

Proposing solutions to improve the effectiveness of domestic solid waste management in Ba Be district, Bac Kan province, Vietnam

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Abstract
The research has applied some traditional methods to assess the domestic solid waste (DSW) management status and suggest appropriate solutions to improve the effectiveness of domestic solid waste management in Ba Be district, Bac Kan province, Vietnam. The results showed that the total amount of DSW is 10 tons/day The composition of DSW includes organic matter (67.52%), inorganic matter (22.13%) and hazardous waste (0.32%). Ba Be district currently has only 4/16 communes and towns with incinerators, 01 centralized waste treatment area in Banh Trach commune with a waste treatment capacity of 500 kg/h, only receiving DSW from Cho Ra town and some villages in neighboring communes. Rural DSW is mainly collected and treated simply by manual burning, or buried in the garden of the household. The rate of collected and treated rural DSW is only 50%. Although the local government has made great efforts in the DSW management, however the DSW management still has many shortcomings such as lack of human resources and equipment for DSW collection and labor protection; many localities do not have DSW collection points and have not yet implemented environmental protection fees for DSW; rural DSW has not been effectively treated. Source-based DSW classification has not been implemented in communes and there is still no mandatory mechanism. In order to manage DSW well in the study area, it is necessary to synchronously apply a number of solutions such as: policy solutions, economic solutions, treatment technology solutions and propaganda and education solutions.

Keywords: Solid waste, environmental management, waste, pollution, Bac Kan

1. Introduction

In recent years, solid waste has become an urgent problem for the whole society. Urbanization and economic development often lead to increased resource consumption and solid waste generation rate per capita. Urban residents in developed countries generate six times more waste than in developing countries. It is estimated that in developed countries the amount of solid waste can reach 2.8 kg/person/day and in developing countries it is about 0.5 kg/person/day [1]. The average rate of domestic solid waste generation worldwide is about 0.74kg/person/day; in which, the rate in the lowest country is 0.11kg/person/day and the rate in the highest country is 4.54kg/person/day. In 2016, the total volume of municipal solid waste generated globally was about 2 billion tons. In which, the largest amount of urban solid waste is in the East Asia - Pacific region with 468 million tons; The lowest was in the Middle East and North Africa with 129 million tons [2]. In Vietnam, the amount of generated DSW is about 25.5 million tons in 2018, of which urban DSW is about 38,000 tons/day and rural domestic waste is about 32,000 tons/day [2]. DSW in urban areas currently accounts for more than 50% of the total DSW of the country and accounts for about 60-70% of the total amount of urban solid waste [2]. It is forecast that the amount of DSW in Vietnam will increase to 54 million tons by 2030 [3]. The average waste generation standard per capita for each type of waste is specific to each locality and depends on the standard of living, civilization and population in each area. However, regardless of the region, there is a general trend in the world that the higher the standard of living, the more waste is generated.

According to a report by the World Bank, in big cities, the rate of solid waste generation in New York is 1.8 kg/person/day while in Singapore and Hong Kong it is 0.8 - 1.0 kg/person/day. In Vietnam in 2015, the total amount of DSW generated in cities was 38,000 tons/day. Estimation of DSW amount generated by 2030 will be 2.59 billion tons, and by 2050 it will be 3.4 billion tons [1].

In the world, there have been so many studies on solid waste management such as: "Analysis of solid waste collection and disposal in oversea, Nasarawa town, Nasarawa state" [4]; "Analyzing key drivers for a sustainable waste management system in Ethiopia: an interpretive structural modeling approach" [5]; Optimal management of solid waste in smart cities using internet of things" [6]; "Urban solid waste management in Chongqing: challenges and opportunities" [7]; "Waste management in Switzerland – Achievements and prospects" [8]; "Solid Waste Management Practices at a Private Institution of Higher Learning in Nigeria" [9]; "Assessment of Domestic Solid Waste Disposal and Management System in Tangail Municipal Area" [10]; "Analysis of Economical and Environmental Costs for the Selection of Municipal Solid Waste Treatment and Disposal Scenarios through Multicriteria Analysis (ELECTRE Method" [11]; "Compliance with household solid waste management in rural villages in developing countries" [12]; " Improving urban household solid waste management in developing countries based on the German experience" [13]; " Household solid waste management practices and perceptions among residents in the East Coast of Malaysia" [14]; " Knowledge, attitudes and practices on household solid waste management and associated factors in Gelemso town, Ethiopia" [15]; " Household solid waste characterization in Tandil (Argentina): Socioeconomic, institutional, temporal and cultural aspects influencing waste quantity and composition" [16]; " Status of household solid waste in Bengaluru and its periphery: synergies and disjunctions between waste management practices and circular economy" [17]... However, there has been no research on the current status and solutions for domestic solid waste management in Bac Kan province, Vietnam.

