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Towards Sustainable Ambon Bay: Evaluation of Solid Waste Management in Ambon City

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Abstract. Ambon Bay is a strategic area in the context of regional economic development, however it also faced environmental problems due to economic development and the growth of population. One of the environmental problems in the Ambon Bay is the growing solid waste which in turn lowers the quality of the water. The purpose of this study is to evaluate solid waste management in the Ambon City and propose recommendation in order to reduce solid waste in the Ambon Bay. The analytical method used is descriptive analysis by comparing a number of criteria based on the concept of solid waste management in coastal region with the current conditions of solid waste management in Ambon City. Criteria for waste management are divided into generation, storage, collection, transport, transfer and disposal. From the results of analysis, it can be concluded that the components of solid waste management at transport, transfer, and disposal level are generally still adequate, but solid waste management at source, storage and collection level have to be improved.

1. Introduction

Ambon Bay is a strategic area in the context of regional economic development. Ambon Bay administratively consists of Ambon City and Central Maluku Region. Based on Spatial Plan of Maluku Province 2007-2027 Ambon Bay is Strategic Area of Maluku Province due to its environmental carrying capacity. In addition, based on the Spatial Plan of Ambon City 2011 - 2031, Ambon Bay is stated as strategic area regarding its environmental condition. Ambon Bay is a coral reef ecosystem, conservation area and water infiltration area. Ambon Bay is also a riparian area that serves to resist erosion and stability of the riverbank. Beside its environmental function, Ambon bay also a strategic area related to its economic function, with the main function in fisheries and marine tourism.



