



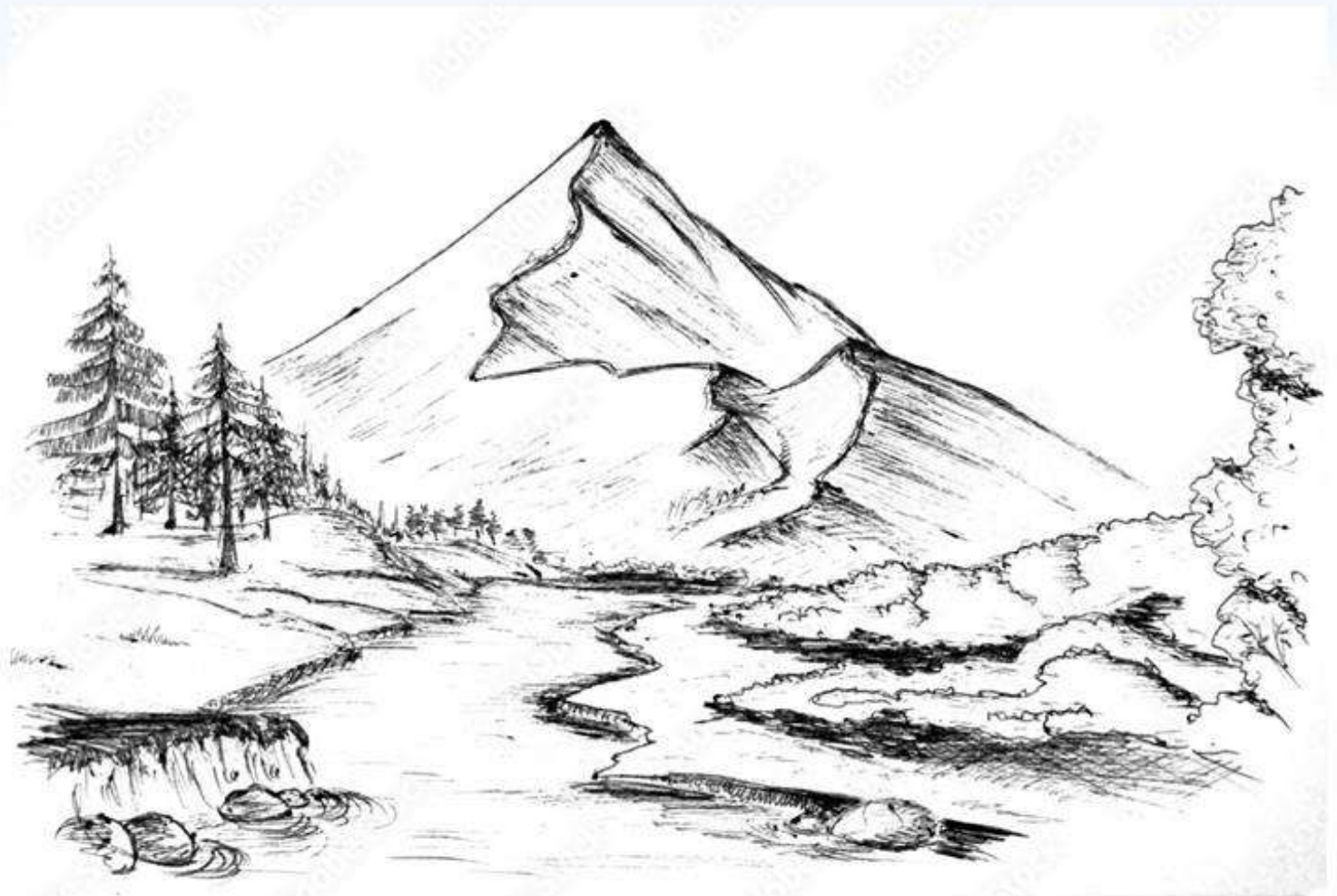
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Assessing the management of the rural domestic solid waste in the Red River delta

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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 $0.3 \div 0.5$ 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 $55 \div 74\%$ 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.

