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PART II: SELECTED FULL PAPERS

Assessment of environmental pollution levels and forecast of changes in some heavy metals and grease in sediment of Nam Cau Trang Port cluster - Quang Ninh Province <i>Phuong Nguyen, Cuc Thi Nguyen, Lan Anh Thi Vu, Dong Phuong Nguyen, Hoang Hai Yen</i>	118
Assessment of surface water quality in Cao Bang city using Vietnam water quality index (VN_WQI) <i>Trung Thanh Dao, Thi Hong Nguyen.....</i>	124
Signs of Acid Mine Drainage and Distribution of Heavy Metal into The Environment at Ban Phuc Nickel Mine <i>Pham Van Chung, Nguyen Van Pho, Nguyen Thi Thuc Anh.....</i>	130
Remote sensing-based indices for mapping of water quality in Thai Binh river at Hai Duong province <i>Nguyen Quoc Phi, Vu Manh Tuong, Nguyen Quang Minh.....</i>	138
Researching the Potential Impact of Industrial Stacks of the Bright International Vietnam Company on the Ambient Environment <i>Tran Anh Quan, Nguyen Thi Hong Ngoc, Do Thi Hai, Do Phuong Nam.....</i>	149
Investigating The Causes of The Flood In Ho Chi Minh City Area -Proposing The Solutions <i>Thiem Quoc Tuan, Do Van Nhuan, Huynh Ngoc Huong.....</i>	156
Studying Causes of The Sand-Flow Hazard in Tien Thanh Area, Phan Thiet City, Binh Thuan Province - Proposing Solutions <i>Thiem Quoc Tuan, Do Van Nhuan, Huynh Ngoc Huong.....</i>	165
Characteristics and Exploitation Reserves of Hot Mineral Water at Nkns Borehole, Bao Yen Commune, Thanh Thuy District, Phu Tho Province <i>Do Van Binh, Ho Van Thuy, Do Thi Hai.....</i>	173
A GIS-Based approach for the sustainable management of livestock effluents at Cam Lam district, Khanh Hoa province <i>Nguyen Quoc Phi, Tran Thi Thu, Phi Truong Thanh.....</i>	185
Comparison between ANN & DT to predict landslide susceptibility in Trung Khanh area, Cao Bang province <i>Trinh Ngoc Nhu Anh, Nguyen Quoc Phi.....</i>	191
Surface Modification of Balsa Wood for Functional Oil/Water Separation <i>Tho D. Le, Duc Anh H. Bui, Bao T.T. Nguyen, Huong T.T. Tong.....</i>	196
Collection of domestic solid waste in Hai Duong province and some proposes <i>Do Van Binh, Vu Manh Hung, Nguyen Thi Hang, Ha Thi Luyen.....</i>	204
Monitoring rice growth and predicting rice biomass by Sentinel-2 data at Giao Thuy, Nam Dinh <i>Hoa Phan Thi Mai, Cuc Nguyen Thi, Phi Nguyen Quoc.....</i>	213

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

Nguyen Quoc Phi¹, Tran Thi Thu², Phi Truong Thanh³

¹Hanoi University of Mining and Geology (HUMG)

²Khanh Hoa Provincial Environmental Protection Department

³Hanoi University of Natural Resources and Environment (HUNRE)

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, BOD₅, 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

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 runoff).

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, BOD₅, 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.