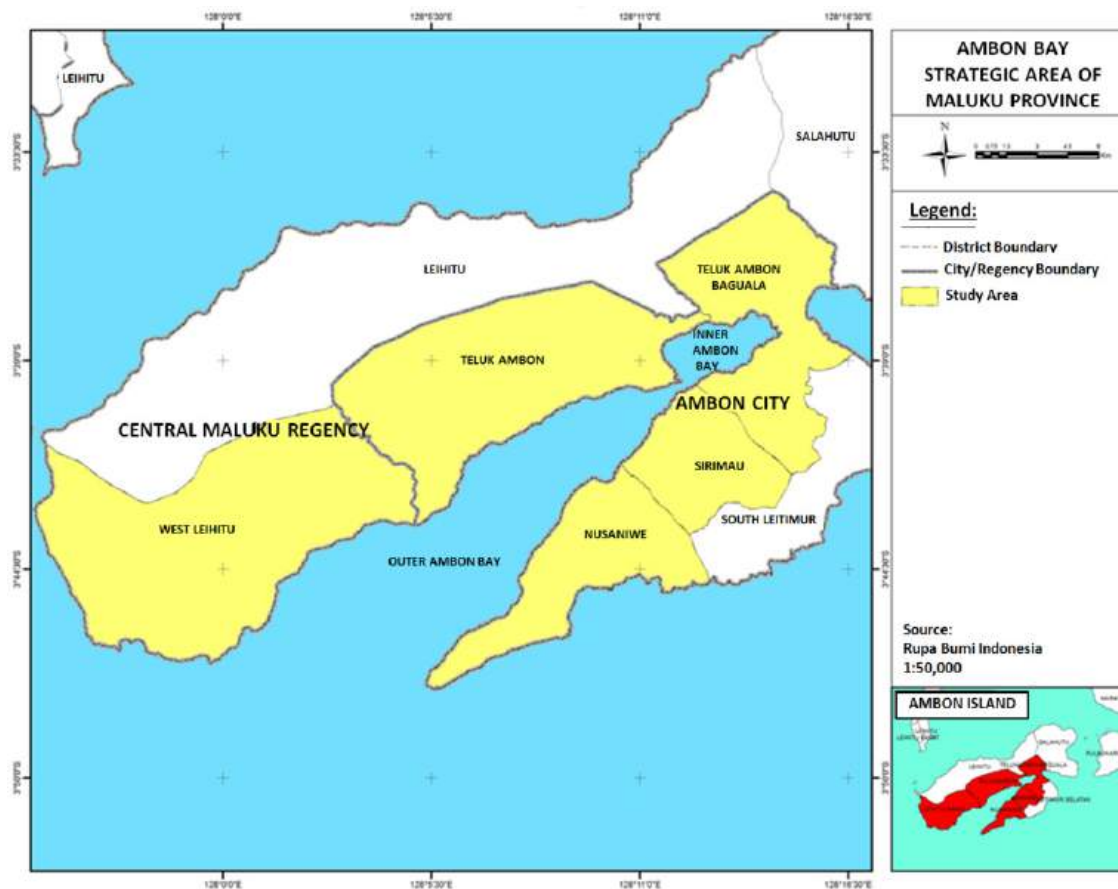


Figure 1. Study Area

As mentioned above, Ambon Bay is strategic area in term of environmental aspect. Ambon bay has the conserved natural resources, such as coral reefs. Nevertheless the existence of the natural resources is threatened because of high level of pollution. One of the reasons for high level of pollution is solid waste. Solid waste is often found in the Ambon Bay. It is estimated that solid waste comes from households or facilities which is not handled properly. The waste enters the streams, which ultimately ends up in the Ambon Bay. The purpose of this study is to evaluate solid waste management in the Ambon City and propose recommendation in order to reduce solid waste in the Ambon Bay. Increasing number of waste generation will give negative impact to environment, especially pollution in air, water, and land, due to the improper waste maangement [1].

The study will be focused in Ambon City, which is one of the administrative region in Ambon Bay. The selection of this city is based on the condition that the number of population in the city is much higher compared to another administrative region, that is Central Maluku Region. Ambon City has developed intensively compared to Central Maluku Region and give more impact to the Ambon Bay compared to Central Maluku Region. The higher the number of population, without good solid waste management, the higher the level of the problem.

The city of Ambon consist of 5 Districts namely Nusanawe, Sirimau, Teluk Ambon, Teluk Ambon Baguala, and Leitimur Selatan. Ambon City is a coastal region. There are five districts in Ambon City and all of the districts have connection to the bay and sea. Total length of coastline is 102.7 km. There are four districts with direct connection to the Ambon Bay. In this study, the analysis was done in districts which have direct connection to the Ambon Bay. The districts are Nusanawe, Sirimau, Teluk Ambon, Teluk Ambon Baguala. Nusanawe is the most densely populated area in Ambon City. The number of population, area, and density of each district in study area are presented in Table 1.

Table 1. The number of population, area, and density of each district in study area

District	Area (km ²)	Population	Density (person/km ²)
Nusaniwe	88.35	111,671	1,264
Sirimau	86.81	174,045	2,005
Teluk Ambon	93.68	47,777	510
Teluk Ambon Baguala	40.11	66,442	1,656

2. Methods

The analytical method used in this study is descriptive and comparative analysis approach. Descriptive analysis is used to describe normative criteria and existing condition in Ambon Bay, whereas comparative analysis is used to compare the normative criteria or standard with existing condition. The study begins by identifying the normative criteria in the provision of waste infrastructure, based on the concepts and rules that exist in Indonesia. The criteria are shown in Table 2. Furthermore, these criteria compared with existing conditions in the city of Ambon. Descriptive analysis is used to identify the phases of waste management in the city of Ambon, which are generation, storage, collection, transport, transfer and disposal. After the problem of each phases have been identified, the type, quantity, and quality of infrastructure within each phase are being explored and compared with the planning standard in Indonesia.

Table 2. Criteria of solid waste management

Criteria	Indicator
Waste Generation	Availability of solid waste bin Availability of reduce, reuse, recycle in source level
Waste Collection	Availability of waste collection system and equipment (1m ³ of volume for 640 people or 128 households)
Waste Transfer and Transport	Availability of temporary waste disposal station with service coverage 500 m) Availability of waste transport mechanism done by government or private sector Availability of waste transport equipment (eg. dump truck, arm roll truck, compactor truck, trailer truck)
Waste Disposal	Availability of sanitary landfill or at least controlled landfill

3. Result and Discussion

3.1. Waste Generation

In line with the increasing number of urban population, amount of generated waste is also increasing. The increasing number of population causes an increase in the activity of the population, which directly affects the increase in the amount of waste. Presented below is the amount of the generated waste in the city of Ambon from year 2010-2014.

