest problem threatening the sustainable development of Bac Ninh province. As one of the economic development centers of the country, Bac Ninh has many industrial zones and major factories, causing air pollution to become more and more serious. In this study, the AERMOD model was used to evaluate the impact of the stack emission from 72 industrial stacks of the Bright International Vietnam factory. Hourly monitored emission data for five consecutive days is fed in the AERMOD model with the hourly meteorological data taken from the ERA5 dataset from 1/1/2018 to 31/12/2020. The maximum 1-HR, 24-HR, 99th percentile, and annual average concentrations of TSP, SO2, and NO2 were simulated within the 20km x 20km domain of 100m x 100m grid resolution. Air dispersion simulation is performed on the observed background gas concentration of the everyday environment. The simulated spatial distribution of gases indicates the strong fluence of the mountainous topography on the dispersion of stack emission. Results also revealed that the emission potentially causes serious TSP pollution over the region if the exhausted gases are not properly treated.

1. Introduction

Air pollution is a worldwide problem and Vietnam is no exception. According to The Environmental Performance Index (EPI) annual report conducted by the US Environment Organization, Vietnam is one of the top 10 air polluting countries in Asia, especially dust pollution. Humans are victims of environmental pollution, but humans are also the main culprit of environmental pollution. Many daily human activities contribute to the increase of air pollution. Among these activities, industrial production is the main cause of air pollution, not only in Vietnam but also in many developing countries. Smoke and dust from the exhaust stacks of factories and factories in industrial zones darkened the sky. They emit CO_2, CO, SO_2, NO_x and a number of other organic substances, with extremely high concentrations.

Bac Ninh province is one of the most polluted cities in the country. As one of the economic development centers of the country, Bac Ninh has many industrial zones and major factories, causing air pollution to become more and more serious. Environmental management and pollution reduction are a top priority in Bac Ninh, especially towards factories that are newly built or increase capacity. Bright Vietnam International Co., Ltd. is a 100% Taiwan - China owned company belonging to Brico Group, specializing in the production of high quality enameled metal utensils for the kitchen. The main company production include pots and pans, furnace bar and mainly for exportation to European and American markets. In 2014, the company has capacity production of 12.000 tons of products per year. In the coming time, the Company will invest in expanding, increasing the project capacity to 48.000 tons of products per year. Increasing three times the original capacity is inevitably increases the pressure on the environment and affects the feasibility of the project. This research focus on researching the potential pollution to the air environment due to the company's production activities. The AERMOD model has been adopted in this study. AERMOD is a short-range emission model specified by US/EPA in air pollution management. This is the state-of-the-science, steady-state Gaussian air dispersion model based on planetary boundary layer theory.

2. Study area and Data

2.1. Study area

This study was conducted for Bright International Vietnam factory in Thuan Thanh II Industrial Park, Bac Ninh province. The scope of the study area is determined within a radius of 10km from the center of the industrial stacks. The factory has a total of 72 industrial stacks that emit many different types of emissions, especially fossil fuel combustion emissions including SO_2, NO_x and total suspended solids (TSP).

2.2. AERMOD model

AERMOD, a steady-state dispersion model, includes the effects on dispersion from vertical variations in the planetary boundary layer (PBL). In the SBL the concentration distribution is Gaussian, both vertically and horizontally, as is the horizontal distribution in the convective boundary layer (CBL). However, the CBL's vertical concentration distribution is described with a bi-Gaussian PDF, as demonstrated by Willis and Deardorff (1981). Buoyant plume mass that penetrates the elevated stable layer is tracked by AERMOD and allowed to reenter the mixed layer at some distance downwind. AERMOD has been widely used for environmental management purposes (Silverman et al 2007; Suadee 2008; Huertas et al 2012). The AERMOD model is recommended for short-range dispersion modelling at a distance up to 50km from the emission source (Seangkiatiyuth et al., 2011; Krzyzanowski, 2011).

2.3. Data and materials

a. In-situ data

Hourly emission data from the 72 stacks of the Bright International Vietnam factory was obtained from periodic environmental monitoring reports that took place twice a year. For each monitoring period, emissions from the stacks are examined for 5 consecutive days for flow velocity and gas volume. At the same time, exhausted gases are sampled and analysed for pollutants concentration including TSP, NO_x and SO_2. Since the factory plans to increase its capacity up to three times higher, the projected emission for future scenarios is calculated in proportion to the current emission volume.

Considering the ambient atmospheric quality in the modeling process, hourly average air quality data were collected at 3 locations for consecutive five days from 20-Jul 2021 to 24 Jul 2021. TSP, NO_x, and SO_2 were considered in this study.

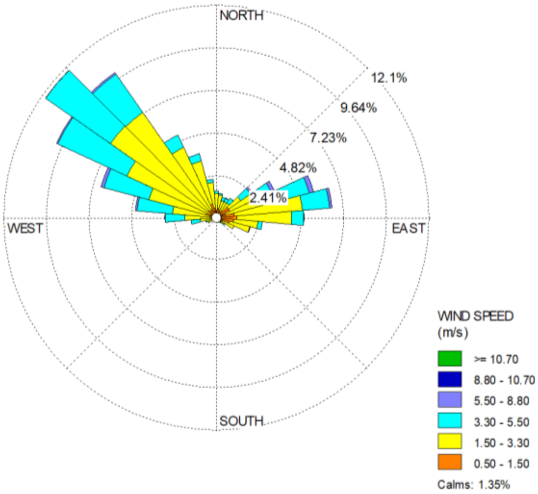

Figure 1. Wind-rose from 1/1/2018 to 31/12/2020 of Bac Ninh province

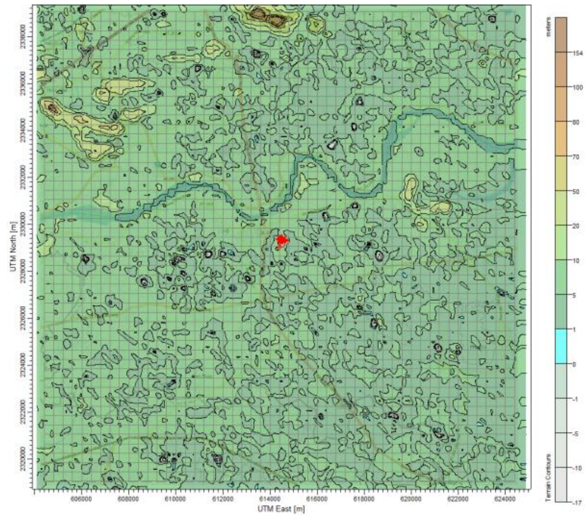

Figure 2. Topography map of the study area and the location of the stacks (red crosses)

c. Meteorology data

We used the ERA5 atmospheric, land, and oceanic climate variables for surface meteorological data. ERA5 data cover the Earth on a 10km grid and resolve the atmosphere from the ground up to 80 km height using 137 vertical levels. Wind direction, wind speed, temperature, precipitation, heat flux, solar radiation, and albedo at hourly resolution were extracted for the research region for the period span from 1st January 2018 to 31st December 2020. The corresponding upper air meteorological condition of the same time period, i.e. wind speed (Figure 1), was taken from the hourly recorded radiosonde data at Noibai International Airport.

d. Topography and surface data

The digital elevation model data used in AERMOD was extracted from 1 arc-second resolution SRTM (Shutter Radar Topography Mission) topographic data (~30m resolution) produced by NASA (National Aeronautics and Space Administration) in collaboration with NGA (Geospatial-Intelligence Agency) (Figure 2). The elevation data on the computed domain is bilinear interpolation to match the spatial resolution to the receptors grid using AERMAP.

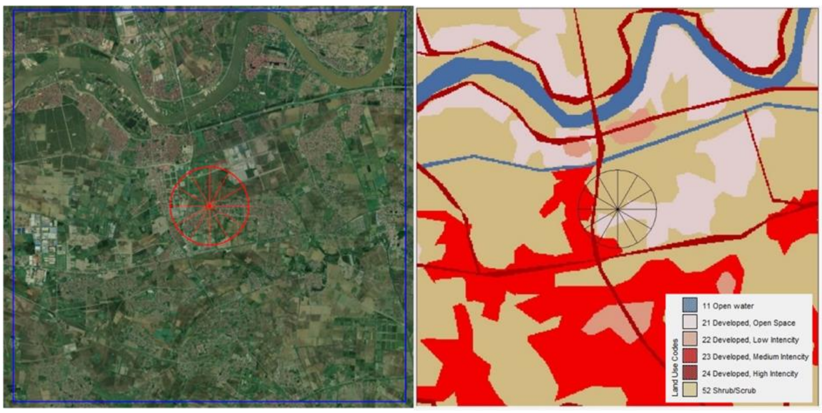

Figure 3. Land cover map prepared at 30m resolution

Surface land cover data at 30m resolution was prepared using the combination with 100m resolution Global Land Cover (GLC) land cover data and Google Maps satellite image data (Figure

3). The Global Land Cover Map is a data product developed by Copernicus' Land Monitoring Core Service (LMCS) - Europe's leading program for Earth observation.

2.3. Model setup

Simulation for the dispersion of stack-born pollutants of the Bright International Vietnam factory is conducted for the period from 1 Jan 2018 to 31 Dec 2020, a total of 26.403 hours. The simulation domain was configured for a 20km x 20 km region centred by the factory and covered by the Cartesian receptor grid made up of 20.201 nodes of 100m x 100m resolution. In this study, future scenarios are assumed using two cases including (1) the exhaust gases treatment system has a problem which leads to the highest environmental impacts on the social and the environment and (2) the factory operates stably and the environmental treatment systems perform as designed. The spatial and temporal impacts of stack emissions on the environment are examined with the following experiments (Table 1).

Table 1. Experiments on the dispersion of stack emissions

No.	Experiments
1	Highest emission averaged for 1 hour, 24 hours
2	Annual averaged concentration
3	Emission averaged for 1 and 24 hours at 50^{th} and 99^{th} percentiles

3. Results and discussion

3.1. Ambient air quality

The results of the ambient air quality surrounding the study area are illustrated in Table 2, where the concentration of the major pollutants from the stack is compared with the national standard (QCVN 05:2013/BTNMT). It can be clearly seen that the current ambient air quality is quite good since the concentration of TSP (59 – 78 µg/m^3), SO_2 (32 – 46 µg/m^3), and NO_2 (29 – 35 µg/m^3) is noticeable lower than the limitations. The research results show that the study area is not affected by the surrounding industrial plants and currently the factory's exhaust gas treatment system is operating effectively.

Table 2. Current status of environmental quality in the study area

No.	Pollutants	Unit	Concentration				QCVN 05:2013/ BTNMT[b]
			K01[a]	K02	K03	K04	
1	TSP	*µg/m^3*	78	74	68	59	*300*
2	SO_2	*µg/m^3*	38	32	46	37	*350*
3	NO_2	*µg/m^3*	31	35	32	29	*200*

Note:
[a]K01-04 are the locations sampling the ambient quality surrounding the factory
[b]National Technical Regulation on Ambient Air Quality

3.2. Potential environmental impacts due to stack emission under exhausted gases treatment system malfunction scenario *a. Highest pollution cases*

The simulation results for the case of the largest possible contaminant concentration with meteorological data from T1/2018 to 12/2020 for an average of 1 hour and an average of 24 hours are shown in Figure 3. The average 1h TSP concentration in the largest case (rank 1) is 14,085 µg/m3 which is 47 times higher than the maximum 1-hour average required threshold of 300 µg/m3. The radius of the polluted area is distributed in a very wide range around the factory area, from 400 - 500m. Outside the 500m radius, the concentration of TSP fluctuates around 5,000 – 7,000 µg/m^3, 17 - 24 times higher than the maximum threshold. Within 10,000m from the factory, the dust concentration in the air is still up to 1,000 – 1,500µg/m3 which still threatens the safety of the environment. The simulation results show that if the exhaust gas treatment system fails, the impact on the environment from the project is pollution on a very wide scale and a high level of harm to the environment and people. This largest 1-h average TSP instance represents the maximum impact level across more than 26,000 time slides. With the average 24h continuous TSP experiment, the highest level of TSP was over 4,900 µg/m3, this index is nearly 25 times higher than the threshold of 24h average maximum concentration of TSP of 200 µg/m3. In all scenarios, the peak concentrations of TSP were well above the norm and distributed over a very wide range. When the exhaust gas treatment system fails to function properly, the emissions will negatively affect the environment, especially within a radius of 500-1000m around the factory.

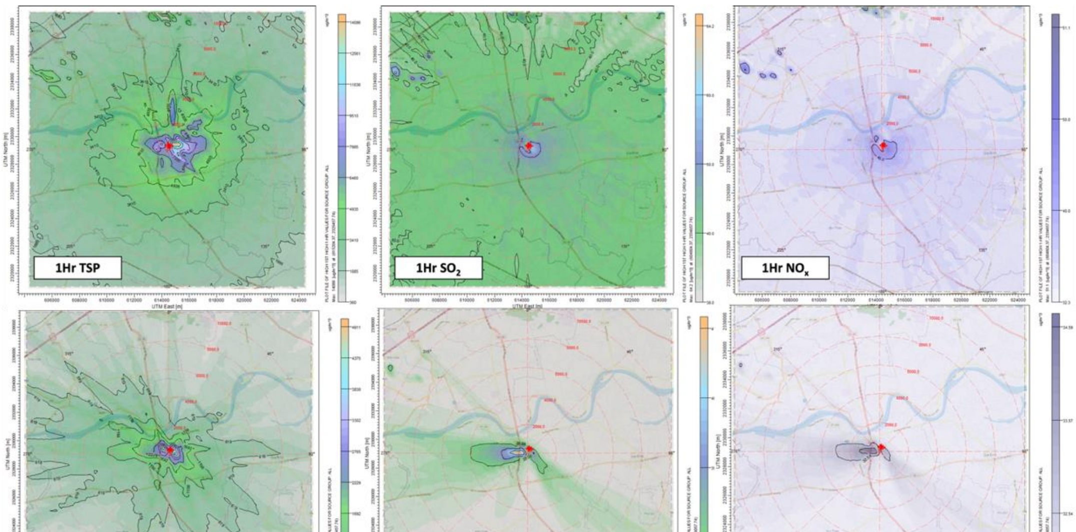

Figure 4. Averaged 1-hour and 24-hour extreme emission cases

The concentration of SO_2 dispersed from the stacks to the environment is also shown in Figure 3. The simulation results show that the average maximum SO_2 concentration in 1h is 64.2 g/m^3 and the average 24h is 41.21 µg/m^3 which is lower than the regulated thresholds of 350 µg/m^3 (average 1 hour) and 125 µg/m^3 (24h averaged), respectively. The results at the 99th percentile threshold are not much lower than the maximum. With a background threshold concentration of 37 µg/m^3, the impact of SO_2 on the environment is negligible. Simulated SO_2 concentration for each season also shows the similarity between times of the year, SO_2 concentration is always at a safe level for the environment.

Simulation results show the largest concentration of NO_2 in the natural environment under the influence of stack is very small, with an average of 51.1 µg/m^3 for 1 hour and 34.59 µg/m^3 for an average of 24 hours which is safe within the regulation of QCVN 05/2013/BTNMT. It is possible to conclude that the NO_2 concentration from the stack does not have a negative impact on the natural environment.

b. Potential environmental impact of extreme emission cases

Since the highest pollution cases reflect the very "rare" occurrence of the pollution among 3 years of simulation, it is sometimes too arbitrary and might be caused by extreme climate events. The extreme emission cases shown by the 99th percentile region, reflect the rare occurrence of 1% possible might be more suitable to examine the potential impact of stack-born pollution. Figure 4 compares the 50th percentile and the 99th percentile emission for TSP which show the difference between normal emission and extreme cases.

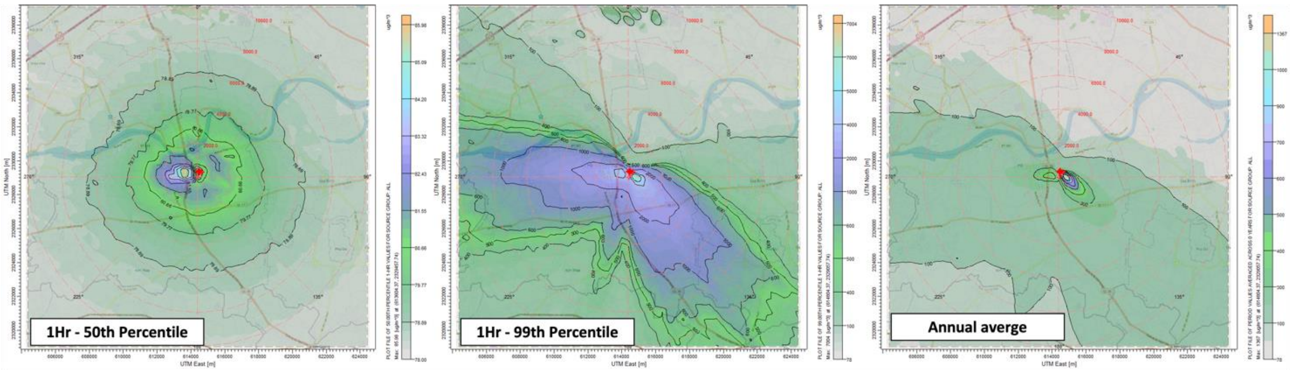

Figure 5. Emission of TSP from the stacks

Simulation result for 1h average TSP at the 50th percentile shows that the most common and most typical concentration level of the project is around 86 g/m^3, close to the regulated threshold 100 µg/m^3. Thus, the common impact level of the stack in any time period is close to the pollution level, potentially causing harm to the environment. The result for 99th percentile emission – the concentration representing 1% probability highest at 7,000 µg/m^3, very high above the norm, above the threshold of 70 times. This finding indicates the high possibility of environmental pollution due to the stack emission in case of treatment system failure.

c. Spatial distribution of air pollution

The annual distribution of pollutants reflects the most affected areas by stack emission. Annual distribution of TSP (Figure 5) is similar to other pollutants showing that the vast areas from the west to the south-east of the factory are strongly influenced by the emission. The negatively affected distance is roughly 5,000m far from the sources.

3.3. Potential environmental impacts under the normal working condition of the gas treatment system

Simulation results (result not shown) for the dispersion of all pollutants at the normal working condition of the gas treatment system show that emissions from the stacks will not cause harm to the environment. For example, the average distribution of TSP at 1h rank 1 is the largest at 188 µg/m3, is still safe within the permissible limit of 300 µg/m^3. With the average 24h TSP distribution results, rank 1 also gave the same results as the average 1h, the TSP concentration was always well controlled and lower than the maximum allowable threshold.

4. Conclusion

Environmental pollution from stack emissions is one of the top concerns of the authorities in Bac Ninh province. In this study, the AERMOD model was used to evaluate the influence of stack-born pollutants from the Bright International Vietnam factory on the ambient air environment, namely TSP, NO2, and SO2 gases. The observed 5-day hourly observation data for ambient air quality and stack emission was used to validate the model. In this study, air dispersion simulation using the AERMOD model with 2018 to 2020 meteorological data has shown the high risk of air pollution if pollutants are not properly treated. The TSP emission is potentially dangerous to the environment, the concentration of untreated TSP has a negative influence radius far beyond the 10km radius. The area with the greatest negative impact is within the 400-1000m radius from the factory. The most negatively affected residential areas are located in the west to the southeast stack location. SO_2 and NO_2 have a very low level of environmental impact, not likely to cause harm to the surrounding environment. The emission source of the above gases is only generated from the medium-frequency induction furnace, the volume of generated exhaust gas is negligible.

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Investigating The Causes of The Flood in Ho Chi Minh City Area - Proposing The Solutions

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Abstract

In recent years, the flood has occurred widely in Ho Chi Minh city area, which causes serious effects on the city's landscape and inhabitants, makes environment polluted … Facing that situation, the authors analyze it, study the causes of the flood and propose some solutions.
Keywords: causes, solutions, flood, Ho Chi Minh city

1. Introduction

According to the statistics of the Control Center for Flooding of Ho Chi Minh City [1, 2], the Center for Technical Infrastructure Management (Department of Construction of Ho Chi Minh City) [3, 8], the Hydrometeorology Station South Vietnam [6, 9], Urban Management Office Thu Duc District [7], Urban Sewerage Company [10], at the same time, combined with the investigation, field survey in recent years shows that In Ho Chi Minh City, there are 66 flooding points on roads (figure 1), also, flooding points in alleys and residential areas have not been listed in District 2 areas (An Phu, An Khanh), District 8 (Ben Phu Dinh, Me Coc), District 12 (Thanh Loc, Thanh Xuan, An Phu Dong), Binh Thanh (Tan Cang, Van Thanh Market, Thanh Da Residential), Thu Duc (Hiep Binh Chanh, Hiep Binh Phuoc, Linh Dong), Hoc Mon (Nhi Binh), Cu Chi (Binh My, Trung An) ... Most of the flooded points are inundated from 0.3-0.5m deep, some places are flooded nearly 1m deep.

The results of aggregation, investigation and surveys show that serious inundation usually occurs in June, July, August, September, October and November every year, not only in low-lying and high-altitude areas varying from 0.5-1.0m. But also in areas with high terrain, with average elevation from 2 to 5m, from 5 to 10m in some places, water sources causing inundation are mainly high tide and rain, or their combination (Figure 2.1 ÷ 2.14).

Figure 1. Map of 66 flooded points on roads in HCMC [3]

Figure 2.1. Flood point in District 1

Figure 2.2. Flood point in District 3

Figure 2.3. Flood point in District 4

Figure 2.4. Flood point in District 5

Figure 2.5. Flood point in District 7

Figure 2.6. Flood point in District 8

Figure 2.7. Flood point in District 10

Figure 2.8. Flood point in District 12

Figure 2.9. Flood point in Binh Thanh District

Figure 2.10. Flood point in Tan Binh District

Figure 2.11. Flood point in Tan Phu District

Figure 2.12. Flood point in Go Vap District

Figure 2.13. Flood point in Binh Chanh District

Figure 2.14. Flood point in Thu Duc City

2. Natural characteristics overview

2.1. Topography

Ho Chi Minh City lies in the transition zone between the Southeast region and the Mekong River Delta. The topography gradually lowers from North to South and East to West [11]. It can be divided into 3 types of terrain as follows:

High delta terrain: located in the North-Northeast and part of the Northwest (in the North of Cu Chi District, Northeast of Thu Duc City), with wavy terrain having an average elevation of 10-25m, and alternately, there are hills with the highest altitude of 32m, such as Long Binh Hill (District 9).

Moderately high plain terrain: distributed in the city center, including most of the inner city, a part of District 2, Thu Duc, all of District 12 and Hoc Mon District, with an average elevation of 2-5m, 5-10m in some places.

Low-lying plain terrain: located in the South-Southwest and Southeast of the city (in District 9, 8, 7, 2 and Binh Chanh, Nha Be, Can Gio District), with an average altitude is approximately 1m. The highest altitude is 2m, the lowest one is 0.5m; often inundated seasonally and flooded during high tide.

2.2. Hydrometeorological characteristics

2.2.1. Rain

Ho Chi Minh City lies in the subequatorial monsoon tropical climate, divided into two distinct seasons: the rainy season lasts from May to November and the dry season lasts from December to April of the following year.

According to the annual rainfall statistics at Tan Son Hoa station in the past 10 years (2009-2018) [12] (Table 1): the average annual rainfall is high, 2106.5mm per year, the highest measured rainfall is 2737.7mm (2017) and the lowest one is 1760.6mm (2015). About 90% of the rain falls is in the rainy season. The lowest rainfall in a year usually occurs in January, February and March, the average amount per month is 16.9-29.7mm. While the highest rainfall in the year usually occurs in June to September with the average amount per month is 196.0-393.6mm, exceeding the drainage capacity of the existing small cross-section sewer system (D400-D600), which was an immemorial investment, causing flooding in many places (even high terrain areas). According to information from the Center for Technical Infrastructure Management (Department of Construction of Ho Chi Minh City), although it has mobilized the maximum force to collect rubbish at the sewers, has been operating and opening at 5 high-tide-prevention culverts and more than 1,000 small-tide-prevention valves but water could not drain in time [8].

Table 1. Monthly rainfall from 2009 to 2018 (Tan Son Hoa station)

Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	0,3	21,4	57,8	187,0	318,5	83,2	223,0	323,9	325,1	249,0	141,2	49,5
2010	23,0	-	3,9	9,9	8,8	160,0	294,3	400,6	373,7	321,8	379,9	40,3
2011	9,4	-	40,3	181,9	124,4	213,1	281,5	244,4	232,1	232,6	321,1	73,0
2012	18,0	68,7	36,4	144,4	72,2	270,6	200,4	113,4	407,9	434,4	91,2	25,4
2013	38,1	0,1	10,1	18,3	196,8	173,3	175,8	260,7	411,2	407,4	257,4	31,3
2014	2,5	22,1	-	111,5	179,7	258,0	234,2	353,4	342,1	306,5	182,2	50,0
2015	1,6	-	10,2	104,4	104,9	143,1	246,4	126,9	504,4	339,3	174,8	4,6
2016	29,3	-	-	-	162,1	195,9	191,4	427,1	500,4	491,7	181,2	128,6
2017	61,2	56,7	20,2	226,8	349,2	219,5	170,8	319,6	440,2	574,6	223,3	75,6
2018	113,9	0,2	31,6	13,1	388,5	243,7	207,2	236,8	399,0	257,3	454,9	57,1

2.2.2. Wind

Ho Chi Minh City is influenced by two main wind directions and mainly the West-Southwest and North-Northeast monsoons. The Southwest wind from the Indian Ocean blows in the rainy season, from June to October, with an average speed of 3.6m/s. And the wind is strongest in August, the average speed is 4.5m/s. The North-Northeast wind from the East Sea blows in the dry season, from November to February, the average speed is 2.4 m/s. Also, there is trade wind, South-Southeast direction, from March to May, the average speed is 3.7m/s [15].

2.2.3. Tide

Ho Chi Minh City is strongly influenced by the irregular semi-diurnal tidal regime of the East Sea. It has two tidal peaks that are approximately the same and the two low tide levels are quite different, which goes up and down twice a day. Every month, high tides appear twice (after the full moon and no moon) and also the low tide (on the first and third quarter moon day).

According to the statistics of Saigon River water level at Phu An station over the past 10 years (2009-2018) [12] (Table 2): tidal amplitude in both dry season and flood season along the Saigon River is quite large and fewer fluctuations, always reaching 2.76-3.59m, the average low tide level is about -1.90m (2018) to -1.74m (2013) with the lowest tide level to below - 2.38 (June 2018) and the mean tidal peak water level is about 1.38m (2010) to 1.50m (2017) with high tidal peaks of 1.65-1.71m, much higher than most of the natural topographic surface. That is why the flooding problem is inevitable.

Table 2. Water level of Saigon river (Phu An station)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
The shallowest water level of Saigon river										
Jan	-1,65	-1,75	-1,70	-1,79	-1,54	-1,67	-1,64	-1,81	-1,79	-1,71
Feb	-1,80	-1,94	-1,47	-1,62	-1,76	-1,53	-1,68	-1,41	-1,63	-1,65
Mar	-1,78	-1,66	-1,45	-1,45	-1,42	-1,55	-1,69	-1,57	-1,57	-1,63
Apr	-1,80	-1,63	-1,77	-1,85	-1,73	-1,69	-1,73	-1,73	-1,70	-1,73
May	-2,06	-2,06	-2,05	-2,02	-2,01	-2,02	-2,08	-2,09	-1,98	-2,01
Jun	-2,27	-2,11	-2,27	-2,20	-2,14	-2,15	-2,21	-2,19	-2,19	**-2,38**
Jul	-2,21	-2,22	-2,16	-2,18	-2,11	-2,09	-2,31	-2,24	-2,08	-2,27
Aug	-2,13	-2,18	-2,11	-2,11	-2,09	-2,02	-1,94	-2,05	-1,97	-2,21
Sep	-1,80	-1,99	-1,91	-1,69	-1,85	-1,85	-1,80	-1,88	-1,75	-1,90
Oct	-1,80	-1,71	-1,69	-1,41	-1,42	-1,55	-1,64	-1,73	-1,52	-1,51
Nov	-1,63	-1,61	-1,52	-1,61	-1,39	-1,66	-1,65	-1,64	-1,53	-1,94
Dec	-1,80	-1,65	-1,47	-1,62	-1,46	-1,52	-1,69	-1,67	-1,49	-1,87
The highest water level of Saigon river										
1	1,54	1,47	1,45	1,42	1,58	1,58	1,54	1,50	1,55	1,61
2	1,43	1,44	1,47	1,40	1,52	1,52	1,48	1,54	1,58	1,71
3	1,39	1,42	1,40	1,50	1,34	1,35	1,39	1,41	1,53	1,45
4	1,37	1,32	1,29	1,44	1,47	1,31	1,33	1,33	1,47	1,44
5	1,26	1,29	1,19	1,27	1,32	1,25	1,25	1,37	1,39	1,39
6	1,17	1,18	1,12	1,30	1,26	1,20	1,21	1,23	1,30	1,21
7	1,28	1,25	1,13	1,21	1,40	1,29	1,11	1,20	1,30	1,29
8	1,37	1,35	1,34	1,29	1,29	1,37	1,31	1,28	1,35	1,31
9	1,37	1,35	1,50	1,49	1,46	1,46	1,51	1,48	1,50	1,44
10	1,42	1,49	1,57	1,62	1,68	1,68	1,58	1,67	1,65	1,67
11	1,56	1,55	1,58	1,54	1,64	1,55	1,61	1,62	1,67	1,62
12	1,46	1,49	1,59	1,62	1,63	1,63	1,51	1,60	**1,71**	1,52

2.3. Geological characteristics

Based on the geological map of Ho Chi Minh City at the scale of 1: 50,000 (Figure 3) [13], combined with the field survey, most of the surface area is covered by Holocene and Pleistocene formations. In some areas, Upper Jurassic - Lower Cretaceous sedimentary and extrusive rock outcrops are exposed.

2.3.1. Upper Jurassic - Lower Cretaceous extrusive and sedimentary formation (J_3-K_1)

Upper Jurassic - Lower Cretaceous extrusive and sedimentary formations of Long Binh Formation (J_3-K_1*lb*) are only visible in a small area in Long Binh (Thu Duc) and a small mass in Giong Chua (Can Gio). The main composition consists of andesite-basalt, andesite and their tuff, silty sandstone, shale. The general thickness of the sediments of Long Binh formation is about over 350m.

2.3.2. Pleistocene sedimentary formations (Q_1)

Pleistocene sedimentary formations occupy most of the North, Northwest and Northeast of the city, in most of Cu Chi, Hoc Mon, North of Binh Chanh, Thu Duc, North-Northeast of District 9 and parts in the inner city area. The common point of these sedimentary formations is usually hilly or wavy terrain, from 20-25m high and down to 3-4m, inclined to the Southeast.

+ Quaternary system, Middle-Upper Pleistocene series, Thu Duc Formation (amQ_1^{2-3}*tđ*)

The sedimentary outcrops of Thu Duc formation are very limited in Linh Xuan and Thu Duc areas. Thu Duc sedimentary formations are distributed at a depth of 27m to the present topographic surface. The composition includes yellow pebble-sand, red gravelly-quartz sand. The thickness of the formation is 27m.

+ Quaternary system, Upper Pleistocene series, Cu Chi Formation (amQ_1^{3}*cc*)

The sediments of this formation are widely distributed, accounting for most of the area of Cu Chi, Hoc Mon, North of Binh Chanh, Thu Duc District, North-Northeast of District 9 and most of the inner city area. The composition includes pebbles, gravel, quartz sand, and gray pebble sand. The thickness of the formation is 10-30m.

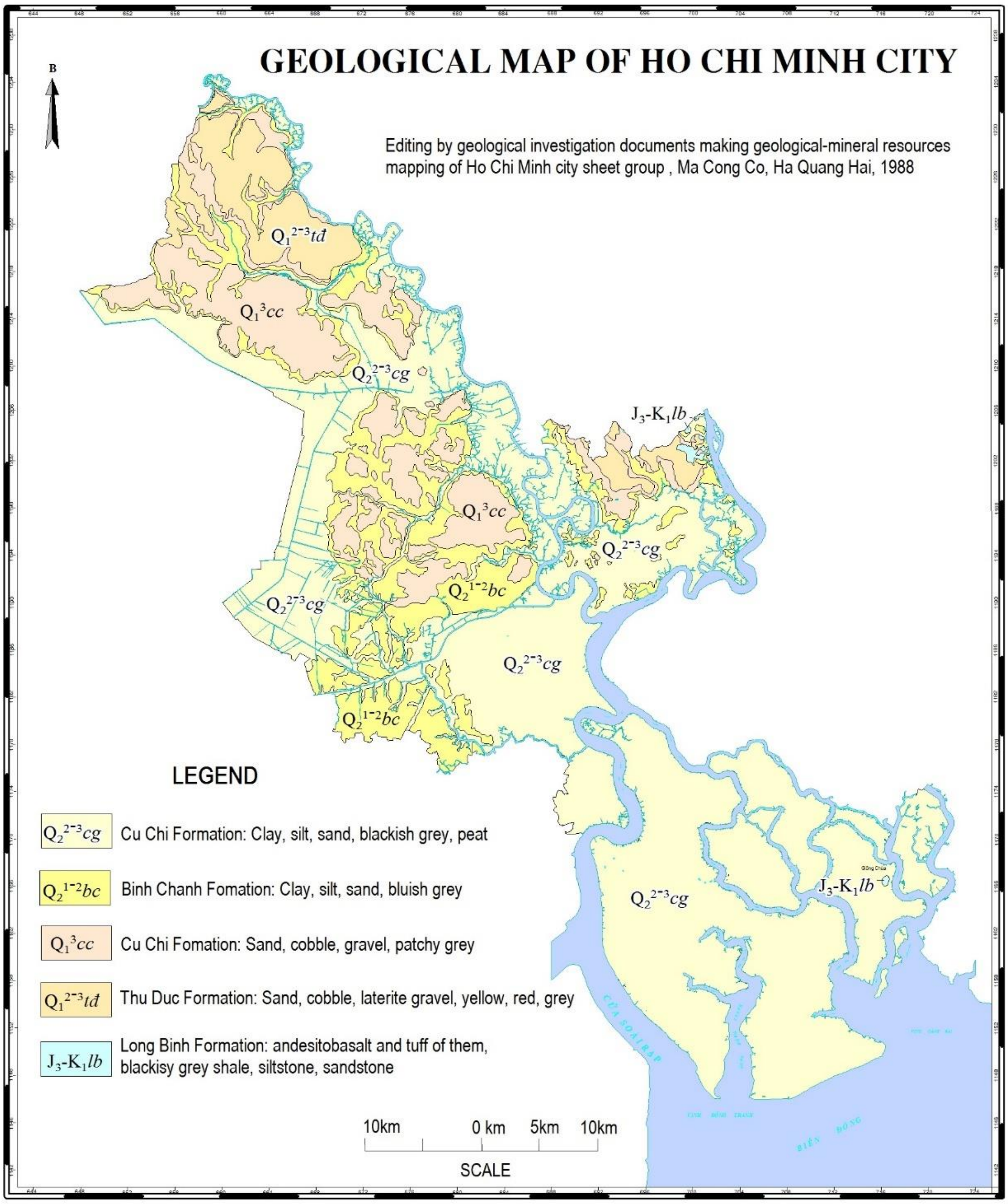

Figure 3. Geological map of Ho Chi Minh city [13]

2.3.3. Holocene sedimentary formations (Q_2)

Holocene sedimentary formations are widely developed in the Southern area of Ho Chi Minh City, at the same time they are exposed on most of the modern terrain surface, found in most areas of Can Gio, Nha Be, Binh Chanh, District 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Binh Thanh and a part of Thu Duc, Hoc Mon, Cu Chi. The common point of these sedimentary formations is that it is usually a low-lying terrain, with an average height of about 1m, some places 2m high and medium-high terrain, from 2 to 5m high. These formations have just been formed, are undergoing natural compression.

+ Quaternary system, Lower-Middle Holocene series, Binh Chanh Formation (am$Q_2^{1-2}bc$)

The sediments of this formation are widely distributed, accounting for most of the area of Binh Chanh District, District 3, 5, 6, 10 and part of the area of District 9, Hoc Mon, Cu Chi. The composition includes gray-white, yellow-gray, blue-green-gray clay mixed with many organic remnants, sometimes with shells, sea oysters, dark gray mixed sand lenses. The thickness of the formation varies from 5-10m to 20-30m.

+ Quaternary system, Middle-Upper Holocene series, Can Gio Formation (am$Q_2^{2-3}cg$)

The sediments of this formation widely developed along the Saigon River valley, covering almost the entire area of Can Gio, Nha Be, District 7 and a part of District 9, Hoc Mon, Cu Chi. The composition includes clay, greenish-gray, dark gray silt containing peat and fine-grained sand, sometimes containing lenses or layers of sand, mixed clay. The thickness of the formation is 5-8m.

3. Causes of flooding

Based on the aggregation of documents on topography, geology, hydrometeorology ... combined with the results of investigating and surveying the flooding situation occurring in the area of Ho Chi Minh City, it is possible to make comments about the cause of flooding are as follows:

3.1. Objective reasons

Tides.

Rain and the resonance of rain and high tide.

Wind and the resonance of wind and high tide.

The natural terrain surface has elevations lower than high tide.

The natural compaction process of Holocene sediments is accelerated by ground filling as a foundation for construction works, creating the constructing environment ... These sedimentary formations, which have poor water permeability, become even less permeable, limiting the vertical permeability of surface water.

3.2. Subjective reasons

Activities against flooding occurred spontaneously and asynchronously, leading to widespread inundation.

The rapid development of urbanization and industrialization has accelerated the consolidation of Holocene sediments, lowering the topographic surface; occupies a considerable area of ponds, lakes and canals to drain natural water.

The existing sewer system is outdated, overloaded and damaged.

The detection of sewer system problems is not in time due to a lack of specialized equipment.

4. Recommended directions

Recalculate the area of natural drainage ponds, lakes and canals that have been lost.

Detailed study of topographic features, geomorphology, geology (paying special attention to natural compaction of Holocene sediments), rainfall variation, wind regime, tidal rule and co-ordination benefits, as the basis for the division of small basins, determining the main drainage direction and choosing the locations of forced pumping stations, milling doors as well as locations of regulating lakes ...

Check the entire existing sewer system, repair and build several new culverts for the roads that do not have drainage systems, perform well the maintenance and maintenance ...

Dredging to open the canal system flow.

Propagating and educating people on awareness.

Tidal prevention measures: installing pumping stations forcing the flooding situation, milling doors at the outlets.

Measures to drain rainwater: regulating lakes can be combined with the use of drilled wells to drain rainwater.

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Studying Causes of The Sand-Flow Hazard in Tien Thanh Area, Phan Thiet City, Binh Thuan Province - Proposing Solutions

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Abstract

In recent years, sand-flow hazard has commonly occurred in Tien Thanh area, Phan Thiet City, Binh Thuan Province, which causes a lot of damages. The authors have analyzed the situation, study conditions and causes of the sand-flow; hence, petition for the direction of prevention and restriction.

Keywords: cause, solution, hazard, sand-flow, Tien Thanh, Phan Thiet

1. Introduction

Tien Thanh is a commune located in the south of Phan Thiet City - Binh Thuan Province, with a residential area situated along the provincial road DT716 - a road running along the coast connecting Phan Thiet City with Ham Tan District and Ba Ria - Vung Tau Province. This is a commune with great potential for tourism development. Over the past years, with the attention of the Provincial People's Committee and the People's Committee of Phan Thiet city, the commune has been planning to invest in infrastructure construction and tourism development.

However, the phenomenon of erosion - sand flood has become a real natural disaster affecting the peaceful life of the community, as well as the planning and socio-economic development, making complete changes of terrain’s surface, destroying many benefits, destabilizing and burying constructions such as houses, roads ... even destroying, causing many human disasters and much loss of wealth.

According to data reported by the People's Committee of Phan Thiet City [17]: catastrophic sand floods continuously occurred; severely damage both lives (3 died, 2 injured) and property of the State as well as of the people (2 houses were completely damaged, collapsed a box culvert on road DT716; 85 houses and hundreds of meters of roads are buried by sand).

Red sand floods flow down from the ditches to people's houses, gardens, and the traffic route DT 716 causes burying (Figure 1), affecting their daily life, obstructing traffic, in the rainy season, to activities and tourism in the region.

Figure 1. Sand floods cause houses and roads to be buried

Figure 2. The protective structure was destroyed after the rains

Some construction solutions have been implemented every year, such as reinforcement against landslides with masonry walls, stone gabions, sandbags ... but the scale of the works are small, not thorough, so they are often destroyed after a rainy season (Figure 2).

All the above facts are enough to prove that the study and assessment of sand flood catastrophes are very necessary and urgent, having a great practical significance.

2. Document basis and research method

2.1. Document basis

The article is completed based on aggregating, processing and analyzing documents of VN-2000 topographic map on the scale of 1:10.000, geological and mineral resources maps of Vietnam on the scale of 1: 200,000, geological maps of Binh Thuan Province on the scale of 1: 50.000, climate, remote sensing image, the socio-economic development plan of the study area, combined with survey results on erosion status - sand flood, geology-geomorphology and geology project in Tien Thanh area, Phan Thiet City, Binh Thuan Province, carried out by ARC Architectural Design Company Limited [8]. The amount of survey work is presented in Table 1.

Table 1. Quantity of geological-geomorphological and engineering geological survey

Work content	Unit	Amount
Total number of geological-geomorphological	Points	20
survey points	Boreholes	20
Total number of boreholes	Meters	300
Total number of meters for drilling and digging	Samples	100
Seed testing	Samples	100
Experiment with basic mechanical parameters	Samples	100
Absorbent test	Samples	50
Disintegrated test		

2.2. Research Methods

2.2.1. Geomorphological survey method

Surveying and describing geological structure features, topographical and geomorphological features in boreholes, survey points' locations are determined by GPS equipment, combined with drilling, digging, and collecting samples for research analyzing and experimenting.

2.2.2. Drilling and digging method

Carry out a hand drill using a spiral drill and a spoon or exploration digging combined with analyzing and laboratory testing according to TCVN 2683: 2012 [2] standards, to serve the study of strata and cities. composition, mechanical properties, permeability as well as disintegration properties, geological processes and phenomena (erosion ditches, erosion trenches) of sand flood development related to red sand formation in the study area.

2.2.3. Experiment analyzing method

This method includes analysis and experiments to determine the composition, physical-mechanical parameters, permeability and disintegration properties of the soil, specifically as follows:

Grain size analysis by sieve method and hydrometer to determine the percentage content of particle sizes (gravel, sand, silt, clay), thereby building the graph of particle accumulation, soil naming and classifying.

Basic physical and mechanical parameter experiments of soil such as natural moisture, natural density, specific weight, cohesion force, internal friction angle, permeability coefficient, calculated parameters such as dry density, void ratio, porosity, saturation ... and especially determine the disintegration properties of sand.

Analysis and experiments were performed at the Geological Laboratory, University of Natural Resources and Environment, Ho Chi Minh City University of Natural Resources and Environment, and were performed according to current Vietnamese standards [3, 4, 5, 6, 7] and other experimental analysis documents [10, 15].

2.2.4. Statistical calculation method

Using statistical calculation method to aggregate collected data, calculate and analyze the variation of factors, physical-mechanical parameters such as dry density, void ratio, porosity, saturation…, thereby, helping to predict catastrophes that can occur.

3. Results and discussion

3.1. Current status

The results of the field survey in Tien Thanh area of the authors showed that the entire 17km long red sandhill from Duc Long Ward to the end of Tien Phu village in Tien Thanh commune developed into many erosion ditches (over 20 outcrops) of different large and small scales. Erosion ditches extending from the top of the sandhill to the foot of the slope are 200-800m long, the mouth enlarges from the tip of the eroded ditch to the foot with a width of 5-150m, the bottom is 2-8m wide, 4-60m deep, creating very steep slopes (80-90^{o}), general development direction is to the Southeast. Here are some initial surveys by the authors:

Figure 3. Developing ditches in Tien Phu village

Figure 4. Developing ditches in Tien Hoa village

Figure 5. Drainage zone at the tip of an eroded ditch Tien Hoa village area

Figure 6. Developing ditches in Tien An village

Based on the survey results on the current state of erosion - sand flood, at the same time combining with the analysis of documents on topography, geology, meteorological climate as well as the time of sand flood ..., initially comments are made: sand flood catastrophe in this place occurred more or less with certain rules.

+ Rule of stratigraphy: sand flood phenomenon only occurs on red sand formations of Pleistocene age, marine origin of Phan Thiet formation ($mbQ_1^{2-3}pt$).

+ Rule of cycle: the sand flood phenomenon occurs very strongly in June, July, August and September. This is also the rainy period that lasts during the year.

3.2. Conditions and causes of sand-flow

3.2.1. Condition

Sand flood catastrophes arise and develop under certain conditions. The arising and developing conditions of catastrophic sand floods are evaluated collectively through the following factors:

Geomorphology

The study area features coastal dune topography, which is composed of Pleistocene sedimentary formations of marine origin (mQ_1^{2-3}) and wind origin (vQ_1^3). The terrain surface is relatively flat, the elevation of the terrain varies from 20m to 100m, the slope varies from 5-10%, leaning towards the sea, the sparse vegetation cover is mainly bushes to barren hills. Most of the surface area is under the influence of strong wind erosion and surface erosion by rainwater, facilitating the development of sand floods in the rainy periods.