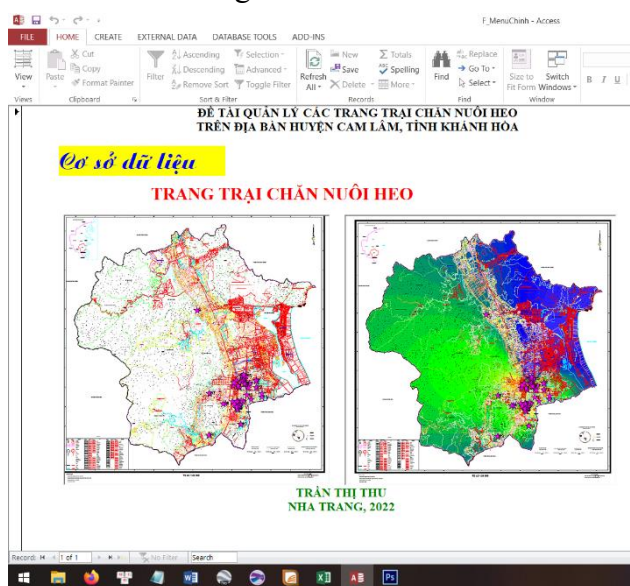


Figure 3. Management tool developed on MS Access

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 necessarily 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.