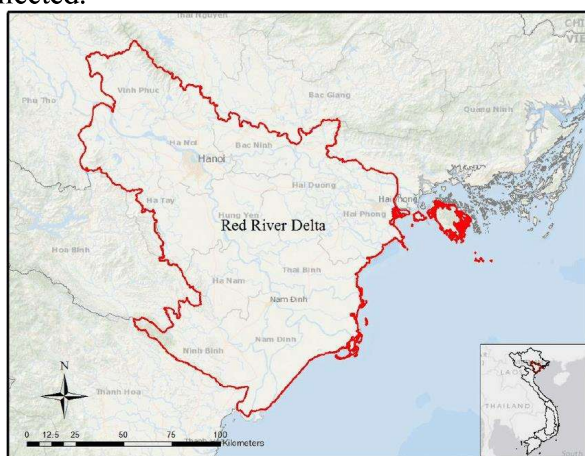


Figure 1. Location of the Red River Delta

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 increased 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.

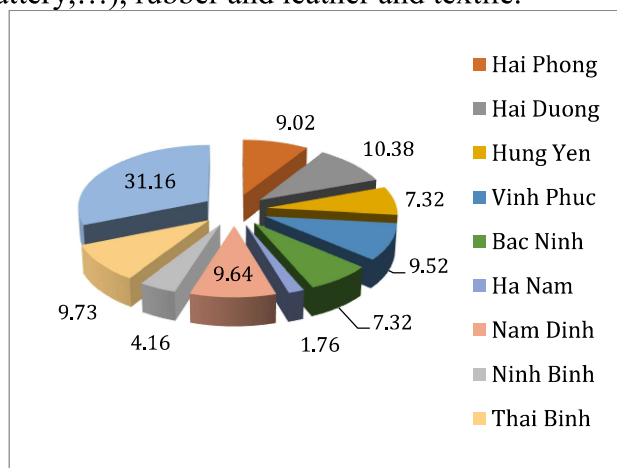


Figure 2. Rate of generation solid waste in provinces, %

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 was 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).

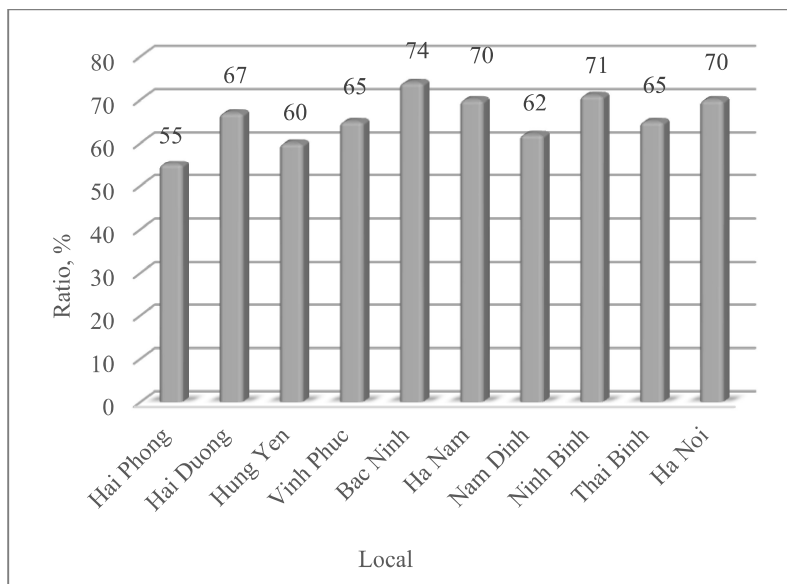


Figure 3. The rate of biodegradable organic components in rural domestic

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. Nowadays, 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.