Geological structure

The geological structure greatly affects the erosion - sand flood phenomenon in Tien Thanh area, particularly in the red sand formation distribution areas of marine origin - Phan Thiet Formation ($mbQ_1^{2-3}pt$) (Figure 7). This phenomenon happened very strongly; while in the white sand distribution areas, wind origin (vQ_1^3) directly covers the red sand formations, this phenomenon hardly occurs.

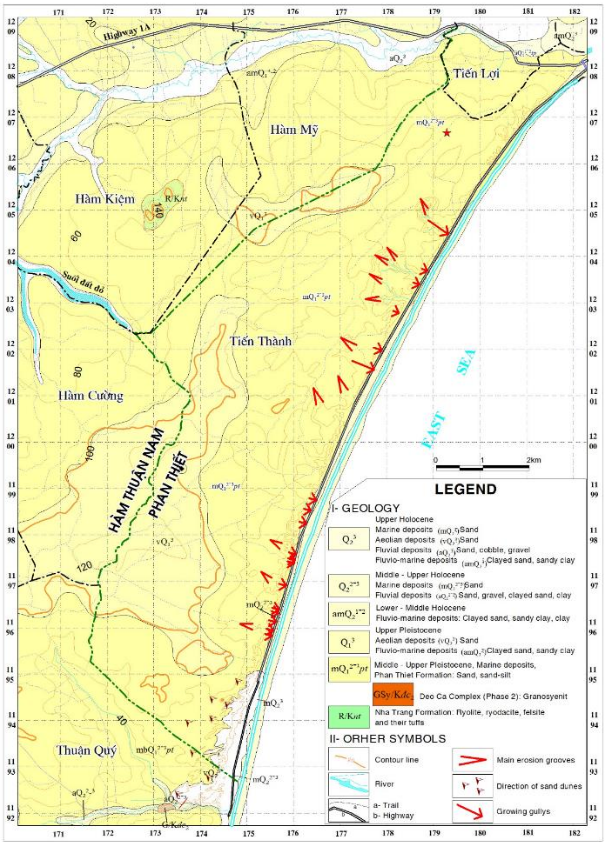

Figure 7. Geological map of Tien Thanh area, Phan Thiet city, Binh Thuan province [13]

Physical-mechanical properties of soil

Based on the results of field surveys, sampling and testing of physical and mechanical properties of the soil types, it shows that the strata of the study area can be divided as follows:

Layer 1: Medium-grained white sand, wind origin, late Pleistocene age (vQ_1^3) distributed in a strip with ***axial latitude direction*** and a steep slope toward the continent, and a gentle slope toward the sea, with the following composition:

Diameter of particle (mm)	Very coarse	Coarse	Medium	Fine	Very fine
	2-1	1-0.5	0.5- 0.25	0.25-0.1	< 0.1
Content percentage	0-0.4	7.5-9.61	47.6-55.7	31.3-36.68	5.1-6.11

Some basic physical and mechanical properties are as follows: natural moisture W=6.52-8.68%, natural density γ_w=1.53-1.54g/cm^3, dry density γ_d=1.41-1.45g/cm^3, specific weight γ_s=2.65-2.66g/cm^3, void ratio e=0.83-0.89, porosity n=45.44-47.07%, dry angle of repose α_d=35-37^o, wet angle of repose α_w=22-24^o, cohesion C=0.04-0.08kG/cm^2, internal friction angle φ=21^{o}15'-23^{o}41', permeability coefficient K=1.92×10^{-2}cm/s.

Layer 2: Small red-grained sand, marine origin, middle-late Pleistocene (mbQ_1^{2-3}*pt*) widely distributed in the study area as a stretch of hills, including the following composition:

Diameter of particle (mm)	Very coarse	Coarse	Medium	Fine	Very fine
	2-1	1-0.5	0.5-0.25	0.25-0.1	< 0.1
Content percentage	0.02-0.06	2.85-4.01	24.46-33.15	58.28-65.7	5.7-5.77

Some basic physical and mechanical properties are as follows: natural moisture W=6.90-12.45%, natural density γ_w=1.53-1.68g/cm^3, dry density γ_d=1.43-1.49g/cm^3, specific gravity γ_s=2.64-2.65g/cm^3, void ratio e=0.77-0.86, porosity n=43.44-46.16%, dry angle of repose α_d=37-38^o, wet angle of repose α_w=24-25^o, cohesion C=0.05-0.11kG/cm^2, internal friction angle φ=20^{o}13'-22^{o}25', permeability coefficient K= 1.22×10^{-3}cm/s, complete disintegration rate 15s.

Climate

Tien Thanh area, Phan Thiet City, Binh Thuan Province is located in the sub-equatorial tropical monsoon climate, divided into two distinct seasons: rainy season lasts from May to October and dry season lasts longer, from November to April next year. According to the annual rainfall statistics at Phan Thiet station for the past five years (2015-2019) [9] shown in Table 2: the average annual rainfall is 736.2-1322.7mm. Rainfall is mainly concentrated in the rainy season, averaging 709.4-1110.5mm. This is a decisive factor for the generation and development of the sand flood disaster.

Table 2. Monthly rainfall from 2015 to 2019 (Phan Thiet station*)*

Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	-	-	-	-	66.5	159	201	80.5	145	165	7.6	72
2016	-	-	-	1.1	254	144	187	122	97.5	306	70.1	141
2017	40,7	0,4	-	17.5	44.7	73.3	159	149	98.3	275	63.6	5.3
2018	1.9	-	0.5	-	28.2	131	152	204	258	121	145	15.2
2019	8.8	1.2	0.5	16.3	66.5	106	187	166	182	1.9	-	-

3.2.2. Causes

The analysis of the current state, topographic characteristics, geology, engineering geology, economic activities of the people ... allows the authors to make an opinion on the causes of the sand flood:

1- Indiscriminate deforestation, unreasonable agricultural practices, human travel ... accidentally lose the vegetation cover and create small eroded ditches (shallow trenches) on the surface of the hilly sand area, which is favorable for erosion along the stream during the rainy periods, gradually grows larger, forming erosion ravines and ditches.

Figure 8. Small erosion trenches (shallow trenches) developing on the surface of the dune area. The photo was taken in the area of Tien Hoa village

2- The nature of the red sand formation: the main composition is small-grained sand containing few dust particles, high porosity, loose state, the permeability coefficient is much smaller than that of white sand (vQ_1^3), which very easily dissolve in water. Therefore, in the rainy period, in the condition of the steep slope of a large sand slope (40-90^o), this red sand formation tends to form a flood of sand, with a large density and very strong destructive power, which buries houses, roads... damages construction works, causes damage to people and property.

Figure 9a: Soil sample before the experiment

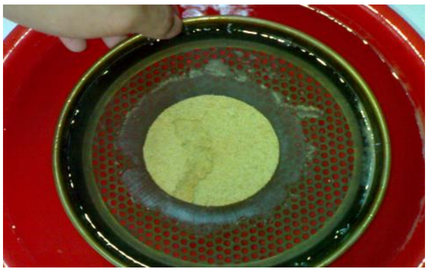

Figure 9b: Soil sample begins to soak in water

Figure 9c: Soil dissolve in water

Figure 9d: The soil sample completely disintegrated after 15 seconds

3.3. Proposing solutions to prevent sand flood

3.3.1. Base proposition

To orient solutions for sand flood prevention in Tien Thanh area, the authors rely on the following bases:

- Results of analysis of the erosion - sand flood current state;

- Features of nature, topography, geology, hydrogeology, engineering geology ...

- Objective of the project: prevent sand flood, create tourist landscape, socio-economic sustainable development.

3.3.2. Solutions to prevent sand flood

Based on the study of current status characteristics, topography, geomorphology, vegetation cover, population distribution, geology, engineering geology, hydrogeology..., these initial solutions are proposed to prevent sand floods:

1- Ground filling and lowering combined with sand exploitation to create land fund

To lower the foundation, reduce the terrain slope, create a land fund to establish a residential area or invest in the development of resorts, ecotourism ... and exploit a reasonable amount of sand, which meets the demand of local materials for ground filling.

2- Create a regulating system for surface flow and drainage

Create a system to regulate the surface flow and drain water in a natural direction to limit or eliminate the necessary conditions for the occurrence of sand floods in the rainy periods.

3- Reinforce the bottom and wall of the ditch

Reinforcing, building construction systems in critical places (bottom and wall of erosion ditches) by lowering terraced reinforcements in strongly eroded areas, creating favorable conditions for reinforcement, planting trees to cover the surface.

4- Stabilization, resettlement for residents

- Stabilize concentrated residential areas with relatively good infrastructure, do not need to be relocated, continue to develop in the long term, in-situ resettlement.

- In scattered and sparsely populated areas, they will be relocated, and resettled, focusing on new residential areas after reinforcements and loading backfilling materials.

5- Planning for socio-economic sustainable development

Re-planning the use of the land fund to suit the socio-economic development conditions of the region; paying special attention to calling for investment in the construction of residential areas, resorts and eco-tourism areas...; at the same time focusing on planting trees, greening the white areas to ensure economic development, creating a cover to prevent erosion and water retention; also creating a natural landscape and environment.

4. Conclusion

From the results presented above, some conclusions can be drawn as follows:

Sand flood catastrophe in Tien Thanh area, Phan Thiet City, Binh Thuan Province arises and develops under certain conditions, occurs more or less with a rule: only occurs on the formation of red sand of the Phan Thiet strata ($mbQ_1^{2\text{-}3}pt$) (Stratigraphy Law) and occurs very strongly in June, July, August and September. This is also the rainy period of the year (The cycle law).

It is necessary to have solutions to prevent sand floods in this area based on the aggregation of research results, analysis of the current state of erosion - sand flood, natural features, topography, topography, geology, hydrogeology, engineering geology... with the goal of both preventing sand floods, creating a tourist landscape and socio-economic sustainable development.

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Characteristics and Exploitation Reserves of Hot Mineral Water at Nkns Borehole, Bao Yen Commune, Thanh Thuy District, Phu Tho Province

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Abstract: The source of hot mineral water at NKNS borehole has good quality that can be used for many different purposes. Mineral water originates from deep ground, accumulating and distributing in forous sediment formations. The results of research and experiment show that the hot mineral water in the area of NKNS borehole is distributed at a depth of 27.5 to 70m, located in the Pleistocene aquifer (qp). Mineral water belongs to pressurized water, the static water level at NKNS is 4.87m. Research results through pumping tests shows that the borehole has quite abundant exploitation reserves, the total exploitation reserve is 1,070.50 m^3/day, of which grade B reserve is 704.16 m^3/day and grade C_1 reserve is 366.34 m^3/day. The value of water drawdown reaches 5.21m when sucking water with a flow of 704m^3/day. With 86 analyzed mineral water samples, it shows that the water quality is stable over time, which can be used for drinking, bathing, and ecotourism. The type of mineral water identified is Sulfate-Sodium, hot. The cluster water absorption experiment shows that mineral water has no hydraulic relationship with groundwater in the upper aquifer (qh). This is a valuable mineral water source that needs to be exploited and used effectively

Keywords: Ngoc Son, hot mineral water, reserve exploitation

1. Introduction

Thanh Thuy district area, Phu Tho province is blessed with hot mineral water over a wide range [3,7,8,9] Ngoc Son mineral water source is part of a large mine, distributed in Ngoc Son commune, which is being researched, invested, exploited and used. This is a source of hot mineral water with good quality and large reserve, so it needs to be researched, evaluated and exploited for social life

The study of Ngoc Son mineral water source in order to clarify the distribution characteristics, quality, and reserves of mineral water serving the assessment and classification of quantity for exploitation, rational and sustainable use is important and very necessary.

2. Research Methods

To elucidate the characteristics of quality, reserve, and reserve classification for rational exploitation, the author collective has used the following research methods

- Method of field survey: Conduct geological and hydrogeological research survey in the area of 2km^2
- Drilling method: Drill 01 exploratory well combined with hot mineral water exploitation (NKNS). Studying soil and rock composition, water level monitoring, experimental water

absorption, water samples in boreholes. Drilling 01 borehole for water monitoring in qh aquifer. Absorb water beam at this borehole beam (Boreholes NKNS and LKQS). Suction 3 times to lower the water level with the volume of 45 cases/3 times and suck the experimental exploitation (trial exploitation 540ca)

- Method of water pumping tests: Conduct water pumping tests with 3 times of water drawdown, each period lasted 15 machine shifts. After the end of water pumping test in each period, measure the water level recovery. Measure immediately after stopping the pump until the water level reaches its initial state. Take water samples during water pumping tests to demonstrate the stability of the ingredients in the mineral water
- Collecting and analyzing samples of all kinds: 86 samples with periods of water pumping tests, trial exploitation, and monitering of mineral water dynamics. Sample analysis of components to evaluate according to drinking water standards, identification of mineral water, classification of mineral water
- Methods of synthesis and evaluation: Conduct analysis of drill core samples to study stratigraphy, assess the level of storage, water separation by stratigraphy. Evaluate mineral water distribution according to drilling documents. Design structures of mineral water exploitation wells.

3. Results and Discussion

3.1 Geographical location

- The mineral water mine is located on a flat area belonging to the alluvial Da river. Surrounding the mine are low and gentle hills with absolute heights from 65m to 150m. To the east of the mine site is the Da River dyke running in the northwest-southeast direction with a height of about 3m above the mine site (see Figure 1). Borehole coordinates NKNS: X= 2339348; Y= 529052 [1]

Figure 1. Water borehole location mineral NKNS

3.2 Quality of mineral water according to mineral water identification standards

To evaluate the quality of Ngoc Son mineral water, we sampled, analyzed and compared the ingredients in mineral water with the regulations on mineral water identification standards according to Circular 52/2014/BTNMT. Accordingly, for an underground water source to be classified as mineral water, it must contain one or more of the 12 components shown in Table 1 below.

Table 1. The criteria for identifying mineral water

No.	Criteria	Content	Name
1	Total dissolved solids TDS	< 50 mg/l ≥ 50 - 500 mg/l > 500 - 1500 mg/l > 1500 mg/l	Very low mineralization water Low mineralized water Medium mineralized water Highly mineralized water
2	Free (dissolved) CO2	≥ 500 mg/l	Carbonic mineral water
3	Total content (H_2S + HS^-)	≥ 1 mg/l	Sulfur mineral water
4	($H_2SiO_3^+$) Content	≥ 50 mg/l	Silica mineral water
5	(Fe^{2+} + Fe^{3+}) Content	≥ 10 mg/l	Iron mineral water
6	(F^-) Content	≥ 1,5 mg/l	Fluorine mineral water
7	Asen (As^-) Content	≥ 0,7 mg/l	Arsenic mineral water
8	Brom (Br^-) Content	≥ 5 mg/l	Bromine mineral water
9	Iod (I^-) Content	≥ 1 mg/l	Iodine mineral water
10	Radon (Rn) Content	> 1 nCi/l	Radon mineral water
11	Radi (Ra) Content	> 10^{-11} g/l	Radium mineral water
12	Temperature	≥ 30°C	Hot water

(Source: Circular 52/2014/TT-BTNMT)

Comparing the analysis results of water samples at Ngoc Son mineral water borehole (NKNS) with the standards in Table 1 gives the results in Table 2

Table 2. Results of analysis and assessment of mineral water identification, borehole NKNS

No.	Targets	Unit	Minimum content	Results of analysis (Min-Max) Average	Assessment
1	Mineralization (for water without specific elements)	mg/l	< 50 ≥ 50 - 500 > 500-15000 > 1500	2630-2768 2737	Meets high mineralized water standards
2	Free (dissolved) carbon dioxide	mg/l	500	134-136 135	Not meet high mineralized water standards
3	Total Hydrogen Sulfur (H2S + HS)	mg/l	1	KPH	Not meet high mineralized water standards
4	Axit metasilic (H_2SiO_3)	mg/l	50	38,23-39,78	Not meet high mineralized

No.	Targets	Unit	Minimum content	Results of analysis (Min-Max) Average	Assessment
				39,17	water standards
5	Total iron ($Fe^{2+} + Fe^{3+}$)	mg/l	10	0,098-0,160 0.126	Not meet high mineralized water standards
6	Fluorid (F^-) Content	mg/l	2	KPH	Not meet high mineralized water standards
7	Arsenic Content	mg/l	0,7	KPH	Not meet high mineralized water standards
8	Bromine content (Br)	mg/l	5	KPH	Not meet high mineralized water standards
9	Iodine content (I-)	mg/l	1	KPH	Not meet high mineralized water standards
10	Radon content (Rn)	nCi/l	1	0,0010-0,0022 0,0015	Not meet high mineralized water standards
11	Content of Radi (Ra)	g/l	$> 10^{-11}$	KPH	Not meet high mineralized water standards
12	Temperature (for water without specific elements)	ºC	30	38,9-39,1 39,0	Meet high mineralized water standards

Thus, according to Table 2, the water at the NKNS borehole has 2 specific components: mineralization (2630-2768mg/l) and temperature (38.9-39.1 ºC). From the results of sample analysis, the Curlov formula was established and Ngoc Son mineral water was identified as hot, highly mineralized natural mineral water. Curlov's formula has the form:

$$M_{2,6}\frac{SO_{74}^{4}Cl_{20}}{Ca_{64}Na_{20}Mg_{16}}pH_{7,0}T_{39}$$

3.3 Evaluation of mineral water quality according to bottled natural mineral water standards

To evaluate the quality of mineral water according to the criteria of bottled mineral water for drinking, we base ourselves on the National Technical Regulations on natural mineral water and bottled water QCVN 6-1:2010/BYT issued together with the Circular No. 34/2010/TT-BYT issued on June 2, 2010, effective January 1, 2011

Based on the analysis results, when compared with the Bottled Mineral Water Standards, it shows that the quality of the water source is quite good, the analytical criteria are in accordance with the regulations, Table 3

Table 3. Results of quality assessment of mineral water according to Standard QCVN 6-1: 2010/BYT

No.	Analysed targets	Unit	Limit	Results of analysis (Min-Max) Average	Assessment
1	Antimony (Sb) Content	mg/L	0.005	KPH	Meet the standard
2	Arsenic Content (As)	mg/L	0.01	KPH	Meet the standard
3	Bari Content (Ba)	mg/L	0.7	KPH	Meet the standard
4	Borat Content (B)	mg/L	5	KPH	Meet the standard
5	Cadmi Content (Cd)	mg/L	0.003	KPH	Meet the standard
6	Crom Content (Cr)	mg/L	0.05	KPH	Meet the standard
7	Copper Content (Cu)	mg/L	1	KPH	Meet the standard
8	Xyanid Content (CN)	mg/L	0.07	KPH	Meet the standard
9	Fluorid Content (F^-)	mg/L	-	KPH	Meet the standard
10	Lead Content (Pb)	mg/L	0.01	KPH	Meet the standard
11	Manganium Content (Mn)	mg/L	0.4	KPH	Meet the standard
12	Mercury Content (Hg)	mg/L	0.001	KPH	Meet the standard
13	Nickel Content (Ni)	mg/L	0.02	KPH	Meet the standard
14	Nitrat Content (NO_3^- - N)	mg/L	50	2,96-3,60 3,25	Meet the standard

No.	Analysed targets	Unit	Limit	Results of analysis (Min-Max) Average	Assessment
15	Nitrit Content (NO_2^- - N)	mg/L	0.1	KPH	Meet the standard
16	Selen Content (Se)	mg/L	0.01	KPH	Meet the standard
17	Surfactant content	mg/L	KPH	KPH	Meet the standard
18	Phosphorus pesticide residues	µg/L	KPH	KPH	Meet the standard
19	Chlor pesticide residues	µg/L	KPH	KPH	Meet the standard
20	PCB Content	µg/L	KPH	KPH	Meet the standard
21	Mineral oil content	mg/L	KPH	KPH	Meet the standard
22	Polycyclic hydrocarbons	µg/L	KPH	KPH	Meet the standard
25	Streptococci Feacal	CFU/250ml	0	KPH	Meet the standard
26	Pseudomonas aeruginosa	CFU/250ml	0	KPH	Meet the standard
27	Spores of sulfite-reducing anaerobic bacteria	CFU/50ml	0	KPH	Meet the standard

From the results of analysis of mineral water quality compared with Standard QCVN 6-1:2010/BYT, most of the indicators are within the allowable limits. Therefore, the quality of Ngoc Son hot mineral water is completely satisfactory for bottling purposes

3.4. Evaluation of mineral water quality according to relaxing bathing standard

This assessment is based on the solute composition and temperature of the water. According to the data of exploration and dynamic monitoring, it shows that in mineral water, TDS is quite high (>1.5 g/l) and the temperature is very suitable for relaxing bathing (38-39.5oC). The results of quality assessment of mineral water according to the standard of bathing water are shown in Table 4.

Table 4. Mineral water ingredients for relaxing bathing

No.	Targets	Unit	Results of analysis (Min-Max) Average
1	TDS	mg/L	2.630-2.768 2737
2	Radon (Rn)	nCi/l	0,0010-0,0022 0,0015
3	Nhiệt độ Temperature	ºC	38,9-39,1 39,0

Due to the warm temperature (39.5oC), high total mineralization, Ngoc Son mineral water source is a precious mineral water, suitable for bathing, soaking and restoring health.

3.5. Determination of the hydrogeological parameters of the mine

Mineral water in Ngoc Son area belongs to pressurized water. Therefore, hydrogeological parameters are determined according to Theis - Jacob formula by time tracking method. Based on water pumping test data, draw a graph to show the relationship between the drawdown value S with time according to the relationships S-lgt; S-lg(t/T+t)

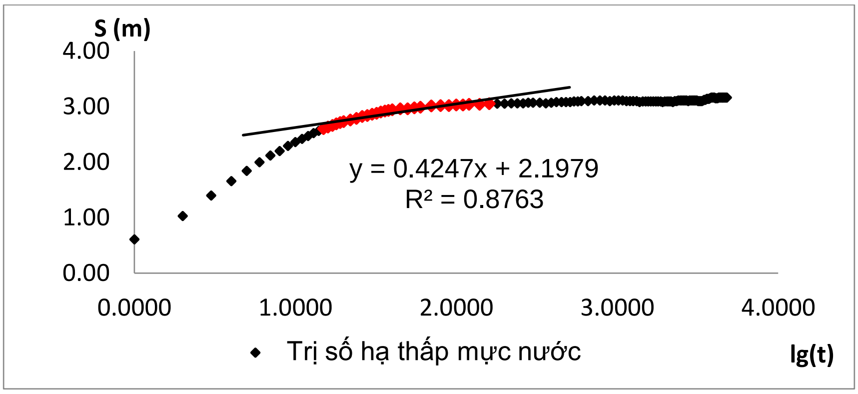

Figure 2. Graph showing the S-lgt relationship, period 1, borehole NKNS

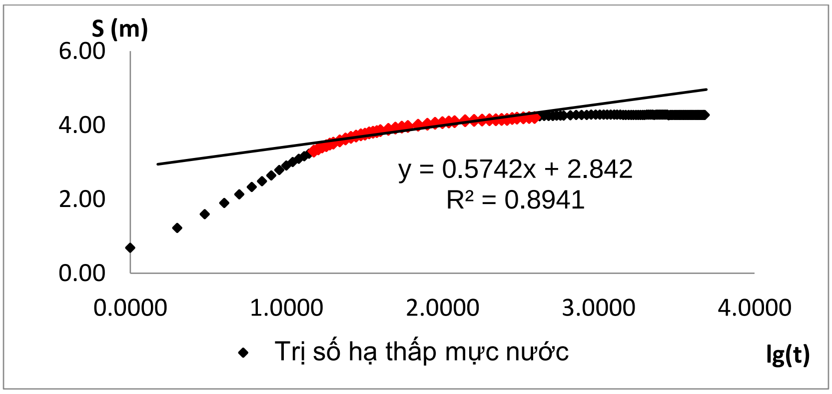

Figure 3. Graph showing the S-lgt relationship, period 2, borehole NKNS

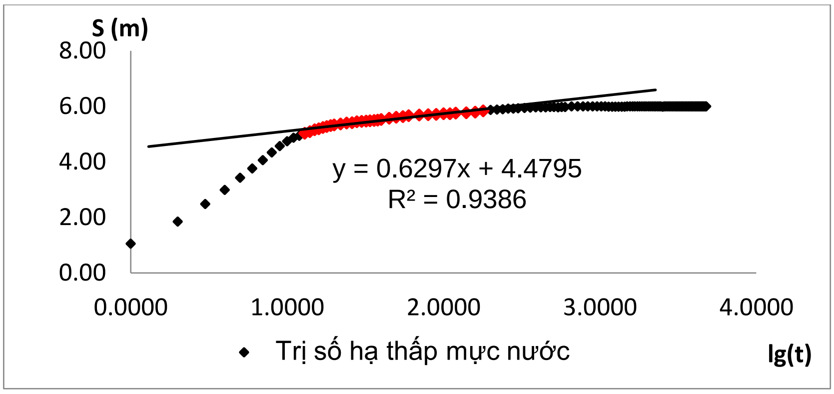

Figure 4. Graph showing the S-lgt relationship, period 3, borehole NKNS

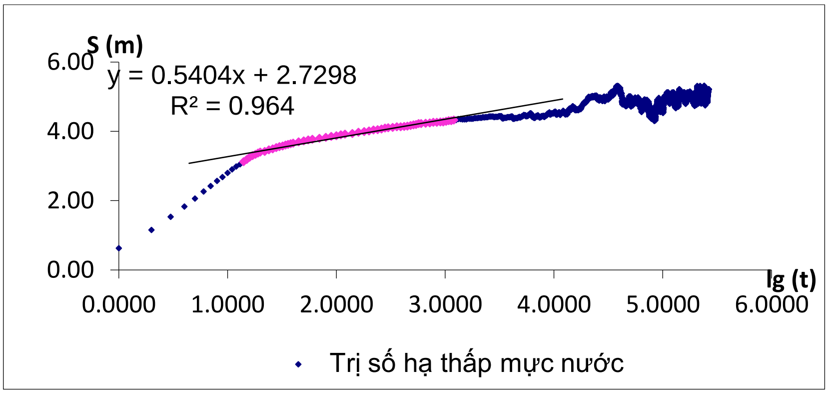

Figure 5. Graph showing the S-lgt relationship, trial period, borehole NKNS

The calculated aquifer parameters including the water conductivity coefficient (Km) and the permeability coefficient K are determined by data of water pumping test in the field and shown in Table 5 below.

Table 5. Calculation results of Km parameters according to experimental data in the field [2,3,4,10]

No	Pumping periods	Equation of relationship	R^2	Km (m^2/ng)	K (m/ng)
1	1st water pumping	y = 0,4247x + 2,1979	0.8763	242	5.69
2	2nd water pumping	y = 0,5742x + 2,842	0,8941	226	5.31
3	3rd water pumping	y = 0,6297x + 4,4795	0,9386	241	5.68
4	Water pumping for trial exploitation	S = 0,3636 lgt + 3,0844	0,964	238	5.61
	Average			**236,88**	**5,57**

(Note: the aquifer thickness is from 27.5m to 70m)

From the results of the parameter calculation, the following comments are drawn:

- The correlation between time t and water drawdown value S (or water level rise value S*) is very close.

- The results of parameter calculation (Km and K) according to the water pumping test data are quite stable through water pumping tests. That shows that the results of water pumping are reliable and the use of calculation parameters and reserve evaluation ensures accuracy

- The value of water conductivity selected for calculation is the average value of the water pumping test periods and trial exploitation, so Km = 236.88 m^2/day

3.6. Determination of the allowable water drawdown value

According to expertise in hydrogeology, mineral water is distributed under pressure, so the allowable water drawdown is calculated by the formula.

$$Hcp = \Delta H + 1/3m \quad (1)$$

Hcp: Allowable water level when exploiting mineral water in the works

ΔH: is the difference between the still water level and the roof of the aquifer, (m)

m: Thickness of aquifer (m

Research results have determined stratigraphy and water level documents at the NKNS borehole as follows: static water level is 4.87m; aquifer roof at borehole NKNS is 27.5 m, bottom of aquifer: 70.0m. Therefore, allowable water drawdown at NKNS borehole is:

$$Scp= 27.5 - 4.87 + (70.0 - 27.5)/3 = 36.79m$$

On the other hand, according to Decree 167/2018/ND-CP dated December 26, 2018 stipulating, allowable water drawdown value of exploiting water sites outside the large urban is: Scp = 30m

Summarizing professional and management regulations (Decree 167/2018/ND-CP), the allowable water drawdown value at NKNS borehole will be 30m

3.6.1. Calculation of the water drawdown value according to data of the water pumping test (trial exploitation)

The water drawdown value at the exploitation sites is determined according to equation of relationship between the water drawdown value (S) and the water pumping time (t). From the data of water pumping test in the fields, this relationship can be determined as S = ax +b [6,10]. Results of water pumping test (trial exploitation), the relationship between water drawdown value and time is dertermined: S = 0.3636 lgt + 3.0844. Therefore, if the site continues to be exploited with a flow rate of 8.15 l/s, after 30 years the value of water drawdown at the borehole NKNS will be determined as: S = 0.3636 * Lg (30*) 365*24*60) + 3.0844 = 5.70m

Comparing the calculated value S=5.7m with the allowable water drawdown value of 30m, it is much smaller (5.7m<<30m). At the end of the exploitation period, the dynamic water level in the borehole has not yet reached the aquifer roof. Thus, exploiting reserves are guaranteed.

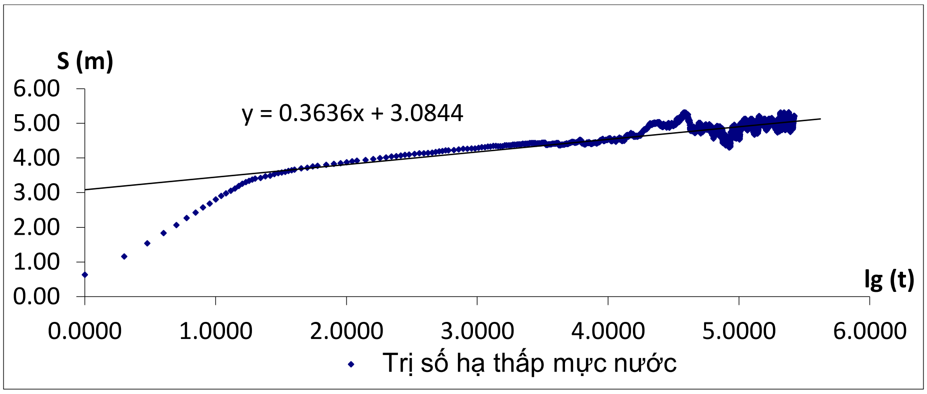

Figure 6. Graph showing the relationship S - lg(t), water pumping for trial exploitation

3.6.2. Evaluation of exploitation reserves according to data of water pumping test with 3 times of water drawdown

Data of water pumping test with 3 times of water drawdown is summarized in Table 6 below

Table 6. Summary of water pumping test with 3 times of water drawdown at borehole NKNS

SHLK	LHL	S (m)	Q (l/s)	S_0=S/Q	lgQ	lgS
NKNS	1	3,16	6,50	0,49	0,81	0,50
	2	4,28	8,20	0,52	0,91	0,63
	3	6,00	9,61	0,62	0,98	0,72

Based on the results shown in Table 6, draw a graph of the relationship between the water drawdown value and the discharge. The graphs are shown in Figure 7 as follows:

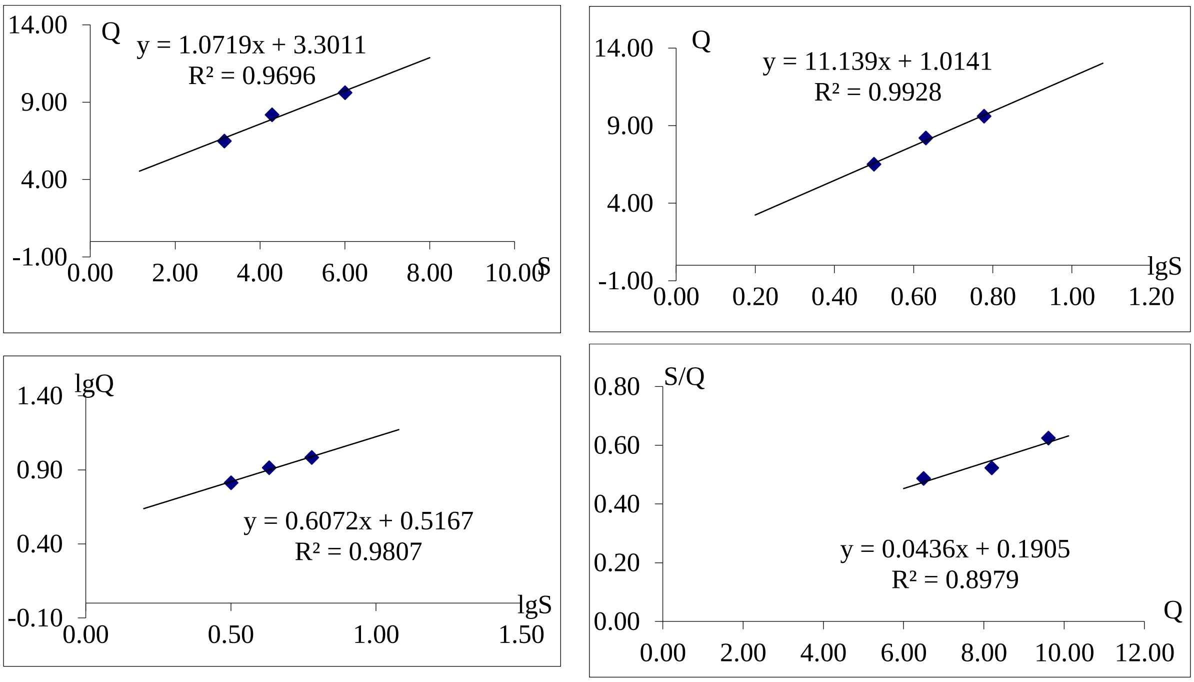

Figure 7. Graph showing the relationship between flow rate and water drawdown value according to the data of pumping with 3 times of water drawdown.

The results determined by the flow curve method are summarized in Table 7. The method with the largest regression coefficient will be the most suitable equation for the NKNS borehole.

Table 7. Summary of calculation results of flow curves at borehole NKNS

No.	Relationship	Function form	Regression coefficient R^2
1	Duipuit	Q = 1,0719S +3,3011	0,9696
2	Altovxki	Q = 11,139lgS + 1,0141	0,9928
3	Smerker	LgQ = 0,6072lgS + 0,5167	0,9807
4	Keller	S_0 = 0,0436Q + 0,1905	0,8979

From the above graphs, we can determine the relationship between discharge and water drawdown value according to Altovxki's relationship (Q = a + blgS) [3,5]

$$Q = 11,139lgS + 1.0141 \qquad (2)$$

To calculate the theoretical exploitation reserve, we can take SKT = (1.75 ÷ 2) Smax [3,4,5,10], where Smax is the greatest value of water drawdown when pumping water. In order to increase the safety for exploitation, we choose the value of water drawdown at the end of the exploitation period SKT = 1.75 Smax¬¬. Thus, Skt at the boreholes is determined as: Skt = 6.0 x 1.75 = 10.5 m

Substituting the values into formula (2), we can determine the exploitation flow at the borehole as: NKNS is 12.39l/s or 1,070.50 m^3/day.

3.6.3. Decentralization of exploitation reserves

To decentralize exploitation reserves, we base on experimental exploitation flow and extrapolated flow according to established water drawdown curve equation (Equation 2 above). Accordingly, we calculate and rank mineral water reserves as follows:

Grade B reserves: Equal to long-term trial (experimental exploitation) reserves [3,8,9] at the NKNS borehole with a flow rate of 8.15 l/s or 704.16 m^3/day.

C_1-grade reserves: C_1-grade reserves are determined by the difference between the calculated maximum water intake volume (QKT) minus the grade B discharge. From the above calculation results, the exploited reserves can be determined at borehole NKNS is 12.39 l/s or 1,070.50 m^3/day. Therefore, the reserve of grade C_1 is C_1 = 1,070.42 – 704.16 = 366.34 m^3/day.

From there, we suggest to rank the reserves as follows: Class B: 704.16 m3/day and C_1: 366.34 m^3/day.

4. Conclusion

Ngoc Son mineral water is a valuable water source with good quality and abundant reserves. Research results have initially clarified the quality and exploitation reserves at the NKNS borehole. Mineral water is formed from deep sedimentary layers following tectonic faults, penetrating holes in loose rock and stored in alluvial sediments, forming pressurized mineral water fungi.

Mineral water at Ngoc Son borehole (NKNS) is identified as hot, highly mineralized natural mineral water

Exploiting reserves at NKNS borehole are calculated reliably and classified as follows: Grade B reserves: 704.16 m^3/day; Reserve level C1: 366.34 m^3/day

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A GIS-Based approach for the sustainable management of livestock effluents at Cam Lam district, Khanh Hoa province

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Abstract

Sustainable livestock effluent management is becoming an increasingly important issue in Cam Lam district of Khanh Hoa province, with particular regard to the agro-environmental performance of forage production and the social acceptability of organic fertilizer application in mixed urban-rural contexts. The present paper proposes a GIS-based methodological approach to the management and planning of digestate spreading on hay meadows, based on the integration of spatio-functional database about cultivated agricultural land. The proposed methodology was tested in Cam Lam district, with pig 78 farms. Environmental parameters of TSS, BOD_5, COD, nitrogen production by pig was quantified and compared to sustainable requirements provided by national and local regulations were spatially implemented. Findings are transferrable to other regions based on cattle farming management.

Keywords: livestock effluents, organic fertilization, pollution, Cam Lam district, Khanh Hoa province.

1. Introduction

The economy of Cam Lam district is based on agriculture, light industry, tourism and livestock farming, which ensures the attractiveness of urban-rural territories by providing high quality traditional dairy products and maintaining typical, bio-diverse cultivated landscapes. One of the main critical issues in study area related to the co-existence of animal husbandry and other human activities, especially tourism, is the odor impact of livestock breeding and effluent spreading. National and local legislation provide spreading restrictions in order to minimize the odor emissions of organic fertilization, but issues persist.

Considering the small size of livestock farms in Cam Lam district, anaerobic digestion plants have to be planned, constructed and run by several farms together, grouped in cooperatives or enterprise networks. This is necessary not only to take advantage of economies of scale, but also to tackle odor issues at a larger level. In addition, creating multiple-farm cooperation in livestock effluent management represents a chance to address the sustainable use of organic fertilizers in the area (Peratoner et al., 2010).

The overall objective of the present study is to provide livestock farms operating in alpine environments with innovative tools for a sustainable use of livestock effluents. The methodological approach proposed, based on GIS tools, was developed on Microsoft Access database for Cam Lam district but it is transferrable to any other similar context with urban-rural economies built on livestock farming.

2. Materials and methods

a. Data collection through farm surveys

As required by national and local legislation, data collected through direct on-farm survey, regarding in particular farm size and composition, were used to calculate TSS, BOD_5, COD and nitrogen production. Initial data about herd size, herd composition, housing system and current effluent management were collected through farm surveys, in order to quantify housing related environmental parameters produced by each farm on a yearly basis. Standard field values provided by national legislation were applied.

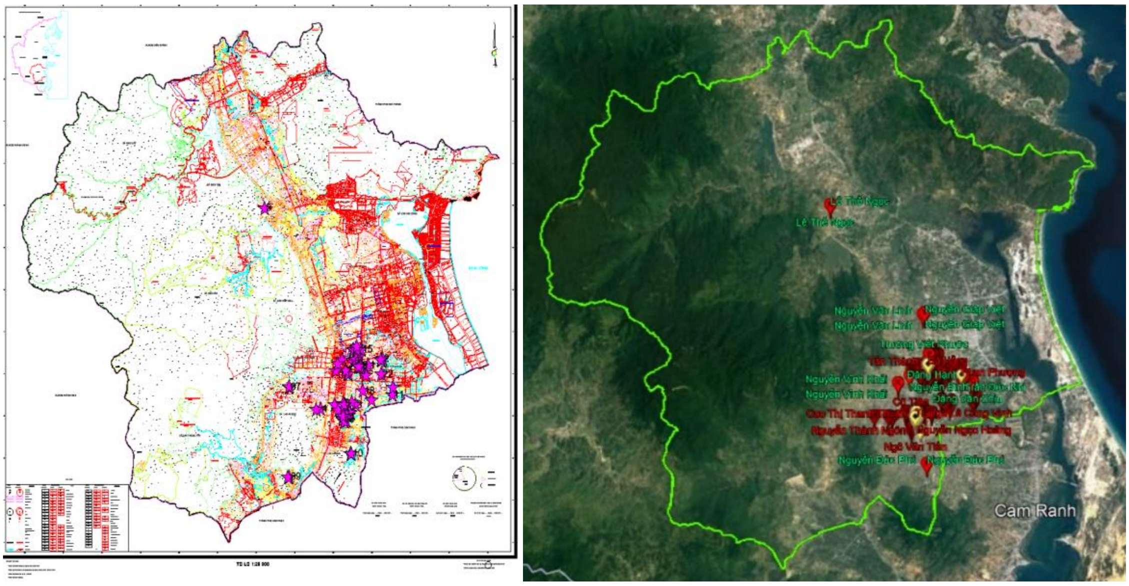


Figure 1. Location of 87 pig farms in study area

b. GIS-Based data management framework

Dealing with spatial patterns of environmental database and potential pollution spreading requires a common data framework with spatial reference, in which existing information layers, i.e., topographic maps, infrastructure maps, cadastral maps, can be integrated with newly processed or collected data, i.e., farm plots, areas with spreading restrictions. Such framework was created for the area of interest using a GIS application of MapInfo and a database on Microsoft Access.

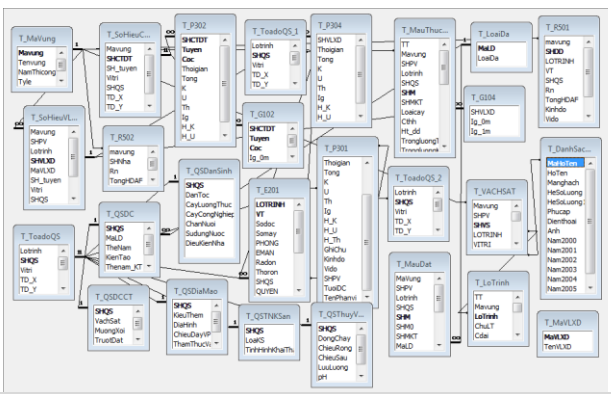


Figure 2. Relational database for environmental parameters on pig farms

One of the preliminary steps was to convert existing data into spatial layers, which contains the polygons plots cultivated by each farm, net of non-productive areas such as trees, roads and buildings, with information about the user and cultivated surface. These layers represents the base for further data collection and processing. National and local legislation define spreading restrictions for livestock effluents were also included, in order to compare and minimize the impact of organic pollution on other human activities (i.e., tourist, housing, public infrastructures) and on the environment (i.e., contamination of surface and groundwater through leaching and surface run-off).

3. Results and discussion

The 78 farms surveyed farms with slurry-based effluent management were collected in the database and the declared total number of pig was about 84.700 units. The total size of the biogas tanks is 113.805 cubic meters and settling tanks is 123.736 cubic meters. Total effluent stock capacity was equal to 237.541 cubic meters. Main environmental parameters of TSS, BOD_5, COD and nitrogen excretions are mapped for intensive pig farms in Cam Lam district and may be over-estimated when applied to more extensive farming systems in other areas in Vietnam or other countries. For instance, the data in the North Vietnam or in Italian Alps (Regione Autonoma Valle d'Aosta, 2017) have introduced lower nitrogen excretion values for local breeds.