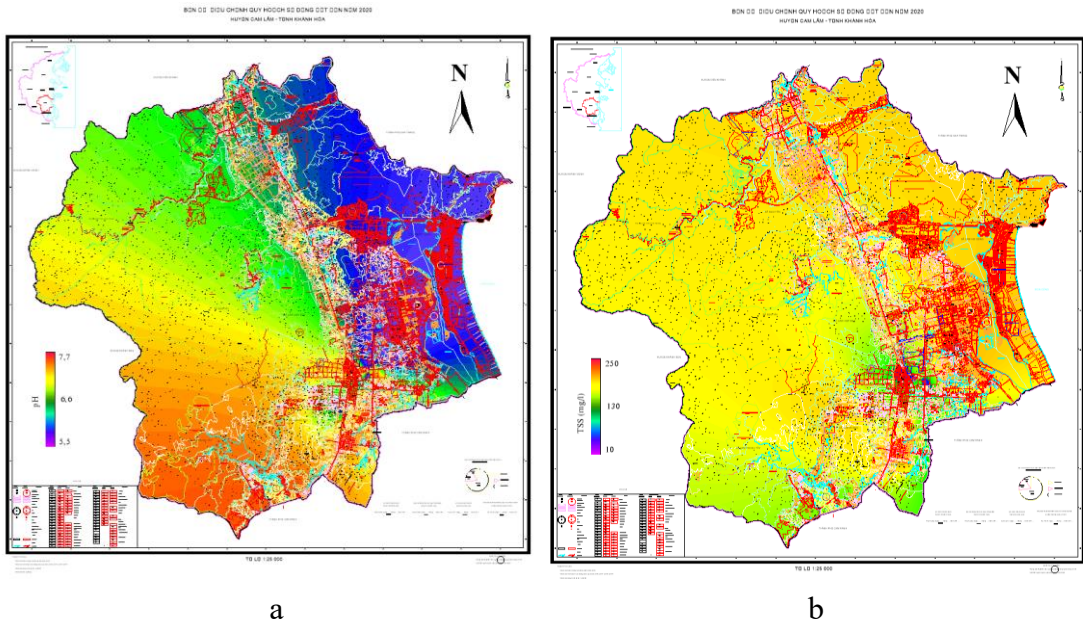


Figure 4. Maps of pH (a) and TSS (b) derived from the management database

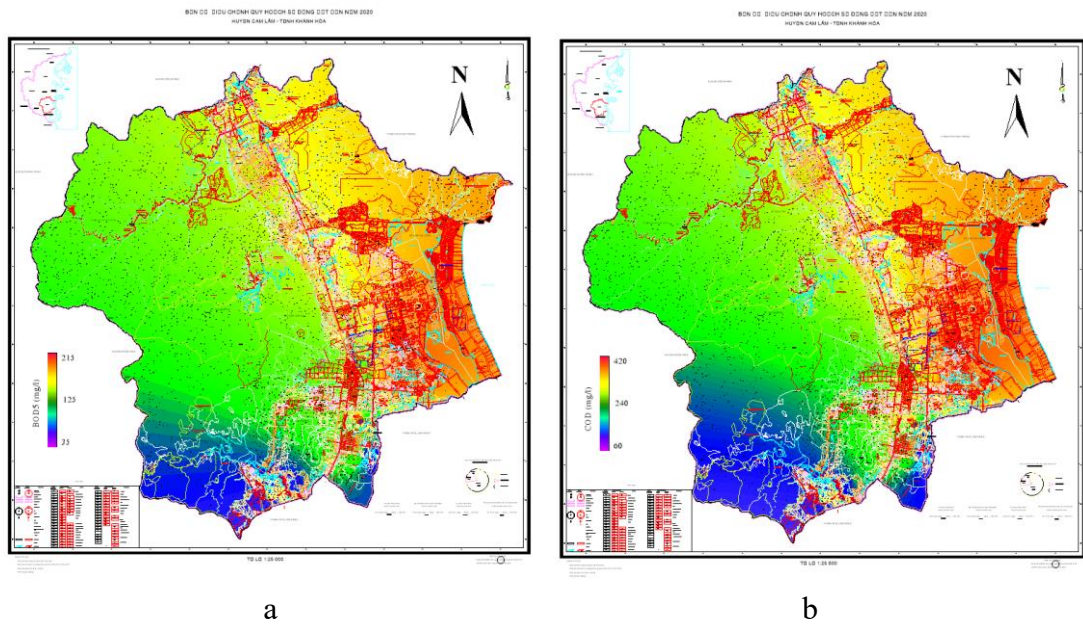


Figure 5. Maps of BOD₅ (a) and COD (b) derived from the management database

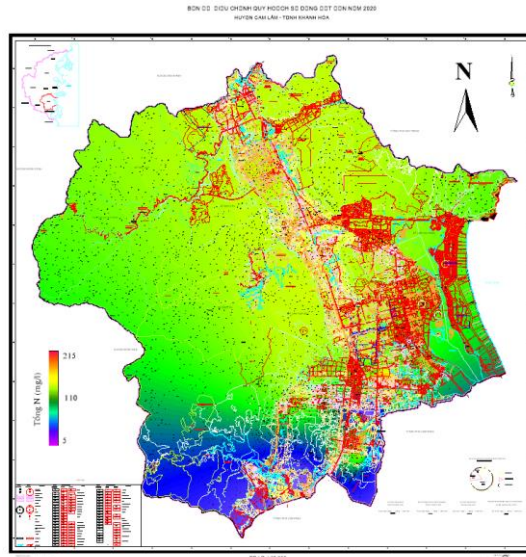


Figure 6. Maps of nitrogen production derived from the management database

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, BOD₅, 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.

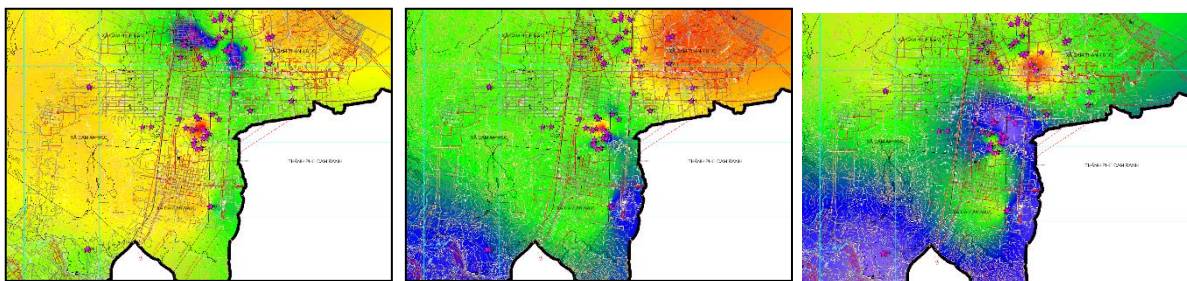


Figure 7. Close look at the Southern part of Cam Lam district for TSS (a), BOD₅ (b) and nitrogen (c)

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 management. 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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ĐT: (024). 66860751 - (024). 66860753

Email: nxbdantri@gmail.com

Website: nxbdantri.com.vn

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