Ba Be is a mountainous district of Bac Kan province in the Northeast of Vietnam, with a total natural area of 68,408.5 hectares (accounting for 14.08% of the total natural area of the province), mainly forestry land accounting for over 80%, agricultural land accounting for 10%. Ba Be district has 15 administrative units, including Cho Ra town and 14 communes with 183 villages and hamlets with a population of 49,934 people. The main ethnic groups of Ba Be district are: Tay, Kinh, Dao, Mong, Nung, Hoa and some other ethnic groups. Ba Be district has a complex terrain, mainly high mountains mixed with rugged limestone mountains, divided by rivers, streams, and mountains, so transportation is still difficult, especially in the highland villages. In recent years, Ba Be district has had many changes in all aspects, especially socio-economic development, so there have been many significant changes: good economic growth rate; people's living standards are improved; infrastructure and facilities are increasingly spacious and modern. Along with those positive aspects, environmental issues such as: The amount of domestic waste increases; waste has not been properly collected and segregated; many communes/wards do not yet have a domestic solid waste treatment plant. These problems have the potential to affect the quality of the natural environment and reduce the beauty of the area. Before that situation, topic "Proposing solutions to improve the effectiveness of domestic solid waste management in Ba Be district, Bac Kan province, Vietnam." was implemented with the purposes: Assessing the situation of generation, collection, classification, transportation and treatment of domestic solid wastes and proposing appropriate solutions to improve the efficiency of domestic solid waste management in the area. Furthermore, this will contribute to the improvement of environmental quality and landscape beauty in the study area.

2. Research Subjects and Methods

2.1. Research subjects

Focused research on household solid waste management in Ba Be district, Bac Kan province, Vietnam.

2.2. Research methods

Methods of data collection

In this study, the authors collected information from books, newspapers, magazines, The internet. From there, the authors synthesized and analyzed documents and data related to the research content.

Methods of actual investigation and survey in the study area: The field survey method in the study area is used for the purpose of correcting information, verifying existing documents, adding missing or incorrect information, especially focusing on waste collection and treatment activities. The survey method is applied mainly by interviewing with a set of open-ended questions with prepared topics. The study has conducted field surveys in the study area to collect specific information and objectively evaluate the research problem such as domestic solid waste collection route, domestic solid waste classification at source, domestic solid waste treatment area... The actual survey areas are residential areas, solid waste collection points, collection routes, domestic solid waste treatment areas.

Methods of statistics and data processing

All collected documents must be processed, evaluated to check and detect possible errors, thereby taking measures to correct and supplement relevant documents in a timely manner. The data is processed by Microsoft Excel software.

Expert interview method:

Interview with staff from the Department of Natural Resources and Environment of Bac Kan province to verify the results of the interview survey.

3. Results and Discussion

3.1. Domestic solid waste management status in Ba Be district, Bac Kan province, Vietnam

Ba Be is a mountainous district of Bac Kan province in the Northeast of Vietnam, with a total natural area of 68,408.5 hectares, mainly forestry land accounting for over 80%, agricultural land accounting for 10%. Ba Be district has 15 administrative units, including Cho Ra town and 14 communes (Banh Trach, Cao Thuong, Chu Huong, Dia Linh, Dong Phuc, Ha Hieu, Hoang Tri, Khang Ninh, My Phuong, Nam Mau, Phuc Loc, Quang Khe, Thuong Giao, Yen Duong) with 183 villages. According to the announcement of the General Statistics Office, the official average population in 2022 of Ba Be district is 49,934 people. The main ethnic groups of Ba Be district are: Tay, Kinh, Dao, Mong, Nung, Hoa and some other ethnic groups. Ba Be district has a complex terrain, mainly high mountains mixed with rugged

limestone mountains, divided by rivers, streams, and mountains, so transportation is still difficult, especially in highland villages. The main sources of impact on the environment currently in the district are mainly: Domestic wastewater, livestock wastewater; domestic waste, construction waste; waste from agricultural production (bottles, bags containing plant protection drugs); smoke, dust from construction activities, projects; emissions from means of transport; medical waste.