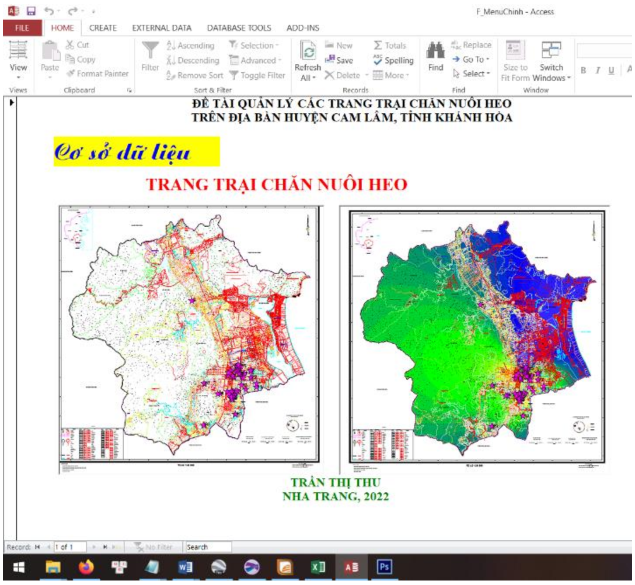
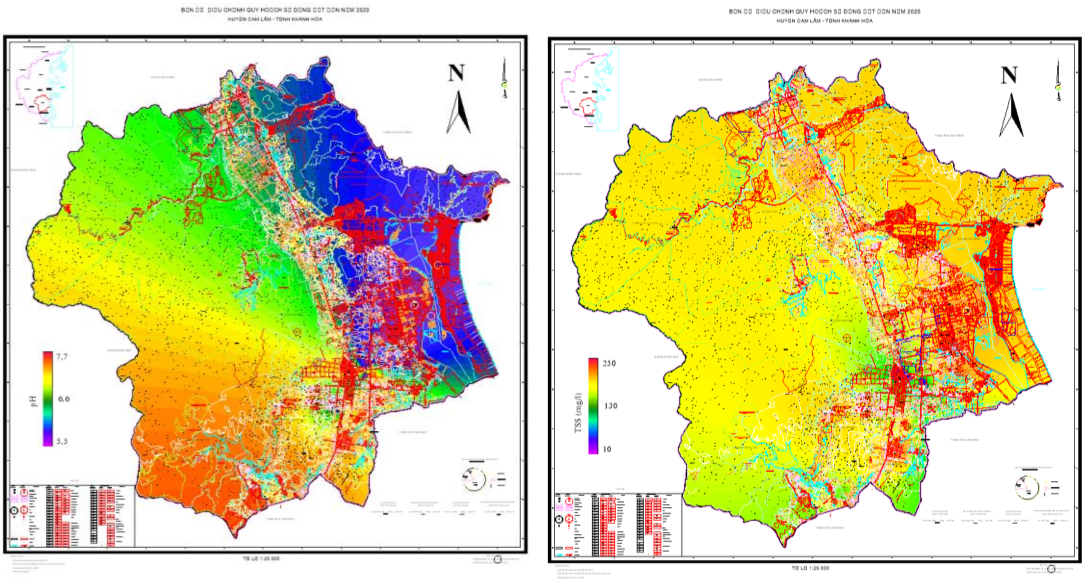


Figure 3. Management tool developed on MS Access

The effluent spreadings were cartographically implemented to identify and evaluate the portions of plots subject to limitations in organic fertilization. Figures below show cartographic detail of these implementation in study area. Pig farms are heavily concentrated in the South of Cam Lam district, therefore interpolated values on other regions are not neccesseraly corrected for mapping pollution spreading. This confirms the need to take the specificity of concentrated areas into consideration when planning normative tools for the agro-environmental management of livestock effluents.



a b

Figure 4. Maps of pH (a) and TSS (b) derived from the management database

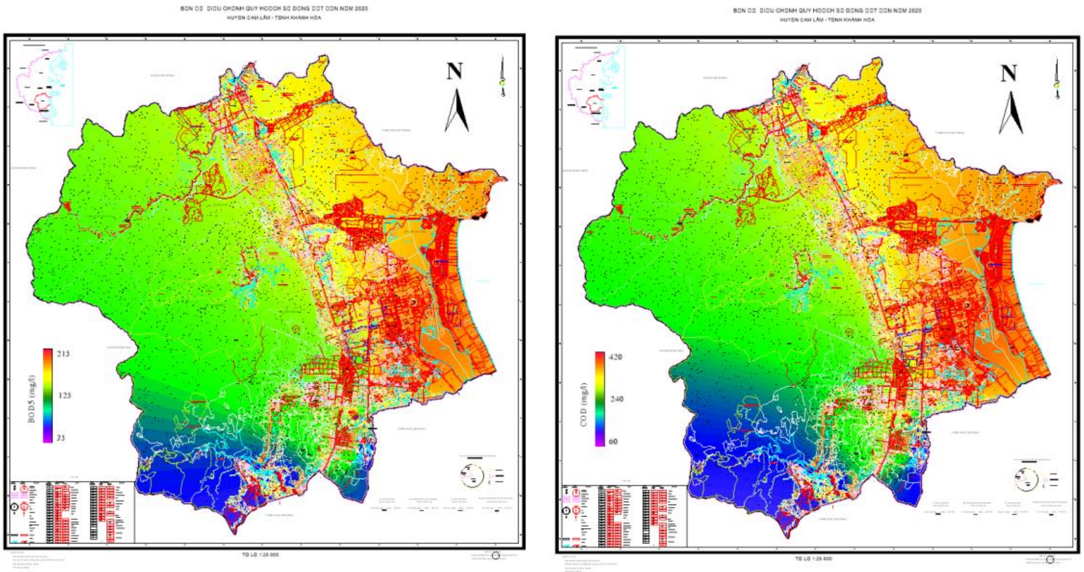


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Figure 5. Maps of BOD_5 (a) and COD (b) derived from the management database

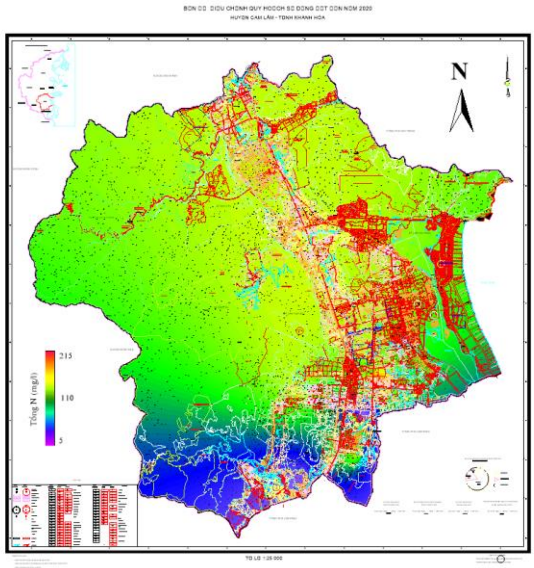

Figure 6. Maps of nitrogen production derived from the management database

Effluent spreading restrictions maps were showed in detail for the Southern part of study area in order to see the environmental impact of effluent spreading. The information layers created for this purpose might be potentially integrated in an open-access webGIS application, which helps not only the farmers but the local management agency to identify areas to pay more attention. Information about environmental parameters such as pH, TSS, BOD_5, COD or nitrogen production of each farm were used to map the dispersion of pollution in the study area. The spatial distribution patterns as well as site-specific pollution potentials could be taken into account when compared with the allowed legislation.

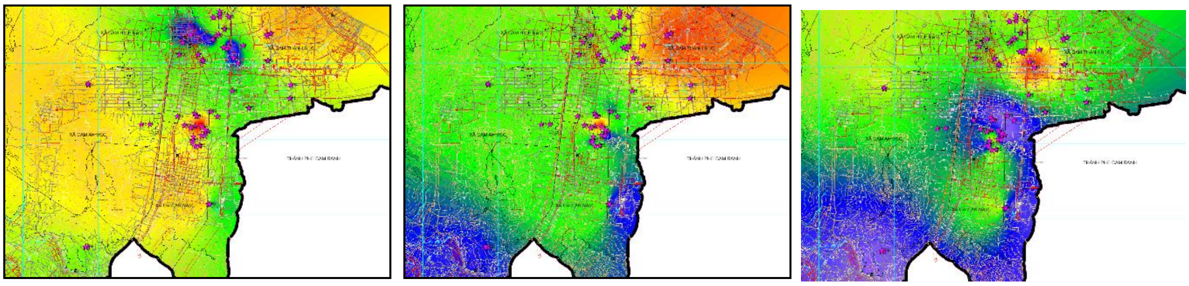

Figure 7. Close look at the Southern part of Cam Lam district for TSS (a), BOD_5 (b) and nitrogen (c)

For other regions, transferability may be limited by the lack of comprehensive, site-specific information. However, simplification of farm types integrated with literature data about pollution potentials still allows method implementation, even if with a larger degree of approximation. The developed dataset can also helps to quantify the sustainable digestate volume per operation and runoff risk potential.

4. Conclusion

The methodological approach proposed in the present study allows to tackle the issue of animal effluent spreading in Cam Lam district of Khanh Hoa province, with a specific focus on the environmental aspect of pig farms. Data collected on-site were spatialized and integrated with existing geographic information layers, in order to develop new management and planning tools which are transferable to livestock farmers and help them adjust effluent spreadings and pollution patterns as well as to the potential risk of surface runoff. The case study of Cam Lam district allowed to test a new methodological approach, delivering usable results for the agronomic utilization of digestate in seven 78 farms in an urban-rural context. The methodological procedure as well as findings about the potential pollutions and effluent related surface runoff are transferrable to other regions based on livestock farming, and are also applicable for other type of farms for management in general.

To date, the present study represents the first implementation of GIS tools for the management of livestock effluents in Cam Lam area. Besides methodological aspects, one of the most important elements is the spatial scale, which enables to deliver agro-botanical and management information about pig farming at the local level of managemant. Further developments regard the implementation at a larger geographic scale and the integration of computed geo-referenced data in existing regional cartographic portals and web-GIS applications. Validation as well as monitoring of results will occur in the next 3 years during practical implementation, in order to verify the quality and effectiveness of the proposed framework.

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Comparison between ANN & DT to predict landslide susceptibility in Trung Khanh area, Cao Bang province

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1. Introduction

The main purpose of this study is to establish an effective landslide susceptibility zoning model with 12 landslide condition factors were selected as the evaluation indices to construct the susceptibility assessment model. Two machine learning algorithms for landslide susceptibility prediction (LSP) including: C4.5 Decision Tree and artificial neural network (ANN), which have been used for landslide susceptibility mapping in the Trung Khanh region of Cao Bang province, and the results were compared. Landslide areas were delimited and mapped as landslide inventory after gathering information from historical records, remote sensing detection and periodic field investigations. In the database, 87 landslides were plotted and classified into training (70%, 61 landslides) and testing (30%, 26 landslides) subsets randomly to train and validate the models. The ANN model has a higher correct prediction rate than DT, with a rate of 89.28%, and DT is 83.64%. This research might be useful in landslide studies in mountainous areas, especially in locations with comparable geophysical and climatological characteristics, to aid in decision making for land use planning.

2. Methodology and Research Data

2.1. Study Area and Landslides Inventory

Landslides are one of the most common natural hazards and when they occur, they usually cause loss of life and significant economic losses. The main type of environmental hazard in the study area is landslide. Thus with a total of 87 landslide sites has been mapped by applying the remote sensing (RS), geographic information system (GIS), and spatial data analysis method.

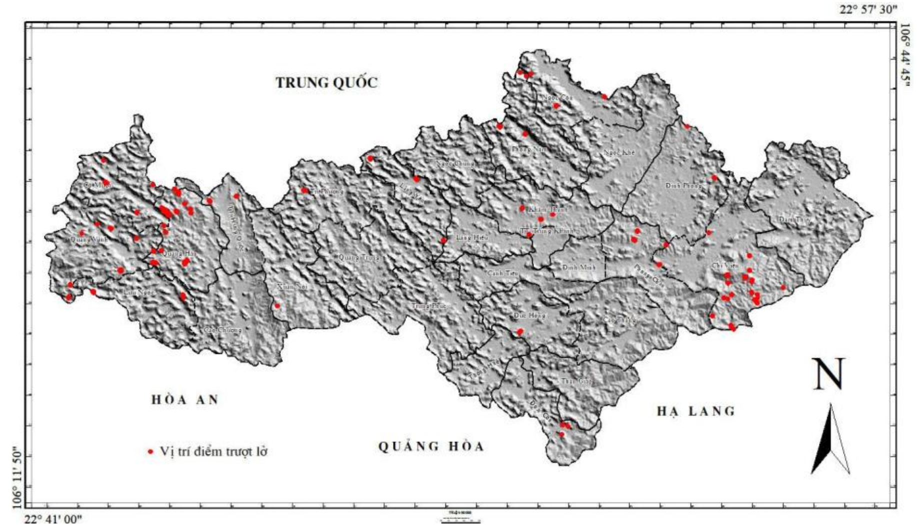


Figure 1. Overview of landslides in Trung Khanh County

The area of Trung Khanh County is about 688.01km^2 and the population is about 70,424. The study area is one of the most landslide-prone areas in Cao Bang province, one of the reasons that is karst landscape with easily leaking surface water and high soil moisture. The annual average precipitation of study area is about 1,500-2,000mm, precipitation is the major inducing factor for landslides.

2.2. Condition Factors

In this study, we collected multi-source data such as field survey data, precipitation data and remote sensing satellite data from Trung Khanh County, Cao Bang province and used the advanced big data models to construct landslide susceptibility map, and compared their performance and applicability in the study area. Landslides in the study areas are affected by many different factors, however, we give 12 most important factors, the data make the most of it to compare the susceptibility assessment landslides in the area.

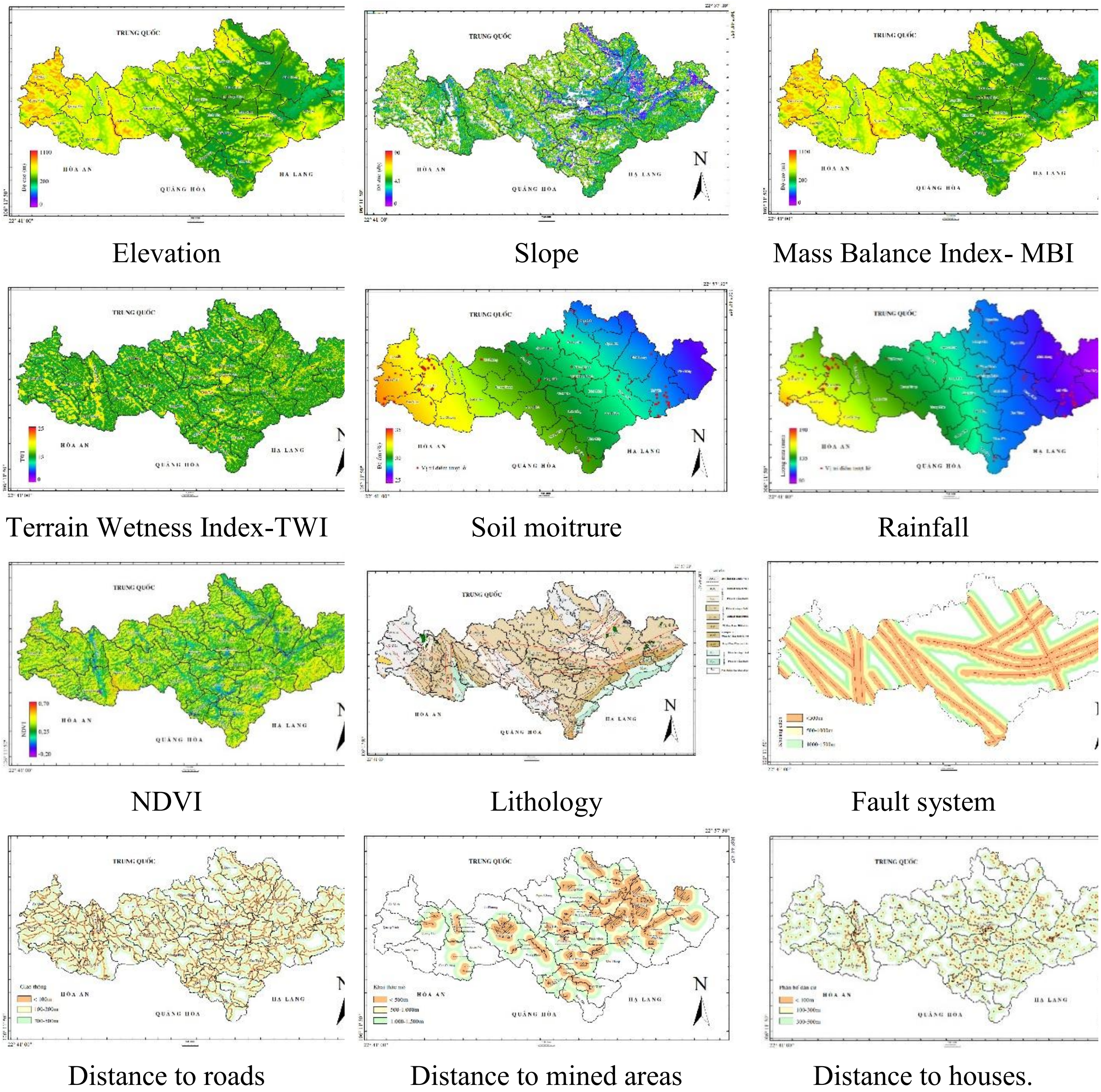


Figure 2: The 12 Landslide condition factors

Combined with multi-source, field and remote sensing data, landslide statistics were collected for 87 landslide sites. A total of 12 conditioning factors were selected based on their impact on the landslides and the data accessibility (in Figure 2). , which including: elevation, slope, TWI, MBI, lithology, fault system, soil moisture, rainfall, NDVI, distance to mined areas, distance to roads, distance to houses. The purpose of analyzing these inputs factors, it is necessary to format the DEM pixel size, they are resized to 20m × 20m. The relationship between landslide hazards and the environment was studied, and its sensitivity was classified and evaluated.

a. Methodology

Evaluation of the models, including their advantages and applicability, is important to obtain a satisfactory landslide susceptibility map. The strongest point of big data analysis methods is that the input data does not need to be normalized or created dummy variables, can use all classes of information collected by checking the statistical independence of the data. The information layer is not required. At the same time, these methods can work with both numerical data (rainfall, slope, etc.) and labeled data (rock groups, land use types, etc.) . The dataset included in the calculation consists of 11 information layers, each layer consists of 1426 pixels, of which 587 pixels of landslide locations and 839 pixels of no landslide are randomly selected over the entire study area. Due to the relatively large data source (total: 1,848,582 pixels), the research data set is divided into three data sets with a separation ratio of 70% for the training dataset to build, 15% for the cross-validation dataset and 15% for the testing dataset to check the efficiency of the computational model.

i. Artificial Neural Network (ANN)

ANN is a learning simulation model identical to the human nervous system. Neural networks consist of a large number of artificial neural connections that can be used to estimate or approximate functions. The back-propagation neural network is the most commonly used neural network architecture.

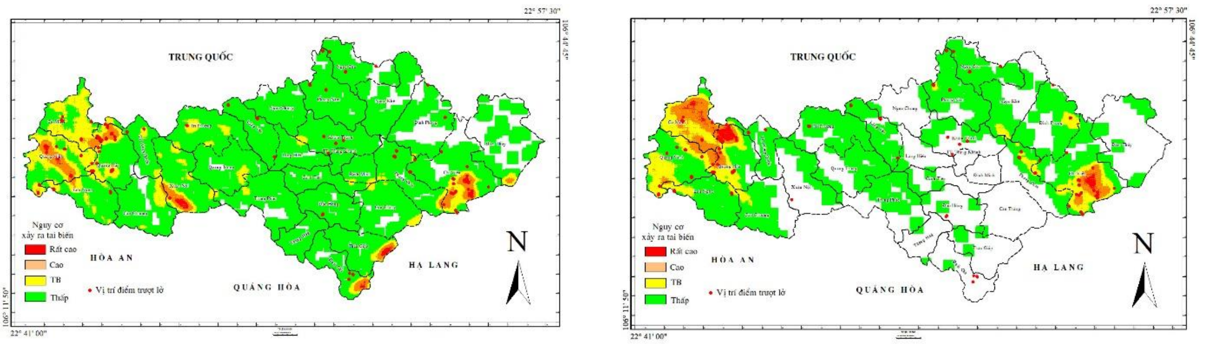
In this study, the ANN model includes 12 input layers, 04 hidden layers and one output layer. Each neuron in the input layer represents different corresponding evaluation factors, the output represents the occurrence of landslides.

ii. Decision Tree Model (DT)

A decision tree is a non-parametric supervised learning method used to generate a model that predicts the value of a target variable by learning the rules, through making inferential decisions. from data features. The tree features a root node, internal nodes, and terminal nodes (leaves). CART (C4.5, J4.8) is a decision tree generation algorithm that divides data with simple predictor variables that can be used for landslide susceptibility analysis.

3. Results and discussion

Since analyzing landslide susceptibility, the landslides are mainly located in the very high and high LSP. ANN has more accuracy but DT model is much easier to understand and interpret.



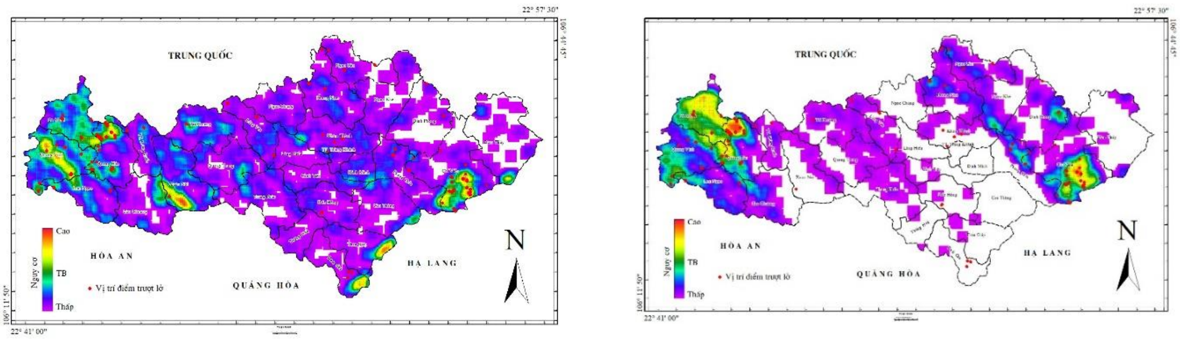
a) b)

Figure 3. Landslide susceptibility maps from a) ANN, b) DT algorithms

The ANN artificial intelligence network model gave the best results with global accuracy of 89.3%, decision tree model (83.6%), followed by the ability to effectively analyze data models. large data for the purpose of predicting the risk of accidents in the study area very well.

To a certain extent, it provides a reference for the link between landslide early warning and extreme precipitation warning. Mining disturbances have also caused extensive damage to the surface, and mining activities have influenced the occurrence of landslides in the area.

For using two models, the training and testing data are both defined as 70/30.



a) b)

Figure 4. Landslide susceptibility maps from a) ANN, b) DT algorithms

In fact, different models have different performance, the different condition factors cannot equally contribute to the development of landslides in the area.

The main cause of landslides in Trung Khanh are rainfall, soil moisture, elevation and the distance to mining area is the conditions of the significant influence contribution in the occurrence of geological hazards.

Compared with the two black box models (ANN), the diagram of the Decision Tree model is quite easy to understand, can create rules (rules) associated with each leaf branch is a rule of the tree. The results indicated ANN, DT have 70 landslide sites (80.75%), 53 landslide sites (60.48%) in the high and very high areas respectively, and the high and very highly prone areas account for 20.97% and 32.46% of the study area. They all have high enough model accuracy to be applied to the prediction of the susceptibility of landslides in study area. These two models also predict that the landslide sensitivity of the Trung Khanh County is low or moderate, and predict that the highest landslide sus- ceptibility lies in the west section, and the southeast part of the area.

4. Conclusion

This study has contributed to compare 02 machine learning methods (ANN and DT) for landslide susceptibility zoning in Trung Khanh district, Cao Bang province. The study area is affected by 87 recorded landslide sites and 12 condition factors and the results show that ANN is more suitable to assess landslide susceptibility through the analysis of accuracy and characteristics. landslide distribution point. Of all the 12 condition factors, three including rainfall, soil moisture and elevation are the most favorable conditions for landslide susceptibility; land cover (NDVI), mining and other factors contribute less. Last but not least, it is necessary to consider the dangerous support points for management.

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Surface Modification of Balsa Wood for Functional Oil/Water Separation

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Abstract

The ecological environment is in danger due to severe pollution brought on by industrial emissions and oil spills, which are global problems. This article has been dedicated to developing effective and eco-friendly approaches for separation of oil−water mixtures. Inspiration from the tubular porosity and hierarchical organization of wood, a mesoporous, and hydrophobic three-dimensional wood structure is developed for selective oil/water separation. Nanostructured wood with naturally aligned cellulose microfibrils, cell wall nanoporosity, and precisely tuned composition has opened up numerous possibilities for advanced design of functional materials.

In the current study, balsa wood was modified in just two steps: delignification and liquid phase imbibition, to acquire simultaneously hydrophobic and oleophilic qualities. According conventional wisdom, hydrophobic surfaces exhibit underwater lipophicility while hydrophilic surfaces do the opposite. Here, from a chemical point of view, a lignocellulosic fiber surface with hydrophobic characteristics was successfully fabricated by the strategically adjusted condensation of acetone and epoxy. The morphology and characteristics of epoxy-wood were characterized by FT-IR, SEM, and the oil/water contact angles.

Keyword: epoxy-wood biocomposite, deligninfied, oil/water separation, hydrophobicity

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1. Introduction

The deterioration of the global environment and ecosystems caused by oily waste water has become extremely serious problems as industries continue to develop, and there is now increased interest in oil/water separation for dealing with industrial oily wastewater (Hou et al., 2015; Parbat et al. 2020). For example, oil spills and emissions are common during the extraction, transportation, drilling, processing, and use of oil, posing a severe danger to environmental and ecological security. Numerous oil/water separation methods, such as fencing, skimming, burning, absorbing, and distributing via various physical or chemical tactics, have been described to address these difficulties (Zhan et al, 2019; Dai et al, 2019). Furthermore, various materials such as foams, sponges, and fabrics have been produced to deal with situations. However, these methods can only produce limited oil/water separation since they often absorb both water and oil, resulting in poor separation selectivity or absorption ability. Additionally, traditional oil/water separation materials have a great difficulty resisting oil contamination, and the majority of the materials are often disposable. The burning of oil-absorbing materials frequently causes secondary pollution of the air and soil as a result (Ge et al. 2016, Kleindienst et al. 2015). To treat with oily wastewater, it is necessary to develop economic, environmentally friendly, and recyclable materials as well as efficient oil/water separation technologies.

The emphasis of research in the literature has focused on surface wettability, an inherent attribute of wood surfaces that demonstrates the final wetting/dewetting behavior when liquids like water or oil are brought into contact with them.

Wood is widely available, economical, readily processed, environmentally friendly, and easily manufactured. Scientists are motivated to create porous materials by using wood as a hygroscopic and anisotropic template because of its unique structure and mechanical characteristics. Wood is a biological substance having cells that resemble honeycombs, a high stiffness to weight ratio, and a high value for hierarchical organization. In particular, it consists of parallel hollow tubes with layers of nanocomposite materials made of oriented cellulose microfibrils in a hydrated matrix of lignin and hemicellulose on the cell walls of the wood (Burgert et al., 2015, Zhu et al., 2016). In the wood structure, matrix components like lignin and hemicellulose can be partially removed to create nanoporosity in the wood cell walls, increasing the porosity of wood templates and facilitating the penetration of chemical compounds into the wood cell walls. After pretreatment step, resin-impregnated wood-based products having pores have been created.

In the study, we describe how balsa wood was used as a template to create robust, mesoporous, and hydrophobic 3D wood structures for selective oil/water separation. By removing lignin in the first step, a highly porous delignified wood template with excellent hydrophilic performance is produced. In a subsequent process, the delignified wood template is impregnated with epoxy in acetone. Delignified epoxy-wood biocomposites with excellent oil absorption capacity and hydrophobicity/oleophilicity are successfully created after curing. The delignified wood template and delignified wood/epoxy biocomposite are studied in terms of their chemical composition, morphology, mechanical characteristics, and selective wettability.

2. Experimental

2.1 Materials

Balsa wood was purchased from San Ho Timber Pte Ltd, Singapore. The wood sample was cut into size of 30 × 30 × 2 mm^3 (longitudinal × radial × tangential). Sodium hydroxide (NaOH), sodium sulfite (Na_2SO_3), hydro peroxide (H_2O_2) and acetone were purchased from Xilong Scientific Co., Ltd., China. Acrylic epoxy resin and hardener epoxy resin were provided by JDiction.

2.2 Preparation of Delignified Wood Template

The balsa samples were chemically extracted with NaOH/Na_2SO_3 solution at 110°C for 6 h. Samples after removing lignin with NaOH/Na_2SO_3 continued to removing lignin with H_2O_2 (9%). After boiling the wood sample with alkaline solution, the solution in the bottom flask was removed then replace it by H_2O_2 (9%). Continue boiling the wood with H_2O_2 in 30 minutes at 100°C.

2.3 Preparation of Delignified Wood/Epoxy Biocomposite

The porous delignified wood template was impregnated with epoxy/acetone solution (the ratios of epoxy/acetone were 2:8, 3:7, and 4:6, v/v). The epoxy solution was impregnated into the wood template by using 0.3 bar vacuum for 30 min. After that, these impregnated samples were polymerized by increasing temperature step by step in an oven to 90 °C for 12 h. The biocomposite samples were thoroughly washed with acetone twice to remove extra epoxy.

2.4 Characterizations

The surface morphology and microstructure of the samples were characterized using a scanning electron microscope Quanta 450 FEI. Changes in the surface chemistry of the wood before and after the treatment were analyzed using Fourier transform infrared spectroscopy (IRAffinity-1, Shimadzu). The FTIR spectra were recorded using the KBr pellet method, ranging from 4000 to 400 cm^{-1} at a 4 cm^{-1} resolution for 32 scans. Water contact angles were measured using a Ramé-hart Contact Angle Goniometer model 250. Wettability and absorption capability of water are reported in the supporting information.

3. Results and Discussion

Balsa wood was used as the raw material.

3.1 Fourier Transform Infrared (FTIR) Characterization

The FTIR spectra of the natural and modified wood samples are showed in Figure 1. According to the spectral results, lignin was removed from the wood sample. The aromatic ring structure remained on the lignin-type sample (1509 cm^{-1}). However at 1238 cm^{-1}, in the delignified samples, no signal of valence fluctuations appeared. This is the signal for C – O in a G_Ring (guaiacyl unit) C=O stretching structure. Therefore, it can be assumed that some of the lignin has been removed from the sample, but not completely. The absorption peaks epoxy resin include the symmetric stretching vibration of the C – H group on CH_3 at a wavelength of 2965 cm^{-1}, the antisymmetric stretching vibration of the C – H group on CH_3 at 2865, 1606, and 1508 cm^{-1}. Besides, it include the asymmetric vibration band of the benzene ring skeleton at 1455 cm^{-1}, the scissor swing vibration of CH_3 at 734 cm^{-1}, the stretching vibration of aliphatic ether C – O – C at 1241 cm^{-1}, the out of plane deformation of para- substituted benzene ring of = CH at 830 cm^{-1}. It can be seen from the figure that the infrared spectrum of the transparent sample obtained by impregnation of epoxy resin has not only the characteristic absorption peak of delignified wood, but also the characteristic peak of epoxy resin.

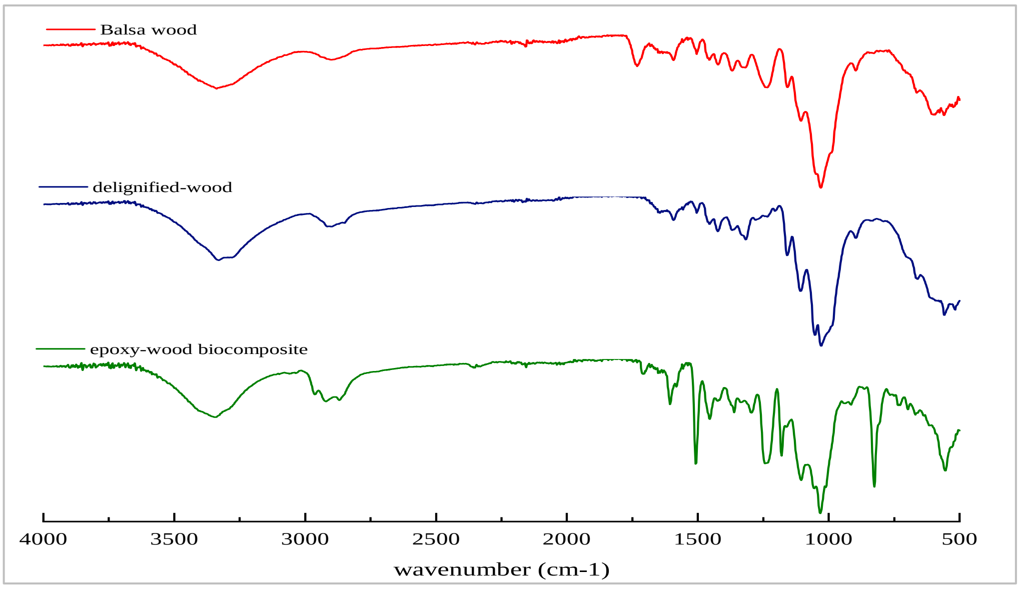

Figure 1. FTIR spectra of the Balsa wood sample and modified wood samples

Therefore, from the molecular point of view, the wood – epoxy composite sample contained the molecular groups in the delignified wood template and epoxy resin, and the epoxy resin was successfully polymerized with the delignified wood template.

3.2 Surface Morphology

SEM investigations allowed us to determine the microstructure morphology and the chemical structure of wood before and after the epoxy surface modification. Figure 2 shows the SEM images of the original and modified wood samples. The cross section of wood should have abundant micron-sized pores. After modification, the micron-scale pores in the middle lamella and cell wall corners were infiltrated with epoxy (Figure 2c). In addition, the pit membranes were blocked and covered with a thin layer of epoxy, resulting in a smooth surface of lumen cell walls, due to the evaporation of acetone and formation of a thin epoxy coating of the inner surface of the lumen.

The delignified wood/epoxy biocomposite was yellow due to infiltration of epoxy in the microstructure. High-magnification images reveal the nanoscale structure of the cell wall (Figure 2). As long as lignin is embedded in the cell walls, the layer of balsa wood appears nonporous (Figure 2a). After partial removal of lignin and hemicellulose, nanoscale pores (Figure 2b) were observed in the layer, leading to increase in porosity. The cell wall of delignified wood/epoxy biocomposite exhibited a nonporous cell wall structure (Figure 2c) due to the infiltration of epoxy in the nanopores in the cell walls.

For the delignified epoxy-wood composite, the interface between lumen and the cell wall was coated with a thin layer of hydrophobic epoxy polymer. Thus, the pits on the fiber walls were blocked with hydrophobic polymer. In conventional hydrophobic wood biocomposites, the hydrophobic polymers infiltrate not only the free space in the cell walls but also the lumen space so that water transport pathways are completely blocked. In the present work, the polymer is only infiltrated inside the cell wall. The delignified epoxy-wood biocomposite is thus highly porous and hydrophobic, which is different from traditional wood modification methods.

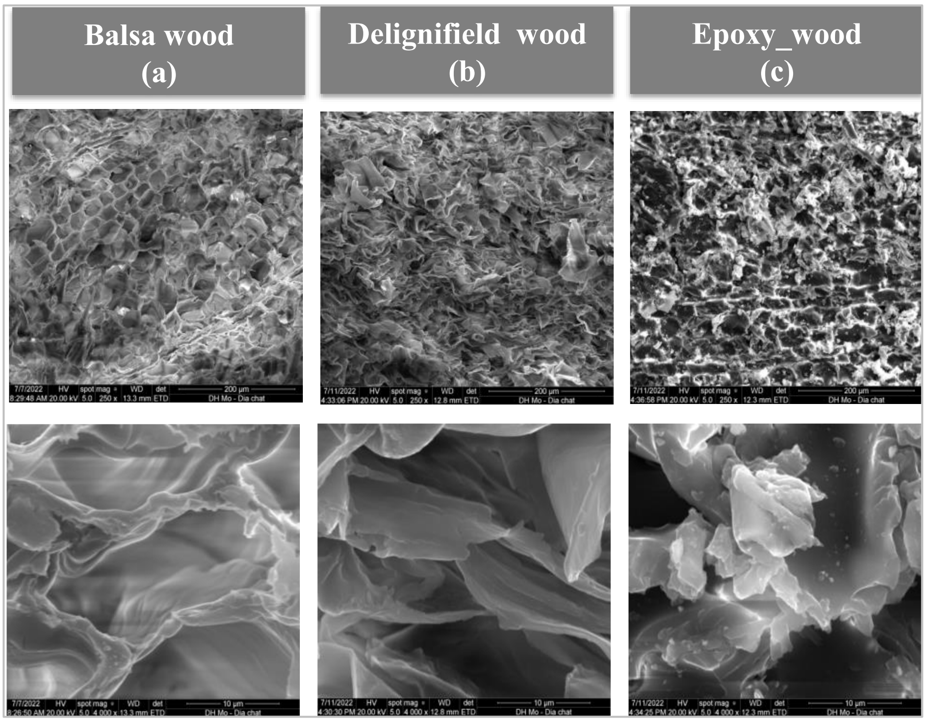

Figure 2. Scanning electron microscopy (SEM) images of the (a) balsa wood, (b) delignified wood template, and (c) epoxy-wood biocomposite.

3.3. Hydrophobicity of Wood

The aim of this study is to improve the hydrophobicity, and hence, anti-fouling property of wood by epoxy surface modification. The hydrophobicity could be represented by water contact angle (WCA).

When a drop of water was placed on the surface of the longitudinal cross section, the water droplet was immediately absorbed into the samples of native wood and delignified wood template (Figure 3). For the delignified epoxy-wood biocomposite, the initial contact angle was rather high (126°) and decreased slightly to 121° over a period of 5 min. This indicates that the delignified epoxy-wood biocomposite not only is hydrophobic but also has much lower rate of water absorption. In contrast, the highly porous delignified wood template is hydrophilic.

Figure 3. Water drop in delignified wood template

The epoxy concentration is also affect to hydrophobic of epoxy-wood biocomposite. As shown in Figure 4, the WCA of epoxy-wood biocomposite increased significantly with the epoxy concentration. The WCAs of the original balsa wood at cross is only 0°, indicating that the unmodified wood is very hydrophilic. As the epoxy/acetone content in the modifier solution increases from 2/8, 3/7, and 4/6 (v/v), the WCAs of the modified woods at the cross sections increase ~ 126°. So it can be explained that increasing the amount of epoxy in the mixture has increased surface energy of the wood. After modification, there are epoxy chains with very low surface energy grafted onto the wood surface, which increased the wood WCA significantly. More importantly, it should be pointed out that the epoxy/acetone modification of the wood surface is highly efficient. As shown in Figure 4, a good hydrophobicity could be realized when epoxy was covered in the surface.

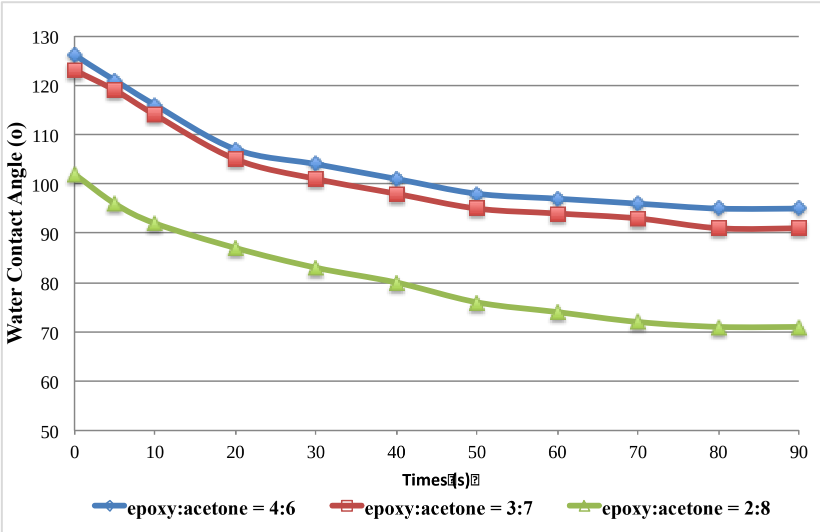

Figure 4. Water contact angle on the surfaces of modified wood samples at different epoxy/acetone ratios.

3.4. Oil Absorption

A droplet of paraffinic oil that was coloured with Oil Red O and was found at the bottom of the water container served as a demonstration of the wood structures' selective oil absorption. The natural balsa and the delignified wood template were unable to absorb the paraffinic oil droplet. These two hydrophilic wood structures, in contrast, instantly absorbed water, demonstrating their hydrophilicity. For oil/water separation, the material's physical composition is certainly critical. Delignified wood template fiber walls develop nanoporosity, which promotes capillary action and water absorption, making the delignified wood template hydrophilic.

The oil droplet was quickly absorbed by the delignified epoxy-wood biocomposite underwater. Additionally, it was observed that the epoxy-wood biocomposite removed paraffinic oil, which was dyed with Oil Red O, off the water's surface (Figure 5). As a result, oil on the water surface is selectively absorbed by the epoxy-wood biocomposite. The highly directional pores in the epoxy-wood biocomposite also exhibit a directional oil absorption property.

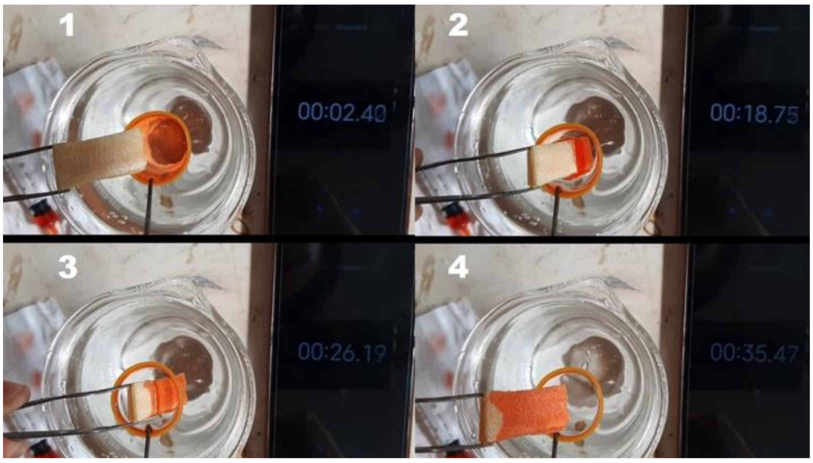

Figure 5. Oil absorption of epoxy-wood biocomposite

The capacity to absorb oil is clearly demonstrated on three samples of delignified epoxy-wood biocomposite with various epoxy/acetone ratios of 4/6, 3/7, and 2/8 (v/v). Time required for samples to completely absorb 0.5ml of paraffin oil was determined. The epoxy-wood biocomposite sample was exposed to the oil on the water, and the absorption time was evaluated from that moment till the red paraffin oil color disappeared from the fluid.

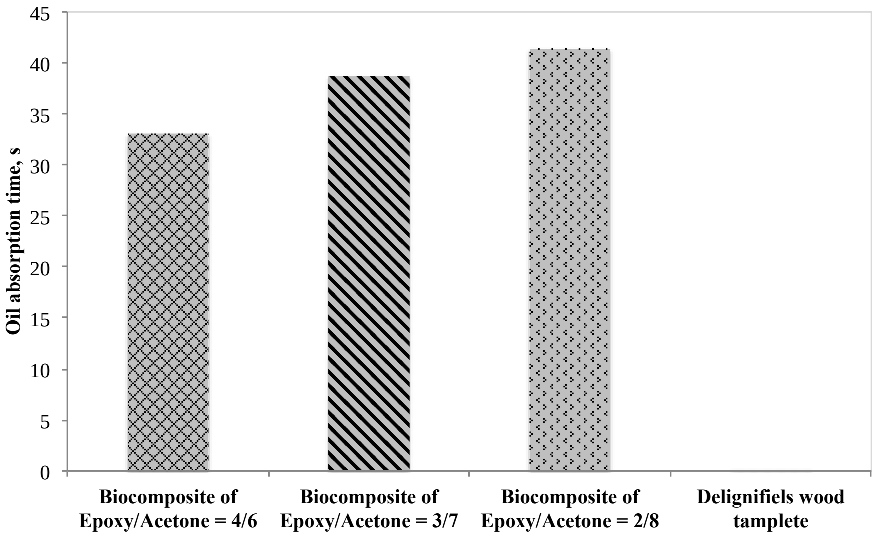

Figure 6. Oil absorption time for wood-epoxy biocomposite

Through the figure, we can see that reducing the ratio of epoxy in the mixture epoxy/acetone will also reduce the oil absorption capacity of the wood sample. This is in agreement with the results of experiments evaluating the water absorption of wood samples, which show that high water absorption capacity reduces the oil absorption ability of wood. Therefore, the optimal epoxy/acetone ratio on epoxy-wood is 4/6 (v/v), as determined by the experiment's measurements of water permeability and oil absorption.

4. Conclusions

In conclusion, we designed wood-based structures for oil/water separation. The starting template was a mesoporous delignified wood nanostructure, with nanoscale pores. Water was selectively absorbed through spontaneous wetting and capillary action in the highly porous delignified wood template due to its hydrophilicity. The delignified wood template was then impregnated with epoxy to create a functional delignified wood/epoxy biocomposite with hydrophobicity and increased oleophilicity. The hydrophobic nature and epoxy cell wall impregnation improved the stability. The delignified wood/epoxy biocomposite may selectively absorb oil not only under water but also from the water's surface. The high oil/water absorption capacity of delignified wood structures with and without epoxy allows for oil/water separation applications.

Acknowledgments

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Collection of domestic solid waste in Hai Duong province and some proposes

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Abstract: Domestic solid waste is a prominent problem of many localities, including Hai Duong. If not properly collected and treated, domestic waste will be a source of environmental pollution and adversely affect human health. The collection and treatment of domestic waste plays an important role in people's lives, especially for a developed society. By 2019, Hai Duong province had a fairly high rate of domestic waste collection and treatment, reaching 88-95% in urban areas and 75-78% in rural areas [2]. The amount of domestic waste generated in urban areas is also higher than in rural areas, reaching nearly 1.5 times. The research results also calculated that the amount of waste in Hai Duong province by 2025 will reach 506,255 tons/year, an increase of 41,610 tons compared to 2020, an increase of nearly 9%[2]. The growth rate in urban areas is high, reaching 1.39 times while the growth rate in rural areas is very low. From the results of calculating the amount of waste generated, the article has proposed management and technical solutions to collect, treat and manage solid waste well in the whole province.

Keywords: domestic solid waste, Hai Duong, collect, treat, propose.

1. Introduction

Socio-economic development and rapid urbanization have contributed to improving people's quality of life and increasing consumption. However, that increase has resulted in the fact that more and more emissions generated, leading to people facing environmental problems (air pollution, pollution of receiving water sources, solid waste, etc.) happening every day. Domestic solid waste is a pressing issue in many villages, districts and towns in our country in general and Hai Duong in particular.