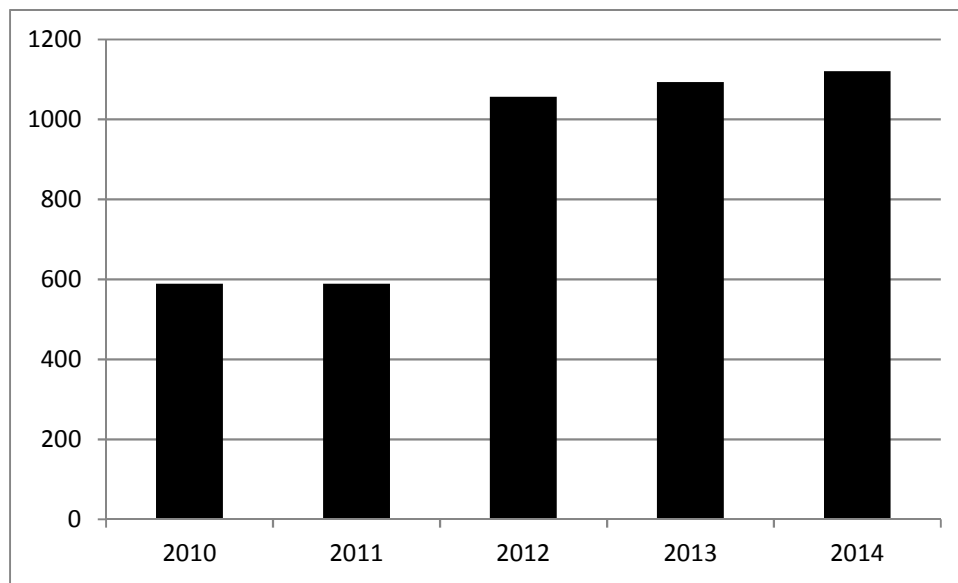


Figure 2. Waste generated per day (m3)
Source: Central Bureau of Statistics, Ambon City 2015

Based on the chart above, it can be seen that the production of waste per day increases from 2010 to 2014. In addition, an average waste of 2.8% from the amount of total waste produced, are not collected at the transfer station. Meanwhile, from all the waste collected at transfer station, an average of 19.7% are not transported to the landfill.

Besides the government, the society also participates in waste management. Based on existing condition, society has participated in the provision of waste management facilities, such as providing trash bin at the source of waste and providing means of collection from the source of waste to the transfer station. In addition, there are groups of people who have provided a means of waste composting and recycling at home. Several schools have done composting and recycling of waste in the school environment. In addition, society also has a role in waste management, starting from collecting waste from the source to the depot transfer, and managing waste at the depot transfer.

Waste generation is not only produced from household activities, but also generated from the tourism sector. Therefore, it can be projected that waste generation will be increased if there is no action to reduce waste. Based on Government Regulation No. 81/2012 about the Management of Household Waste, waste reduction activities consist of restrictions of waste generation, waste recycling, and waste reuse. The three activities are the principles of environmentally sustainable waste management called 3R (reduce, reuse, recycle). In addition, for waste management on the waste production sources such as homes, restaurants, shops, schools, offices and others, waste containers needs to be provided, at least two pieces for each location, one for organic and one for inorganic waste.

If we compare to the criteria that have already defined above, in waste generation aspect in some place there have been reduce, reuse, and recycle system. Government and community also have participated in provision of waste generation facilities. The problems are the facilities and also reduce, reuse, and recycle system have not been equally distributed.

3.2. Waste Collection

Waste collection is the activity of transporting the waste from waste sources to the transfer station or 3R transfer station. Waste collection is defined as waste management from its origin location to the transfer station before heading to the next stage. Based on SNI 3242-2008, waste collection can be classified as individual direct, individual indirect, communal direct, and indirect communal. The terms direct and indirect refer to the process whether the waste is transported directly to the final disposal or

collected in a transfer station before the waste is transported to final disposal. The collection process can be done by the use of garbage motorcycles, garbage carts, garbage bicycle, and others.

Based on an interview with the District Head of Teluk Ambon, Teluk Ambon Baguala, and Nusaniwe, garbage in the residential area is transported by the people to the transfer station. In Teluk Ambon and Teluk Ambon Baguala, each housing area has its own initiative in the collection of waste to the transfer station. People in the same neighborhood collectively use garbage carts, and then these carts haul the waste from each house to the transfer station. However, only in the sub-district of Nusaniwe, Benteng, Wainitu, Mangga Dua, Udameti, and Nusaniwe, where the waste collection is served by waste carts. Meanwhile, for the people who are living at the sub-districts where are not served with the garbage carts, they must bring their own waste to the depot transfer. The size of the depot transfer generally is 2 x 2 x 2 meters, with a capacity of 8 m³. In District of Nusaniwe, people are only allowed to collect their garbage in transfer station between 10.00 pm to 05.00 am.