Origin of household solid waste

Household solid waste originates from many different sources, they differ in quantity, size, composition, spatial distribution... Household solid waste originates in personal activities as well as in social activities from residential areas, restaurants, hotels, companies, offices and industrial factories and from agricultural production activities... Specific survey data is shown in Table 1.

Table 1: Sources of household solid waste in Ba Be district, Bac Kan province, Vietnam

Source	Types of solid wastes
Residential (Cho Ra town, Banh Trach commune, Khang Ninh commune, Cao Thuong commune...)	Food wastes, paper, cardboard, plastics
Service	Plastic bags, plastic bottles, food waste…
School	Plastic bags, carton covers, plastic, paper…
Administrative Agency	Plastic, paper, plastic bags, leftovers...
Agricultural production area	Food wastes, feces of cattle, agricultural by -products ...
Public area	Plastic bottles, plastic bags, food wastes, leaves ...
Industrial production area	Glass, metal, plastic, carton cover…

Composition of household solid waste

The composition of domestic solid waste includes: inorganic substances (glass, ceramic, metal, paper, rubber, plastic, nylon bags, fabrics, electrical appliances, toys...), organic substances (discarded plants, fallen leaves, spoiled vegetables, leftovers, animal carcasses, animal manure...) and other substances.

Determining the composition of domestic solid waste is very important in choosing processing equipment, processing technology, reuse as well as planning management programs for the domestic solid waste management technical system. The volume of domestic solid waste components is not the same due to different usage needs. The needs in the lives of households are different, so the composition of domestic solid waste from different sources is also different. The results of classifying domestic solid waste samples collected during the process of weighing domestic solid waste in the study area show that organic domestic solid waste accounts for the highest proportion (accounting for 67.52%), followed by inorganic waste at 22.13%, the smallest component is hazardous waste at 0.32% and the difference between the survey points is insignificant.

Household solid waste collection and treatment:

The total amount of domestic solid waste generated in Ba Be district is 10 tons/day. Of which, the amount of urban domestic solid waste is 2 tons/day, this amount of waste is collected and treated at about 98-99%. The amount of domestic waste generated in rural areas is 8 tons/day; This amount of waste is collected and simply treated by households by burning it manually, or burying it in gardens or vacant lots in households. However, the amount of domestic solid waste treated is very small, about 50%, the remaining domestic solid waste is discharged directly into the environment by households.

Currently, in Ba Be district, only 4/16 communes and towns have waste incinerators. The whole district has only 01 waste treatment area located in Banh Trach commune, Ba Be district, operated by Bac Kan Market Joint Stock Company, using the method of burning combined with burying, with a capacity of 500 kg/h. This waste treatment area has just received domestic solid waste from Cho Ra town and some villages in neighboring communes. Recently, Ba Be district has also implemented a model for treating domestic waste at the wholesale markets of Ha Hieu, Chu Huong, Khang Ninh and Cao Thuong communes with an investment of about 500 million VND for each model. However, the implementation has encountered difficulties in terms of land for construction and operating costs. Because there are no measures to ensure environmental sanitation, the environmental criteria in the national criteria for new rural construction are currently the biggest obstacle for localities in the district.

Resources for environmental protection:

The human resources for environmental protection in the district are 15 people, including 01 civil servant from the Department of Natural Resources and Environment and 14 part-time civil servants from the People's Committees of communes and towns. The professional qualifications of the staff doing environmental protection work in Ba Be district are only 01 person trained in the right major, the remaining 14 commune-level civil servants are civil servants in charge of the environmental field, mainly trained in land management and cadastral work, assigned to carry out part-time work in the environmental field.