Hai Duong is a province with rapid socio-economic development, GRDP (Gross Regional Domestic Product) increases by 9.1% on average [2]. Therefore, the amount of domestic waste in recent years has also increased significantly. In 2020, the daily amount of waste collected reached 1273 tons/day, of which 754 tons/day in rural areas and 519 tons/day in urban areas. Total collection of domestic waste for the whole year is 464,645 tons. Obviously, if not properly collected and treated, this will be a major source of pollution to the landscape, environment and it will affect the quality of life of people.

Hai Duong province has implemented measures quite strongly and drastically to collect and treat domestic solid waste from provincial to local levels. As of 2019, 100% of communes, wards and towns in the province have teams to collect waste. This is a great effort of the province to protect the environment, landscape and people's health.

The purpose of this study is to evaluate the collection of domestic waste in the province in the period of 2019-2020, thereby proposing solutions for collection and treatment in a reasonable and effective manner in the period of 2020-2025.

2. Research methods

To achieve the above goals, the authors have conducted the following research methods.

- Method of collecting documents: Collect documents related to domestic solid waste (characteristics, properties, sources of waste, current status of collection and treatment). Collect environmental reports for years, environmental reports 2016 -2020, other reports and articles related to the research field.
- Field survey method: Conduct field surveys in some urban areas (Hai Duong city, Chi Linh) and rural areas (Kim Thanh, Ninh Giang, other districts in the province) to investigate waste sources and methods, rate and volume of domestic solid waste collection.
- Methods of comparison, analysis and evaluation: analyze the data, compare and evaluate the current situation of collection, treatment, and forecast sources of waste matter arising in the near future (2025) to propose solutions solutions to improve work efficiency in accordance with the socio-economic conditions of Hai Duong province.

3. Results and discussion

3.1 Source and volume of domestic solid waste in Hai Duong province

The sources of domestic solid waste generated in the area include:

- Family households.
- Commercial and service areas (restaurants, hotels, supermarkets, markets ...)
- Offices (agencies, schools, centers, research institutes, hospitals ...)
- Public areas (stations, piers, bus stations, airports, parks, amusement parks, streets ...)
- Public services (street sweeping, tree trimming ...)
- Activities of production facilities.

The total amount of domestic solid waste in Hai Duong province in 2019 was 1,227 tons/day, of which 462 tons/day in urban areas, 765 tons/day in rural areas; by 2020, reaching 1273 tons/day, of which 519 tons/day in urban areas and 754 tons/day in rural areas [2]. The state of collection in the areas is as follows

- The amount of domestic solid waste generated in Hai Duong city: In Hai Duong city, the amount of garbage collected reaches 200 tons/day, equivalent to 73,000 tons/year. The collection rate in wards and communes will reach 95% by 2020. Thus, the amount of waste generated in Hai Duong city that has not been collected is still up to 3,842 tons/year or more than 320 tons/day. This volume can be a source of environmental pollution that needs to be resolved in the near future.

- The amount of domestic solid waste generated in Chi Linh city: The survey results in 2019 in 14 wards and 5 communes of Chi Linh city show that the average total amount of domestic waste collected is 112.27 tons/day, of which 98.27 tons/day in wards and 14 tons/day in communes. The average collection rate reaches 88% in urban areas and 75% in rural areas, lower than Hai Duong city.

- The amount of domestic solid waste generated in 10 districts includes: The amount of domestic solid waste collected at 13 towns in 10 districts is about 142.67 tons/day. With a collection rate of about 80% - 85%, the total amount of solid waste generated at 13 towns is about 170.33 tons/day. Total collection at 211 communes in 10 districts reached 562.28 tons/day. The collection rate in rural areas is 78.7– 85.62%. Thus, the total amount of waste generated in rural areas was 716.68 tons/day.

The volume of waste in the whole province determined on the basis of the survey and the collection rates in urban and rural areas is shown in Table 1 and Figure 1 below.

Table 1. Domestic solid waste volume in Hai Duong province (in 2019) [2]

No	Administrative units	Volume generated (tons/day)	Ratio generated (%)
1	Hai Duong city	209.47	17.07
2	Chi Linh city	130.34	10.62
3	Kinh Mon town	125.22	10.21
4	Kim Thanh district	81.08	6.61
5	Cam Giang district	97.12	7.92
6	Binh Giang district	65.55	5.34
7	Thanh Mien district	79.94	6.52
8	Ninh Giang district	96.76	7.89
9	Gia Loc district	85.84	7.00
10	Tu Ky district	98.09	7.99
11	Thanh Ha district	83.24	6.78
12	Nam Sach district	74.34	6.06
Total		**1227.00**	**100**

(Source: Statistics of the Environmental Protection Department and 2019 survey data)

The population of Hai Duong province in 2019 is 1,896,907 people, the urban area is 549,200 people, the rural area is 1,302,707 people, the coefficient of domestic solid waste generated in urban areas is 0.84kg/person/day and in rural areas is 0.58kg/person/day [3]. Thereby, it is found that the coefficient of emission in urban areas is 144% higher than in rural areas, which is nearly 1.5 times. The results of calculation of emission coefficients and rates of domestic waste collection for the areas are shown in Table 2.

Table 2. Coefficient of domestic solid waste generated in Hai Duong province [4]

Areas	**According to the management plan of solid waste in Hai Duong province**		**In 2019**	
	Coefficient generated (Kg/person/day)	Rate of collection (%)	Coefficient generated (Kg/person/day)	Rate of collection (%)
Urban area number I	0.8 -1,3	100	0,63 -1,24	95
Urban area number III	0,9	95	0,86	88

Urban Area number V	0,8	90	0,77	80-85
Rural areas	0,4	80	0,52 - 0,68	78,7 - 85,62

(Source: Decision No. 958/QD - People's Committee dated March 27, 2018 of Hai Duong People's Committee)

According to statistics collected from annual reports of districts and cities and actual survey data in 2019, the amount of domestic solid waste generated in the period 2016 -2020 is shown in Table 3.

Table 3. Amount of domestic solid waste generated in the period 2016 -2020

No	Year	Total amount generated (tons/year)	In which,	
			Rural areas (tons/year)	Urban areas (tons/year)
1	2016	328,500	217.905	110.595
2	2017	367.738	238.163	129.575
3	2018	411.355	258.420	152.935
4	2019	447.928	279.298	168.630
5	2020	464.645	275.210	189.435

(Source: Statistics of the Environmental Protection Department and 2019 survey data)

From the data we can draw the graph shown in Figure 2 below.

According to Table 3 and Figure 4, we can see that in the period 2016-2020, each year the amount of domestic solid waste increases quite rapidly, approximately 60% in urban areas and 34-40% in rural areas. With that rate of increase, the investment in equipment, machinery and people to collect all the waste every year will face difficulties for the budget.

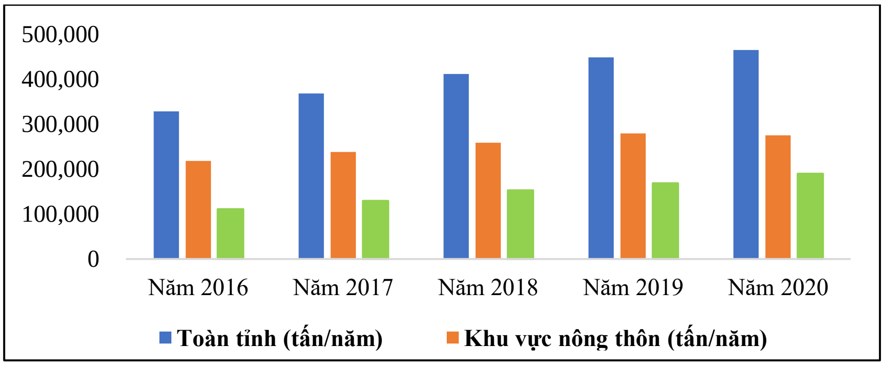

Figure 2. Chart of domestic solid waste generated in the period 2016 -2020 [4]

3.2. Forecast of domestic solid waste generated by 2025

Forecast of domestic solid waste:

According to calculations, the population of Hai Duong in 2020 is 1,917,700 people (in urban areas 617,644 people and about 1,300,036 people in rural areas), by 2025 this number will increase to 2,003,473 people (urban 864,598 people and rural 1,138,875 people). With an emission coefficient of 0.84kg/person/day in urban areas and 0.58kg/person/day in rural areas, the estimated volume of domestic solid waste will reach 506,255 tons [1], see Table 4.

Table 4. Forecast of domestic solid waste generated in 2025 in Hai Duong

No	Year	Total amount of waste (tons/day)	Area (tons/day)		Total amount of waste (tons/year)
			Rural area	Urban area	
1	2020	1273	754	519	464.645
2	2025	1387	661	726	506.255

3.3. Composition and properties of domestic solid waste

Composition of domestic solid waste

The composition of generated solid waste is quite diverse and there is little difference between urban areas. Waste mainly consists of organic substances, inorganic substances and hazardous solid waste. The results of the survey on the current situation at landfills in the province in 2019 show that the percentage of the mass of the components in the total amount of waste is as follows:

- Organic waste mainly accounted for 66.98%.
- Inorganic waste accounted for 31.31%.

In which, recyclable waste accounted for 26.0% in terms of volume (including paperboard of all kinds accounted for 8.01%; plastic and plastic bags accounted for 12.28%; glass and metal accounted for 4.0%).); The composition of waste that cannot be recycled or reused includes dust, sand, gravel of all kinds, coal slag, etc., accounting for about 4.02%.

- Hazardous waste components (urine batteries, paint cans, oil cans) accounted for about 1.71%.

Thus, the composition of domestic solid waste in Hai Duong is basically the same as in other provinces across the country. However, the proportion of waste components varies by season and by region (see Figure 3).

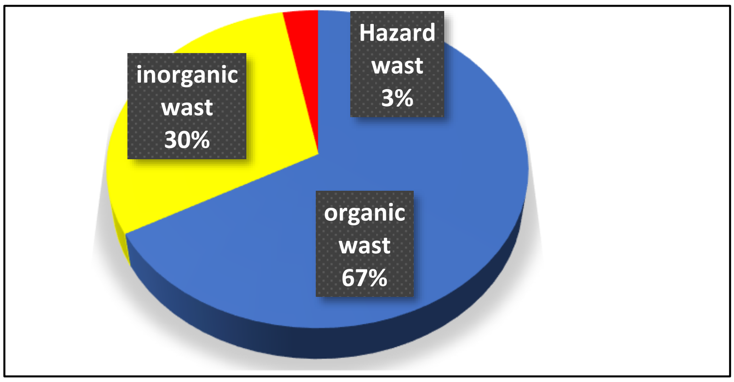

Figure 3: Percentage of domestic solid waste components by classification [1]

Characteristics of domestic solid waste

Solid waste mainly has the following characteristics: physical properties, chemical properties, and biological properties. Each property has its own characteristics and it will have a great influence on the storage and collection of domestic solid waste.

*** Physical properties, including*** density, moisture, water holding capacity and porosity of compacted waste. The density of municipal domestic solid waste taken from garbage compactors usually ranges from 200kg/m^3 to 500kg/m^3. According to Hai Duong APT - Seraphin Environment Joint Stock Company, the density of domestic solid waste in Hai Duong city averages about 450 kg/m^3. The moisture content of solid waste varies depending on the type of material, from a few % to nearly 70% [3]. The moisture of the garbage has the role of increasing or decreasing the decomposition process, increasing or decreasing the specific gravity and affecting the properties of the waste.

*** Chemical properties of solid waste***

The composition and chemical properties of solid waste play an important role in the selection of treatment options and recovery of material. The main components of waste include carbon, hydrogen, oxygen, nitrogen, sulfur, and ash. Usually, elements of the halogen group are also often identified because chlorine derivatives often exist in the exhaust gas composition when burning garbage. Waste composition is the cause of its properties, often of interest are smell, bacteria and viruses. Smell can arise when solid waste is stored for a long time at collection sites, transfer stations, landfills, and in hot and humid climates, the rate of arising smell is usually higher. The formation of smell is the result of anaerobic decomposition of organic components present in municipal waste. The growth and development of insects, virus and bacteria are important issues that need to be taken care of at the place where the solid waste is stored. They are one of the indirect sources of the spread of pathogens to humans.

4. Impacts of domestic solid waste on the environment

- Impacts on the air environment

Degradable waste (such as food, spoiled fruit, etc.) under appropriate temperature and humidity conditions (the best temperature is 35°C and humidity is 70-80%) will be decomposed by microorganisms producing smell and many types of pollutant gases [3] that have very significant impacts on the air environment. For example, hydrogen sulfide gas (H_2S) is an anaerobic decomposition product of sulfur-containing proteins which has smell of a rotten egg and can be measured with conventional analyzers. Decomposed fatty acids also cause a very unpleasant stench.

- Impacts on the soil environment

Microorganisms decompose organic matter in both aerobic and anaerobic conditions, producing a wide range of intermediate products, and final products are water, CO_2, CH_4…. Waste which can contaminate the soil to a large extent is detergents, pesticides, expired drugs... Construction waste such as glass, plastic pipes, cables, concrete... in the soil is very difficult to decompose. Heavy metal waste such as lead, zinc, copper... accumulates in the soil and penetrates the body along the food and drinking water chain, seriously affecting health. If at unhygienic landfills of solid waste, there is no standard wastewater treatment system, chemicals and microorganisms from the waste easily penetrate, pollute the soil and gradually destroy the nutrients present in the soil.

- Impacts on the aquatic environment

Leachate from landfills and dumps will seep into canals, ditches, ponds, lakes, rivers and streams, polluting surface water and groundwater. Organic solid waste decomposes in water, causing stench, causing eutrophication of water sources, causing degradation of aquatic organisms in surface water sources. Decomposing domestic solid waste and other pollutants change the color of the water to black, with an unpleasant smell. At solid waste landfills, leachate contains high levels of pollutants (organic matter, animal manure, leftovers...; toxic waste from fertilizer packaging, pesticides, herbicides, cosmetics). The waste settling to the bottom increases the volume of sediment, leading to anaerobic decomposition, producing toxic gases. The problem of ammonium pollution in the shallow layer (underground water) is also a consequence of leachate and of the indiscriminate discharge of open waste without strict treatment.

-Impact on ecological landscape

Indiscriminate domestic solid waste in the roadways, roadsides and open ditches ... will affect the urban beauty, then it will form an area that is not clean and clear, reducing the value of the landscape and expressing low civilized lifestyle.

Figure 4. Domestic waste in the impact on ecological landscape [5]

At the relics and scenic spots when the festival season comes, although the management boards of the relic sites have equipped garbage containers along the aisles, due to low awareness of a part of tourists, domestic waste is still littered indiscriminately, causing loss of beauty and sanctity of the relics.

-Impact on human health

Domestic solid waste not only pollutes the environment but also greatly affects human health, especially for people living near the waste landfill area... Risk of adverse impacts on people's health through the use of surface water in canals near the landfill area containing leachate to supply water for agricultural farming activities will cause dermatological diseases or bronchitis when inhaling smoke from garbage incineration. Pathogens including viruses, bacteria, and helminths are present risks to people living near or associated with garbage. Domestic solid waste is also the cause of myelitis, hepatitis A, B, diarrhea, typhoid, typhoid fever, food poisoning, dysentery, cholera, enteritis, abscesses liver, malabsorption, breakdown disorder.

5. Some proposed solutions to reduce environmental pollution caused by domestic solid waste

5.1 Management solutions

In order to improve the efficiency of management and minimize the impact of domestic solid waste, it is necessary to do well on the following issues:

+ Review, identify causes, limitations and effectiveness of implementing the planning on domestic solid waste management, assess the feasibility of the construction planning of concentrated waste treatment zones.

+ Develop mechanisms and policies to support people living near waste treatment zones to encourage people to support the construction of waste treatment plants and agree on land allocation

+ Promulgate specific guidelines on the classification at source in the localities, making the collection and classification of waste at source become one of the obligatory activities that must be performed and included in the emulation criteria of each residential area.

+ It is necessary to develop preferential policies for those directly involved in the collection, transportation and treatment of waste.

+ Promulgate specific detailed punishment sanctions suitable to local characteristics and each subject with acts of indiscriminately littering domestic waste.

+ Have specific mechanisms and policies to attract investors to build centralized waste treatment plants in the province with advanced and environmentally friendly technology.

- Strengthen and raise public awareness about the environment. Integrate environmental protection in activities; organize contests to learn about environmental protection.

+ Increase staff in charge of the environment and increase costs for environmental activities.

5.2. Technical solutions

5.2.1 Classification of domestic waste at the place of generation (classification at source)

Classification of solid waste at source before collection is an important step in waste treatment. Domestic waste classified at source is divided into 5 specific categories:

- Degradable organic solid waste
- Solid waste can be reused and recycled
- Hazardous waste (urine battery, printer ink cartridge ...)
- Bulky waste (beds, cabinets, tables and chairs...)
- Other solid waste: Including rubber, coal slag, rock, broken porcelain

In each family, there are at least 02 garbage containers, inside with tight-fitting soft packaging. Use bin color to distinguish each type of garbage. The volume of each container is at least 10 liters/barrel.

Figure 5. Garbage containers for sorting at home [1]

At offices, schools, hospitals, public areas: There are at least 03 garbage containers in each place, each container has a specific color for each type, the volume of each container has a small capacity. at least 100 l/barrel, location of putting the container: by floor or by generation area

Figure 6. Sample of garbage container for sorting in public areas [1]

5.2.2. Improve waste treatment capacity at centralized treatment plants

- For existing waste treatment plants, it is necessary to consider and increase the scale of capacity and change technology.

- Choose to invest in advanced, modern and environmentally friendly treatment technology such as recycling technology, energy recovery, production of products from useful components in domestic solid waste or other environmentally friendly technologies. Not approve the projects with small capacity in the village and commune scale.

+ Close the landfills, which have a high risk of affecting the population in the area.

+ Develop a route for transporting waste at landfills that are likely to cause environmental pollution for treatment at waste treatment plants.

Conclusion

The article presented a picture of domestic solid waste collection in 2019 and 2020 in Hai Duong province. The results show that the collection of solid waste generated in Hai Duong province is quite high, reaching 95% in urban areas and approximately 80% in rural areas.

The amount of domestic solid waste generated in urban areas is much higher, nearly 1.5 times higher than in rural areas. The composition and properties of solid waste between rural and urban areas are not much different and similar to domestic solid waste in other provinces.

The article has forecasted that domestic solid waste generated in 2025 across Hai Duong province will be 1387 tons/day and 776 tons/day in urban areas and 661 tons/day in rural areas. The growth rate in other years is high, the rural area is 33-34% and the urban area is 60-65%.

The article has proposed management and technical solutions to minimize the impact of domestic waste on the environment and people.

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Monitoring rice growth and predicting rice biomass by Sentinel-2 data at Giao Thuy, Nam Dinh

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Abstract

This study aims to monitor the growth of rice using the normalized difference vegetation index (NDVI) and to determine equations for predicting rice biomass at Giao Thuy, Nam Dinh. The field data is divided into two data sections for calibration and data to evaluate a general linear model. Twenty sample plots at pre-harvest time were collected, 15 of which were used for model calibration and 5 plots for model evaluation. The study used remote sensing data (Sentinel-2) for all the covered study areas in the 2020 critical period for rice growth (January to June), combined monthly composite images of vegetation indices as input features, and some seasonal analysis to assist in determining the rice-producing region, and thence determination equations for predicting rice biomass. From the image, the rice-producing region has been zoned to calculate the biomass in the heading of rice. The results are as follows: (1) The heading and flowering stage of vu Chiem in 2020 is characterized by the maximum NDVI, and at the maturity stage, NDVI decreased continuously. The NDVI was 0.75 and 0.72 in the heading stage and flowering stage, respectively; (2) Additionally, to estimate above ground biomass (AGB) of rice, the Sentinel- 2 NDVI index was better in the heading stage: the coefficient of determination (R^2) = 0.885 and root mean square error (RMSE) = 30.2ton/ha, and regression analysis between NDVI and AGB for the equation is AGB = 346.45*NDVI – 156.98; (3) the relationship between NDVI and AGB can be used to monitor the growth of rice plants from which to determine when the biomass value is highest during the period.

Keyword*:* NDVI, AGB, the growth of rice, Giao Thuy

1. Introduction

Agricultural crops have a causal relationship with climate change. Although production is directly affected by high temperatures, this activity can affect the GHG concentration in the atmosphere, causing some changes in climate. One key solution to mitigate climate change and boost farming in the country's coping with Climate Change is to conserve carbon stocks. Rice is a viable option for increasing carbon Stocks in agricultural systems in Vietnam.

There are two types of remote sensing techniques: one uses optical sensors and the other uses (SAR) sensors. For example, the general time-series analysis of the vegetative and water-derived indices of these sensors can be used, such as the Vegetation Index (NDVI), the Enhanced Vegetation Index (EVI).) and Water Index (NDWI), which can be used to estimate rice parameters (Xiao, X., 2006; Xiao, X., 2005), monitor growths of rice in rice fields (Nuarsa, I.W, 2007). Contrary to optical sensors, SAR data can work in these conditions, so it is more effective for monitoring rice fields than optical sensors. RADARSAT-1/2 were used to map and monitor rice (Li, K., 2012). Sentinel-2 data (level-1C) have been corrected for atmospheric effects and geometric distortions. In Vietnam, Pham Quoc Trung et al (2018) applied remote sensing and satellite imagery to determine the carbon stock of perennial trees in Bo Trach district, Quang Binh provinc. Tran Thi Hien et al (2013) based on image characteristics (NDVI value) that are related to changes in growth status of rice plants in space and time to help determine sowing time, and crop structure in rice growing regions. Nguyen Thanh Son et al. (2014) used MODIS image data from December 2000 to December 2012 with the EVI index to classify and manage rice along the Mekong River, Vietnam region.

Therefore, this study has adopted remote sensing technology using Sentinel-2(level-1C) imagery for calculating NDVI value through a field survey; rice growth stage monitoring in order to create models for predicting rice biomass

2. Methodology

2.1. Material

The study site is located in Giao Thuy, Nam Dinh, a coastal district (lat. 20110 –180 N; long. 106220 –320 E) at the mouth of Red River in Nam Dinh Province. Among the four coastal provinces (Nam Dinh, Thai Binh, Ninh Binh, and Hai Phong) of the Red River Delta (Figure 1), Nam Dinh has the longest coastline, and hence considered as possibly most vulnerable to salinity intrusion.

Rice production is a main agricultural activity in the district. There are two crops of rice in a year, the spring rice (vu Chiem in local Vietnamese language) from January to June and the summer rice (vu Mua) from July to November.

Figure 1. Study site of Giao Thuy district, Nam Dinh Province, Vietnam (blue circles indicating the locations of 15 points in the field)

2.2. Satellite data processing

The remote sensing image used in the study is a Sentinel-2 data (level-1C), acquired on table 1 and corrected for atmospheric effects and geometric distortions. The data are tiled and formatted by using UTM/WGS84 reference frames.

To obtain the pixel values associated with biomass, the NDVI equation was used (*Rouse et al*. 1973)

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (1)$$

Where NDVI: Normalized Difference Vegetation Index

NIR : Near Infrared Band (band 8)

Red : Red Band (band 4)

The purpose of NDVI image is to convert multi-spectral data into a multichannel image that shows the distribution of plants.

2.3. Field data collection

To find the growing rice stage with the highest NDVI value, the study calculated the NDVI value at 6 development stages of rice (table.1). The simulated NDVI/LAI and actual NDVI/LAI values in the heading and flowering stage are less different than in others (Huyen, P., 2014). The sample plots are collected at the growth rice stage for the highest NDVI value at 2 regions, and then measured biomass in the field. The study area has 2 regions: rice cultivation area and the mixed-cropping with rice-aqua co-culture (MCAC). In the study, GPS Etrex10 is used to gather 20 sample plots. And surveys in the field were carried out with Sentinel-2 data together to calculate the rice biomass stock before the harvest stage (the heading and flowering stage – April, May 2020), and then build the correlation function between NDVI and AGB.

Table 1. Sentinel-2 image selected date in this study

No	Scene ID	Creation date	Growth phase
1	20200131T032917	31/1/2020	Seedling
2	20200225T032326	25/02/2020	Tillering
3	20200312T033026	12/3/2020	booting
4	20200421T033212	21/4/2020	Heading
5	20200520T031539	20/5/2020	Flowering
6	20200625T032832	25/6/2020	Harvesting

2.4. Data analysis

The correlations were calculated by the linear regression equation; y = a + bx. the values of a and b can be calculated using the following formula (Walpole. 1992):

$$b = \frac{n\sum_{i=1}^{n} x_i y_i - (\sum_{i=1}^{n} x_i)(\sum_{i=1}^{n} y_i)}{n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2} \quad (2)$$

$$a = \frac{(\sum_{i=1}^{n} y_i)}{n} - b\frac{(\sum_{i=1}^{n} x_i)}{n} \quad (3)$$

Where x = NDVI value

y = AGB value

And then, the correlation analysis is calculated using the following Pearson correlation test equation:

$$R^2 = \frac{\sum_{i=1}^{n} [(Y_i - \underline{Y}_i)(X_i - \underline{X}_i)]}{\sqrt{\sum_{i=1}^{n} (Y_i - \underline{Y}_i)^2 \times \sqrt{\sum_{i=1}^{n} (X_i - \underline{X}_i)^2}}} \quad (4)$$

In which: Yi and Y¯_i are the estimated variables and their average value

Xi and X¯_i are the measurement variables and their mean

n is the number of samples in the data set.

If $r^2 = 1$ or $r^2 = -1$, the relationship of x and y is determined; that is, for any value of x we can determine the value of y. If r = 0, the variables x and y are completely independent and are not related. The r-value is classified as follows: $0.1 \leq r^2 < 0.3$ have little if any (linear) correlation, $0.3 \leq r^2 < 0.5$ indicate variables which have a low correlation, $0.5 \leq r^2$ indicate variables which can be considered highly correlated.

3. Results

3.1. Relationship between vegetative indices NDVI and growth of rice plants

The variation in NDVI value of the rice planted area at the growth stages is very important. It is the basis for monitoring the crop, estimating the rice growth period, the post-harvest period, and estimating the maximum biomass value during the growing rice.

There are 15 NDVI values at rice cultivation areas and MCAC in 6 stages presented in Figure 3. The NDVI results were evaluated based on the value curve at 15 sample plots for 6 growing periods of rice plants in Figure 2.

The results showed that NDVI value started to increase gradually when the rice appeared leaves, reaching maximum at the time before heading and flowering, then decreasing gradually when harvesting. After this period, NDVI also began to decline. Rice with a short growth time is shorter than that of rice with a longer growth period. This affects the growth rate of NDVI.

During the sowing period, the field was flooded with water so the NDVI value ran from -0.2 to -0.1,

In the growth period, the rice plant develops through three stages including the growth phase, the reproductive stage and the main rice stage, therefore, the value of NDVI will reach the highest value in both the growth process of plants with NDVI in the range from 0.5 and 0.75.

In the post-harvest period, the field is bare and arid, the value of NDVI decreases gradually, between 0.05 – 0.15.

Through the survey results and statistics, the chart showed the fluctuation of NDVI index over time in Figure 3. Simultaneously compared with the growth of rice, the variable of NDVI value is suitable for the rice growing season. NDVI index of vu Chiem in Giao Thuy district, Nam Dinh province in 2020 changes from 0.2 to 0.75, following the rule of low from the beginning of the season, increasing gradually and peaking at the time when the rice plant is well developed in the post-tillering period. Then it decreases gradually in the ripening stage, and decreases to the lowest level at the end of the season (in the post-harvesting stage).

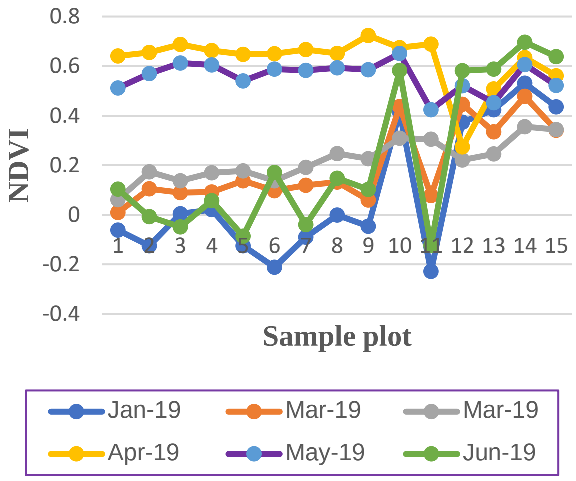

Figure 2. The development of rice in the winter-spring season through NDVI index

The high temporal access to NDVI data provides more details regarding the agriculture season.

3.2. Correlation between AGB and NDVI

Biomass is relevant with rice production and normally biomass classified into wet and dry biomass[2]

The relationship between rice biomass and NDVI has shown the highest determination coefficient (R^2 = 0.885) with the equation Y = 346.45X - 156.98 (Eq.5), where y and x are the rice biomass (rice AGB) and NDVI, respectively in Figure 4.

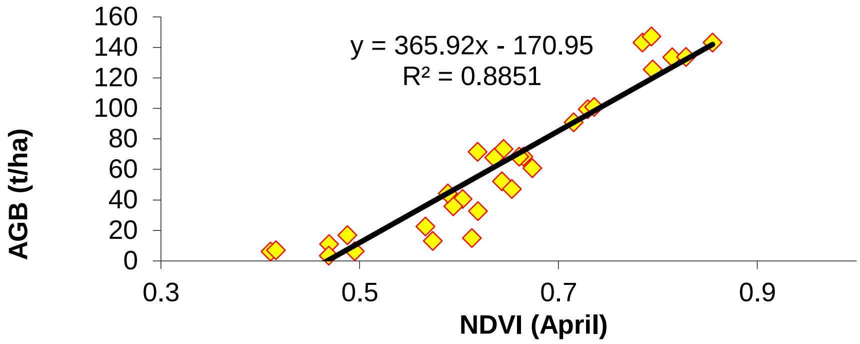

Figure 4. Correlation graph between NDVI and rice biomass (AGB)

Retest reliability of the biomass value for five other plots is based on Eq.5 and the field data measurement. Quantitative comparison of rice plants between analysis results and reference data showed a linear relationship with $R^2 = 0.6685$, where y was the rice biomass of reference data, and x is the rice biomass of the analysis results of the Sentinel-2. The standard error of this estimation is 30.2 ha. The ratio of the sampling *error* to the measurement *error* is about 23.69% (Tab. 2); or the biomass estimation on Sentinel-2 images can give an accuracy up to 76.3%. Sentinel-2 has good capabilities to monitor rice plants and map rice biomass.

Figure 3 also shows the analysis and reference data scattered in ascending direction and centered near the Linear. Linear line showed the rice biomass of reference data and the rice biomass of the analysis results with concentration and upward trend in the rise of NDVI.

However, there are still simulated and actual AGB points that do not match. These simulated values are largely higher than the measured values. Simulated results depend on the growing time of rice and weather data. The Winter-Spring (vu Chiem) crop in 2020 falls in the dry season of Giao Thuy's year. This is also a cause of higher biomass simulated results. With the same weather data, the simulation results of NDVI, AGB at different points are different. This difference is due to different growing conditions in terms of cultivation techniques, soil conditions, and optimum water–fertilizer management, and the time of sowing. Due to the different planting date, the influence of weather on the growth and development of rice at these points is also different.

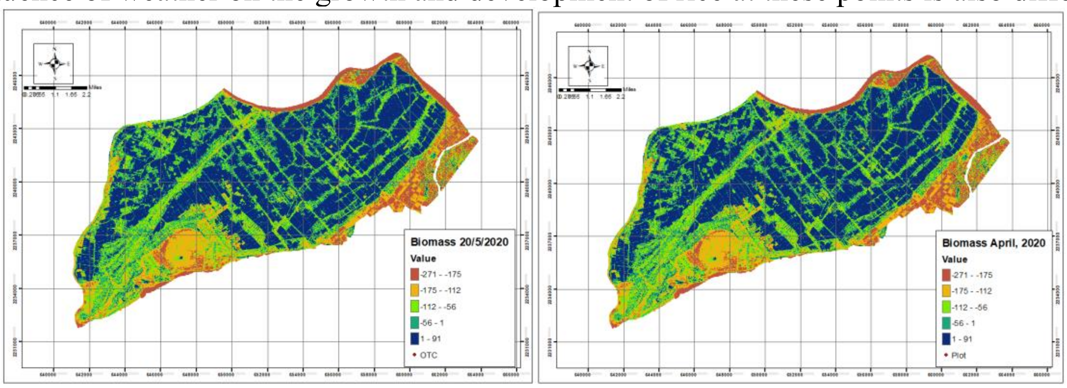

Figure 5. Biomass map of Giao Thuy, Nam Dinh in April (left panel) and May (right panel), 2020

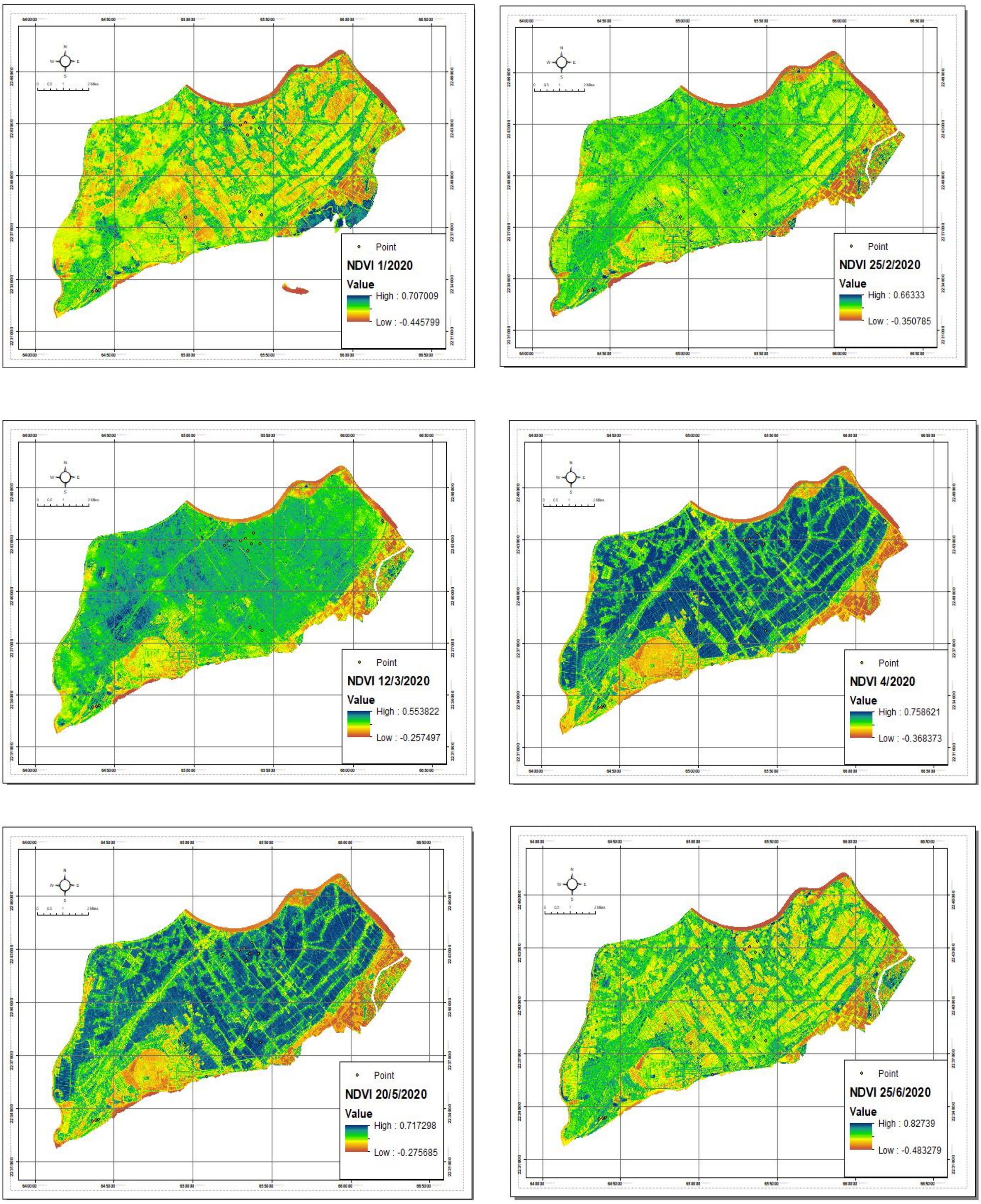

Figure 3. NDVI spatial distribution in each period for 6 times

Table 2. Detailed statistics of multiple regression between observed biomass and predicted biomass in Giao thuy

No	UTM X	UTM Y	Observed Biomass (t/ha)	Predicted Biomass (t/ha)	Value difference	Percentage (%)
1	665474	2237743	68.29	100.1	-31.81	68.29

2	664915	2237937	28.75	32.77	-4.02	28.75
3	667420	2246300	35.67	42.99	-7.32	35.67
4	654845	2243523	44.10	23.34	20.76	2.58
5	659631	2244795	25.67	39.57	-13.90	25.67
Average				47.75		
Min				23.34		
Max				100.1		
Std.e				30.20		23.69

Conclusions

Modeling the Relationship between rice field AGB and (Sentinel-2) is a method of determining rice biomass without destroying the crop. AGB values predicted by remote sensing images are correlated with NDVI. It is possible to monitor the changes of NDVI each day during the life cycle of a rice plant. This result can be used in the prediction of rice biomass.

The NDVI value in the area of winter – spring rice cultivation in Giao Thuy was from 0.41 to 0.78. Giao Chau and Giao Thanh communes have the potential to exploit rice and the agricultural by-products with the highest biomass. Biomass values of Giao Chau and Giao Thanh are 23.17 and 43.59 tons / ha respectively. Therefore, the exponential equation form of NDVI was used for rice biomass mapping with the following equation: $y = 365.92x - 170.95$; where y, and x are the rice AGB, and the NDVI, respectively.

Quantitative comparison of rice biomass between analysis results and reference data showed a linear relationship with $R^2 = 0.6685$. The standard error of this estimation is 30.2 ha. To improve the accuracy and increase the applicability of the research into practice, a number of measures can be taken such as: using satellite images with a higher resolution; sample plot size is also larger than.

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Evaluation of metal pollution in surface water at some mines mining copper and gold ore in Lao Cai provine by HPI index

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1. Introduction

Lao Cai province has relatively developed mining activities such as copper, zinc, gold, and iron apatite ore mining concentrated mainly in the districts of Bat Xat, Bao Thang, Van Ban and Lao Cai city. Besides economic benefits, mining activities, especially copper and gold ores, have a significant impact on surface water environment. In particular, the impact of heavy metal dispersion from ore bodies, landfills, chemicals used in mining and processing is degrading the surface water system around the mines. Some studies on environmental quality assessment in mining areas in Lao Cai province such as Cuc Nguyen Thi et al, 2020. The above studies have shown that surface water environment near the mining site, especially rivers and streams, where is the direct receiving source that is polluted by COD components BOD_5, NO_2-, NO_3-… Most of the above studies focused mainly on assessing water quality by WQI index, using multivariate statistical calculations (MCA) or comparing with allowable standard. Level of pollution heavy metals in surface water are mainly evaluated individually by each index compared with the permitted standards. However, this does not give comprehensive assessment of the effect of metals composition on surface water quality.

Therefore, having a unique value is the basis for assessing the impact of heavy metals on surface water quality such as HPI (Heavy metal pollution index, HEI (Heavy metal evaluation index) is very important. In this study, the author used HPI index to assess seasonal heavy metal pollution in surface water copper and gold ore mining areas in Lao Cai province. Specifically, the author uses the analysis results of suface water at copper Sin Quyen and gold Minh Luong mines in Lào Cai provine in 2018 to assess heavy metal pollution in surface water in here.

2. Material and Methods

2.1. Study area

Sin Quyen copper mine in Bat Xat district, Lao Cai province has been exploited since 2006. The recovered products after processing are Cu and Fe ores. Exploited and processing wastewater after treatment is brought to receiving sources such as Hong River, Ngoi Phat Stream (Centre for Environment and Natural Resources Monitoring of Lao Cai province). Minh Luong gold mine in Van Ban district, Lao Cai province has been exploited since 2011 where Nam Xay stream and Chan stream flow through and is also the receiving source of wastewater from the mine. These are rivers and streams used by local people for living and irrigation purposes. Therefore, the assessment of surface water quality, especially heavy metal contamination is necessary. This paper uses the analysis of surface water samples in rivers and streams flowing through the two mines in the rainy season (6/2018) and the dry season in 2018 (12/2018) shows in table 1. The parameters used to evaluate heavy metal pollution in surface water include Cu, Pb, Zn, As, Fe, Cd.

2.2. Methods

HPI index developed by Mohan et al in 1996. HPI index is considered to be an effective method to evaluate the aggregate effect of heavy metals on water quality. In addition, the HPI index can be calculated for individual metals, thereby showing the effects of the water quality in different degrees (Sheykhi and Moore, 2012). Recently, there are many studies using HPI index to evaluate the effect of heavy metals on surface and groundwater quality (Sheykhi and Moore, 2012, Bably Prasad, 2020) had high efficiency.

Table 1. Details of the locations for surface water sampling at copper Sin Quyen and Minh Luong gold mines

S.no	Code	Sampling location	Location details	
			Latitude	Longtitude
1	SP1	Hong river water in front of the prossesing copper factory	2510208	397976
2	SP2	Hong river water behind the prossesing copper factory (300m downstream)	2502559	404004
3	SP3	Ngoi phat spring water at the foot of Ngoi Phat bridge	2502625	403857
4	SP4	Ngoi Phat spring water at the upstream of 500 underground	2502373	403720
5	SP5	Ngoi Phat stream at the downstream of 300m underground	2502028	403619
6	SP6	Nam Xay spring water	2434369	429180
7	SP7	Chan spring water in Minh Luong commune	2434737	428090
8	SP8	Chan spring water in Hoa Mac commune	2443491	442427

Source: Centre for Environment and Natural Resources Monitoring of Lao Cai province, 2018

The HPI is calculated with the following equation 1 (Mohan SV, 1996). For this study, the concentration limits (the highest permissive value for drinking water (Si) and maximum desirable value (Ii) for each parameter) were taken from the World Health Organization drinking water specifications (WHO 2006). The highest permissive value for drinking water (Si) refers to the maximum allowable concentration in drinking water in the absence of any alternative water source. The desirable maximum value (Ii) indicates the standard limits for the same parameters in drinking water. The HPI values of the groundwater water samples
were computed as per the following equation, which was provided by Mohan et al (1996).

$$\text{HPI} = \sum_1^n Q_i x W_i \,/\, \sum_1^n W_i \quad (1)$$

Where:

Q_i is the Sub index of the ith parameter

W_i is the unit weight of the parameter and n is the number of parameters considered. The sub index (Qi) of the ith parameter is calculated by the Eq. 2

$$Q_i = \sum_{i=1}^{n} \frac{\{M_i(-)I_i\}}{(S_i - I_i)} \quad (2)$$

Where:

M_i is the monitored value of heavy metal of the ith parameter, I_i is the ideal value (maximum desirable value for drinking water) of the ith parameter, and S_i is the standard value (highest permissive value for drinking water) of the ith parameter. The sign (-) indicates the numerical difference of the two values, ignoring the algebraic sign.

Currenntly there are many scales to classify HPI values (Sobhanardakania et al. 2016; Prasad and Bose (2001); Edet and Offiong (2002). Specifically, Sobhanardakania et al 2016 divided HPI values in to 3 levels (Low heavy metal pollution: HPI <100; Heavy metal pollution on the threshold risk HPI = 100 and High heavy metal pollution HPI > 100). In this study, the author used the classification scale of Edet and Offiong, 2002.

Pollution status	HPI
Low	< 25
Medium	25 - 50
High	> 50

3. Results and discussion

The summary statistics of metal concentration for dry and rainy seasons at the study area is presented in Table 2, 3. Statistical was calculated by SPSS.