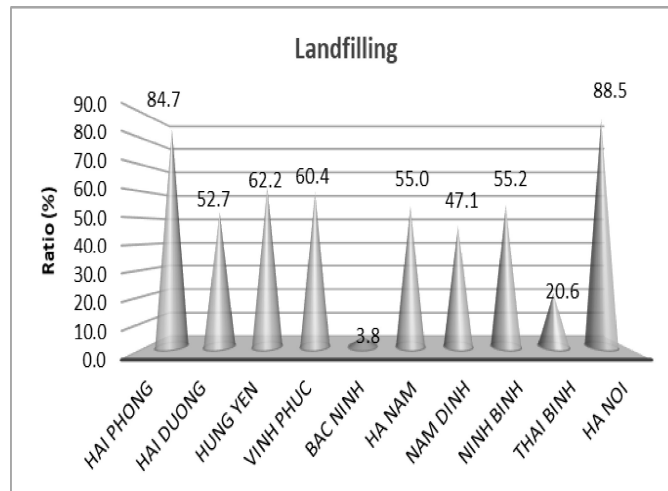


Figure 4. The rate of solid waste was treated by different methods in the Red River Delta

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

| Provinces/Cities | The volume of rural solid waste is treated by technologies, tons/year | | | |
|------------------|---|--------------------------|-----------------|-------------------|
| | 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).

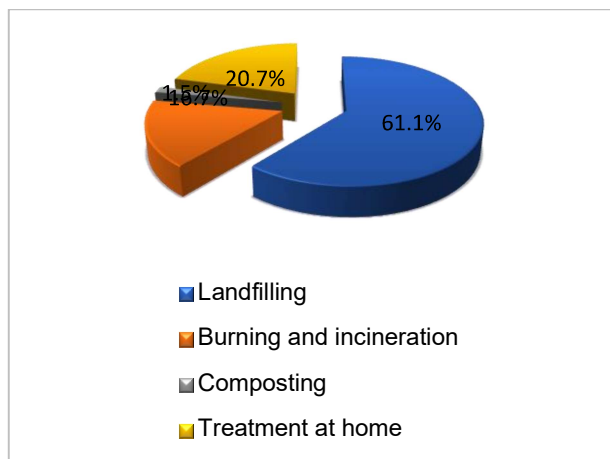


Figure 5. The rate of solid waste treatment by landfilling technologies in the provinces/city of the Red River Delta

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).

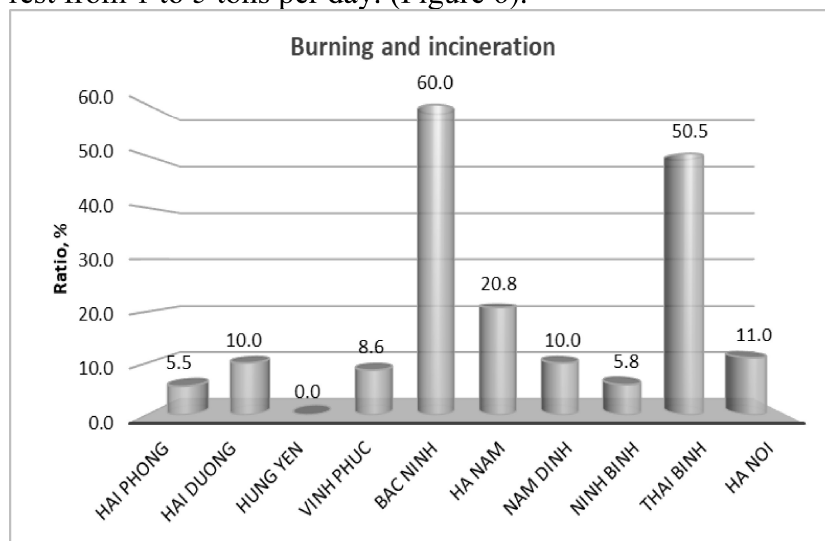


Figure 6. The rate of solid waste treatment by burning and incineration technologies in the provinces/city of the Red River Delta

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 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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