Regarding financial resources, in 2022, the People's Committee of Ba Be district spent 2 billion VND to collect and treat household waste in the district. However, the budget source has not yet met the urgent requirements for environmental protection in the current period.

General assessment

Up to now, authorities at all levels have applied many measures to protect the environment such as: Issuing guiding documents, regulations, conventions, and village covenants on environmental protection; Organizing the implementation of legal regulations, inspections, examinations, and administrative procedures on environmental protection; Propagating, educating, and raising awareness of environmental protection in the district has always been of interest and achieved many important achievements, contributing to raising awareness of people and the community on environmental protection. In particular, Ba Be district has made great efforts in propagating to households and individuals in communes about environmental protection and guiding households to self-treat household waste. At the

same time, directing the district's radio and television stations to broadcast news, articles, and legal documents on environmental protection to propagate and mobilize people to practice a cultural lifestyle, be friendly to the environment, and voluntarily comply with regulations on environmental protection.

However, resources and conditions for environmental protection are still limited. The number of specialized environmental officers at the district and commune levels is still weak and lacking. Therefore, environmental management and supervision at the local level is not uniform and strict.

Awareness and compliance with environmental protection laws in the community, production, business and service establishments are not high. Consulting work of specialized environmental officers is still weak, domestic waste in some communes has not been collected and treated according to regulations.

There are still some shortcomings in the DSW management such as: lack of collection equipment and labor protection equipment; many areas do not have DSW collection points and have not implemented environmental protection fees for DSW; rural waste has not been effectively treated. DSW classification at source has not been widely implemented and there is still no mandatory mechanism.

3.2. Proposing solutions to improve the effectiveness of domestic solid waste management in Ba Be district, Bac Kan province, Vietnam

Although authorities at all levels have made great efforts in the management of domestic solid waste in the study area, the rate of collected and treated domestic solid waste is still very low, and domestic solid waste in many places has not been classified at source. There are many reasons leading to limitations in the management of domestic solid waste in the study area: investment in building infrastructure for the collection and treatment of domestic solid waste is still limited, not meeting actual needs; awareness of a part of the people in the collection and treatment of domestic solid waste is still low, and littering still occurs in some places. In some communes, the responsibility of local authorities, especially the leaders, is not really concerned with the collection and treatment of domestic solid waste, and there is still littering, causing environmental pollution and spoiling the beauty of the area; The central government does not have mechanisms and policies suitable for each region on the management of domestic solid waste...

Therefore, to improve the management of domestic solid waste in Ba Be district, Bac Kan province, it is necessary to apply the following solutions synchronously:

- For the organizational structure of solid waste management: it is necessary to adjust the powers, functions, duties and responsibilities of each agency and unit in line with the National Strategy on Integrated Solid Waste Management to 2025, with a vision for the year 2050 to ensure consistency, appropriateness, avoid overlapping management, not knowing which party's responsibilities can easily lead to duplication or omission.
- Pursuant to national and provincial regulations on solid waste management. Ba Be district needs to be specific into district documents, suitable to local actual conditions but not against national documents.
- There should be specific encouragement, support and socialization documents to attract organizations and units to participate in DSW collection, transportation and treatment.
- It is necessary to have a policy on training and retraining on environmental protection work to thoroughly understand the processes, regulations and necessary contents related to environmental management in general and DSW management in particular. The training content focuses on the ability to develop a DSW management plan, communication skills to raise public awareness, environmental economics, and the ability to examine and evaluate DSW management. In addition, local authorities need to strengthen human resources with professional expertise in the field of environment.
- To ensure funding for DSW management, People's Committees at all levels, departments and agencies need to coordinate with Urban Environment Joint Stock Company to adjust the collection fee to suit the economic conditions of each locality.
- It is necessary to have a pilot model of "classifying DSW at source in the study area" in a specific commune, then summarize and evaluate the effectiveness, learn from experience and replicate the effective model.
- About equipment and means of transport DSW: DSW equipment and means of transport need to be upgraded to meet the classification of DSW at the source. Make a procurement plan, select equipment and facilities suitable to the budget as well as DSW handling requirements.
- Expanding types of DSW treatment such as using biodegradable organic waste to produce fertilizers by biological methods, saving costs for environmental protection, improving the economic efficiency of DSW, incinerating waste to energy harvesting, reuse of plastic or inorganic materials.