Table 2. The concentration of metals in surface water at copper Sin Quyen and gold Minh Luong, Lao Cai in rainy season

STT	Code	Concentration of metals (mg/l				
		Cd	Pb	Cu	Fe	As
1	SP1	0,005	0,006	0,025	0,092	0,008
2	SP2	0,006	0,005	0,016	0,085	0,007
3	SP3	0,008	0,006	0,028	0,068	0,007
4	SP4	0,001	0,0012	0,06	0,64	0,002
5	SP5	0,001	0,008	0,05	0,47	0,006
6	SP6	0,003	0,001	0,029	0,856	0,006
7	SP7	0,002	0,001	0,009	0,34	0,002
8	SP8	0,004	0,001	0,024	0,087	0,002
Mean		0,0038	0,004	0,030	0,330	0,005
Min		0,0013	0,001	0,009	0,068	0,002

STT	Code	Concentration of metals (mg/l				
		Cd	Pb	Cu	Fe	As
Max		0,0080	0,0080	0,0600	0,8560	0,0080
Std		**0,0024**	**0,0024**	**0,017**	**0,302**	**0,0026**
WHO 2006		**0,003**	**0,010**	**2,0**	**-**	**0,010**

Table 3. The concentration of metals in surface water at copper Sin Quyen and gold Minh Luong, Lao Cai in dry season

STT	Code	Concentration of metals (mg/l)				
		Cd	Pb	Cu	Fe	As
1	SP1	0,002	0,003	0,048	0,08	0,001
2	SP2	0,004	0,002	0,051	0,072	0,006
3	SP3	0,003	0,005	0,027	0,059	0,007
4	SP4	0,002	0,001	0,05	0,54	0,006
5	SP5	0,002	0,001	0,08	0,64	0,002
6	SP6	0,001	0,0009	0,008	0,659	0,005
7	SP7	0,004	0,0009	0,012	0,732	0,001
8	SP8	0,002	0,0009	0,006	0,701	0,001
Mean		0,0024	0,002	0,035	0,435	0,004
Min		0,0010	0,001	0,006	0,059	0,001
Max		0,0040	0,0050	0,0800	0,7320	0,0070
Std		**0,001**	**0,0014**	**0,0262**	**0,307**	**0,002**
WHO 2006		**0,003**	**0,010**	**2,0**	**-**	**0,010**

From the statistical calculation results, the average contents of Cd, Pb, Cu, Fe, As were respectively; 0.004; 0.030; 0.330; 0.005 mg /l in rainy and dry seasons is 0.0024; 0.002; 0.035; 0.435; 0.004 mg /l. Most of the metals in the water are below the permitted threshold of WHO (2006), especially the Cd content almost exceeds the permissible standard according to the standards for drinking water, the Fe content is suddenly high. In SP5, SP6 and SP7 these are the locations near the discharge site of ore mining. We can also see that the higher concentrations of Cu and Fe concentrated at the sampling location on Ngoi Phat stream, Nam Xay stream and Chan stream near the ore-mining area. In general, the average concentration of metals in the surface water system near copper and gold mining areas in Lao Cai in the rainy season is usually higher than that in the dry season. This shows that the cause of heavy metal pollution is not only from ore mining and processing activities but also by dispersion from surrounding soil and rock and other sources. If cause of only mining resource, the concentrate of heavy metal in the rainy season will is lower than that in the dry season beacause in the rainy, level of water on the rivers and streams is higher than in the dry season. This means that the concentrate heavy metal is diluted lead to lower.

Although the water level on rivers and streams increases in the rainy season, but due to rain in mountainous areas, the terrain is steep, soil, dust, clay and other components increase due to leaching and erosion. The process of metal release into water leads to higher metal content in the water in rainy season than in dry season. The correlation matrix created for the metals are presented in Table 4.

Table 4. Correlation matrix of the metals

	Cd	*Pb*	*Cu*	*Fe*	*As*
Cd	1				
Pb	**0,44**	1			
Cu	-0,29	0,07	1		
Fe	**-0,57**	**-0,53**	0,03	1	
As	**0,47**	**0,65**	-0,03	-0,37	1

Table 4 shows that the metals in surface water are related by correlation value (R). In which, the most positive correlation is the correlation between As and Pb (R = 0.65), between As and Cd (R = 0.47). Inverse correlation was shown between Fe and Cd (R = -0.57) between Fe and Pb (R = -0.53). From this correlation it can be seen that the metal groups As, Cd and Pb can be the same source of decomposition.

Based on the metal concentrations in the water in the rainy season (June 2018) and the rainy season (December 2018) and the WHO limit values (2006), the HPI value is calculated for Hong river and streams Ngoi Phat, Nam Xay and Chan. The parameters considered are Cd, Pb, Cu, Fe and As. HPI is determined by the formula ... Where, M_i is the mean of the parameters in each river or stream. S_i và I_i were taken from the World Health Organization drinking water specifications (WHO 2006). The highest permissive value for drinking water (Si) refers to the maximum allowable concentration in drinking water in the absence of any alternative water source. The HPI values of the surface water in the study area was calculated and classified follow classification scale of Edet and Offiong, 2002. The results shows in tables 5 and 6.

Table 5. HPI values of the surface water at mining copper and gold ore areas in Lao Cai province in the rainy

River/Spring	HPI	Pollution status
Hong	41,32	Medium
Ngoi Phat	28,75	Medium
Nam Xay	23,49	Low
Minh Luong	24,41	Low

Table 6. HPI values of the surface water at mining copper and gold ore areas in Lao Cai province in the dry

River/Spring	HPI	Pollution status
Hong	24,22	Low
Ngoi Phat	17,58	Low
Nam Xay	9,53	Low
Minh Luong	25,13	Medium

From the tables 5 and 6 shows that surface water in Nam Xay stream has the smallest HPI value of 9.53 in the dry season and the highest is at the Hong River location in the rainy season is 41.32. In general, the level of heavy metal pollution in rivers is mostly low, and some locations are moderate in the rainy season. The level of heavy metal pollution in the dry season tends to be lower than in the rainy season, which is consistent with the above statistical results. The calculation also showed that components Cd and As are the cause of the high HPI value in the study area. Although the water in rivers and streams in the study area is mainly for irrigation purposes, this will be a water source for domestic use when there is no alternative water source.

Therefore, the HPI index is an important data to assess whether the water quality is suitable for domestic purposes or not. The HPI value in the water in most locations is from low to medium, but research results also show that the metal concentration in the water is not only affected by the mineral extraction process, but also has an impact. by other sources such as the process of releasing metals from rocky soil where flows pass and dust, clay ... in the surrounding environment. However, However, there are certain limitations to these methodologies. The HPI needs an ideal value (Ii) or a required value which is not provided by any agency for the metals. Moreover, the metals with lowest standards have the highest influence on the HPI as the weightage (*W*i) is the inverse of the standard values of the (*S*i).

4. Conclusion

The assessment results of heavy metal pollution in surface water in Hong River and Ngoi Phat, Nam Xay, Chan streams by HPI index showed that it is low to medium. The lowest found HPI value was 9.53 in the dry season in Nam Xay stream and highest at the Hong river location in the rainy season at 41.32. The statistical results and HPI index both show that the average concentration of metal in the water is higher in the rainy season than in the dry season, and the concentration variation level is also greater. Research results also show that the metal concentration in water is not only affected by mineral extraction, but also by other sources such as the release of metals from rocky soil and dust. , clay, clay ... in the surrounding environment. Thus, it can be seen that HPI is a useful method to assess whether water quality is affected by heavy metals or not. However, the HPI calculation method is also limited because for some metals we have difficulty determining the maximum permissible value for drinking water when there is no alternative source.

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Radioactive activities in plant in the area the rare earth mine Muong Hum, Lao Cai

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Abstract: Nowadays, the determination of the total content of radioactive substances contained in plants is a great concern of public health care and in radiation safety control. However, the radioactivity in this type of sample is often very low, making their determination very difficult. This paper presents a method to determine the total alpha and beta radioactivity in plants by the HPGe gamma spectrometer and the LB4200 total alpha and beta measurement system at the laboratory of the Institute of Nuclear Science and Technology, the Institute of Energy. Vietnamese atom. Analytical results of 10 plant samples (04 samples of vegetables, 03 samples of water spinach, 02 samples of beans, 02 samples of potatoes) collected from households growing in the area of rare earth mine Muong Hum, Bat Xat district, Lao Cai province showed a clear distinction between plant samples, total alpha activity in tubers and fruit samples was higher than in green vegetable samples; The total beta activity in the samples was very low, almost negligible.

Keywords: alpha activity, beta activity, plants, Lao Cai

1. Introduction

Currently, the study of using plants as indicators in environmental monitoring, evaluation and treatment has been widely applied in the world. Because indicator plants are closely related to the living environment, they are also an important link in the transport of radionuclides from the source of pollution to humans and can be used as a method. environmental treatment techniques [1-3]. Therefore, in recent years, the method of using plants to treat radioactive pollution has been interested in research and investment because of its low investment cost, safety and environmental friendliness [4-6].

In the process of growth and development, plants absorb natural or artificial radioisotopes in the surrounding environment, especially in areas containing high levels of radionuclides. Therefore, in plants, there is a certain amount of radionuclides, and depending on the high or low radioactive content, the long or short use time of the plant will directly affect human health. Therefore, the determination of total alpha and beta activities in plant samples has been studied recently by domestic and foreign scientists [6-10].

The article presents the results of determining alpha and beta radioactivity in plant samples taken in the area of Muong Hum commune, Bat Xat district, Lao Cai province. This is an area of rare earth mines containing natural radionuclides with high concentration.

2. Research Methods

2.1. Research subjects

In this study, the author selected to conduct with 04 types of samples as follows: 03 samples of morning glory; 04 samples of cruciferous vegetables; 02 samples of beans and 02 samples of potatoes. These are samples grown and used by people in the area every day.

+) Water spinach: Water spinach contains many substances that are very important for the living organism such as: protit, glucose, cellulose. On the other hand, water spinach has good ability to absorb heavy metals, radiation, toxic substances... in water and soil.

+) Vegetables contain many substances such as protein, glucose, fiber, vitamins, minerals such as calcium, potassium, sodium, phosphorus ... Vegetables also have the ability to absorb toxic substances, heavy metals, radioactive substances. uranium, radium…

+) Cowpea contains protein, vitamins A and C, many vitamins of group B and many important trace elements for the body's development such as calcium, iron, potassium, phosphorus, magnesium, zinc...

+) Potatoes: Potatoes contain a lot of starch, many B vitamins and minerals necessary for humans such as zinc, calcium, magnesium, iron, phosphorus ...

Samples of morning glory, vegetables, cowpeas, potatoes were collected in the vegetable growing area of households in Muong Hum commune, these are the foods commonly consumed by people in the area.

2.2. Research Methods

In this work, the author has selected the method of processing and processing samples according to the ashing method. The advantage of this method is that it avoids chromogenic reactions that increase the “Quenching” effect in the detector and has high sample recovery. The disadvantage of the method is that it requires specialized skills and equipment. The treatment of samples by the ashing method is depicted [6-10].

3. Sample treatment

3.1. Sample cleaning

- Samples of green vegetables were removed from the root, withered leaves, then washed with water, rinsed with distilled water twice, and left to dry at room temperature.
- Potato samples were washed, peeled and allowed to dry at room temperature.

Table 1. Quantification of samples by ashing method

Sample	Symbol	Mass (g)	Note
Water spinach	M.01	175,0	Fresh samples
	M.02	174,6	Fresh samples
	M.03	176,1	Fresh samples
Cabbage	C.01	163,2	Fresh samples
	C.02	160,0	Fresh samples
	C.03	157,6	Fresh samples
	C.04	162,4	Fresh samples
Pea	Đ.01	158,0	Fresh samples
	Đ.02	159,3	Fresh samples
Potato	T.01	167,0	Fresh samples
	T.02	165,6	Fresh samples

3.2. Sample drying

The above samples were chopped and dried at 85ºC for 72 hours. After the checkweighing, the loss in mass is shown in Table 2.

Table 2. Sample weight loss after drying

Sample	Amount of fresh samples (g)	Amount of sample after drying (g)	Attenuation (%)	Note
M.01	175,0	17,7	89,4	Water spinach
M.02	174,6	16,8	88,9	Water spinach
M.03	176,1	18,2	90,1	Water spinach
C.01	163,2	11,8	93,5	Cabbage
C.02	160,0	10,7	92,3	Cabbage
C.03	157,6	10,2	92,7	Cabbage

C.04	162,4	11,3	93,8	Cabbage
Đ.01	158,0	16,5	88,4	Pea
Đ.02	159,3	16,7	88,7	Pea
T.01	167,0	38,3	78,6	Potato
T.02	165,6	37,4	76,9	Potato

3.3. Sample heating

After drying, the samples are ashed in a specialized furnace. In order to ensure that the sample is completely ashed, after a number of tests, we have selected the firing temperature to be 700oC and the firing time to be 4 hours. The mass of ash obtained and the reduction in mass reduction are given in Table 3.

Table 3. Mass of calcined sample and amount of ash received

Sample	**Amount of dry sample (g)**	**Amount of ash obtained (mg)**	**Attenuation (%)**	**Note**
M.01	10	512	88,2	water spinach
M.02	10	517	88,7	water spinach
M.03	10	509	88,5	water spinach
C.01	10	623	90,4	Cabbage
C.02	10	621	90,2	Cabbage
C.03	10	627	90,5	Cabbage
C.04	10	624	90,6	Cabbage
Đ.01	6	202	92,8	Pea
Đ.02	6	204	92,7	Pea
T.01	10	301	94,5	Potato
T.02	10	305	94,6	Potato

4. Results and Discussion

In HPGe gamma spectrometer and alpha total counting system, beta LB4200 is used to analyze vegetable and tuber samples, by pulse discriminant technique, the signal of alpha radiation and signal of beta will be separated. on two separate channels.

Data analysis on the alpha channel and mass correction according to the instrument's standard data on the standard sample, determined the specific activity value of alpha radiation in the analyzed samples. The results are given in Table 4.

Table 4. Alpha activity in samples

Sample	The count has subtracted the font (CPM)	Alpha activity (Bq.kg-1)	Note
M.01	35,65 ± 0,74	41,33 ± 0,87	Water spinach
M.02	36,42 ± 0,72	42,18 ± 0,81	Water spinach
M.03	35,31 ± 0,72	42,25 ± 0,83	Water spinach
C.01	67,87 ± 0,92	45,24± 0,62	Cabbage
C.02	66,75 ± 0,91	46,04± 0,63	Cabbage
C.03	66,57 ± 0,91	45,32± 0,61	Cabbage
C.04	67,87 ± 0,92	45,87± 0,61	Cabbage
Đ.01	41,55 ± 0,78	48,12 ± 0,95	Pea
Đ.02	42,12 ± 0,77	48,79 ± 0,96	Pea
T.01	63,53 ± 0,91	82,34 ± 1,23	Potato
T.02	65,24 ± 0,93	83,75 ± 1,25	Potato

Results obtained in Table 4 show that there is a clear distinction in total alpha radioactivity in the samples. Radioactivity was highest in fruit and tuber samples (48.12 ÷ 83.75 Bq/kg), lower than in green vegetables (41.33÷46.04 Bq/kg).

The measurement results of beta radiation in the above samples, the beta channel of the instrumentation system shows that there is very little signal, almost insignificant. This proves that the amount of beta radiation in the plant samples is mainly from the element carbon (14C isotope). During the ashing process, this element was released in the form of carbonnic gas (CO2) out of the ash. This shows that, to determine the total beta radioactivity in plant samples, we can completely apply the method of measuring radiocarbon activity according to the radiocarbon age measurement process [12,13].

5. Conclusion

Using ashing technique, gamma spectrometer and alpha and beta total activity counter system are effective methods to determine the total alpha radioactivity in plant samples. Analytical results from 10 samples showed that there was a clear distinction between samples, total alpha activity in tubers and fruits was higher than in green vegetables.

With this ashing method, in the measurement results, the amount of beta radiation from the ash sample was not recorded, indicating that the beta radiation is mainly from the radioactive isotope of carbon. This element has been heated to CO2 and so to determine the total beta activity in plant samples we can completely use the radiocarbon age measurement procedure.

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Assessing the management of the rural domestic solid waste in the Red River delta

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Abstract

The unappropriated collected and treated solid waste is the one of main sources of severe pollution of the environment in rural area in Viet Nam. Therefore, the management of rural solid waste is becoming necessary. By using the collection data method and survey, community, the study has shown that the total amount of solid municipal waste created from Red River Delta which are 2,591,235 tons per year. The generation rate for solid waste in the rural is 0.3 ÷ 0.5 kg/person/day. The rate of collected waste is counts 79.1% of total waste. However, there is different to the rate of waste collection between provinces, which ranges from 67% to 95%. The organic in the solid waste is high, about 55 ÷ 74% of total solid waste. Only 1.78% of solid waste are separated at the sources (equal to 46,180 tons per year). Currently, there are 4 treatment methods to treat solid municipal waste. Almost the solid waste is treated by landfilling (61.1%), 16.7% is treated by burning and incineration, and composting is 1.5%. The rest amount is self-treated by residents by combustion, dumping of composting in their property gardens. To contribute to rural development for Red River Delta towards sustainability, the improvement of solid waste management is essential. The management includes waste separation, collection, storage and treatment of solid waste in order to protect our living environment

1. Introduction

The Red River Delta is located in Northern Vietnam, including 10 provinces and a city (Hanoi city, Hai Duong, Hai Phong, Hung Yen, Nam Dinh, Ha Nam, Thai Binh, Ninh Binh, Bac Ninh, and Vinh Phuc province). The Red River Delta has a low topographic and tropical monsoon climate and normally is flooded in the rainy season. The area region is about 15.040 square km. With the small area but region has the highest population and population density of all regions (22% of the population) and most of the population is concentrated in rural areas. At present, the management, collection, and treatment of rural solid waste has a lot difficult. Total amount of solid municipal waste in this region was about 2,591,235 tons per year. With these natural conditions, it has accelerated the decomposition process and dispersed solid waste to other areas if it was not collected and treated immediately. Besides, solid waste treatment technology is not suitable with reality and people's awareness is low. A large amount of solid waste was not collected and was discharged directly to the riverside, lakeside, field, and vacant land. It is one of the reasons making the polluted environment and destroying landscapes. Therefore, the management of domestic solid waste in the rural of Red River Delta need to attend and control by suitable solutions. In addition, the results of the study will summarize and evaluate the situation of solid waste collection and treatment and propose management solutions to domestic solid waste in rural areas of the Red River Delta.

2. Study methods

2.1. Collecting and editing data

Collecting situation data solid waste management in 10 provinces and a city in The Red River Delta (Ha Noi, Hai Phong, Quang Ninh, Hai Duong, Hung Yen, Vinh Phuc, Bac Ninh, Ha Nam, Nam Dinh, Ninh Binh and Thai Binh provinces). Listing the collection and treatment methods which were applied in the region collection and treatment methods which were applied in the region. All the data were collected from government organizations such as People's Committee of communes, districts, New Rural Offices and Department of Natural Resources and Environment of provinces or cities. The following descriptions are details of the methods. The information of the treatment process for the domestic solid waste was also collected. Reports and documents on domestic solid waste management, domestic solid waste collection fees, transportation, and treatment services in the Red River Delta were also collected.

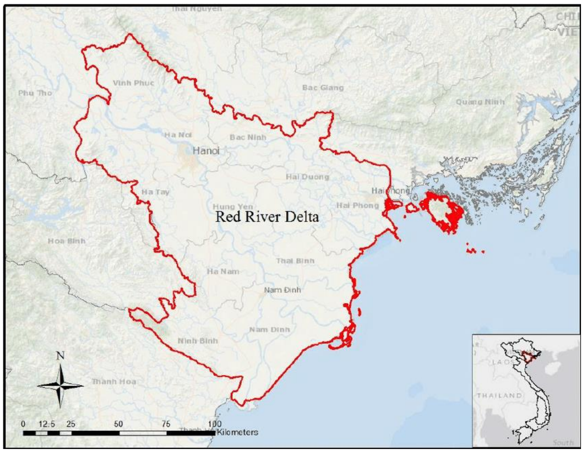

Figure 1. Location of the Red River Delta

2.2. Field survey

The field survey is essential to overview the actual situation of generation, collection, and treatment of rural solid waste in the study area. The survey was carried out to collect information on socio – economic development in the area, sampling and determination of rural domestic solid waste components, and habits and methods to manage the solid waste. Surveying, sampling and analyzing the composition of the solid rural waste base on living habit, treatment method in 10 provinces in the Red River delta.

Developing questionnaires table with issues such as habits, amount of solid waste generation, collection status, treatment methods and the desires of people and managers in the study area. Interviewing local environmental officials, workers of collection teams, incinerators, and landfill sites.

3. Results and discussion

3.1. The current of rural domestic solid waste management

The result of the investigation, survey and community consultation in 2018 showed that the total amount of solid municipal waste in the Red River Delta was about 2,491,527 tons per year. Such as Ha Nam is province having the lowest amount of solid waste with 43,800 tons per year and the highest is Ha Noi with 776,355 tons per year. The mass solid waste generated is shown in Figure 2. The generation source is from activities of households, markets, warehouses, agencies, shops, and public places. On average, each person generates from 0.3 to 0.5 kg of solid waste per day. The composition of rural domestic solid waste in the region is relatively diverse. It is consistent with the average amount of solid waste generation for person in rural area in Vietnam of Anh et al., 2018 is about 0.33 kg per day and in the Red River Delta is 0.4 kg per person per day. It is the similar to research of World Bank in 2004 estimated the average generation solid waste in rural of Vietnam is 0.3 kg per person per day (Thanh et al., 2011). However, this rate is also lower than that in the rural areas in big cities like Hanoi and Hai Phong, which is 0.86 kg per person per day (World Bank, 2018). In addition, the organic component in solid waste is also increasest over time, especially in the developed areas. According to the study by Ngan, 2018, the organic component waste in Hanoi in 2010 was 51.9% while in this study it is 70%. The percentage of organic waste was very high, mainly was decompose components (foods, leaves, vegetables…) and having humidity up to 60%. Inorganic components mainly were glass waste, crockery, metal, paper, plastic, plastic bags, broken electrical appliances. The waste composition of households was leftover food, plastic bags, confectionery covers, cans, leaves, electronic appliances, damaged items (light bulbs, the battery,…), rubber and leather and textile.

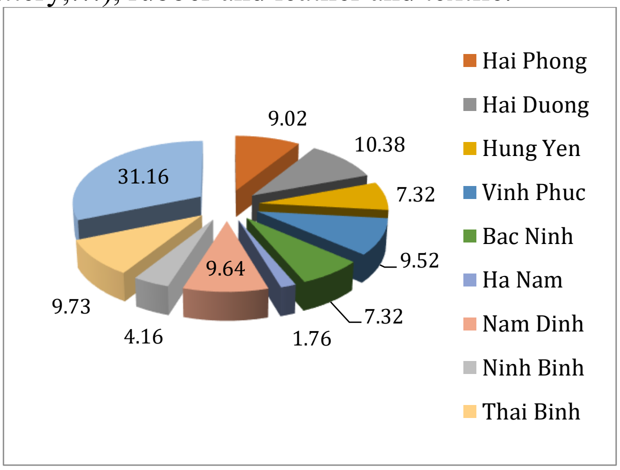

Figure 2. Rate of generation solid waste in provinces, %

Waste generated from tourism, service, restaurant, and market also was easily biodegradable organic such as leftovers, vegetables, tubers, and leaves. And waste from companies, offices, schools, public services mainly is paper, paper packaging, plastic, and discarded equipment. The amount of recycle waste in rural domestic waste in this area was only about from 2 to 8% that mainly is plastics, glass, metals, and paper. The biodegradable organic component ranges from 55 to 74% of rural domestic waste (Figure 3). Organic components in solid waste have increased and changed over time, especially in developing areas. In the researching result of Truong in 2018, the organic component in waste in Hanoi in 2010 was 51.9% but now is 70% (Truong, 2018), According to the World Bank's announcement, in 2004, the percentage of organic waste in domestic solid waste in rural areas in Vietnam ranged from 60 to 65% and of Thanh's research in 2011 was from 55 to 70% (Thanh et al., 2011).

Most of the domestic solid waste in this area is not classified at source, decomposable and difficult-to-decompose wastes are mixed together, this leads to efficient recycling and reuse of waste is not valuable. Only 2% of documented solid waste wase separated at the sources (46,180 tons). At present, the separation of waste at the source with components such as paper, wood, rubber, glass, metal, plastic and textiles has only been implemented in 4 provinces: Ha Nam with 67% (29,127 tons); Hung Yen with 6% (10,950 tons); Ninh Binh with 5.7% (5,928 tons) and Bac Ninh with 1% (174.96 tons).

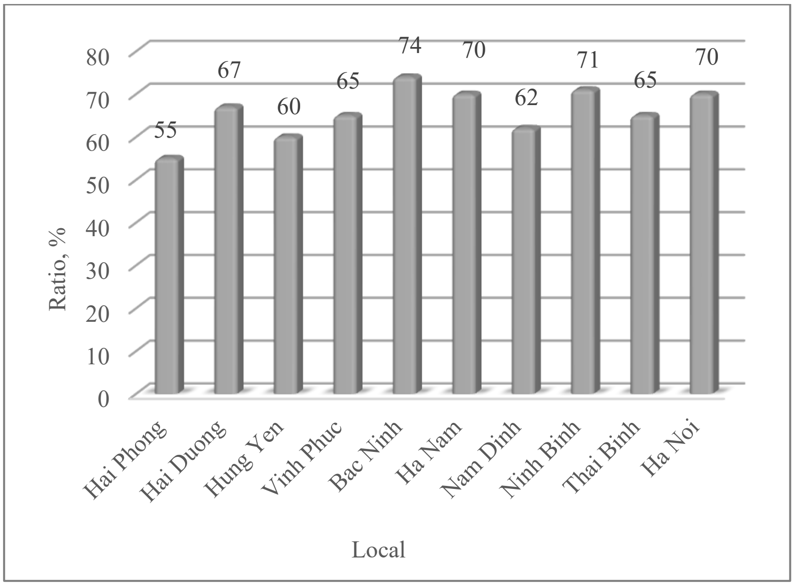

Figure 3. The rate of biodegradable organic components in rural domestic

In the past and present, rural solid waste is not collected, it is discharged directly to riverside areas, lakeside, fields and vacant land. But in recent years, with the task to build new rural areas, many different criteria were established and one of which is the environmental criteria. This has made the solid waste collection and management task in rural areas get more concerned. The solid waste collection rate in the region ranges from 67 ÷ 95% and reaches an average of 79.1%. According to the research results of Anh et al., 2018, about 60% of villages or communes is cleaned up and collected solid waste. Nowaday, over 40% villages and communes have forming self-managed waste collection groups with the rate of domestic solid waste collection in rural areas about 40 - 55%. In the research results of the authors, the rate to collected solid waste in the Red River Delta is higher than the collection rate of the whole country, about 79.1% of the whole province. Ha Nam and Hai Phong were provinces having the highest solid waste collection rate with amount respectively were 95% (41,610 tons/year) and 92.5% (207,847 tons/year) and the lowest are Hung Yen and Vinh Phuc provinces with collection rate respectively were 67% (124,476 tons/year) and 69% (163,702.5 tons /year). The reason is that the management of localities have paid attention to environmental protection, investment in equipment and manpower in solid waste collection and transportation. Beside that, the People's Committees of provincial or distric support financial for facilities collection. In addition, the people’s awareness is higher that they pay the fees for collection and support for the local environment management.

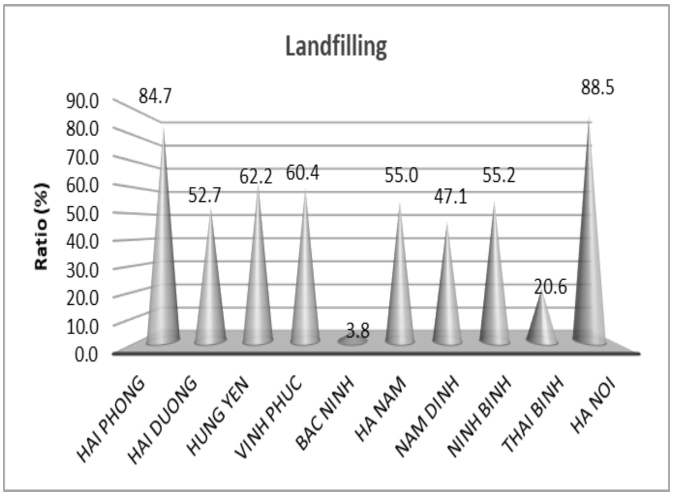

Figure 4. The rate of solid waste was treated by different methods in the Red River Delta

To achieve this result, the Commune People's Committee called on households to collect waste by themselves, increased the frequency of collection from two to six times a week depending on the region and introduced financial policies to suit with reality. After collected, solid waste will be transported to solid waste treatment plants or treated by a number of different methods such as combustion, composting, etc. Besides, with the difficulty of collecting and transporting solid waste to treatment plants, people often treat their domestic solid waste at home by burning, burying or composting in the garden. In the communes where this method is applied, the local authority has assigned the Women's Union to be responsible and implement a solid waste sorting model at source to recycle waste as well as minimize disposal costs. The volume of domestic solid waste in each province in the Red River Delta region was treated by different treatment methods is shown in Table 1.

Table 1. The current of technologies to treat domestic solid waste in the Red River Delta

	The volume of rural solid waste is treated by technologies, tons/year			
Provinces/Cities	Landfilling	Burning and incineration	Composting	Treatment at home
Hai Phong	190,368	12,373.5	-	21,887.5
Hai Duong	136,145.0	25,853.0	-	9,6531.5
Hung Yen	113,526.0	-	-	68,974.0
Vinh Phuc	143,262.5	20,440.0	-	73,547.5
Bac Ninh	6,957.0	109,500.0	-	66,043.0
Ha Nam	24,090.0	9,125.0	-	10,585.0
Nam Dinh	112,967.5	24,000.0	-	103,093.0
Ninh Binh	57,190.0	6,000.0	18,250.0	22,103.0
Thai Binh	50,037.6	122,275.0	16,425.0	53,622.5
Ha Noi	687,074.2	85,399.1	3,881.8	-
Total	**1,521,617.7**	**414,965.6**	**38,556.8**	**516,387.0**

Source: New rural coordination offices in provinces/ city of Ha Nam, Hai Duong, Bac Ninh, Hai Phong, Ninh Binh, 2018, Department of Natural Resources and Environment of Vinh Phuc province, 2018, People's Committee of Nam Dinh province, 2018.

Almost the amount of domestic solid waste was treated by landfilling, burning and incineration methods, a few were treated by composting and treated at home by household. The treatment methods are shown in Figure 4. The reasons for the difference in solid waste treatment methods in this area are due to costs, solid waste management policies, collection methods, land use planning, and planning. regional economic development plan. Almost the provinces are using landfill methods to treat solid waste. (Hoa, 2019). Landfill places are mainly temporary landfills, they do not have enough adequate technical infrastructure and not follow operated proper hygienic burial procedures. And only have 3 landfills meet quality standards such as Nam Son in Hanoi, Do Son in Hai Phong and Loc Hoa in Nam Dinh (Department of Natural Resources and Environment of Hanoi city, 2017; People's Committee of Nam Dinh province, 2018; New rural coordination office of Hai Phong province, 2018).

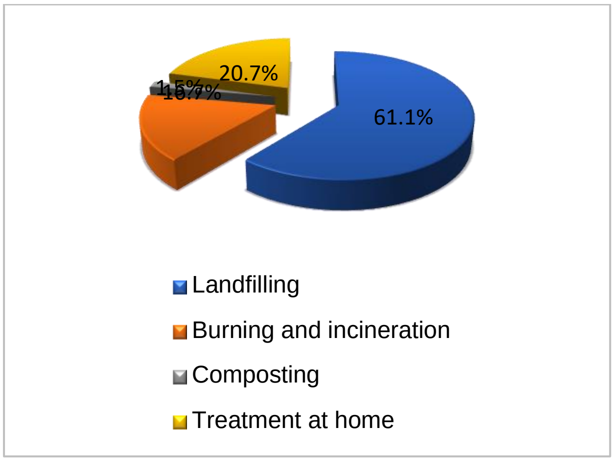

Figure 5. The rate of solid waste treatment by landfilling technologies in the provinces/city of the Red River Delta

Many temporary landfills have been formed for a long time and have become a serious source of pollution to the water, soil, and environment such as the landfills in Ha Nam and Bac Ninh provinces. 61.1% of the solid waste is treated by the landfill method and the rest was treated by concentrated burning and composting method. (Figure 5). In the rural areas that the condition to collect and transport is difficult or the areas is not large to built the landfill and concentrated waste treatment areas, people often collect and treat the domestic solid waste at home by burning, burying or composting methods in the garden. In the communes where this method is applied, the local authority has assigned the Women's Union to take responsibility and implement the domestic solid waste classification model to take advantage of resources and saving costs to treat the solid waste. (Department of Agriculture and Rural Development of Hung Yen province, Department of Natural Resources and Environment of Thai Binh province, 2018). In particular, each household will separate two types: organic and inorganic. Organic waste is treated by people at home by feeding fish or burying it under the tree as fertilizer, or aerobic composting to produce manure and anaerobic composting to recover methane, producing household electricity in the family. Inorganic waste is collected and burned in the corner of their garden.

Like other areas in Vietnam, 80 - 83% amount of solid waste in the rural in the Red River Delta was mainly treated by landfill, next is by composting method (7%) and recover and recycle by private facilities (10 - 12%) (Chi, 2018). The provinces having the highest amount of solid waste was treated by landfill method (including open landfills and sanitary landfills) are Hanoi with 88.5% and Hai Phong with 84.7%. The reason for the difference between the rate of treatment by technologies in each local in the Red River Delta is changes on regional conditions such as: costs, the mechanism to manage solid waste of the locality, collection methods, land uses, planning to develop economic region... In particular, almost the provinces in this area use landfill to treat the solid waste but only 3 landfills have conform environment standard that is Nam Son landfill in Hanoi, Do Son landfill in Hai Phong and Loc Hoa landfill in Nam Dinh. In the others landfill, the solid waste is mainly buried in temporary landfills, technical infrastructure has not been invested much, some localities have not followed the process hygienic burial.

At present, in the region have several solid waste treatment plants such as Loc Hoa plant in Nam Dinh province, Dai Dong plant in Hung Yen province, Xuan Son plant in Son Tay town and Nam Son in Soc Son district. In areas where the area is not enough to build sanitary landfills, need to apply other methods to treat solid waste. One of the well-known private companies, Tan

Thien Phu has been researching new technology and manufacturing incinerators with the LOSHIHO brand having treatment capacity up to 1,000 tons per day. Combustion methods can be used at the sanitation landfill to reduce the volume wastes bring to burial sites, increase the operating time of landfills, reduce the backlog of waste and limit the pollution of soil, water, and air. The incineration on site and burning in landfills has increased the landfill's treatment capabilities. According to the survey results, in the study area have 79 incinerators, of which 18 incinerators with a capacity over 50 tons per day, 4 incinerators with capacity from 10 to 50 tons per day, and the rest from 1 to 5 tons per day. (Figure 6).

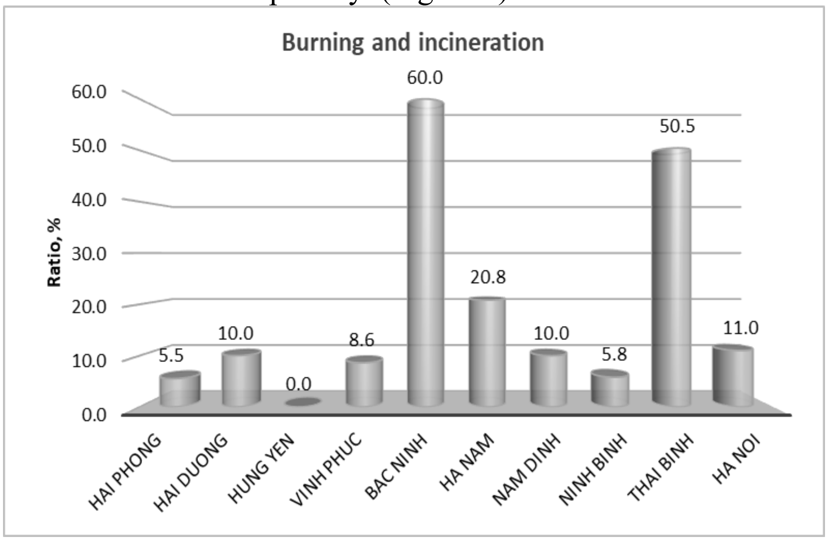

Figure 6. The rate of solid waste treatment by burning and incineration technologies in the provinces/city of the Red River Delta

Many incinerators were old or were damaged, the gas treatment system did not operate substandardly and caused pollution. (Lam et al., 2019). The management and operation of these incinerators faces many difficulties and inefficiencies. For large scale incinerators, the exhaust treatment system is well invested but the treatment capacity is not satisfactory as the amount of solid waste collected is insufficient. This causes made waste and inefficiency. Therefore, with the incinerator technology, the authorities need to pay attention to the inspection of technical requirements and operation to minimize the risk of secondary pollution.

According to the survey results, there are only two provinces in the Red River Delta their composting factories are still operating, however, lower than the designed capacity, which is Ninh Binh solid waste treatment plant in the Tam Diep city (200 tons per day), Cau Dien composting plant (5 tons per day) and Kieu Ky solid waste treatment plant (18 tons per day) in Hanoi city. In addition, in recent years, many provinces have borrowed ODA capital to build waste treatment plants that have composting technology. But many factories had to close because the product could not be sold. For example, the Hai Duong organic fertilizer factory was invested by Hai Duong Urban Environment Company in late 2012 and closed in 2015. After that, all the domestic waste was transferred to the Seraphin Waste Treatment Plant to incinerate. Not only in Hai Duong, many other waste treatment plants in Hai Phong, Nam Dinh with ODA from Spain, Korea, France, Belgium... also had to close because of unexpected results and also polluted the environment (Tuan, 2017). According to the survey results, there are only two provinces in the Red River Delta their composting factories are still operating, however, lower than the designed capacity, which is Ninh Binh solid waste treatment plant in the Tam Diep city (200 tons per day), Cau Dien composting plant (5 tons per day) and Kieu Ky solid waste treatment plant (18 tons per day) in

Hanoi city. The main reason is that solid waste is not classified well at source, the solid waste contains too many inorganic components. The process of reclassifying waste at the factory is still done manually. This leads to an unsecured solid waste component, which makes fertilizer quality not high and did not meet the requirements of the market and farmers.

Some other provinces have invested in solid waste recycling technology such as plastic recovery and recycling technology of Thanh Dat Trading Joint Stock Company in Thai Binh province, Dai Dong waste treatment plant in Van Lam, province. Hung Yen (URENCO 11). However, the amount of waste treated by this technology is very small. Like the composting plants, the waste has not been classified at the source so the output and product quality are uneven, the efficiency is not high.

The model of self-treatment at the households in rural areas of the Red River Delta is often implemented in communes with difficult conditions, difficult to collect and transport. This method is quite useful because it can reduce the amount of solid waste discharged directly into the environment and can be used as fertilizer for farming. In this model, people build tanks or use plastic containers to compost organic fertilizer. Households will be supported with partial funding and microbiological products used for composting. This model was implemented with the highest rates in Nam Dinh (42.9%) and Hung Yen (37.8%) and received the acceptance and attention of the people.

3.2. Solution proposal

This paper also summarized and pointed out some difficulties and obstacles in the management and treatment of rural domestic solid waste in the Red River Delta region, including the following issues:

- There were not have concrete regulations that allow organizations and individuals joint to solid waste treatment filed; especially for foreign companies.
- The effectiveness of treatment technology in treatment plants is still low.
- Current treatment technology does not guarantee environmental standards. Many localities still use open burial sites, the waste gas quality of incinerators did not get the limit permitted standards, the composting factories operate inefficiently;
- The solid waste classification at source is limited, people do not have this habit;
- The procedure of borrowing capital to build a solid waste treatment plant is still difficult. The number of projects borrowed from preferential sources is very small;
- People's awareness of solid waste management and public sanitation is still low. A part of people has been trying to obstruct, making it difficult for the implementation of waste treatment plant projects;
- The socialization of investment in solid waste treatment is limited. Environmental sanitation fees are still low, and private businesses find it unattractive to invest in building solid waste treatment plants.
- Therefore, in order to improve the efficiency of solid waste management in the area, it is necessary to synchronize a number of specific solutions as follows:
- Formulating criteria and standards to assess the capacity conditions of organizations and individuals that can collect, transport and treat solid waste;
- The Ministry of Science and Technology should combine with the Ministry of Natural Resources and Environment to build and promulgate the standards or guide book for selection of suitable treatment technologies for rural areas in the Red River Delta

- Solid waste management is mainly carried out by the people's committees of communes, towns, and even by groups of villages, hamlets and families. Therefore, it is necessary to plan solid waste collection sites and construction sites for waste treatment plants;
- Investing and replacing old equipment and supplying new equipment, increasing the frequency of collection in order to meet the amount of solid waste generated annually;
- Researching and developing treatment technology to reduce the amount of solid waste to be buried, and increasing the rate of recycling, reuse and recovery of energy from solid waste;
- Limiting the construction of small-capacity incinerators at commune level. Upgrading and renovating incinerators that did not meet QCVN 61-MT: 2016 / BTNMT - National Technical Regulation on Domestic Waste Incinerators.
- Need to build concentrated solid waste treatment plants with the district or inter-district scale. To be able to use synchronous treatment technologies from recycling, reuse such as compost, recovering heat from combustion and using ash to make suitable products such as unburnt bricks to minimize the amount of solid waste to be buried
- Continuing to build and expand the model of solid waste classification at source and synchronized in the collection, transportation, and treatment solid waste in this region;
- Promoting socialization and privatization of collection, transportation and construction of waste treatment plants increasing environmental fees; reducing support from the government budget; Formulating policies in construction investment, management, and operation of solid waste treatment plants;
- Need to check the activities of collecting, transporting and treating solid waste regularly to detect, prevent and handle violations;
- Establish a database to systematize rural solid waste management. Increase in the preferential policies and financial support in rural domestic solid waste management. (Huong et al., 2012);
- Educating to raise people's awareness and encouraging community participation in solid waste management (Tuan, 2017). Need developing and implementing communication programs to raising people's awareness about social guidelines, policies, and laws. Assignment responsibilities of levels, branches, localities, and households in the classification, collection, and treatment of solid waste in rural areas are more clearly.

4. Conclusion

- The researching results showed that the total amount of solid municipal waste in Red River Delta was about 2,591,235 tons per year (0.3 - 0.5 kg/capita/day) and the waste collection rate by region is different from 67% to 95%, with an average of 79.1%. Only 2 % of solid waste was separated at the sources (equal to 46,180 tons per year).
- The collection, transportation, and treatment of solid waste in this region had many difficulties because solid waste was not classified at source. Human and equipment for solid waste management were limited. The management of solid waste is performed by the People’s Committee of provinces but it was not uniform among localities. Besides, awareness of people was not high, solid waste treatment technology was not suitable. There are the reasons make the t solid waste management was not effective.
- At the present, in this region had 4 methods which were applied to treat rural solid waste, in which 61.1% by burial method; 16.7% by burning method; 1.5% bay composting method and 20.7% was treated by households (burning, burying or composting in the garden).
- The operation of solid waste treatment works did not reach the technical requirements such as some open landfills did not have leachate wastewater treatment system, daily cover layer

or burned waste manually. In small-scale incinerators, the emission treatment system did not meet the safety and quality standards. Ash and slag after burning were not collected and treated. In the composting method, the solid waste was not classified carefully and it made the product's quality was not good and using efficiency not so high.

- Basing on the current state of management and difficulties during the implementation process, it can be said that rural solid waste management is a complex issue that needs the participation of all levels, sectors and all of the people. The socialization of solid waste management and treatment should be promoted. Besides, it is necessary to combine all the solutions, including institutions, policies, science and technology, Economy, education and propaganda. Rural solid waste management will achieve positive results.

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Assess The Current State of The Environment In Brackish-Water Shrimp-Farming Areas In Nam Dinh Province And Proposing Measures To Improve Efficiency

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1. Introduction

According to the report of the Directorate of Fisheries, in 2021 the brackish water shrimp farming area is estimated to reach 740 thousand hectares (equivalent to 100.5% compared to 2020); in which, the farming area of black tiger shrimp is 630 thousand ha, the area of white leg shrimp farming is 110 thousand ha. However, besides the achievements in production, there are also many difficulties faced by shrimp farmers, including problems of disease and environmental control. According to the Department of Animal Health's report, in the first eight months of 2021, the total damaged brackish water shrimp farming area was 15,698 hectares, accounting for about 2.2% of the country's total shrimp farming area and 96.6% of total aquaculture area suffered damage, mainly white spot disease, acute hepatopancreatic necrosis, and microsporidian diseases.

Nam Dinh is one of the three major shrimp farming provinces of the North, with 72km of coastline, farming here was established in 2000 with the form of extensive farming of sea crabs and tiger shrimp. Breeding form and species are gradually changed over time to suit the needs of economic development and market. Like other shrimp farming areas, farmers here often face difficulties in diseases, environmental degradation and fluctuations. Therefore, the purpose of this study is to assess the environmental status of brackish water shrimp farming in Nam Dinh province and propose solutions to improve efficiency.

2. Methodology and Data

The data is collected from the environmental monitoring task of shrimp farming in Hai Chinh commune, Hai Hau district and Quat Lam town, Giao Thuy district, Nam Dinh province in 2021.

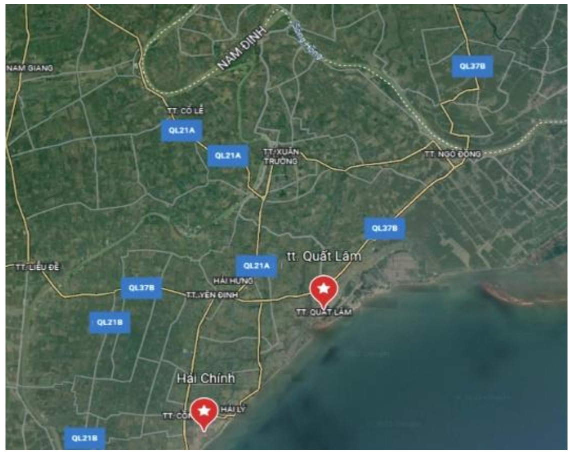

Figure 1. Sampling sites for water supply in Hai Chinh and Quat Lam

Monitoring parameters and frequency: Temperature, pH, Salinity, Alkalinity, N-NO_2, N-NH_4, total Sulfide, COD, TSS, Toxic Algae, total Vibrio, Coliforms, Vp AHPND monitoring frequency is 2 times/month and 03 seasons change in April, August and September.

Method of collecting and analyzing samples: Water samples were collected into plastic bottles and kept cold and transferred to the laboratory for analysis of the following parameters: Alkalinity (SMEWW 2320 B: 2011), N-NH_4 (SMEWW 4500-NH_3 F: 2017), N-NO_2 (SMEWW 4500-NO_2 B: 2017), COD (SMEWW 5220 C: 2017), TSS (TCVN 6625: 2000), total Sulfide (SMEWW 4500-S2- D: 2017), total Vibrio (Buller., (2004). Shrimp samples were collected and fixed in alcohol 90° and transferred to the laboratory for analysis of acute hepatopancreatic necrosis disease (AHPND)

3. Results and discussion

3.1. Monitoring results of some indicators of water supply

Table 1. Percentage of sample is out of allowable limit

Location	Temperature (°C)	pH	Salinity (%)	Alkalinity (mg/l)	N-NO_2 (mg/l)	N-NH_4 (mg/l)	H_2S	COD (mg/l)	TSS (mg/l)	Total Vibrio	Coliforms (CFU/100ml)	VpAHPND
QCVN 02-19:2014/BNNPTNT	18-33	7-9	5-35	60-180	≤0.05	≤0.3	≤0.05	≤10	≤50	≤1000	≤1000	positive
Number of times beyond the allowable limit	2	0	1	3	21	27	0	0	8	3	11	1
Number of monitoring	46	46	46	46	46	46	46	46	46	46	46	46
Percentage	4.35	0.0	2.17	6.52	45.65	39.13	0.0	0.0	17.39	6.52	23.91	2.17

Temperature: During the monitoring period, the measured temperature is within the allowable range according to industry standards (TCN:18-33°C) [1]. Particularly in

January, the average temperature is lower than the limit value suitable for shrimp farming (>18 ºC).

pH: The monitoring results show that pH is an indicator with a stable average value in the monthly monitoring periods, ranging 7.8 - 8.5.

Salinity: Suitable salinity for farmed shrimp is recommended to be from 15-25‰ and no sudden change in salinity [2]. The monitoring point of the supply source is regulated by the sluice that takes saline water from the coast to the canal of the farming area, so the salinity is relatively high, but the monitoring times are priced within the allowable range.

COD: The COD concentration at the monitoring point is in the range suitable for aquaculture. COD in aquaculture pond water is usually in the range of 40-80 mg/l, COD value from 0-50 mg/l is considered good water quality for aquaculture. *(Boyd et al., 1998).*

Alkalinity: The results of monitoring ponds showed that the alkalinity fluctuated slightly but within the allowable range. Because the supply channel has a sluice that regulates salt water from the sea, the salinity and alkalinity are always maintained at a high level and suitable to natural conditions.

$N\text{-}NO_2$: The average $N\text{-}NO_2$ concentration in the feed water at the monitoring points is almost too high to exceed the allowable limit. In Hai Chinh there are 8/10 months (except March and September), in Quat Lam 2/10 months (January and February).

$N\text{-}NH_4$: According to Boyd *et al*. (1998) and Chanratchakool P *et al.* (2003) suitable $N\text{-}NH_4$ content for shrimp ponds from 0.2 - 2.0 mg/l. The concentration of $N\text{-}NH_4$ in the source water supplied to monitoring points in Nam Dinh is 1.2 times higher than the allowable limit.

Total Sulfide: All monitoring points have the presence of total sulfide but with low concentrations within the allowable limits according to QCVN 02-19:2014/BNNPTNT (<0.05 mg/l).

TSS: In Hai Chinh in January, March and July, Quat Lam in January was higher than the threshold of 50mg/l. These are the beginning of the agricultural season of the year, so the water supply is also affected. When the water is cloudy, the TSS value is usually high.

Toxic Algae: In April, Hai Chinh observed that the concentration of toxic algae *Pseudo-nitzschia seriata* was 2.6 times higher than the warning limit. Toxic algae in feed water were mainly detected at the beginning of the year, no toxic algae were detected in May-July and October.

Total Vibrio: At the time of January in Hai Chinh, the value exceeded the allowable limit by 1.3 times.

Coliforms: The supply water at the monitoring point generally has coliform fluctuating about 2 times higher than the allowable limit.

Vp AHPND: The water supply in Hai Chinh has an infection rate of 4.35%. The time to record the occurrence of AHPND in the water samples collected from the water supply monitoring points in brackish water shrimp farming areas is in July and August.

3.2. Results of monitoring brackish water shrimp ponds:

In ponds where the water temperature is quite stable because the ponds are over 1.5 m, the salinity is within the allowable limit. The pH value is suitable for the growth and development of shrimp. Alkalinity, COD, TSS, $N\text{-}NO_2$ and $N\text{-}NH_4$ in ponds are high and affect shrimp culture. Total sulfide in water is low, suitable for shrimp farming. The total concentration of Vibrio bacteria in the water with a low frequency of occurrence in ponds was 6.3% of the samples. However, due to good care, total Vibrio has little adverse effect on farmed shrimp. The pathogen VpAHPND was detected in the water, but all cultured shrimp samples were negative for this pathogen. Farmed shrimp samples were all negative for VpAHPND throughout the growing season.

3.3. Proposing measures

Management measures: Strengthen the management of wastewater treatment and sanctions for violations at farming facilities. Proposing to invest in modern technology applications throughout the farming process.

Proposing management agencies to issue new regulations and standards with a full set of parameters to provide a basis for recommendations to farmers.

Technical measures: Change 20-30% of the water in the pond with a frequency of 3 times/month to reduce alkalinity and TSS. Using probiotics containing strains of Nitrobacter, Nitrosomonas, Bacillus to decompose $N\text{-}NH_4$, $N\text{-}NO_2$, $P\text{-}PO_4$ and organic matter, cleaning ponds. Limit running water fans during the day, treat algae with microbial products, after 2 days of microbiology to treat pond bottoms to decompose dead algae that accumulate on the pond bottom. In the hot season, it is necessary to keep the water level in the pond from 1.3-1.8m to stabilize the temperature of the pond, to reduce the phenomenon of shrimp suffering from heat shock.

4. Conclusion

The monitoring points have 10 parameters with observed samples exceeding the permissible limit, in which the parameters with the sample rate exceeding the permissible limit greater than 10% include: N-NO2 (45.65%), N-NH4 (39.13%)), coliform (23.91%) and TSS (17.39%). Detection of AHPND in feed water samples at

Hai Chinh in July and August. The pathogen of acute hepatopancreatic necrosis disease (AHPND) was detected in the water but all cultured shrimp samples were negative for this pathogen.

5. Acknowledgement

The authors would like to thank the strong research group (Research of Organic Matter, ROOM), Environmental and Life Science Research Laboratory, Thuyloi University for their support during the research.

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Research on Sterols pollution in the water of Kim Nguu River, Ha Noi

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1. Introduction

Sterols are special forms of steroids (also known as steroid alcohols - polycyclic alcohols), with a hydroxyl group at position-3 and a skeleton derived from cholestane.

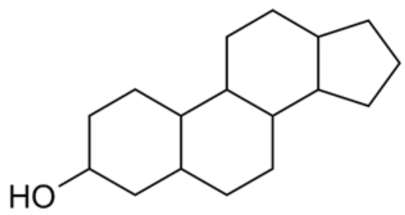

Figure 1. Molecular structure of Sterol

Sterol substances disrupt metabolic activities in the natural environment such as stimulating natural hormone synthesis and plant sterol synthesis. These substances also cause endocrine disorders in humans. The monitoring and evaluation of sterols also partly helps to assess the pollution level of the environment.

Kim Nguu River is one of Hanoi's wastewater drainage rivers, receiving a large volume of wastewater daily from human activities. Therefore, the evaluation of sterols in the water of Kim Nguu river partly helps to identify the source of the waste so that appropriate measures can be taken.

2. Methods

2.1 Methods of investigation and data collection

Six water samples were taken along the length of the Kim Nguu River. Because Kim Nguu River is Hanoi's wastewater drainage river, the source of discharge to the river is quite complicated, so each sampling location has its own characteristics for that area's waste source.

2.2 Sampling method

Surface water samples were collected in April 2017, samples were taken according to TCVN 6663-3-2008- Guidelines for sampling in rivers. The distance between samples is from 800 to 900m. Surface water samples were collected and analyzed at the Environmental Laboratory of the Institute of Environment - Vietnam Academy of Sciences.

2.3 Methods of sample analysis.

Water samples were analyzed according to the procedure of Kadokami et al. (Kadokami et al., 2009). Add 30g of anhydrous NaCl to 500ml of water sample and shake well. Add 100 ml of Dichloromethane to the solution and shake well for 10 min, then filter the extract through a filter funnel with anhydrous Na_2SO_4. Repeat this process 2 more times, each time with 50ml of Dichloromethane. Concentrate the solution after filtration with a rotary vacuum evaporator. Next, the solution was cleaned with an activated silica gel column. After cleaning, continue to concentrate the solution obtained by the rotary vacuum evaporator to a solution volume of about 5 ml. Blow N2 gas until the solution is 1ml . Analyzed on GC-MS-MS-SRM 9TSQ Quantum XLS, Thermo Fisher Sicentific, USA)

Figure 2.1: Sampling diagram of Kim Nguu river water

3 Results

3.1 Evaluation of Sterol contamination in the sediments of the Kim Nguu river

Through analysis, 8 sterols were found in the water. The highest concentration of sterols found in water was Coprostanol (1991.2 µg/ L), the location with the highest concentration of sterols in water was M2 (2663.35 µg/L). This is the sampling location at Lac Trung Bridge where wastewater is received from Thanh Nhan Hospital, Hanoi Lung Hospital and Hanoi Oncology Hospital. In addition, location M2 is also a place to receive wastewater from old residential areas . The location with the lowest concentration of sterols is at location M6, this is the location of Yen So conditioning reservoir where wastewater has been treated through Yen So wastewater treatment plant. This demonstrates the plant's treatment effect on Sterols . The concentration of sterols decreases in the order M 2 < M 3 < M 4 < M 5 < M 1 < M 6.

Table 3.1 Concentrations of Sterols in Kim Nguu River Water

TT	Sterols	Concentration (mean±SD)
1	Cholestane	0.18 - 2.55 (1.24 ± 0.82)
2	Coprostanol	14.4 – 654 (331.86 ± 259.24)

3	Cholesterol	10.1 – 502 (280.91 ± 215.81)
4	Cholestanol	0 – 613 (110.28 ± 247.04)
5	beta-Sitosterol	2.69 - 75.4 (44.04 ± 30.11)
6	Epicoprostanol	10.6 – 602 (281.53 ± 230.49)
7	Coprostanone	5.71-231 (128.78 ± 97.14)
8	Campesterol	0.82 – 36 (20.75 ± 15.85)

3.2 Evaluation of the percentage of sterols

Of the 8 sterols found in the water of the KimNguu River, the concentration of Coprotanol was the highest (accounting for 27.66%), followed by the concentration of Epicoprostanol (23.47%) and Cholesterol (23.42%). These high percentage sterols are all sterols of animal origin, and these sterols are commonly found in municipal wastewater.

3.3 Evaluation of the emission source of Sterols

With the ratios of Coprostanol/(Coprostanol+Cholestanol), (Coprostanol+Epicoprostanol)/ (Coprostanol+ Epicoprostanol+ Cholestanol), if > 0.7 is an indication of pollution due to wastewater, < 0.3 is not contaminated (Jobling, S. et al, 2006) (Gagne,F. el al, 2001). If the ratio is in the range of 0.3 - 0.7, it is wastewater pollution with natural sterol sources. From the analysis results, all sterols in the water were contaminated at all sampling locations. Specifically, the source of pollution at locations M 2 and M3 is the combined pollution of both wastewater and natural sterols, the remaining locations are caused by wastewater pollution.

The ratio of Coprostanol/Cholesterol and Coprostanol/(Cholesterol+Cholestanol) is the ratio that represents the source of pollution, man-made or natural. It is found that for water, all positions are >1 and >0.06, showing that the main source of pollution comes from wastewater, which is raw untreated wastewater. Especially with the ratio of Coprostanol/Cholesterol. This is the rate of human fecal contamination. It can be seen that at all sampling sites are contaminated with human feces. This is the clearest proof that Kim Nguu River is Hanoi's wastewater drainage river. Wastewater discharged into rivers is mostly raw and untreated wastewater.

The ratio of Coprostanol/Epicoprostanol and Epicoprostanol/Coprostanol is also the ratio of pollution to the discharge source. If this ratio is > 1.5, then there is pollution and the source of pollution is caused by humans. found that in the water of the Taurus River, all locations are at the threshold of possible contamination. Locations where many people live and work have high concentrations because of sterol pollution from human activities and activities.

4. Conclusion

Through analysis, it was found that 8 Sterols exist in the water of Kim Nguu River. The concentration of Sterols in the water is 208.76 - 7276.63 μg/Kg. The concentration of sterols was high in locations with a lot of people's living activities (M 2) and lowest in Yen So conditioning reservoir when the water was treated.

Among the sterols found in the water of Kim Nguu river, Hanoi, the 3 sterols with the highest percentage are Coprotanol, Epicoprostanol and Cholestrol. These 3 sterols are all plant-derived sterols and are the sterols that are abundant in municipal wastewater.

The proportion of sterols after analysis, most of the waste source locations are due to untreated raw water, this is also a reasonable result because Kim Nguu river is the drainage river of Hanoi.

Acknowledgement

This study was carried out within the framework of the strong research group (ROOM) and Environmental and Life Sciences Research Laboratory, University of Water Resources. The authors would like to thank ROOM team, Environmental and Life Sciences Research Laboratory, University of Water Resources for providing support during the research process.

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Adsorptive removal of heavy metals from water using thermally treated laterite: an approach for purification of rainwater

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1. Introduction

The heavy metal pollution raised global concerns in recent decades due to its negative impact to human health and environment. Due to the high stability of heavy metal species, heavy metals could be absorbed by plants and animals, then accumulated in human bodies, causing heavy metal induce (Koedrith et al, 2013). Previous studies showed that most heavy metals are carcinogens in different body parts such as kidney, blood, bones and nervous system. Several methods were developed to remove the heavy metals in aqueous solutions. Each method had its own advantages and drawbacks. Among these methods, adsorption is a simple, selective and effective method. There were hundreds of absorbents for heavy metals including natural material and its derivatives like zeolites, clay materials, laterites; carbon-based materials…The application of natural materials in the removal of heavy metals and purification of drinking water is increasingly gaining attention. But the performance of heavy metal adsorption of raw materials has been found to be limited, due to its low specific surface area as well as low porosity. They required further modification and/or treatment to enhance the adsorption capacity. Laterite, naturally available, is a natural rock that could be used for the adsorption of heavy metals and drinking water purification as it contains minerals. This research aims to produce thermal treatment laterite for heavy metals adsorption and rain water purification.

In this work, the raw laterite was collected and modified by a thermal process. The obtained laterite was examined by different methods such as XRD, SEM/EDX, FT-IR, BET, pH_{pzc}. Cu^{2+} and Ni^{2+} were chosen as model ions for adsorption study. The purification of rain water by modified laterite to produce drinking water was also evaluated.

2. Experimental

2.1. Activation of natural laterite

All chemicals were of analytical grade provided by Sigma Aldrich, and used without any further purification. Natural laterite collected from Thach That district, Hanoi, Vietnam was first grinded then sieved to obtain particles with the size range of 0.5-1.0 mm. The obtained samples were subsequently washed with distilled water, then dried at 105 °C for 48 h in an oven, prior to being heated under air environment at 500 °C for 6 h to remove organic materials remained in the raw laterite.

2.2. Characterization of materials

The crystal structure of materials was examined by a X-ray diffraction spectroscopy (XRD, D8 Advance – Bruker), composition and morphology of the samples were studied with the aid of a Scanning Electron Microscope (SEM) Nova NanoSEM 450, coupled with an Energy-Dispersive X ray spectroscopy (EDX), JED-2300 Analysis Station Plus. Surface functional groups were identified using a FT-IR spectroscopy, Jasco 4600, Japan. Nitrogen isothermal adsorption-desorption (Brunauer-Emmett-Teller-BET) was determined by TriStar 3000 V6.07 A. Concentrations of Ni^{2+} and Cu^{2+} ions were determined by an Atomic Absorption Spectrophotometer (AAS), Shimadzu AA-7000 F.

2.3. Batch experiments

For the adsorption of Ni^{2+}, Cu^{2+}, a typical batch experiment was conducted as follow: 100 mL of heavy metal with known concentration were transferred to a 250 mL conical flask. A known amount of treated laterite was added to the solution. The mixture was shaken for 2 h. To study the effect of contact time, 5 mL of the reaction solution was taken with an interval of 15 min. The solution was then filtered prior to be subjected to AAS to determine the remaining heavy metal contents. The pH value of solutions ranged from 2 to 12 to examine the impact of pH. The effects of adsorbent dose and initial metal concentration were studied with the same procedure, with the optimal pH. The adsorption isotherm study was carried out by fitting experimental data to Langmuir and Freundlich models. The kinetics of adsorption process were evaluated by pseudo-first order, pseudo- second order, and intramolecular models. Finally, modified laterite was deployed for purifying real rain water samples.

3. Results and discussion

3.1. Characterization of materials

The peaks at $2\theta = 21^o, 26^o, 33^o, 37^o, 54^o, 61^o$ represented the presence of goethite in the structure of laterite. The peaks at $2\theta = 24^o, 35^o, 49^o, 62^o, 64^o$ in the modified laterite were associated with of hematite. The presence of quartz in the laterite structure was confirmed at $2\theta = 20^o$. FT-IR spectra showed that the band at 3406.29 cm^{-1} was assigned to -OH group of Si. The peaks at 1031.92 cm^{-1}, 1036.84 cm^{-1}, 912.33 cm^{-1}, and 796.60 cm^{-1} were due to Si–O–Fe, Al–OH, Fe–OH vibrations. The Fe–O bonds stretching at 534.28 confirmed the presence of hematite (Pham et al, 2017).

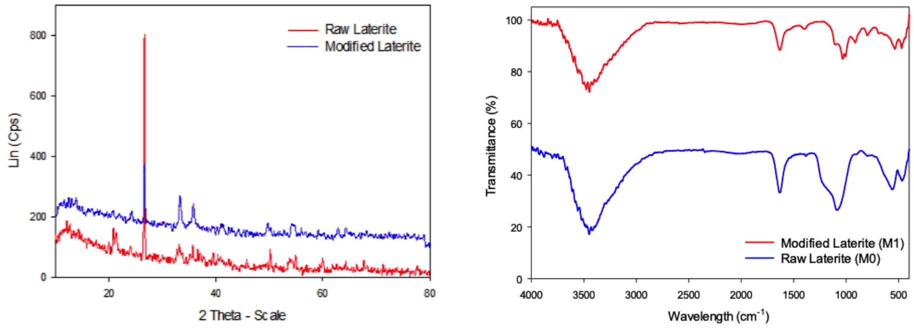

Figure 1: XRD pattern (left) and FT-IR spectra (right) of raw and modified laterite samples.

Thermally treated laterite presented a clear prominent coating of fine particles on the surface (Figure 2 right) while raw one had a bulker and more heterogeneous surface texture and was visibly less porous (Figure 2 left). The presence of fine particles on surface of modified laterite could be attributed to the thermal decomposition of organic materials from raw laterite.

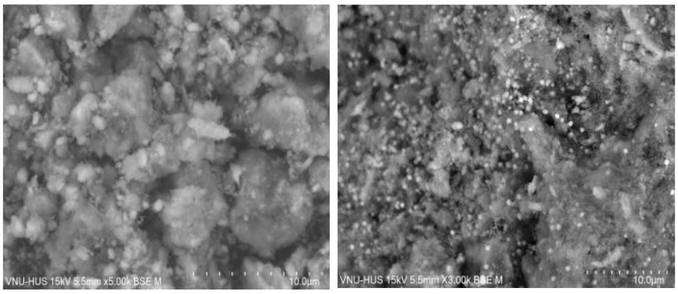
Figure 2: SEM images of raw (left) and modified (right) laterite.

The N_2 adsorption-desorption diagrams of both raw (Figure 3a) and modified laterites (Figure 3b) are of type IV, and hysteresis loops are respectively of form H3 and H1 for treated and raw laterites. This suggests that both materials are shaped by mesoporous material. It is noted that the thermal treatment of laterites resulted in a decline in total surface area (24.87 m^2/g for modified laterite vs 49.73 m^2/g for raw laterite), conversely to average pore diameter and total pore volume. Indeed, average pore diameter of raw and treated laterites were respectively 3.47 nm and 12.2 nm while their corresponding pore volume were 0.0432 and 0.0756 cm^3/g. This might be linked with the loss of porous organic materials on the surface of laterites when being heated at 500°C, leading to the changes in porous structure and decrease in surface area of laterite. Although, the thermal treatment of raw laterite led to decrease in its surface area, this process was really important to remove organic materials and others which could be released to treated water causing secondary pollution. The pH_{pzc} of the treated laterite was 8.0, implying positive surface charge in solution having $pH \leq 8$ while it was negatively charged in $pH > 8$ solutions.

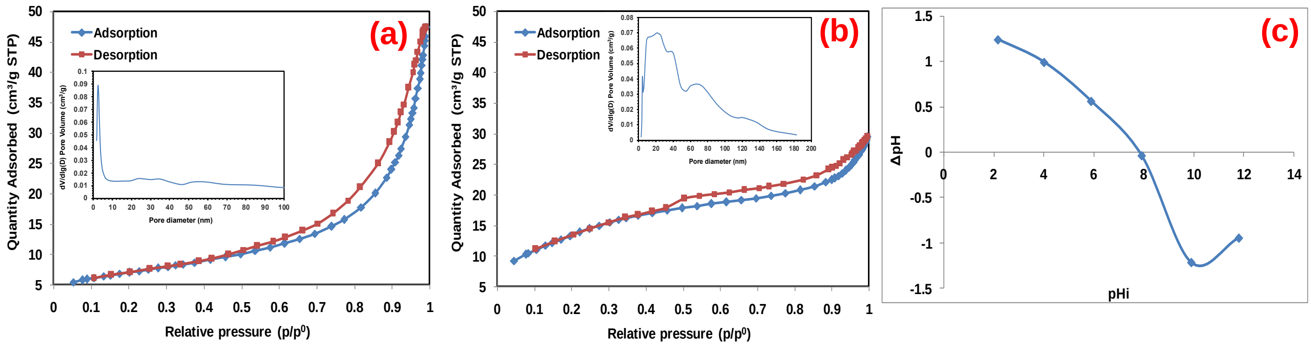

Figure 3: Nitrogen adsorption–desorption isotherms and pore distribution of (a) raw and (b) modified laterite samples, (c) pH_{pzc} of the modified laterite.

3.2. Adsorption experiments

The results in Figure 4a shows that the removal efficiency increased with increasing contact time. 91.6 and 94.2 % of Ni^{2+} and Cu^{2+} were removed after 40 min, suggesting equilibrium time was 40 min. The optimal pH was around pH 7.0 as when it went above 8 there was precipitation of Ni^{2+} and Cu^{2+}, leading to higher removal efficiencies but it was not linked to the adsorption process.

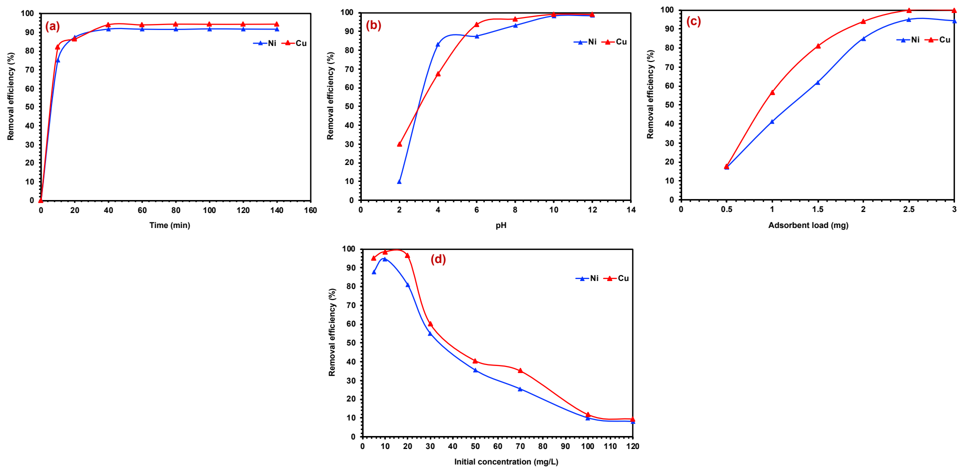

Figure 4: Impacts of contact time (a), (b) pH, (c) adsorbent load, and (d) initial concentration on the adsorption capacity/efficiency of treated laterite.

The equilibrium adsorption was analyzed using the Langmuir and Freundlich isotherm models. The validity of the isotherm models can be estimated by using their linearized plots (Figure 5). The Langmuir isotherm model described the best the Ni^{2+} and Cu^{2+} adsorption (R^2>0.99), implying monolayer adsorption. The maximum uptake for Ni^{2+} and Cu^{2+} were respectively 10.3 mg/g and 8.1 mg/g. The results in this research show that the combination of laterite with sand and SODIS method allowed to safely removal turbidity and contaminants, including pathogens to produce water reaching Vietnam national standard for drinking water (QCVN 01:2009/BYT).

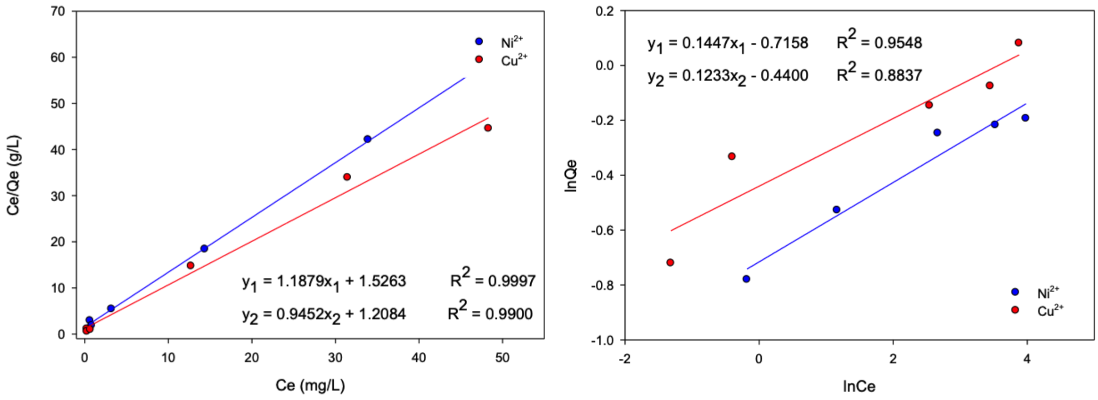

Figure 5: Langmuir (left) and Freundlich (right) model plots.

4. Conclusions

Natural laterites collected from Thach That, Hanoi, Vietnam were successfully treated by thermal process to produce more stable materials. The results showed that treated laterites contained mainly mineral oxides and SiO_2, Al_2O_3, which are suitable for purifying water to produce drinking water. The adsorption study revealed that the adsorption processes occurred quite fast, with the equilibrium time of 40 min. The heavy metal adsorption followed the Langmuir isotherm model, with the maximum uptakes of 10.3 mg/g and 8.1 mg/g for Cu^{2+} and Ni^{2+}, respectively. The application of treated laterite also indicated that it could be used in combination with natural sand and SODIS method to safely produce drinking water from rain water.

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Superior removal of Methylene Blue by mesoporous g-C_3N_4@WO_3 nanocomposite: equilibrium and kinetic study

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1. Introduction

Water pollution has been a great concern and attracted increasing attention of the society, especially the problems related to heavy metals and pigment pollution. Therefore, researches on the removal of pollutants are of significant importance. Recently, graphite carbon nitride (g-C_3N_4) has been considered a promising material for environmental remediation because of its chemical stability, high adsorption capacity. g-C_3N_4 could be also used as a support for adsorbents, especially for those in nanoscales (Modwia et al, 2022). WO_3 presents stable physicochemical structure, high surface structure, and could be used to remove organic pollutants from solutions. The combination of g-C_3N_4 and WO_3 could lead to better removal of organic pollutants and more feasible in real applications. In this work, a series of g-C_3N_4@WO_3 nanocomposites were synthesized by hydrothermal process using Na_2WO_4 and urea as precursors. The as-synthesized materials were then examined by means of various techniques and applied for studying the adsorption process of Methylene Blue (MB) in solutions.

2. Experimental

2.1. Synthesis of g-C_3N_4, WO_3, and g-C_3N_4@WO_3 nanocomposites

All chemicals were of analytical grade provided by Sigma Aldrich, and used without any further purification. g-C_3N_4 in yellow bulk form was synthesized by pyrolyzing urea in a muffle furnace at 550 ºC for 2.5 h according to our previous study (Nguyen et al, 2019). WO_3 nanoparticles were synthesized by hydrothermal method using modified procedure from our previous work (Vu et al, 2021). The g-C_3N_4@WO_3 nanocomposites were synthesized using the same synthesis procedure of WO_3 in which g-C_3N_4 was added to Na_2WO_4 solution with the content of 0, 0.5, 1, 3, and 5% wt before the mixture was subjected to hydrothermal process. The samples prepared with 0; 0.5; 1; 3; and 5% wt of g-C_3N_4 were denoted CNW-000; CNW-005; CNW-010; CNW-030; and CNW-050, respectively.

2.2. Characterization of materials

The crystalline structure and phase purity were examined by using X'pert Pro (PANalytical) MPD with CuK-α1 radiation (1.54056 Å) at a scanning rate of 0.03°/2s. Raman spectra were observed using a Renishaw Invia Raman Microscope with a 633 nm laser and 25mW power. FT-IR spectra were analyzed using a FT-IR-4600 type A (JASCO) with wavenumbers ranging from 400 cm^{-1} to 4000 cm^{-1}. The morphology of materials was studied by a field-emission scanning electron microscopy (FE-SEM, JEOL JSM-7600F). Surface area was tested by a NOVAtouch LX4, Quantachrome Instrument, USA.

2.3. Removal of MB by adsorption process

In a typical experiment, 20 mg of the g-C_3N_4@WO_3 nanocomposites were well-dispersed into 100 mL of MB solutions (10 mg/L) with constant stirring in dark. At each time interval, 5 mL of the mixture was sampled and filtered to remove the adsorbent. The remaining MB concentration was quantified by using an UV-Vis spectrometer at the wavelength of 664 nm.

3. Results and discussion

3.1. Material characterization

The CNW-000 sample (pure WO_3) observed at 14.0°, 22.7°, 24.2°, 26.7°, 28.1°, 33.5°, 36.5°, 37.5°, 49.7°, 55.3° and 63.2° respectively, indicating high crystallinity of WO_3. g-C_3N_4 exhibited two fundamental diffraction peaks at around 13.10° and 27.80° (Mamba, G., Mishra, 2016). The characteristic peaks of WO_3 and g-C_3N_4 were observed in almost all C_3N_4@WO_3 composites (Figure 1a and b), confirming successful load of WO_3 nanoparticles on the g-C_3N_4. The crystal size calculated according to Williamson-Hall equation showed the more g-C_3N_4 content, the larger crystalline size (WO_3 had an average diameter of 15.41 nm vs 20.70 nm for CNW-050).

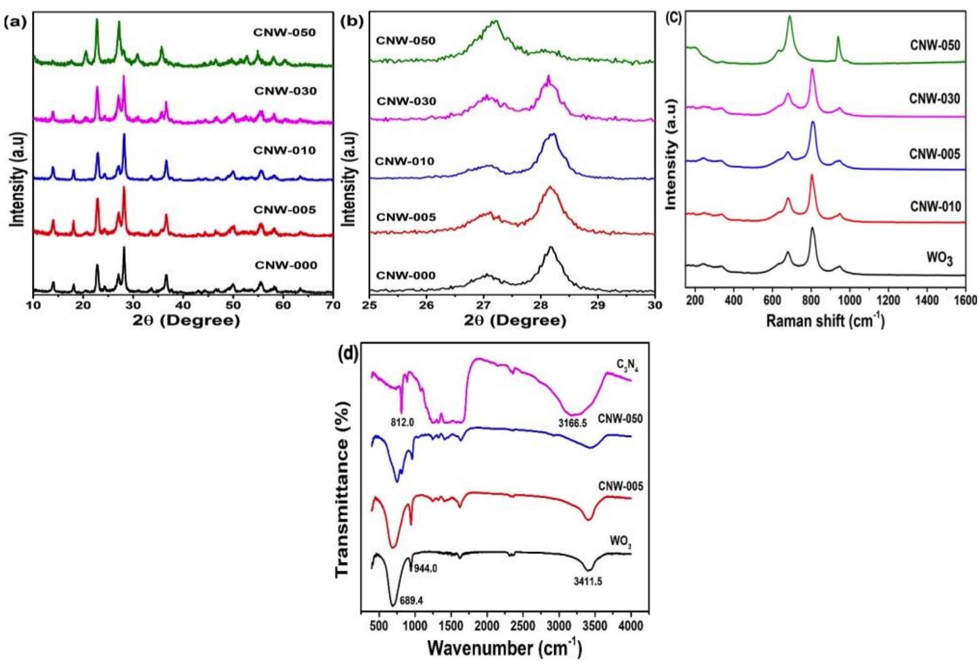

Figure 1: XRD pattern of samples (a) within 10 – 70° and (b) within 20 – 30°. (c) Raman spectra, and (d) FT-IR spectra of the samples.

Raman spectra of CNW-000 showed two peaks at around 807 cm^{-1} and 680 cm^{-1} corresponding to the $O-W^{6+}-O$ stretching modes (Figure 1 c). In the CNW-050 sample, different scattering signals were observed at 982 cm^{-1}, 939 cm^{-1}, 690 cm^{-1}, 629 cm^{-1} and 337 cm^{-1}, respectively, probably due to the formation of C-O-W bonds between the g-C_3N_4 and WO_3. FT-IR spectra revealed pristine g-C_3N_4 presented several characteristic peaks ranging from 1630 cm^{-1} to 811 cm^{-1}, being assigned to aromatic C-N elongation modes, to aromatic C-N stretching vibration of heptazine- derived repeating units, and to vibrations of triazine ring unit. The nanorods were attributed to g-C_3N_4 while spheric shape was due to WO_3 nanoparticles (Figure 2). Both adsorption and desorption isotherms of g-C_3N_4/WO_3 and g-C_3N_4 samples shared a common characteristic, presenting type IV isotherms with H3 hysteresis loop, which represented for mesoporous materials (Figure 3). The specific surface area calculated by the BET method for g-C_3N_4 and g-C_3N_4/WO_3 samples were 35.4 m^2/g and 68.6 m^2/g, respectively, implying an enhancement of surface area. The pore-size distribution of g-C_3N_4 processed a typical peak with pore diameter < 20 nm while those values for g-C_3N_4/WO_3 was below 10 nm.

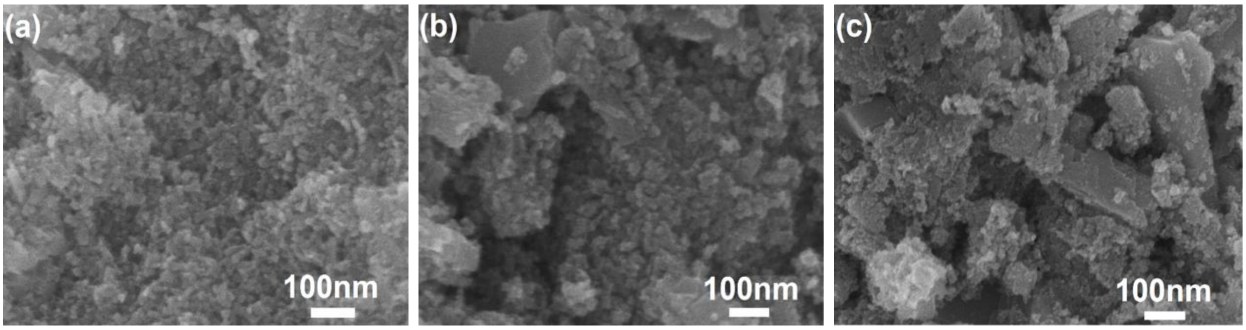

Figure 2: FE-SEM images of (a) CNW-000; (b) CNW-010; (c) CNW-005 nanocomposites.

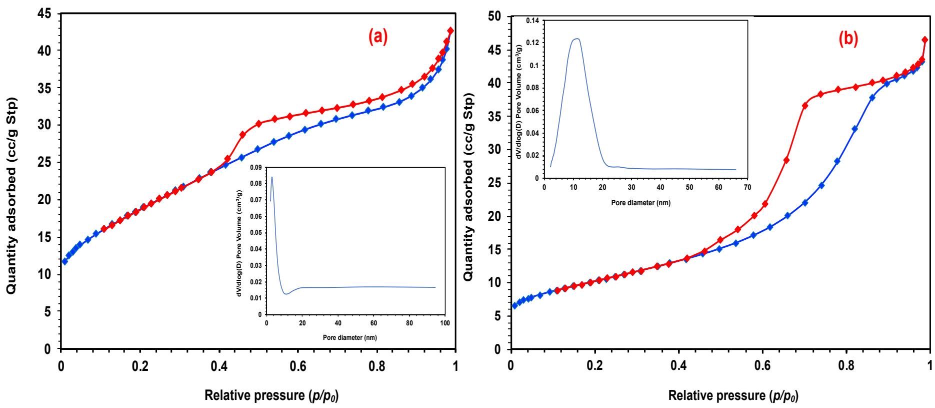

Figure 3: Nitrogen adsorption–desorption isotherms and pore distribution of (a) g-C_3N_4/WO_3 (0.5%) and (b) g-C_3N_4 samples.

3.2. The adsorption process of MB on the g-C_3N_4@WO_3 nanocomposites

The MB adsorption process occurred very quickly, reaching equilibrium at about 8 min, suggesting a potential adsorbent for real application. The g-C_3N_4@WO_3 nanocomposites presented better MB adsorption capacity than pristine WO_3, implying a promising adsorbent for dyes removal. The CNW-005 nanocomposites showed the best adsorption efficiency than the other. The results indicated the second-order kinetics models described the best experimental data with correlation coefficients (R^2) higher than 0.9 in all cases compared to R^2<0.9 for the first-order kinetics model (Figure 4).

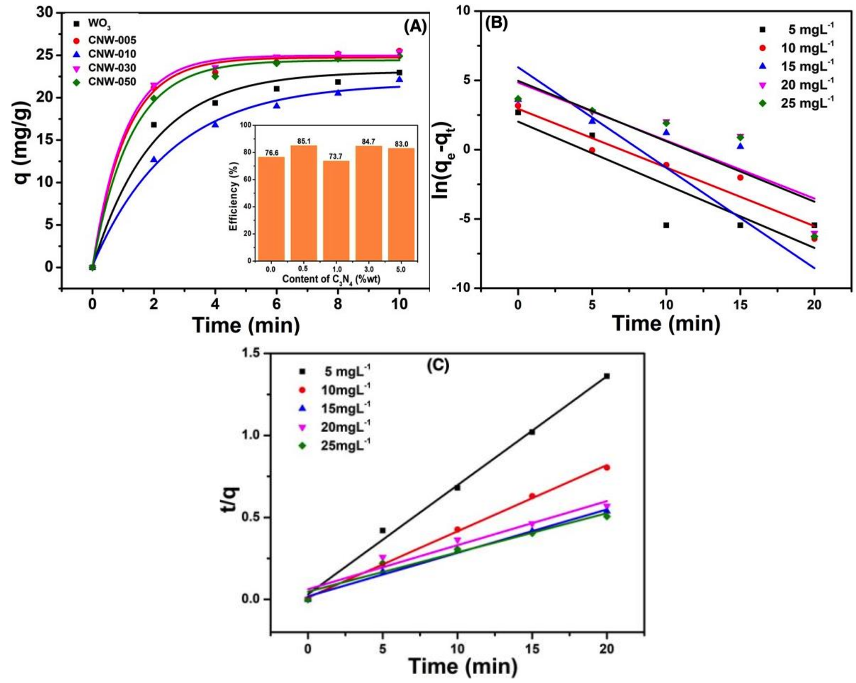

Figure 4: (A) the adsorption capacity/efficiency of the samples, and (B) first order and (C) second-order kinetics of the MB adsorption process.

The equilibrium adsorption isotherm model of the adsorption process was analyzed using the Langmuir isotherm, Freundlich isotherm, and Temkin isotherm models. The validity of the isotherm models can be estimated by using their linearized plots (Figure 5). The regression coefficient (R^2) is used as a criterion to compare between models. Freundlich isotherm model described the best the MB adsorption (R^2=1), implying monolayer adsorption with uniform adsorption energies. The Temkin model showed adsorption was an exothermic process.

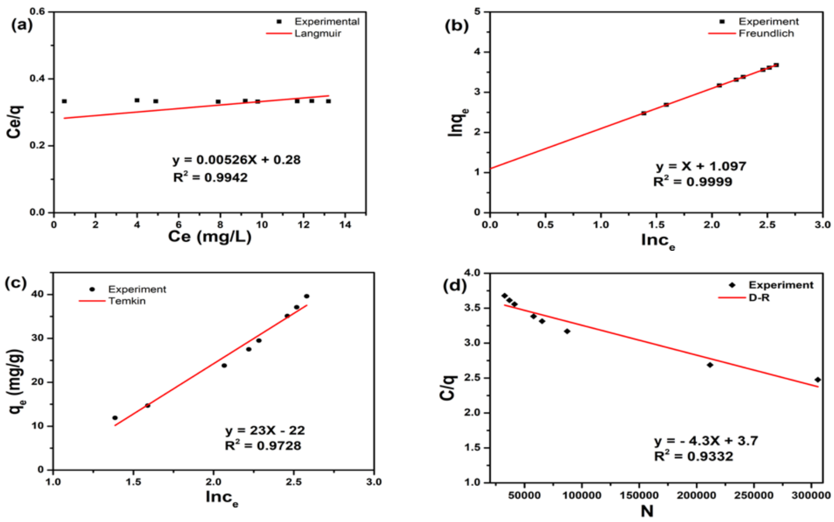

Figure 5: (a) Langmuir, (b) Freundlich, (c) Temkin, and (d) Dubinin–Radushkevich model plots.

3. Conclusion

A series of g-C_3N_4@WO_3 nanocomposites were successfully produced from Na_2WO_4 and g-C_3N_4 precursors using the hydrothermal method. The g-C_3N_4 content affected structure, morphology and properties of g-C_3N_4@WO_3 nanocomposites. The results showed the CNW materials exhibited a better MB adsorption capacity than WO_3. The CNW-005 sample showed the highest MB adsorption efficiency (85.10%), with an adsorption capacity of 39.55 mg/g. The Freundlich isotherm model fitted the best the adsorption data. The adsorption was best described by the second-order kinetics model.

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Residue and ecological risk assessment of Polybromine diphenyl ethers (PBDEs) in the surface water of West Lake, Hanoi

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1. Introduction

For the purpose of flame retardants in products, people have synthesized and produced PBDEs since the first decades of the 20th century. PBDEs are a family of 209 isomers and congener (divided into 10 groups according to the number of Br in the product). Substances in the PBDEs family have high boiling points (in the range of 310oC - 425oC), low cost production and are used as additives in many polymers (poly vinylchloride, polypropylene, poly ester, poly ethylene terphthalate, poly acrylnitrite, etc.) poly amide, poly butylene terphthalate, poly urethane, epoxy resin, phenol resin...), greatly increase the fire resistance of plastic products. Bromine flame retardant is widely used in explosion-proof materials such as furniture, textiles, plastics, building materials, electrical appliances and electronic equipment to prevent fire. The global production of these techniques was 67,440 tons in 2001 (Olisah et al., 2020)

Since 1990, when strange effects on humans and domestic animals were discovered, many studies began to focus on PBDEs. The results obtained are worrisome as this family of substances has the potential to be toxic to humans and animals. The main effects include endocrine disorders, affecting the human brain, liver, and kidneys. PBDEs can enter the environment by evaporation from plastic products, dust from electronic waste, exhaust fumes from municipal solid waste incinerators, and then entering the food chain (accumulation). in food such as fish, beef...) and then into the human body (eating, breathing, skin contact). They persist in the environment for a long time, are hydrophobic, bioaccumulative and highly contagious. Many studies show that PBDEs has accumulated in blood, human milk and environmental components such as air, soil, and sediment in many countries around the world.

West Lake, in addition to its extremely important ecological significance, the lung of Hanoi, is also a symbol of the thousand-year-old capital with the surrounding environment and landscape creating a harmonious natural picture. However, West Lake is facing pollution without many really effective treatment solutions. Pollution appears on the lake more and more affecting the landscape, lake water quality as well as the daily life of people living along the lake. Based on the current status of the West Lake area, the study mainly clarified the residual problems and risks in lakes and lakes of some typical PBDEs substances in the aquatic environment.

2. Materials and methods

2.1 Methods of investigation, data collection

Using the method to investigate information on the main waste sources of West Lake. At the same time, collect information of existing researches in the country and in the world on research subjects

Sampling locations were selected to represent the space and waste sources of the study area. Based on the field survey, ten sampling locations were selected (symbols from M1 to M10), from locations near the beginning of To Ngoc Van street to the end of Lac Long Quan street. At each location, take a surface water sample in December 2021 (sample symbols from NM1 to NM10). The distance between sampling locations ranges from 800 m to 900 m. The steps are followed: TCVN 6663-1:2011 (ISO 5667-2:2006), Water quality – Sampling – Part 1: Technical guidance for taking QCVN 08-MT:2015/BTNMT 6 samples; TCVN 6663-3:2003 (ISO 5667-3:1985) Water quality – Sampling – Part 3: Guidelines for storage and handling of samples; TCVN 5994:1995 (ISO 5667-4:1987) - Water quality - Sampling. Guide to sampling in natural and artificial ponds.