Some other solutions

- Raise the responsibility of the leader in domestic waste management; Strengthening the organizational system for environmental protection from central to local levels according to the Law on Environmental Protection 2020 [18].
- Enhance the inspection and supervision role of the residential community on the collection and treatment of domestic waste in the localities;
- Commune-level People's Committees should promote the inclusion of domestic waste management in incense, a convention to mobilize community participation in waste management;
- It is necessary to maximize the role of mass and social organizations such as Farmers' Union, Women's Union, Veteran's Association, Elderly Association... to participate in DSW management in the area.
- There are preferential policies, calling for and creating favorable conditions for individuals, organizations and businesses to invest in the field of waste treatment, especially domestic waste.
- Mobilize all investment resources for solid waste management and treatment: State budget sources, environmental protection funds. In addition, it is possible to mobilize investment capital from domestic and foreign organizations and individuals.
- Propagating to raise public awareness about DSW co-management, contributing to environmental protection.
- Strengthening socialization in DSW management.

Improve the capacity of the unit that directly collects, transports and treats DSW.

4. Conclusion

The process of socio-economic development in Ba Be district, Bac Kan province has made the amount of DSW in the province tend to increase over the years, creating a lot of pressure on environmental management in the area. Research results show that DSW in the study area arises mainly from residential areas, schools and markets; The total amount of domestic solid waste generated in Ba Be district is 10 tons/day. The amount of urban domestic solid waste is 2 tons/day, the rate of collected and treated urban domestic solid waste is about 98-99%. The amount of rural domestic waste is 8 tons/day, the rate of treated rural domestic solid waste is very low, only 50%. The remaining amount of domestic solid waste is discharged directly into the environment by households. Regarding the composition of domestic solid waste in Ba Be district, organic waste accounts for the highest proportion (accounting for 67.52%), inorganic waste accounts for 22.13%, hazardous waste accounts for 0.32% and the difference between the survey points is insignificant. Regarding waste treatment, Ba Be district currently has only 4/16 communes and towns with incinerators, 01 centralized waste treatment area in Banh Trach commune, Ba Be district managed by Bac Kan Market Joint Stock Company, using the combined burning and landfill method, with a capacity of 500 kg/h. This waste treatment area only receives domestic solid waste from Cho Ra town and some villages in neighboring communes. Rural domestic solid waste is mainly collected and treated by households simply by manual burning, or buried in gardens and vacant lots of households.

Although the local government has made great efforts in the management of DSW, however the DSW management still has many shortcomings: lack of collection equipment and labor protection equipment; many areas do not have DSW collection points and have not implemented environmental protection fees for DSW; rural waste has not been effectively treated. DSW classification at source has not been widely implemented and there is still no mandatory mechanism. Human resources operating in the field of environmental protection are still lacking, professional qualifications cannot meet actual needs; Lack of funds to invest in the construction of concentrated DSW treatment facilities and operating expenses when they are put into use; Vehicles used in the collection and transportation of DSW are mainly handcarts, vertical trucks or trucks; Many villages and hamlets are far from the town center, the terrain is complicated, the population is sparse, the human resources are lack so the collection and treatment at Centralized DSW treatment area has not been implemented, so households often collect and treat their DSW by themselves.

To improve the efficiency of DSW management in the study area, it is necessary to apply a number of solutions synchronously, such as: Raise awareness of the community on how to identify types of waste and the importance of sorting DSW at source; perform DSW classification at source; collecting all DSW generated from households; effective use of existing incinerators and waste treatment facilities; additional human resources and increased capital mobilization for DSW management; expanding types of DSW treatment such as using biodegradable organic waste to produce fertilizers by biological methods, saving costs for environmental protection, improving the economic efficiency of DSW, incinerating waste to energy harvesting, reuse of plastic or inorganic materials; enhance the inspection and supervision role of the residential community on the collection and treatment of domestic waste in the localities; It is necessary to maximize the role of mass and social organizations such as Farmers' Union, Women's Union, Veteran's Association, Elderly Association... to participate in DSW management; strengthening socialization in DSW management. Improve the capacity of the unit that directly collects, transports and treats DSW...

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