2.2 Sample analysis method

Treat the sample with liquid extraction according to EPA method 3510C and clean the sample according to EPA Method 3630C. Samples after extraction and cleaning were injected into a gas chromatograph mass spectrometer (GC-MS).

2.3 Methods of risk assessment

The environmental risk posed by PBDEs in West Lake surface water was assessed using the risk quotient (Risk quotient, RQ). RQ is calculated according to the formula:

RQ = C / MAC (formula 1)

Where: C: concentration of research substance

MAC (Maximum allowable concentration): the maximum allowable concentration for the research substance in the medium. The levels of risk are classified as: very low risk ($RQ \leq 0.01$), low risk ($0.01 < RQ \leq 0.1$), medium risk ($0.1 < RQ < 1$) , high risk ($RQ > 1$) (Trân L.T.H, n.d.)

3. Results and discussion

3.1 Assessment of PBDE pollution in West Lake

The analysis results showed that all 7 selected PBDEs were detected in the lake water samples and are shown in Figure 1.

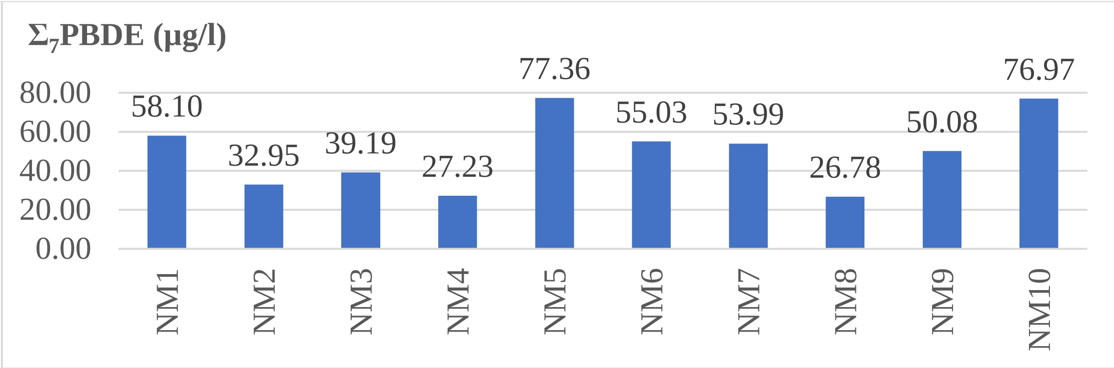

Figure 1. PBDE concentration (µg/l) in West Lake water in December 2021

Analytical results in December 2021 obtained the concentration of Σ_7PBDEs in West Lake surface water ranging from 26.78 to 77.36 µg/l. The general assessment from Table 1 shows that the concentration of Σ_7PBDEs and its components tended to decrease gradually according to the positions from NM5 > NM10 > NM1 > NM6 > NM7 > NM9 > NM3 > NM2 > NM4 > NM8. According to the results in Figure 1, it is easy to see that the total PBDEs concentration at NM5 has the highest value of 77.36 µg/l and the lowest concentration at NM8 is 26.78 µg/l. The concentration of Σ_7PBDEs did not decrease gradually along the length of the studied lake, but reached the highest value at NM5, which is near Trich Sai road. This may be because in this location PBDEs emissions from activities in apartment buildings, and restaurants and hotels nearby, are the most significant. From those sources, PBDEs enters the wastewater, affecting the lake water quality at point NM9. At the same time, the above study has clarified that PBDEs can not only spread by air, but also can be spread on the surface, entering the surface water on West Lake.

3.2 Evaluation of PBDEs composition in West Lake water

The composition of PBDEs in lake water is related to the change and physicochemical properties of each PBDEs. The average percentage of PBDEs in the lake water samples is presented in Figure 2.

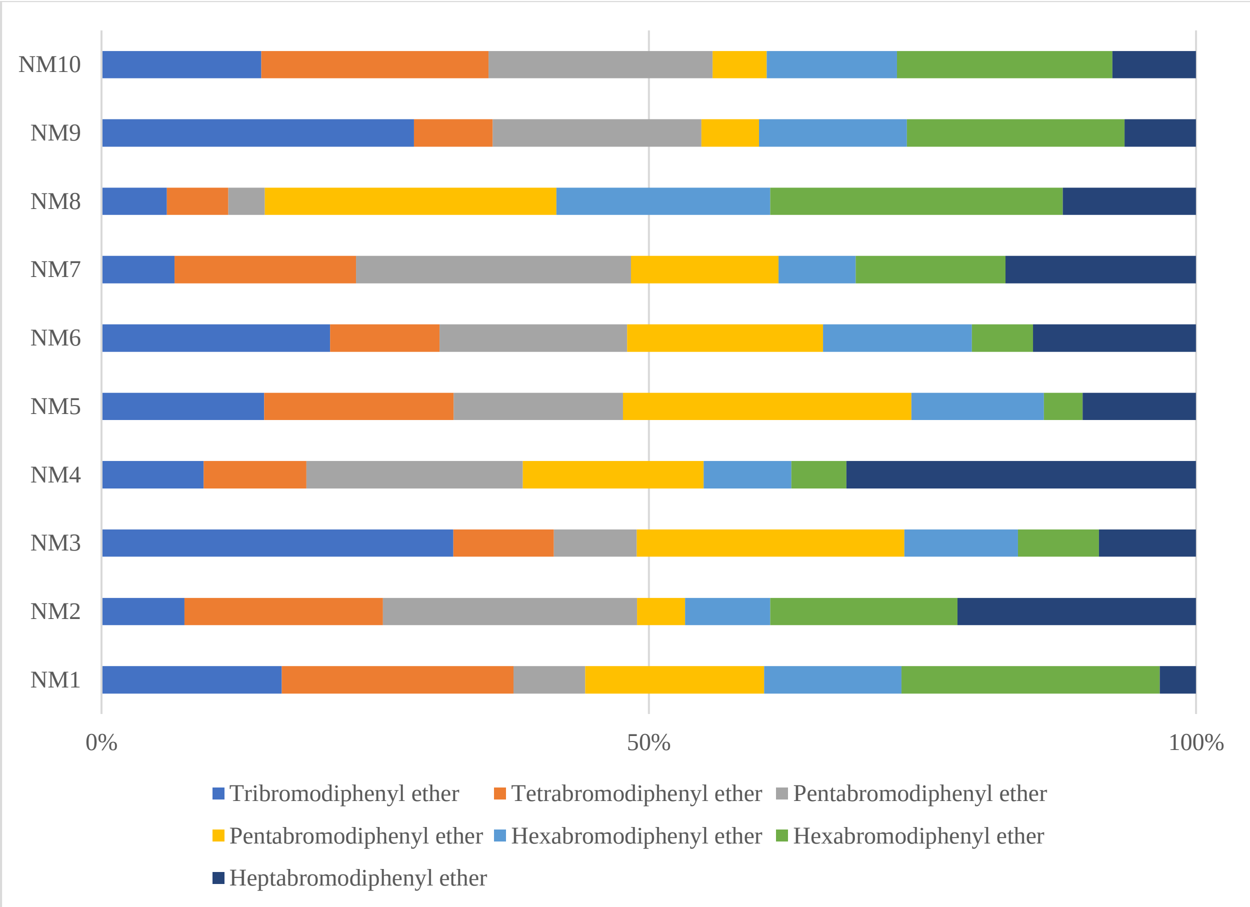

Figure 2. Average percent of 7 PBDEs in water samples December 2021

The results showed that the average percentage of 7 PBDEs (Figure 2) did not change much over the sampling time. At positions NM3 and NM8, Tribromodiphenyl ether and Heptabromodiphenyl ether have the largest average percentage compared to the remaining positions. In 7 PBDEs, PBDEs is produced in larger volume and more application than other PBDEs. The results of analyzing the percentage of PBDEs in the lake water sample showed that there was a match for the physicochemical properties of PBDEs and the ability of PBDEs to change in the environment.

PBDEs has penetrated into the water surface of West Lake and from there has the ability to spread in a wide range. Risk assessment due to PBDEs in water is necessary to consider the potential impact on water quality of West Lake water environment. From there, the RQ values at the sampling points are calculated and presented in Table 1.

PBDE	MPC (mg/l)	RQ December 2021	
		Min	Max
PentaBDE	53	0.030	0.269
OctaBDE	17	0.113	0.552

The results of RQ calculation showed that Heptabromodiphenyl ether at all sampling points in lake water was in the medium risk level with a specific concentration of 0.552 µg/l (0.1 < RQ < 1). Particularly, PentaBDE at most locations was in the medium risk level with the highest concentration of 0.269 µg/l and the lowest of 0.030 µg/l (0.01 < RQ ≤ 0.1).

4. Conclusion

PBDEs pollution in surface water at West Lake, Hanoi has occurred on a large scale. The concentration of Σ_7PBDEs ranged from 26.78 µg/l to 77.36 µg/l. Heptabromodiphenyl ether was the predominant percentage in water samples (average 60%). The level of environmental risk posed by PBDEs ranges from low to moderate. Because PBDEs has the potential to cause endocrine disorders to humans, it is very important to continue to monitor in the next time.

Acknowledgement

The authors would like to thank the strong research group (Research of Organic Matter, ROOM), Environmental and Life Science Research Laboratory, Thuyloi University for their support during the research.

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GHG Inventories for Vietnam Cement Industry

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1. Introduction

The impacts of climate change have been more and more severe and can be observed all over the world. Green house gas (GHG) is considered as one of the major factors that cause climate change. Thus GHG emission reduction plays a crucial role in climate change response strategy whether at global, national, enterprise or even individual level. In the 2021 - 2030 period, Vietnam should develop a long-term strategy and action plan on GHG emission reduction. For that purpose, GHG emission data from every sector need to be collected to provide baseline data for decision makers to project and plan GHG emission reduction actions.

Manufacturing industries is among the highest emitters together with power generation, transportation and commercial/residential buildings. Cement production has been among the most polluted industries due to intensive natural material use and outdated manufacturing technology. Among the five biggest cement producers in the world, the government of Vietnam has been urging cement industry to cut down GHG emission to meet the country's commitment on Climate Change Agenda and to transform toward more environmental-friendly and sustainable production.

This study aims to estimate CO2 emission from cement manufacturing in Vietnam over the last decade and projection to 2030.

2. Methodology

2.1. The IPCC Guidelines

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options.

The IPCC Guidelines were first accepted in 1994, published in 1995, and revised in 1996. The UNFCCC COP3 held in 1997 in Kyoto reaffirmed that the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories should be used as "methodologies for estimating anthropogenic emissions by sources and removals by sinks of greenhouse gases" in calculation of legally-binding targets during the first commitment period. The series consists of three volumes: The Reporting Instructions (Volume 1); The Workbook (Volume 2); and The Reference Manual (Volume 3).

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines) provide methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases. It was developed to assist countries in fulfilling their commitments under the UNFCCC on reporting on inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. The 2006 IPCC Guidelines are in five volumes. Volume 1 "General Guidance and Reporting" describes the basic steps in inventory development and offers the general guidance in greenhouse gas emissions and removals estimates based on the authors' understanding of accumulated experiences of countries over the period since the late 1980s, when national greenhouse gas inventories started to appear in significant numbers. Other volumes offer the guidance for estimates in different sectors of economy, namely Energy (Vol.

2); Industrial Processes and Product Use (Vol. 3); Agriculture, Forestry and Other Land Use (Vol. 4); and Waste (Vol. 5).

2.2. Three-tier approach

In cement manufacturing, CO_2 is emitted during the production of clinker, an intermediate product which will subsequently be finely ground and mixed with a small proportion of additives into cement. During the production of clinker, limestone containing mainly $CaCO_3$, is heated, to produce lime (CaO) and CO_2 as a by-product. If a factory produces cement entirely from imported clinker, its process-related CO_2 emissions is considered insignificant. Emission estimates should account for emissions associated with the cement kiln dust (CKD) which may be generated during the manufacture of clinker. The fuel used for production process is also a source of CO_2 emission.

The 2006 IPCC Guidelines proposes three levels of estimates for countries based on availability of input data, from most aggregated data at national level (tier 1) to most breakdown data from factory level (tier 3).

In the Tier 1 method, emissions are based on clinker production estimates inferred from national cement production data, correcting for imports and exports of clinker.

In the Tier 2 method, emissions are estimated directly from clinker production data and a national (or default) emission factor.

The Tier 3 approach is a calculation based on the weights and compositions of all carbonate inputs from all raw material and fuel sources, the emission factor(s) for the carbonate(s), and the fraction of calcination achieved. The Tier 3 approach relies on plant specific data.

Both Tier 2 and Tier 3 include a correction for CKD.

2.3. Tier selection

It is suggested by IPCC that in case plant-level data to be unreliable or highly uncertain, then it is good practice to use Tier 2 for GHG inventory calculation. In case of Vietnam, the data from different cement producers are neither complete nor consistent. Therefore, Tier 2 was selected based on availability of data on nationwide cement production, import and export, collected from the Vietnam Cement Association and Statistic Books.

2.4. Sources of emission

CO_2 emitted during the cement production process consists of:

- Direct CO_2 emission from the processing:
    + CO_2 emission from raw materials:
    + CO_2 emission from material carbonation;
    + CO_2 emission from combustion of organic carbon in the materials.
- CO_2 emission from fuel combustion:
    + CO_2 emissions from coal combustion;
    + CO_2 emissions from combustion of alternative fuels;
    + CO_2 emissions from fuel used in mining, transport and power generation, etc.
- Indirect CO_2 emission:
    + CO_2 emission from electricity purchase;
    + CO_2 emission from outside clinker purchase (if applicable).

3. Results and discussion

3.1. Emission by product types

In production of cement, the total CO_2 emission from material decomposition, uses of coal and power consumed per ton of output product is expressed by:

$$CO_{2total} = CO_{2carbonation} + CO_{2coal} + CO_{2power}$$

Due to differences in the composition of product types and amount of energy required for the production process, the amount of emissions can vary significantly. The following table summarizes emissions per ton of product by the sources.

Table 1. Average emission rates

No.	CO_2 emission sources	Volume (ton CO_2)	Contribution (%)
A	**Clinker**		
1	CO_2 from raw materials	0.520	57.42
2	CO_2 from fuel	0.339	37.47
3	CO_2 from power	0.046	5.11
	Total CO_2	0.905	100
B	**Ordinary Portland Cement (OPC)**		
1	CO_2 from clinker	0.869	97.57
2	CO_2 from power	0.022	2.43
	Total CO_2	0.891	
C	**Portland Cement Blended (PCB – 30% additives)**		
	CO_2 from clinker	0.634	96.7
	CO_2 from electricity	0.022	3.3
	Total CO_2	0.656	100

3.2. Rate of emission

For the whole cement production sector of Vietnam, average CO2 emission per unit of product are weighted summation of cement production outputs of all types. The calculated results for the period of 2010-2015 are as follows:

CO2 from carbonation = 0.364 ton CO2/ ton cement
CO2 from use of coal = 0.238 ton CO2/ ton cement
CO2 from use of power = 0.057 ton CO2/ ton cement
Thus, the total CO2 emission per ton of cement product is:

$$CO2_{total} = CO2_{carbonation} + CO2_{coal} + CO2_{power}$$
$$= 0.658 \text{ ton CO2/ ton cement.}$$

3.3. Sector emission

From the calculated emissions rates and actual/planned production outputs, we can estimate the amount of CO2 emissions each year from the cement industry as follows.

Table 2. Estimate CO2 emission from Vietnam cement industry (million tons)

No.	Item	2010	2015	2020	2030 (planned)
1	Cement production output	55.801	67.427	94.00	112.00
2	CO2 carbonation	20.312	24.543	32.750	37.274
3	CO2 coal combustion	13.254	16.015	18.909	21.521
4	CO2 electricity	3.018	3.814	4.786	5.702
5	Total CO2 emissions	36.583	44.373	56.445	64.497
6	CO2 emissions coefficient (ton CO2/ton cement)	0.6556	0.6558	0.600	0.576

3.4 Reduction of emission

For the cement industry to cut down CO2 emission in compliance with the national target set in the National Green Growth Strategy (yearly reduction of GHG emission by 1.5-2%), improvement of the production technologies is necessary. To reduce the CO2 emission coefficient in cement production, and total volume of CO_2 emitted by the industry, cement enterprises may look for some directions, namely:

a) To reduce CO_2 emissions from the material ingredients (embodied CO_2), such as re-use industrial wastes containing CaO instead of limestone as raw material;

b) To reduce emissions from fuel use, by decreasing the clinker firing temperature, reduce heat lost from firing process and reuse the heat; use fuel with less CO_2 emissions; reduce clinker content in cement by re-using industrial wastes for mineral additives;

c) To reduce emissions from energy use by using high-efficient equipment, installing inverter for motors, improving productivity of grinding machine; using fine mineral additives like silica fume; Recover exhausted heat from combustion kiln for power generation; Reduce power lost in production through management measures.

Among those measures, most viable and immediate measures in the short term are reducing clinker firing temperature and reduction of clinker contents in final product of cement, which will immediately result in economic merit thanks to production cost reduction simultaneously with less GHG emission.

4. Conclusions

Cement production has been perceived as one of the most polluted industry due to extensive natural resource use and emission of GHG as well as fine dust. Ranking among the five biggest cement producers in the world, the threat of cement production to the environment in Vietnam is obvious. Going green and cleaner production mean reservation of natural resources, energy saving, less GHG emission and higher social accountability, conforming with the government policy, a must-go to cement enterprises.

GHG inventory data is crucial for the sector's development planning toward greener and cleaner. This paper presents the application of IPCC methodology to estimate total emissions and emission rates of the cement industry in Vietnam. The paper also highlights a rough picture of the cement industry, and its potentials for GHG emission reduction.

Based on this insight, target for emission reduction and incentive mechanisms for the industry to go green can be set. The methodology is applicable for other production industries as well.

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Research and forecast of surface water quality in mineral mining and processing areas in Lao Cai province using arima model

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Abstract

Mining and mineral processing is one of the main industrial activities in Lao Cai province. Despite economic benefits, the quality of surface water in rivers and streams flowing through the mine or adjacent to mineral mining and processing areas are more or less affected. The survey indicates that surface water in mining and mineral processing areas in Lao Cai province is mainly used for domestic purposes and irrigation. Therefore, assessing the quality and forecasting the future surface water quality is necessary for environmental management agencies and people using this water source. This study used ARIMA models to predict surface water quality by WQI on some main streams in the mining and mineral processing area of Lao Cai province, such as Ngoi Duong and Chu O streams. The analysis results have selected the most suitable model for short-term forecasting of water quality in Ngoi Duong and Chu O streams, respectively, ARIMA(1,1,5) and ARIMA(2,1,3). According to the forecast results, the WQI index of Ngoi Duong and Chu O streams in the period of 2023-2024 does not have large fluctuations, mainly fluctuates in the threshold of 51-75, it is suitable for irrigation purposes. The ARIMA forecasting model is based on previously collected time series data. Therefore, the larger the data collected, the more reliable the forecast results, especially in short-term forecasting.

Keywords: WQI, ACF, PACF, ARIMA

1. Introduction

Mining and mineral processing is one of the main industrial activities in Lao Cai province. Besides economic benefits, surface water quality in streams flowing through the mine or adjacent to mineral mining and processing areas is also more or less affected. The survey results show that surface water in mining and mineral processing areas in Lao Cai province is mainly used for domestic purposes and irrigation. Therefore, assessing the quality and forecasting the future surface water quality is very necessary for environmental management agencies and people using this water source. Currently, many researches have evaluated and predicted water quality using different mathematical models such as Mike, Wasp, Swat [3,6]. In general, the application of the above models allows researchers to assess water quality on a large scale and simulate on the basis of 3D or 2D maps to help readers easily visualize. However, in order to accurately simulate water quality by the above models, it is necessary to collect quite complex data such as meteorology, flow characteristics, discharge sources, etc. The simulation results depend on the conditions boundaries set in the model. The Arima model was researched and developed by George Box and Gwilym Jenkins, in order to forecast the fluctuations of research subjects over time series. Currently, Arima model is mainly applied in economic and environmental fields such as forecasting rainfall, salinity intrusion, rice production, or import and export situation ... [2,4,5].

The advantage of ARIMA model is simple and easy to use. We can run the model on different applications such as SPSS, R, Eviews and can forecast effectively in the short term. In this study, the author builds a model to predict surface water quality through the WQI index on some main streams in the mining and mineral processing of Lao Cai province.

2. Methods and Study area

2.1. Study area

The research object is a stream flowing through or near the apatite mining and processing area in Lao Cai province. Specifically, this study focuses on assessing and forecasting surface water quality of Ngoi Duong stream and Chu O (Figure 1).

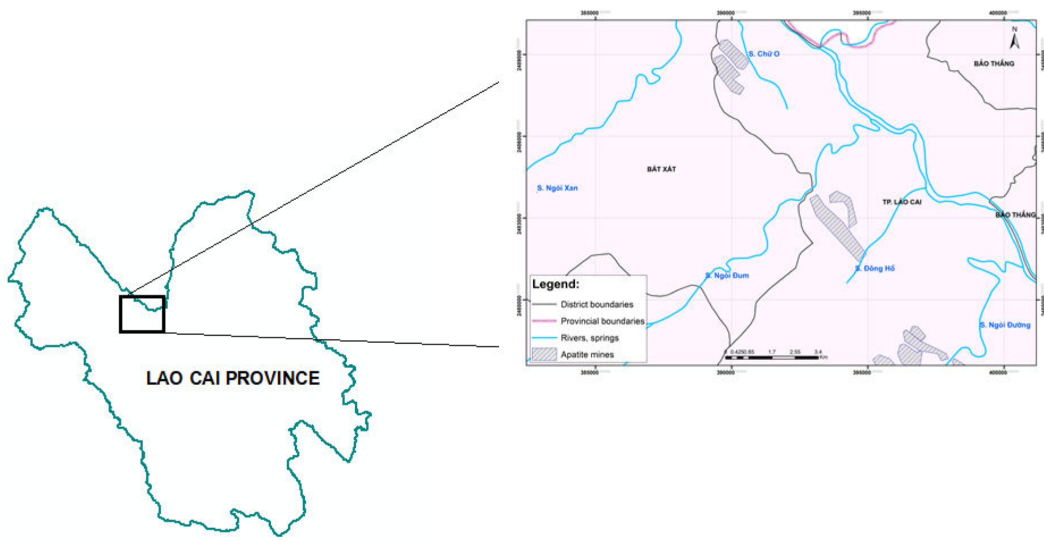


Fig1. Location of apatit mining and processing, Lao Cai

2.2. Methods

Arima (AutoRegresive Inegrate Moving Average) model was first introduced by Box – Jenkins in 1974 [1]. Arima model is combined by 3 main components: AR – Autoregressive component; I – Stationarity of the time series; MA – Moving Average Component.

Arima model is a quantitative forecasting model over time, the future value of the predictor variable will depend on the movement trend of that object in the past. Arima model analyzes the correlation between observed data to provide a predictive model through the stages of model identification, parameter estimation from observed data, and testing of estimated parameters to find out suitable model. The confidence limit of the forecast is based on the variance of the forecast error.

The integrated autocorrelation model with moving average ARIMA (p,d,q) has the following general equation form:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \ldots + \theta_q u_{t-q}$$

Where:

u_t white noise

ϕ, θ: parameters regression

p. number of autoregressions

q: moving average

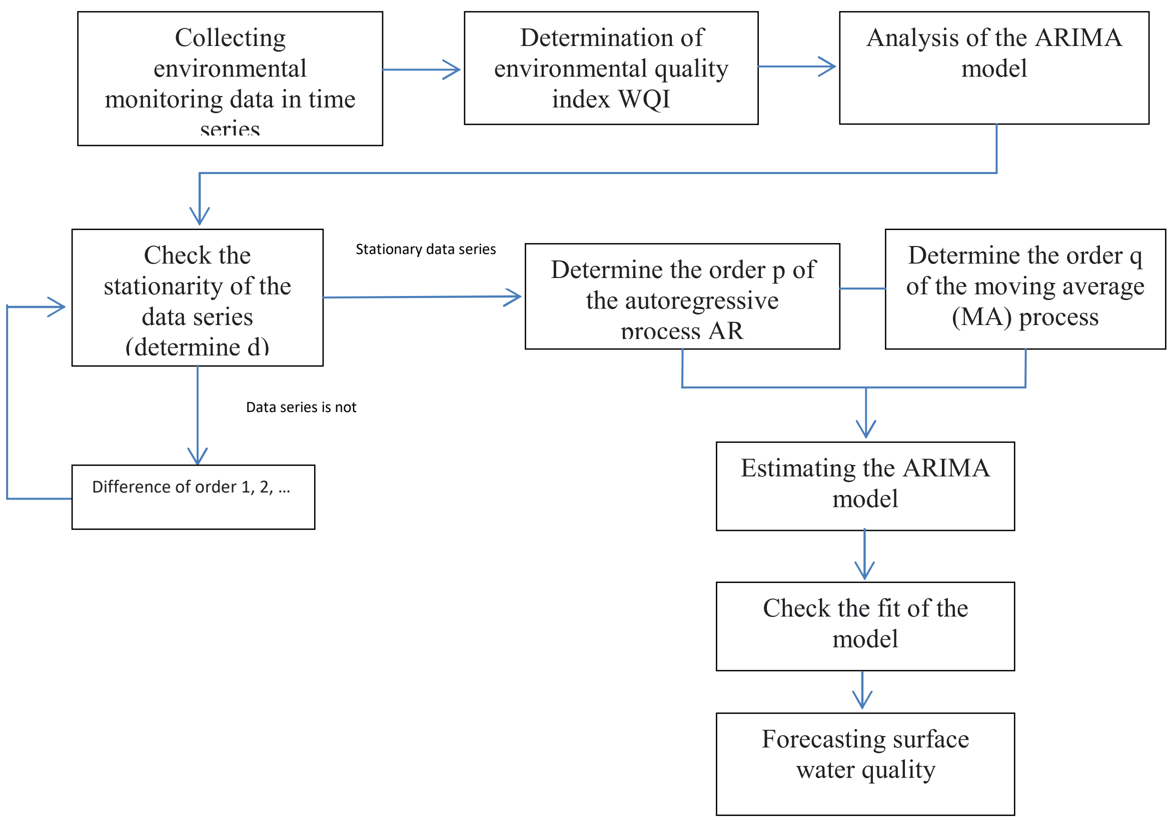


Fig2. Water quality forecasting diagram (WQI index) by ARIMA model

The process of building ARIMA predictive model to forecast water quality according to the Box - Jenkins method [4] consists of 4 steps:

Step 1: Identify the model

The ARIMA (p,d,q) model includes parameters p, d, q. So, it is necessary to find the appropriate values of p, d and q of the model (where d is the difference of the time series data under survey), p is the order of autoregression, and q is the order of the moving average). These values are determined based on autocorrelation histogram (ACF) and partial autocorrelation plot (PACF). In which, the choice of AR model (p) depends on the PCAF histogram if it has a high value at the lags 1, 2, ..., p and then suddenly decreases, and the ACF function form turns off gradually.

Step 2: Estimate the parameters of the ARIMA model (p,d,q)

Estimating the parameters for the models identified by Eviews software, based on of comparing the standards of coefficient of determination R2, AIC index and Schwarz criteria (SBIC). The model with the largest R2 index, the smallest AIC and SBIC values is considered as the best fit model.

Step 3: Check the model

The estimated model must then be retested to ensure representativeness of the observed data series. This will be done on the range of error values of the model to determine if they are white noise or not. Here, the ACF plot of the residual will allow this criterion to be checked.

Step 4. Forecast

Based on the equation of the ARIMA model forecast surface water quality.

3. Results and discussion

3.1. Data used

The research data are surface water quality monitoring values taken at Ngoi Duong and Chu O streams from 2017 to 2022. The data was aggregated and determined the WQI water quality index according to Decision No. 879/QD. -TCMT dated July 1, 2011 of Vietnam Environment Administration. The combined results are in Table 1.

Tab. 1 . WQI index from 2017 to 2022

Year	Quarter	Name	WQI index	Year	Quarter	Name	WQI index
2017	I	S.NgoiDuong	75	2020	I	S.NgoiDuong	75
2017	I	S.chuO	76	2020	I	S.chuO	74
2017	II	S.NgoiDuong	9	2020	II	S.NgoiDuong	68
2017	II	S.chuO	50	2020	II	S.chuO	79
2017	III	S.NgoiDuong	50	2020	III	S.NgoiDuong	66
2017	III	S.chuO	53	2020	III	S.chuO	59
2017	IV	S.NgoiDuong	8	2020	IV	S.NgoiDuong	67
2017	IV	S.chuO	60	2020	IV	S.chuO	70
2018	I	S.NgoiDuong	80	2021	I	S.NgoiDuong	69
2018	I	S.chuO	72	2021	I	S.chuO	77
2018	II	S.NgoiDuong	76	2021	II	S.NgoiDuong	59
2018	II	S.chuO	65	2021	II	S.chuO	80
2018	III	S.NgoiDuong	9	2021	III	S.NgoiDuong	66
2018	III	S.chuO	57	2021	III	S.chuO	60
2018	IV	S.NgoiDuong	77	2021	IV	S.NgoiDuong	72

Year	Quarter	Name	WQI index	Year	Quarter	Name	WQI index
2018	IV	S.chuO	59	2021	IV	S.chuO	67
2019	I	S.NgoiDuong	83	2022	I	S.NgoiDuong	81
2019	I	S.chuO	77	2022	I	S.chuO	76
2019	II	S.NgoiDuong	82	2022	II	S.NgoiDuong	78
2019	II	S.chuO	78	2022	II	S.chuO	86
2019	III	S.NgoiDuong	67	2022	III	S.NgoiDuong	76
2019	III	S.chuO	56	2022	III	S.chuO	81
2019	IV	S.NgoiDuong	65	2022	IV	S.NgoiDuong	47
2019	IV	S.chuO	74	2022	IV	S.chuO	47

Tab.2. Descriptive statistics of the WQI index

Ngoi Duong stream	**WQI**
Mean	62.71
Standard Deviation	22.76
Kurtosis	2.12
Skewness	-1.76
Minimum	8
Maximum	83
Count	24
Chu O stream	**WQI**
Mean	68.04
Standard Deviation	11.02
Kurtosis	-1.09
Skewness	-0.32
Minimum	47
Maximum	86
Count	24

Statistical results show that the water quality of Ngoi Duong and Chu O springs fluctuates strongly according to the seasons, in general, in the first and second quarters, the water quality is usually better than in the third and fourth quarters. This fluctuation is mainly due to the influence of meteorological factors such as temperature, precipitation, wind ... because mining and processing activities basically do not change in terms of exploitation capacity. Therefore, the impact from this activity on surface water quality is constant. The current surface water quality mainly meets the standards for use for irrigation purposes and other equivalent purposes.

3.2. Water quality forecasting model

a. Check the stationarity of the data series

The condition for predictive analysis by ARIMA model is that the analytical data series must be stationary series. Therefore, before building a forecasting model, it is necessary to check whether the data series (WQI) over time is stationary series or not?

Figure 3 shows that, the data series has trend and seasonal factors. We perform the stationarity test of the WQI series by the Augmented Dicjkey-Fuller (ADF) test called the unit root test.

Tab 3. ADF test results for data series WQI

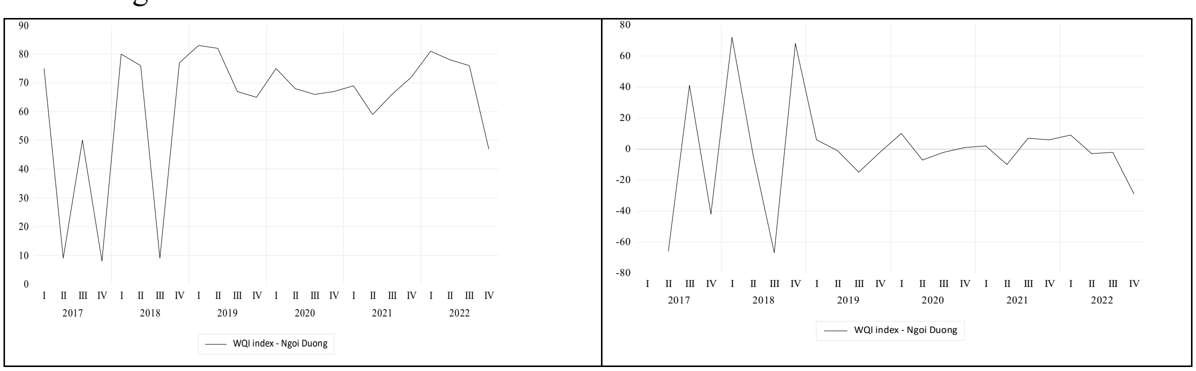
	Ngoi Duong		Chu O	
	t-Statistic	P-Value	t-Statistic	P-Value
ADF	-1.675617	0.7197	-1.439641	0.8141
Test critical values:				
1% level	-4.571559		-4.532598	
5% level	-3.690814		-3.673616	
10% level	-3.286909		-3.277364	

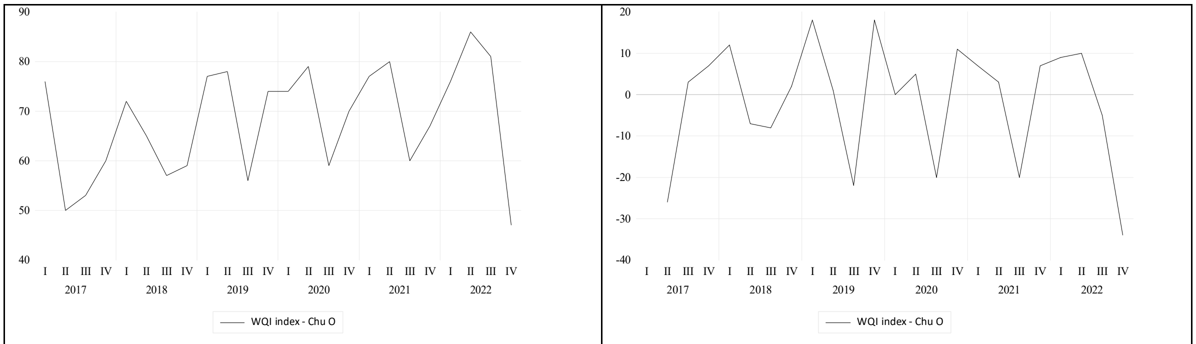
The test results shows that, for the WQI series at Ngoi Duong stream and Chu O stream, the t-Statistic values are larger than the critical values, and the P-values are all less than 0.05; 0.01; 0.1, concluding that the WQI series of Ngoi Duong and Chu O are non-stationary series at all 3 levels of significance.

b. Fix the stationarity of the data series.

Thus, the WQI data series of Ngoi Duong and Chu O has both trend and seasonal factors, and is also a non-stop series. Therefore, it is necessary to perform the correction of the above two data series to the stationary series.

Implementation of the first-order variance of the WQI of Ngoi Duong stream and Chu O stream and test the stationarity of each of these series. The data series after taking the first difference is shown in Figure 3.





a) b)

Fig 3. a). WQI series before difference; b). WQI stop series after difference

Check the stationarity by the Augmented Dicjkey-Fuller (ADF) test for the series after the first difference. The test results are summarized in Table 4.

Tab 4. ADF test results of WQI series at Ngoi Duong stream and Chu O stream

Test	Ngoi Duong		Chu O	
	t-Statistic	P-Value	t-Statistic	P-Value
ADF	-5.489023	0.0002	-5.966469	0.0001
Test critical values:				
1% level	-3.788030		-3.831511	
5% level	-3.012363		-3.029970	
10% level	-2.646119		-2.655194	

Table 4 shows that after the first difference, the P-values are all less than 0.05, meaning that the WQI series after the difference of the Ngoi Duong stream and Chu O stream is stationary.

c. Building ARIMA model for WQI values on Ngoi Duong, Chu O streams

*** Step 1:** Identification

The WQI series of Ngoi Duong stream and Chu O stream stop at the first difference, so we have d = 1.

*** Step 2:** Estimating the model

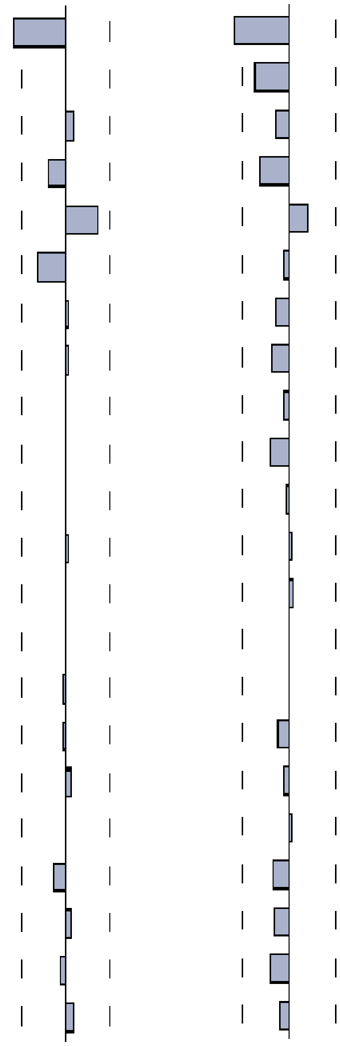
The p, q values are determined based on the table of autocorrelation coefficients (ACF) and partial correlation coefficients (PACF).

- Estimating parameters and choosing a water quality forecasting model for Ngoi Duong stream

From Table 5, we use the autocorrelation coefficients ACF to choose the order q for MA and the partial autocorrelation coefficient PACF to choose the order p for AR. The PACF chart shows that the partial correlation coefficients have large values at the lags of 1,2. For the ACF histogram, we have large autocorrelation coefficients at lags 1, 5. Thus, we will consider the following models:

ARIMA (1,1,1); ARIMA (1,1,5); ARIMA (2,1,1); ARIM (2,1,5)

Tab 5. Autocorrelation coefficients ACF and partial correlation coefficients PACF of WQI data series at Ngoi Duong stream



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.488	-0.488	6.2301	0.013
		2	0.007	-0.304	6.2314	0.044
		3	0.069	-0.108	6.3698	0.095
		4	-0.170	-0.254	7.2429	0.124
		5	0.311	0.160	10.327	0.066
		6	-0.258	-0.052	12.579	0.050
		7	0.017	-0.109	12.590	0.083
		8	0.019	-0.155	12.603	0.126
		9	-0.004	-0.046	12.604	0.181
		10	-0.002	-0.163	12.604	0.247
		11	0.005	-0.022	12.606	0.320
		12	0.024	0.021	12.637	0.396
		13	-0.002	0.040	12.637	0.476
		14	0.005	-0.006	12.639	0.555
		15	-0.023	0.002	12.678	0.627
		16	-0.021	-0.106	12.715	0.694
		17	0.045	-0.041	12.906	0.742
		18	0.002	0.017	12.906	0.797

19	-0.116	-0.134	14.839	0.733
20	0.051	-0.130	15.347	0.756
21	-0.048	-0.170	15.995	0.770
22	0.076	-0.098	19.333	0.625

The identified models were checked again for suitability based on the test parameters: adjusted R^2 index, AIC criterion (Akaike info criterion), SBIC criterion (Schwarz criterion). In particular, the higher the model R^2, the more significant the model, and the smaller the AIC and SBIC values, the more significant the model

Tab 6. Statistical results of some standards of tested ARIMA models at 95% significance level

Model	R^2	Akaike info criterion (AIC)	Schwarz criterion (SBIC)	Sig.Coff
ARIMA (1,1,1)	0.21	9,41	9,60	0
ARIMA (1,1,5)	0.25	9.72	9,42	2
ARIMA (2,1,1)	0.48	9.44	9.64	0
ARIM (2,1,5)	0.15	9.91	10.0	1

The results of the statistical comparison of several standards of the 4 models show that the ARIMA model (1,1,5) is the most suitable model to predict the WQI index of Ngoi Duong stream.

- Estimating parameters and choosing a water quality forecasting model for Chu O stream.

From Table 7, we use autocorrelation coefficients (ACF) to choose the order q for MA and the partial autocorrelation coefficient (PACF) to choose p order for AR. The PACF chart shows that the partial correlation coefficients have large values at the lags 2,3,10, equivalent to p-values that can receive 2,3,10. As for the ACF histogram, we have large autocorrelation coefficients at the lags 2,3,4 and 13 .

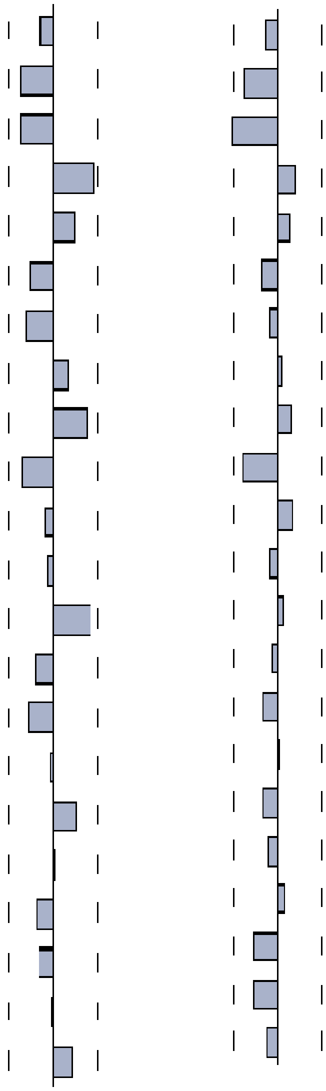
Thus, we will consider the following models:

ARIMA (2,1,2); ARIMA (2,1,3); ARIMA (2,1,4); ARIM (2,1,13)

ARIMA (3,1,2); ARIMA (3,1,3); ARIMA (3,1,4); ARIM (3,1,13)

ARIMA (10,1,2); ARIMA (10,1,3); ARIMA (10,1,4); ARIM (10,1,13)

Tab 7. Autocorrelation coefficients ACF and partial correlation coefficients PACF of WQI data series at Chu O stream



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.109	-0.109	0.3122	0.576
		2	-0.302	-0.318	2.8154	0.245
		3	-0.307	-0.434	5.5255	0.137
		4	0.371	0.169	9.6833	0.046
		5	0.199	0.115	10.945	0.052
		6	-0.216	-0.154	12.521	0.051
		7	-0.253	-0.070	14.822	0.038
		8	0.140	0.039	15.573	0.049
		9	0.313	0.126	19.598	0.021
		10	-0.295	-0.323	23.438	0.009
		11	-0.066	0.143	23.648	0.014
		12	-0.050	-0.074	23.779	0.022
		13	0.358	0.052	31.148	0.003
		14	-0.157	-0.057	32.722	0.003
		15	-0.224	-0.138	36.326	0.002
		16	-0.028	0.011	36.391	0.003
		17	0.216	-0.136	40.877	0.001
		18	0.016	-0.083	40.905	0.002
		19	-0.149	0.065	44.091	0.001

20	-0.125	-0.229	47.104	0.001
21	-0.010	-0.222	47.135	0.001
22	0.180	-0.100	65.709	0.000

The identified models are checked for suitability based on the test parameters: adjusted R^2 index, AIC criterion (Akaike info criterion), SBIC (Schwarz criterion). Which, the higher the model, the more significant it is, the smaller the AIC and SBIC values, the more significant the model and must have significant variables (Prob<0.05).

Table 8. Statistical results of some standards of the tested ARIMA models

Mô hình	R^2	Akaike info criterion (AIC)	Schwarz criterion (SBIC)	Sig.Coff
ARIMA (2,1,2)	0.125	8.221	8.418	2
ARIMA (2,1,3)	0.308	8.070	8.268	3
ARIMA (2,1,4)	0.192	8.168	8.366	1
ARIMA (3,1,2)	0.183	8.172	8.369	1
ARIMA (3,1,3)	0.336	8.162	8.360	0
ARIMA (3,1,4)	0.128	8.216	8.413	1
ARIMA (10,1,2)	0.252	8.194	8.391	2*
ARIMA (10,1,3)	0.257	8.152	8.349	1
ARIMA (10,1,4)	0.251	8.157	8.355	1

The results of the statistical comparison of several models show that the ARIMA model (2,1,3) is the most suitable model for WQI data of Chu O stream.

*** Step 3: Check the model**

After selecting models to predict surface water quality at Ngoi Duong ARIMA stream (1,1,5), Chu O ARIMA stream (2,1,3), the above models have violate the assumptions of the regression model not by Breusch-Godfrey test and White test. The results show that there is no autocorrelation and variable variance. Thus, it is concluded that the ARIMA model (1,1,5) and the ARIMA model (2,1,3) are suitable for predicting the WQI index of Ngoi Duong and O-shaped streams.

d. Forecast results

**** Forecasting the quality of Ngoi Duong spring***

The test result of forecast the WQI value for Ngoi Duong stream by ARIMA model (1,1,5) showed in Table 9.

Tab 9. Results of testing the ARIMA predictive model (1,1,5)

Time	2021Q1	2021Q2	2021Q3	2021Q4	2022Q1	2022Q2	2022Q3
WQI. OBSERVED	69	59	66	72	81	78	76
WQI. FORECAST	68.5	60.2	63.9	71.7	82.3	75.1	72.6
Absolute error	0.5	-1.2	2.1	0.3	-1.3	2.9	3.4
Relative error	0.7	-2.0	3.1	0.4	-1.6	3.7	4.4

Table 9 shows that the relative error between the predicted value and the actual measured value is not much different from 0.4% to 4.4%. Thus, with the above error, the ARIMA (1,1,5) forecasting model ensures the reliability to forecast surface water quality at Ngoi Duong stream through the WQI index.

The forecast results of surface water quality in Chu O stream shows Fig4 and Tab 10

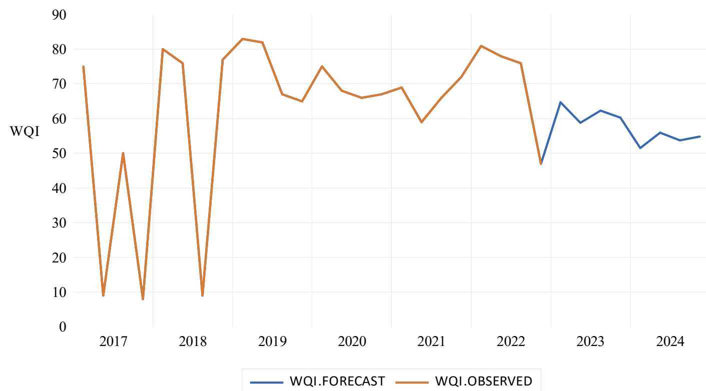


Fig 4. WQI forecast chart of Ngoi Duong stream

Tab 10. Forecast results of WQI value in the period of 2023 - 2024 of Ngoi Duong stream

TIME	2023Q1	2023Q2	2023Q3	2023Q4	2024Q1	2024Q2	2024Q3	2024Q4
WQI.FORECAST	64.7	58.8	62.3	60.3	51.5	55.9	53.7	54.9

The forecast results show that the WQI index at Ngoi Duong stream in 2023 - 2024 ranges from 51.5 to 64.7. Thus, according to the forecast results, in the next 2 years, the quality of Ngoi Duong spring water can still be used for fresh pepper or other equivalent purposes.

**** Forecast of water quality in Chu O stream***

The test result of forecast the WQI value for Chu O stream by ARIMA model (2,1,3) showed in Table 11.

Tab 11. Test results of ARIMA prediction model (2,1,3)

Time	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3
WQI. OBSERVED	77	80	60	67	76	86	81
WQI. FORECAST	76.3	81.6	62.2	65.7	73.9	81.9	78.9
Absolute error	0.7	-1.6	-2.2	1.3	2.1	4.1	2.1

Relative error	0.9	-2.0	-3.7	2.0	2.8	4.7	2.5

Table 11 shows that the relative error between the predicted value and the actual measured value, the difference between 0.9% and 4.7% is acceptable. Thus, with the above error, the forecast model ARIMA(2,1,3) ensures the reliability to forecast surface water quality in Chu O stream through WQI index.

The forecast results of surface water quality in Chu O stream shows fig5 and table 12.

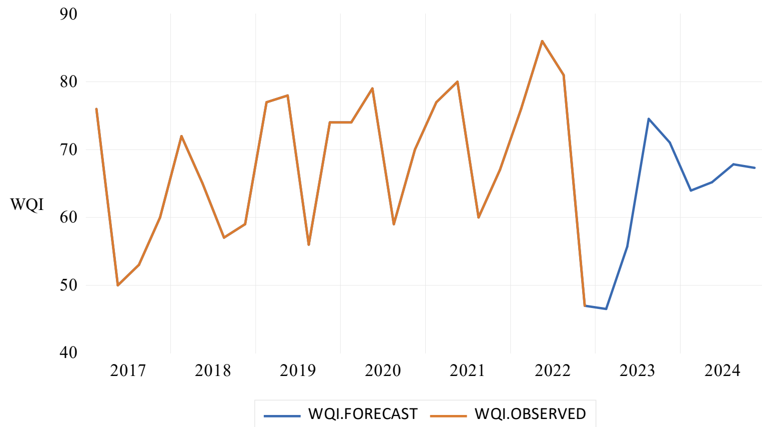


Fig 5. WQI forecast chart of Chu O stream

Table 12. Results of WQI forecast for the period of 2023 - 2024 of Chu O stream

TIME	2023Q1	2023Q2	2023Q3	2023Q4	2024Q1	2024Q2	2024Q3	2024Q4
WQI.FORECAST	47.0	46.5	55.7	74.5	71.0	64.0	65.2	67.8

The forecast results show that the WQI index at Chu O stream in 2023 - 2024 ranges from 47.0 to 74.5, and the water quality is suitable for irrigation and other purposes.

4. Conclusion

The analysis results have selected the most suitable model for short-term forecasting of water quality in Ngoi Duong and Chu O streams, respectively, ARIMA(1,1,5) and ARIMA(2,1,3). According to the forecast results, the WQI index of Ngoi Duong and Chu O streams from 2023 to 2024 does not have large fluctuations, it mainly fluctuates in the threshold of 51-75, what is suitable for irrigation purposes. The ARIMA forecasting model is based on previously collected time series data. Therefore, the larger the data collected, the more reliable the forecast results, especially in short-term forecasting.

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Microbial communities in subsurface flow wetlands

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Abstract

Microbial communities are responsible for the majority of the removal of organic matter in wetlands, making them a key factor for good system performance. However, not many studies performed on wetlands have focused on this aspect. In this paper, a case study is presented, where the microbial communities colonising two laboratory-scale wetlands, one unplanted and one planted, were studied. The functional groups of bacteria present in the two wetlands were found to be very similar, consisting mainly of SRB and methanogens. However, diversity analysis showed that the two systems did not have similar bacterial species, which indicates that systems sharing the same functional bacterial groups cannot be assumed to have equivalent bacterial species.

Keywords*: CW, microbial communities, wastewater, bacteria, SRB, removal*

1. Introduction

Wetlands are used all over the world to remove organic matter, nutrients, metals, suspended solids and pathogens from domestic wastewaters from small or large communities (Nguyễn Hoàng Nam, 2019). They have also been used as part of a treatment chain, for the management of agricultural and farming runoff (e.g. swine and dairy effluents; (Vymazal, 2015)), for the treatment of industrial effluents (e.g. refinery wastewaters, electroplating effluent, textile production; (Maiga, Sperling et al., 2017)), acid mine drainage (Nam Nguyen Hoang, 2011) and high strength effluents (e.g. landfill leachate; (Mulamoottil, McBean et al., 2019)). With all these unquestionable advantages, wetland creation and restoration is being widely promoted across a wide range of climates and geographical locations (Zamora, Marín-Muñíz et al., 2019).

The vast majority of the soluble organic carbon that is removed in wetlands is done so by the microbial consortia, which remove 50 to 95% of the organic matter (both aerobically and anaerobically;(U.S.E.P.A., 2019)), since the uptake by the macrophytes is insignificant (Nguyễn Hoàng Nam, 2019, U.S.E.P.A., 2019, Kochi, Freitas et al., 2020).

In wetland systems, the microbiological transformation of pollutants is aided by energy from the sun and wind, by the presence of plants, animals, by the soil and by the large area of these systems. Hence, constructed wetlands can be used as a low cost, natural technology for wastewater treatment, requiring very small amounts of non-renewable energies and no chemicals (Nguyễn Hoàng Nam, 2019).

2. Microbial communities in wetlands

Wetlands and other aquatic systems are suitable habitats for the development of large communities of microorganisms (Nguyễn Hoàng Nam, 2019). These microbial communities are responsible for most of the removal of soluble organic matter in wetlands. Therefore, in order to optimise the performance and avoid failure in these systems, it is crucial to have an understanding of the factors determining the structure and function of the microbial communities that carry out the organic matter removal (Rajan, Sudarsan et al., 2019, U.S.E.P.A., 2019, Gajewska, Skrzypiec et al., 2020). However, there is considerable lack of information about the communities of microorganisms inhabiting wetlands and processing the treatment of wastewater, which considerably limits the optimisation of these systems (Badhe, Saha et al., 2014, Nam and Kuschk, 2016, Rajan, Sudarsan et al., 2019).

The microbial communities are mainly composed of bacteria and fungi. Fungi are very important in wetlands, where they are commonly found growing in dead and decaying plant litter. They make a significant proportion of the carbon and nutrients available to plants and algae and, if they are inhibited (by high concentrations of toxic materials), this nutrient cycling is reduced, hence inhibiting the primary productivity of algae and plants. In addition, their symbiotic association with primary producers increases their host's capacity for sorption of nutrients from air, water and soil (Nguyễn Hoàng Nam, 2019). However, the role of fungi might not always be that prominent, as evidenced by preliminary work carried out by Boon *et al.* (1996) on two wetlands in Australia showed that the fungal community was not a significant part of the microbial communities in those systems, despite the large amounts of decaying plant material.

As previously mentioned, bacteria in wetlands are responsible for the majority of the degradation of organic matter in aquatic systems and the flow of carbon, nutrients and energy along the food web, all the way to the higher trophic levels, is ruled by the efficiency of this degradation (Vymazal, 2015, Mora-Orozco, González-Acuña et al., 2018). In wetlands, the bacteria are normally attached to solid surfaces forming a biofilm, which is a heterogeneous microbial community that produces a protective gel that consists of slime-like extracellular polymeric substances (Vymazal 2015, Nam and Kuschk 2016). The microenvironments developed by this matrix protect the biofilm from dramatic changes in the environmental conditions (Rajan, Sudarsan et al., 2019). It can also increase intracellular interactions and the surface area of individual cells, allowing for greater nutrient uptake, and its variable charged regions can attract charged particles like ions and humic acids, increasing the biofilm's capacity to take up nutrients from the wastewater (Nguyễn Hoàng Nam, 2019, Rajan, Sudarsan et al., 2019). However, the exopolymer matrix can hinder the diffusion of nutrients through the biofilm to the cells, limiting the substrate conversion rates (Rajan, Sudarsan et al., 2019).

Most of the microbial degradation of the pollutants in wastewater takes place close to the solid surfaces (sediments, medium, litter and below ground plant parts) in wetland systems, since that is where most of the biofilm is located (Nguyễn Hoàng Nam, 2019 and U.S.E.P.A., 2019). Biological degradation within the bulk wastewater in wetland systems also occurs, but at very low rates, since the bacterial numbers there are very low (Kadlec, 2019).

Microbial degradation of organic matter is largely affected by the quality of the organic matter and by its residence time in the system. Highly biodegradable substrates are effectively and quickly mineralised, while refractory organic compounds need large residence times to be even only partially decomposed (Nguyễn Hoàng Nam, 2019). Additionally, the organic matter affects the environmental conditions in the system, subsequently having an effect on the microbial activities. In fact, in sediments rich in biodegradable organic matter, dissolved oxygen is only available in the top millimetres near the surface and near plant roots, so that the mineralisation of most of the organic matter is carried out anaerobically (Nguyễn Hoàng Nam, 2019).

In general, the largest molecules (proteins, lipids and carbohydrates) are too large to penetrate the cell membrane of the bacteria and so are broken down to smaller compounds (peptides, soluble saccharides and fatty acids) by hydrolytic enzymes excreted by primary fermentative bacteria. These smaller compounds are then completely degraded to carbon dioxide if alternative electron acceptors are present or broken down to carbon dioxide and low molecular weight compounds (volatile fatty acids and alcohols) by primary fermentative bacteria, when external electron acceptors are limited. Secondary fermenters, namely syntrophic bacteria (which use hydrogen as electron acceptor) or some groups of sulphate reducing bacteria (SRB), then degrade the fatty acids and alcohols to acetate, formate and carbon dioxide. Terminal bacteria such as SRB and methanogens, completely mineralise the products from this last reaction to carbon dioxide and sulphide or methane, respectively (Nam 2011, Nguyễn Hoàng Nam 2019). These processes are shown schematically in figure 1.

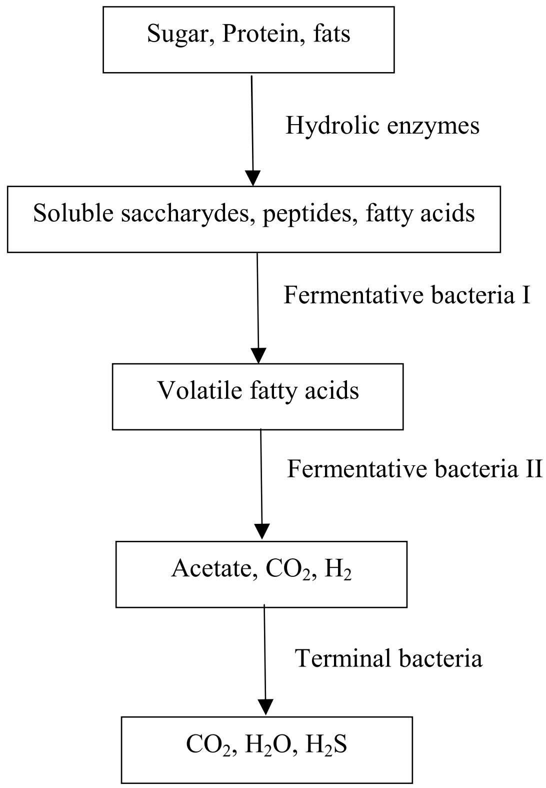

Figure 1. Anaerobic degradation of organic compounds. MOLECULAR TECHNIQUES

Until recently the identification and characterization of microbial communities in the environment was not a straightforward task. The study of microorganisms relied greatly on culture techniques and since the majority of microorganisms cannot be cultured (Head, Saunders et al., 1998), relevant microbial studies were difficult. If we consider that the prokaryotic species have been evolving for more than 3.8 billion years and that they are present almost anywhere in the planet, we come to the conclusion that what we know about microbial diversity through culture techniques is only a minute fraction of that really present (Hugerth and Andersson 2017). In fact, only a very small fraction of the total estimated microbial population has been cultured (Head, Saunders et al., 1998, Hugerth and Andersson 2017, Nguyễn Hoàng Nam, 2019). Estimates of the organisms that have been cultured range widely between 0.1 to 10%, which also indicates how little is yet known about the microbial world (Head, Saunders et al., 1998). Therefore, methods that provided information on the diversity and function of microorganisms were needed, which did not involve the cultivation of microorganisms (Hugerth and Andersson, 2017).

Molecular techniques started being used in the mid eighties and are now widely applied to determine the phylogenetic diversity of microbial communities in the environment (Head, Saunders et al., 1998, Hugerth and Andersson, 2017). With these techniques, it is possible to compare spatial and temporal changes in microbial communities, which had not been possible in the past with culturing techniques (Pesciaroli, Rodelas et al., 2015). The use of molecular techniques has raised the awareness of how vast the prokaryotic kingdoms really are and how little is still known about them.

Characterization and identification of the microorganisms can be carried out using polymerase chain reaction (PCR) followed by either cloning and sequencing the nucleic acid (and subsequent comparison with a public sequence database e.g. the Ribosomal Database Project, RDP;(Cole, Chai et al., 2003, Pesciaroli, Rodelas et al., 2015)) or 'community fingerprinting' (e.g. denaturing gradient gel electrophoresis - DGGE) and sequencing (Huys, Vanhoutte et al., 2008). Microbial diversity can be estimated by using PCR followed by cloning and sequencing; or by using fingerprinting techniques followed by statistical comparison of the results (Huys, Vanhoutte et al., 2008, Pesciaroli, Rodelas et al., 2015). Microbial identity and abundance can be studied using fluorescence *in situ* hybridisation (FISH), membrane hybridisation, quantitative polymerase chain reaction (qPCR) or, in some instances, most probable number (MPN) technique (Head, Saunders et al. 1998) (Head *et al.*, 1998). Rates (e.g. growth rate) and activity remain the hardest parameters to be studied and estimates can be obtained using culture techniques, chemical techniques and radioactive techniques (Morales and Holben, 2011).

Statistical analysis and ecological theory

The microbial diversity, based on the abundance and positioning of the bands in the DGGE gel, can be analysed using different statistical methods, one of which is based on the theory of random community assembly (Raup and Crick, 1979), used successfully by Curtis *et al.* (2002), Rowan *et al.* (2003) and Isazadeh et al. (2016) (Curtis, Rayne et al., 2002, Rowan, Snape et al., 2003, Isazadeh, Jauffur et al., 2016). Random community assembly suggests that the composition of microbial communities is not fixed in space or time, which means that two reactors treating the same wastewater do not necessarily contain the same microbial communities and even the same reactor cannot be assumed to have the same microbial diversity at two different points in time (Rowan, Snape et al. 2003, Nam, 2011).

Raup and Crick developed a method to predict how many species can be expected to be shared between two data sets and the expected variation in this number. They used a sample randomization procedure (Monte Carlo simulations), where (at least) two community data sets were compared against a random set of data, resulting in an index of similarity between the different samples. This index of similarity is equal to the probability that the expected similarity between different samples is equal to or less than the observed similarity. Based on the value of the index of similarity, if two communities are more similar than predicted by the null hypothesis, it means that there was a positive bias in the assembling of the communities and, conversely, if the samples are more different than predicted, it indicates that there was a negative bias in the make-up of the communities (Raup and Crick, 1979).

Case study

Two laboratory-scale wetlands, one planted with *Phragmites australis* and the other one unplanted, were operated for a period of one and a half years being fed with diluted beer with an average COD concentration of 385 mg/l and an average sulphate concentration of 76 mg/l. The initial COD/sulphate ratio was quite low and favourable for SRB, but after the first 3 months of operation, it increased to values well above the optimum for SRB. Most of the organic matter was present as acetate and propionate.

Based on FISH and DGGE analyses, bacteria were found to be the entities responsible for the removal of carbon in the two wetlands. In fact, incomplete oxidisers (SRB) degraded most of the propionate in the wetlands and methanogenic bacteria degraded most of the acetate, both being responsible for at least 90% of the TOC removal and around 70% of the COD removal in both wetlands. The microbial communities around the plant roots consisted mainly of methanotrophic bacteria and SRB (both complete and incomplete oxidizers). These results suggest that both methanogenesis and sulphate reduction coexisted quite well in the sediments from the wetlands. However, if the COD/sulphate ratio had been low in the feed, the majority of the acetate would have most likely been degraded by acetate-degrading SRB, since these have a higher affinity for this substrate than methanogenic bacteria (Winfrey and Zeikus, 1977). If SRB had degraded most of the acetate, the performance of both systems would, most likely, have been better, since SRB have higher growth rates than methanogens, consequently degrading larger quantities of substrate per unit time. However, increased amounts of hydrogen sulphide would be produced and would need careful monitoring, as previously found by Nam, Nguyen Hoang and Nam an Chung (Nam, 2011, Nam and Chung, 2015).

One of the rare studies carried out on the composition of the microbial communities in wetlands was developed by Boon and Sorrell in 1991, when they detected the presence of methanogens, methanotrophs and SRB in a permanently flooded wetland in Australia. These researchers also found that methanogenesis and sulphate reduction coexisted in the wetland (Boon and Sorrell 1991). Then, in 1996, Boon and co-workers used that same wetland and found that methanogens formed as much as a third of the total community of prokaryotes. Methanotrophs and SRB were also detected and their abundances were estimated to be 2% and 0.5%, respectively, of the total prokaryote population. Similarly to the study here described, methanogenesis was found to be one of the main processes of organic degradation, being responsible for over 60% of the carbon mineralization (Boon, Virtue et al. 1996).

The analyses of the diversity of the microbial populations in the two lab-scale wetlands produced some unanticipated results, since plants were expected to influence the make-up of the microbial communities. However, the bacterial communities in the two wetlands were assembled randomly, suggesting that the microbial communities in the two systems were no more similar or different than they would be had they been assembled solely by chance. Additionally, the analyses showed that comparison of the diversity of the eubacterial communities in the wetland samples with the feed, mostly yielded similarity indices between the upper and lower confidence limits of the null hypothesis. This evidence suggests that the introduction of a variation in the environment (plants/no plants) did not result in deterministic changes in the microbial communities, since there were no consistent spatial or temporal differences or similarities in the microbial communities. On the other hand, even though both systems had similar numbers of SRB and methanogens amongst themselves, that did not result in both wetlands sharing similar species of these two major functional groups.

These results corroborate the idea developed by Curtis *et al.* that identical ecosystems cannot be assumed to share the same microbial communities, even when performing in similar ways (Curtis, Rayne et al., 2002). Also, the similar behaviour of the two systems in terms of pollutant removal could be due to each of them containing physiologically different but functionally similar groups of microorganisms, or the two systems could have had different microbial diversities, but could both have common microorganisms which were functionally dominant in the two systems. In this study, the first hypothesis seems to be more viable since there did not seem to be a consistently dominant organism in the samples analysed.

Hence, the conditions in the wetlands determine the functional groups of organisms that will be present, but the species within those groups invade the reactors according to stochastic invasion processes. For instance, at the start of this study, the wastewater had low COD/sulphate ratio and the conditions in the wetlands were anaerobic, both of which favoured the presence of SRB. Additionally, the fermentative bacteria present in the wetlands were breaking down most of the organic carbon into propionate and acetate, hence supporting the presence of organisms that use these substrates efficiently. However, the bacterial species within the groups of SRB that consume acetate and propionate and that were present in the feed colonized the wetlands randomly.

Traditionally, wastewater engineering has been based on the assumption that microbial assemblies are determined by external factors, suggesting that similar environments will have similar microbial communities, and different functions in the system are attributed to distinct restricted bacterial species (e.g. (Metcalf and Eddy Inc., 1991)). The results found here hint otherwise, which suggests that modelling and understanding microbial diversities is a key feature in understanding biological wastewater treatment systems. On the other hand, they are likely to be much more versatile and resistant to changing operating conditions than widely accepted since the microbial communities in the reactors are likely to include a wide range of different microorganisms, probably not all of which are affected by the dramatic changes in the reactor conditions. In reality, the more diverse the microbial communities in a reactor, the more likely they are to resist to perturbed operating conditions (Nguyễn Hoàng Nam, 2019, Gajewska, Skrzypiec et al., 2020). Additionally, two reactors that operate similarly under normal operating conditions might operate completely differently under perturbed conditions, since "minor populations" which are probably distinct in the two systems, are likely to take over when the systems are under stress and result in completely different performances from each reactor(Gajewska, Skrzypiec et al., 2020).

Conclusions

Microbial communities in wetlands are the main entities responsible for the degradation of organic matter. The functional microbial groups present in a given wetland are largely determined by the nature of the feed and by the environmental conditions in that system. However, the species forming each functional group are thought to be no more or less similar than if they had been randomly selected from the source (e.g. feed). Hence, the functional microbial groups present in a wetland can be inferred from the conditions in that system, but the species forming those functional groups can not as yet be known or inferred without carrying out molecular analysis.

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Landslide susceptibility mapping in Nguyen Binh region, Cao Bang province, Northern Vietnam using Random Forest (RF) and Support Vector Machine (SVM) approaches

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Abstract

Landslide is a natural disaster that threatens human lives and properties worldwide. Numerous researches have been conducted on landslide susceptibility mapping (LSM), in which each has attempted to improve the accuracy of final outputs. This study presents Random Forest (RF) and Support Vector Machine (SVM) approaches for LSM to understand the effects of accuracy of data mining models in Nguyen Binh region of Cao Bang province, Northern Vietnam. Results showed that the prediction rate ranging from 0.77 to 0.85 with RF to SVM models. The spatial variations in landslide samples agreements of the models were also good based on Shannon entropy equations. Overall, the data mining approaches show good accuracy and can be replicated to any region with similar landslide conditioning factors.

Keywords: Landslide susceptibility mapping, Random Forest (RF), Support Vector Machine (SVM), Nguyen Binh region, Vietnam.

1. Introduction

Natural disasters, including landsides, are among the global problems that threaten human lives, properties, and economy. Landslides are among the most severe events in the recent history of Vietnam and have led to loss of lives and properties. Landslide susceptibility mapping (LSM) is an important step in landslide risk assessment; it constitutes a standard tool to realize an effective land use management strategy that ultimately supports the decision-making process on land management (Nourani et al. 2014). Either qualitative or quantitative approaches can be used to develop LSM.

The main purpose of this study is to establish an effective landslide susceptibility zoning model with 8 landslide condition factors were selected as the evaluation indices to construct the susceptibility assessment model. Two machine learning algorithms for landslide susceptibility prediction including: Random Forest (RF) and Support Vector Machine (SVM), which have been used for landslide susceptibility mapping in the Nguyen Binh region of Cao Bang province, and the results were compared. Landslide areas were delimited and mapped as landslide inventory after gathering information from historical records, remote sensing detection and periodic field investigations.

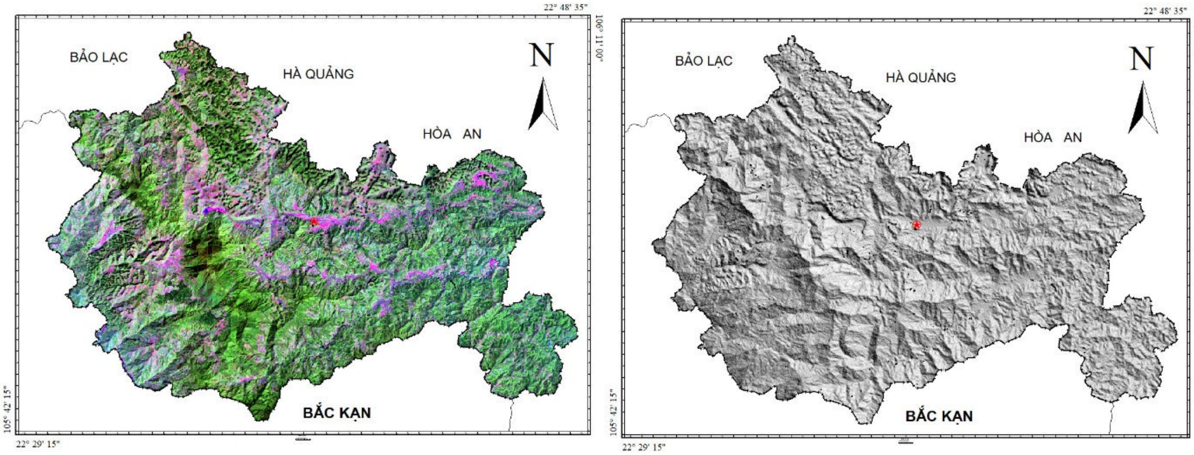


Figure 1. Remote sensing and topographic maps of Nguyen Binh County

Data verification and quality assessment are important steps prior to landslide susceptibility modeling. In the database, 306 landslides were plotted and classified into training (70%, 214 landslides) and testing (30%, 92 landslides) subsets randomly to train and validate the models. The RF model has a higher correct prediction rate than SVM, with a rate of 89.28%, and SVM is 83.64%. This research might be useful in landslide studies in mountainous areas, especially in locations with comparable geophysical and climatological characteristics, to aid in decision making for land use planning.

2. Methodology and Research Data

2.1. Study Area and Landslides Inventory

Landslides are one of the most common natural hazards and when they occur, they usually cause loss of life and significant economic losses. The main type of environmental hazard in the study area is landslide. Thus with a total of 306 landslide sites has been mapped by applying the remote sensing (RS), geographic information system (GIS), and spatial data analysis method. Existing landslide inventory was updated and created a multi-date landslide database from the interpretation of time series of aerial photographs, geomorphological maps, historical reports and field surveys in the years 2021 and 2022.

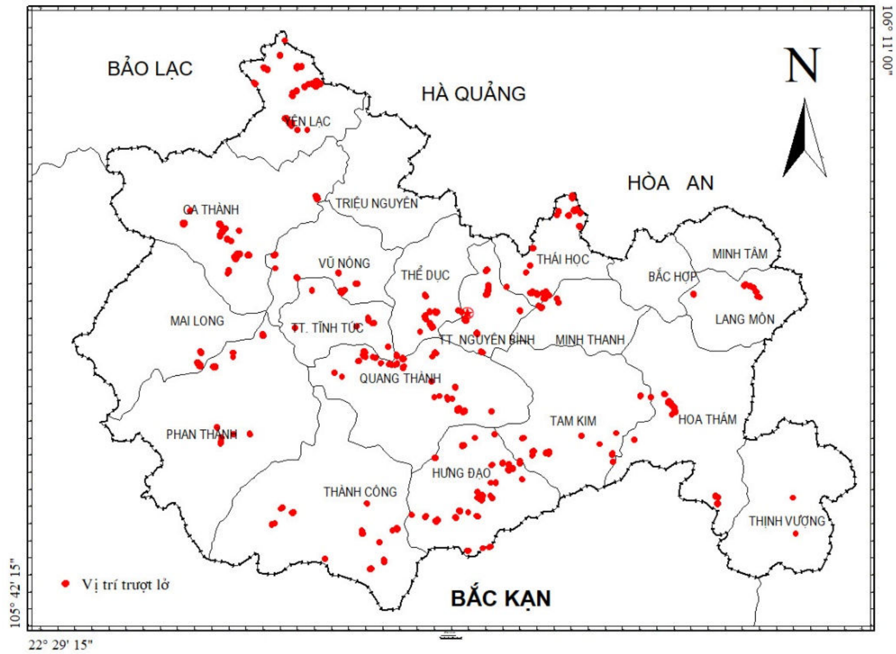
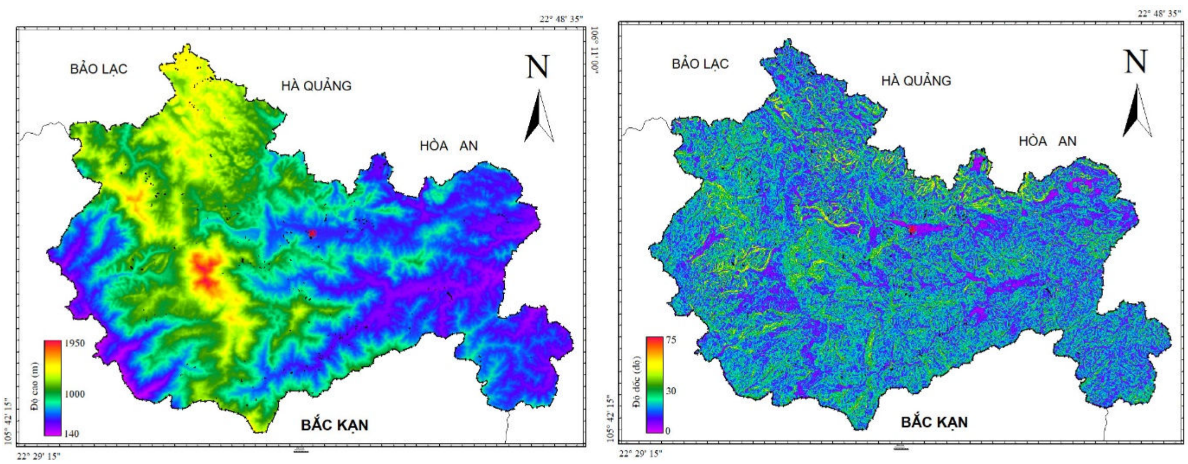


Figure 2. Landslide locations in Nguyen Binh County

The area of Nguyen Binh County is about 841km^2 and the population is about 39,654 in 2019. The study area is one of the most landslide-prone areas in Cao Bang province, one of the reasons that is karst landscape with easily leaking surface water and high soil moisture. The annual average precipitation of study area is about 1,500-2,000mm, precipitation is the major inducing factor for landslides.

2.2. Condition Factors

In this study, we collected multi-source data such as field survey data, precipitation data and remote sensing satellite data from Nguyen Binh County, Cao Bang province and used the advanced big data models to construct landslide susceptibility map, and compared their performance and applicability in the study area. Landslides in the study areas are affected by many different factors, however, we give 8 most important factors, the data make the most of it to compare the susceptibility assessment landslides in the area.



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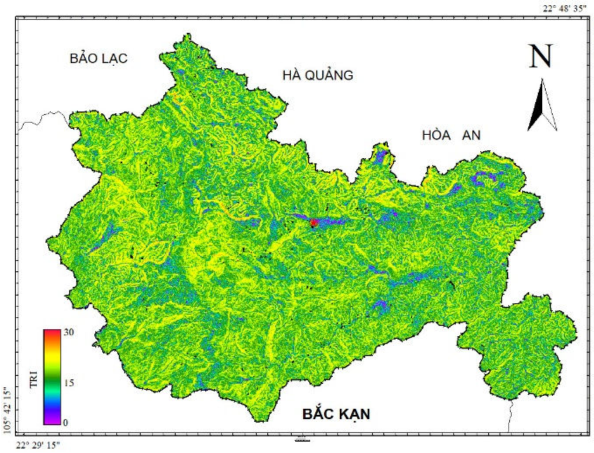

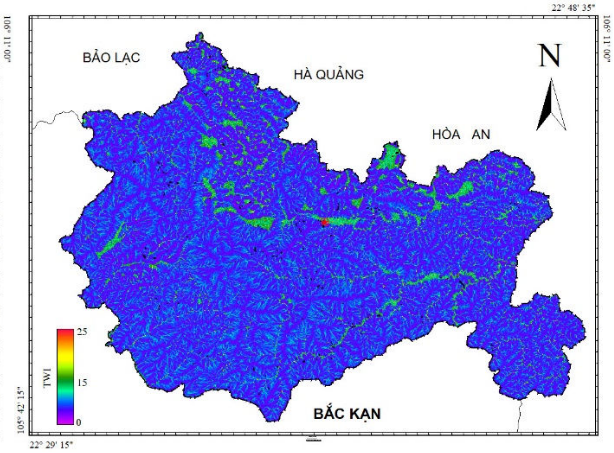

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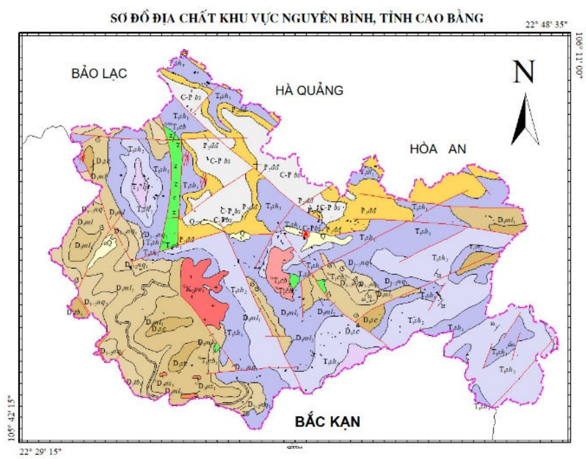

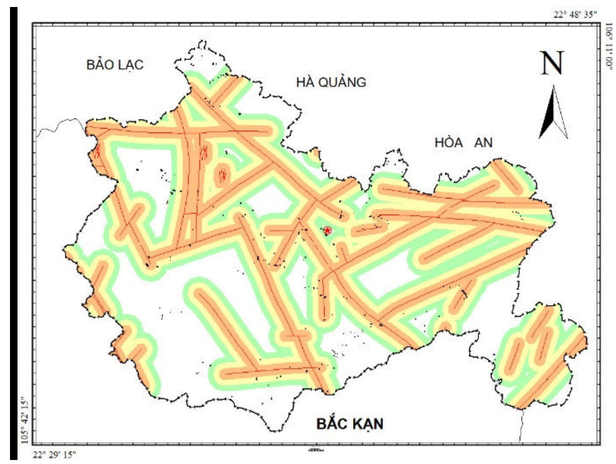

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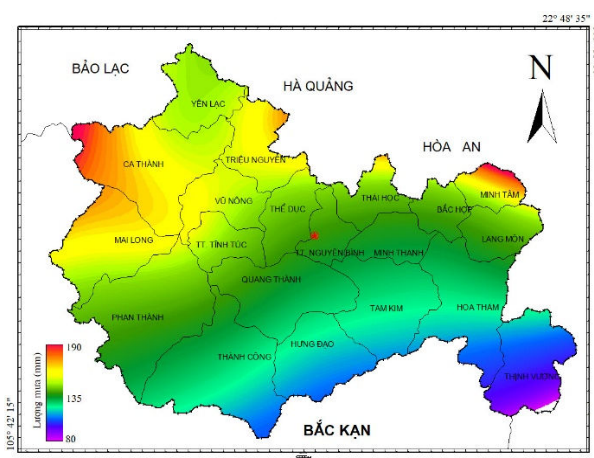
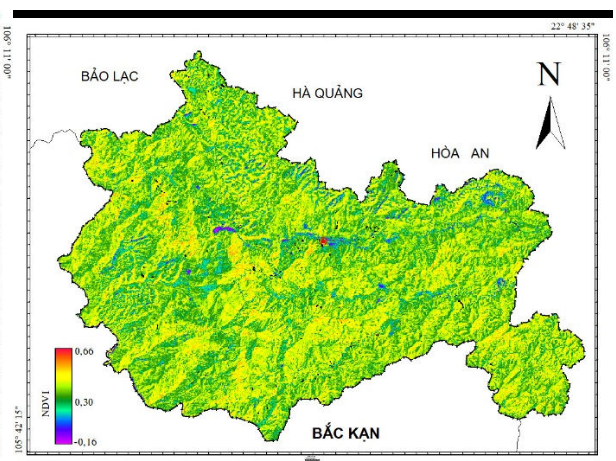




g) h)

Figure 3. Some of the landslide condition factors: a) Elevation, b) Slope, c) Terrain Ruggedness Index (TRI), d) Terrain Wetness Index (TWI), e) Lithology, f) Fault system, g) Maximum daily rainfall and h) NDVI

Combined with multi-source, field and remote sensing data, landslide statistics were collected for 306 landslide sites. A total of 8 conditioning factors were selected based on their impact on the landslides and the data accessibility (in Figure 3). , which including: elevation, slope, TRI, TWI, lithology, fault system, maximum daily rainfall and NDVI. The purpose of analyzing these inputs factors, it is necessary to format the DEM pixel size, they are resized to 20m × 20m. The relationship between landslide hazards and the environment was studied, and its sensitivity was classified and evaluated.

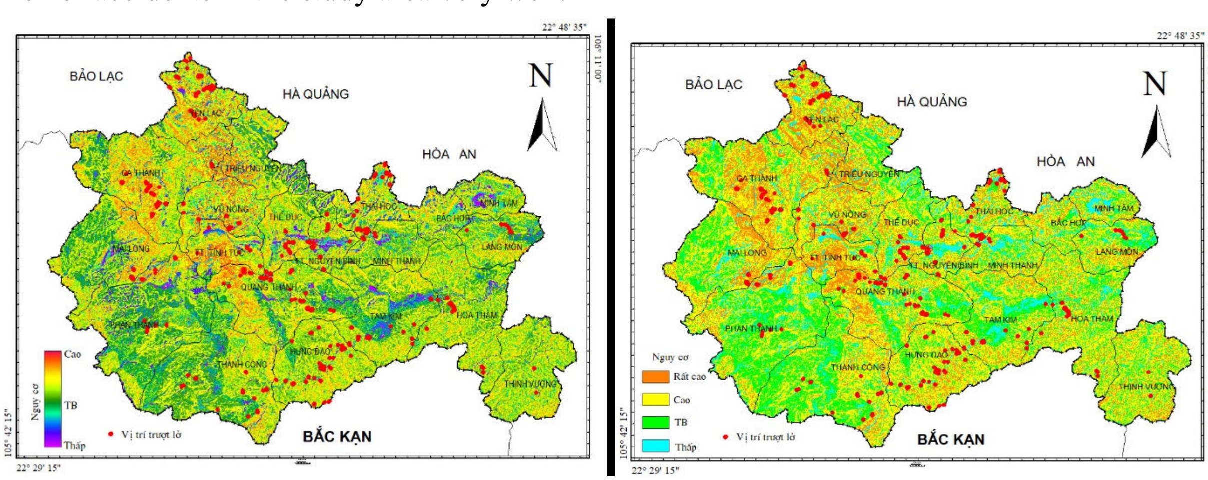
2.3. Methodology

Evaluation of the models, including their advantages and applicability, is important to obtain a satisfactory landslide susceptibility map. The strongest point of big data analysis methods is that the input data does not need to be normalized or created dummy variables, can use all classes of information collected by checking the statistical independence of the data. The information layer is not required. At the same time, these methods can work with both numerical data (rainfall, slope, etc.) and labeled data (rock groups, land use types, etc.). The dataset included in the calculation consists of 8 information layers, each layer consists of 1426 pixels, of which 587 pixels of landslide locations and 839 pixels of no landslide are randomly selected over the entire study area. Due to the relatively large data source (total: 1,848,582 pixels), the research data set is divided into three data sets with a separation ratio of 70% for the training dataset to build, 15% for the cross-validation dataset and 15% for the testing dataset to check the efficiency of the computational model.

3. Results and discussion

Since analyzing landslide susceptibility, the landslides are mainly located in the very high and high LSP. RF has more accuracy and it is much easier to understand and interpret.

The RF model gave the best results with global accuracy of 89.3%, SVM model (83.6%), followed by the ability to effectively analyze data models. large data for the purpose of predicting the risk of accidents in the study area very well.



a) b)

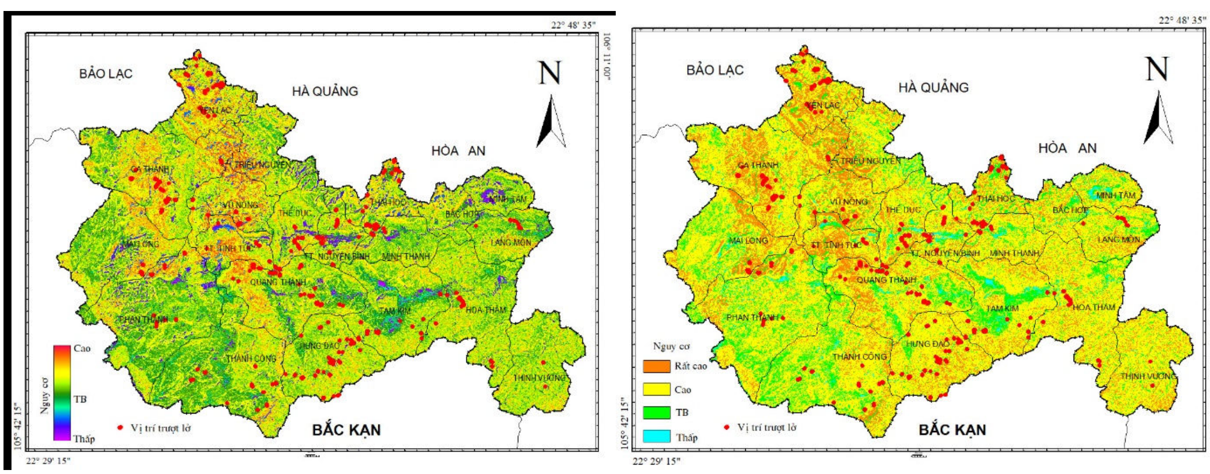
Figure 4. Landslide susceptibility (a) and landslide zonation (b) maps from RF algorithm

To a certain extent, it provides a reference for the link between landslide early warning and extreme precipitation warning. Mining disturbances have also caused extensive damage to the surface, and mining activities have influenced the occurrence of landslides in the area.

For using two models, the training and testing data are both defined as 70/30.

The landslide susceptibility models were evaluated using the receiver operating characteristic (ROC) curve analysis and the confusion matrix. ROC curve is a common method used to measure the performance of predicted models, such as landslide susceptibility models. This method provides a diagnostic that can be used to distinguish two classes of landslide events and visualize the model performance. The model accuracy is calculated based on the area under the ROC curve (AUC), which contains values ranging from 0.5 to 1.0. The correctly predicted events and the probability of falsely predicted ones are plotted in a two-dimensional chart representing the model performance. AUC value of 1.0 indicates an ideal model, whereas an inaccurate model often has an AUC close to 0.5.

In fact, different models have different performance, the different condition factors cannot equally contribute to the development of landslides in the area. The main cause of landslides in Nguyen Binh are rainfall, slope angle and TWI are the conditions of the significant influence contribution in the occurrence of geological hazards.



a) b)

Figure 5. Landslide susceptibility (a) and landslide zonation (b) maps from SVM algorithm

Compared with the black box model (SVM), the diagram of the RF model is quite easy to understand, it can create rules (rules) associated with each leaf branch is a rule of the tree. The results indicated RF have 70 landslide sites (80.75%), 53 landslide sites (60.48%) in the high and very high areas respectively, and the high and very highly prone areas account for 20.97% and 32.46% of the study area. They all have high enough model accuracy to be applied to the prediction of the susceptibility of landslides in study area. These two models also predict that the landslide sensitivity of the Nguyen Binh County is low or moderate, and predict that the highest landslide susceptibility lies in the west section, and the southeast part of the area.

4. Conclusion

Spatial variations that are often present in landslide conditioning factors are the main reason for differences in the prediction accuracy of regression models developed in different regions. This study has contributed to compare 02 machine learning methods (RF and SVM) for landslide susceptibility zoning in Nguyen Binh district, Cao Bang province. The study area is affected by 306 recorded landslide sites and 8 condition factors and the results show that RF is more suitable to assess landslide susceptibility through the analysis of accuracy and characteristics. landslide distribution point. Of all the 8 condition factors, three factors, including rainfall, slope angle and TWI are the most favorable conditions for landslide susceptibility in study area; land cover (NDVI), elevation and other factors contribute less. Last but not least, it is necessary to consider the dangerous support points for management.

Future works should improve the landslide identification methods, in which expert-based models can be applied in data scarce regions and other data mining/statistical methods can be applied where more landslide data is collected. Subsequently, the maps that will be produced by the individual models can be combined to improve the accuracy of LSM. When more data could be available with larger variations in size, distribution, and temporal/spatial characteristics, various scenarios can be studied and it is also worth researching on building build new models for solving similar issues when there are spatial variations in landslide data.

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