If we compared with the indicator have been specified above, the waste collection system and equipment in Ambon City is already available. The same as the problem in waste generation, the distribution of the system and equipment is still in question.

3.3. Waste Transfer and Transport

The operational of waste transfer and transport in the Ambon City done by The *Dinas Kebersihan Kota Ambon* (Ambon City Sanitation Department). Waste transportation facilities that are currently available are shown in the table below. Waste that is transported into the landfill is the waste that is produced at household area, offices, schools, and public facilities (shops, markets, and terminals). In addition, medical waste, which is produced from health facilities, is usually handled by the medical personnel.

All the waste vehicles operate daily, from 05.00 am until afternoon when most of the waste has been transported. Wastes, which are transported by waste motorcycles, are the waste that are collected at the garbage bins along the roads and waste from the roads itself. Then, the wastes that are transported by motorcycle are collected in the trash containers that are located in the city of Ambon. Waste in the City of Ambon, are transported from the transfer station to landfill by the Sanitation Department's garbage truck. There is no transfer station that is located at Laha Sub-District in Teluk Ambon District. While in the District of Nusaniwe and Teluk Ambon Baguala, all sub-districts are served by the transfer station. However, in the District of Teluk Ambon Baguala, people requested to add more numbers of transfer station to increase the service coverage. The sub-districts that ask for additional transfer station are Negeri Lama Sub-district and Halong Sub-district. Moreover, several districts request to provide carts in order to haul garbage from residential area to the transfer station, such as Passo Sub-district.

Table 3. Number of transportation waste facility in Ambon City 2016

No	Type of Facility	Total	Capacity (m ³)	Note
1	Dump Truck	17	10	3 broken
2	Arm Roll Car	8	5	2 broken
3	Container	10	8	-
4	Pick Up Car	8	5	3 broken
5	Speed Boat	3	-	-
6	Garbage Carts	40	2	-
7	Tossa Motorcycle	9	2	-

Table 3 shows that capacity of transportation facilities in Ambon City (Dump Truck, Arm Roll Car, Pick Up Car, Garbage Car, and Tossa Motorcycle) is 293 m³, whereas the number of solid waste generation by using 2014 data is 1120.2 m³. It means that in average each transportation waste facility have to work 4 times a day for transporting waste.

Other than land waste, marine debris is also generated by the people's activities at the Ambon Bay. Therefore, Sanitation Department has a regular schedule to collect marine debris that is done by speedboat. In addition to marine waste transportation schedule, the department also has regular schedule to pick up waste, which are located at the transfer station, apparent transfer station, road waste, and *Kliko* garbage bins.

Currently in Ambon City there are 146 transfer stations, spreading at the four districts, which the 59 units are located in Sirimau District, 37 units in the Nusaniwe District, 24 units in the Teluk Ambon Baguala District, 26 units in the Teluk Ambon District and none in Leitimur Selatan District. In addition, to accommodate the increasing volume of waste, there are 18 units of garbage container at the 18 points of garbage disposal. In addition, there are 76 apparent transfer stations, which is a point of storage or accumulation of garbage that is not formed as a transfer station. This apparent transfer stations generally found in densely populated urban areas in the central city of Ambon, such as in the Sub-district of Ahusen, Honipopu, Uritetu, Rijali, Wainitu, Waihaong, Kuda Mati, and Batu Merah. Moreover, there are also garbage bins "Kliko", which separates among organic, non-organic, and dangerous waste.

When compared to SNI 3242-2008, waste transport by carts or motorcycles with a pickup or sectional pickups, needed to be done at least two days and transport to the transfer station or integrated transfer station. Additionally, streets and parks litter sweeping in the neighborhoods area, needed to be done by the environmental waste management according to the schedule that has been set. Transportation of waste from transfer station or integrated transfer station to the landfill, needed to be done when the container has been filled and in accordance with the schedule that has been confirmed with the transport of municipal waste management.

3.4. Waste Disposal

Final waste processing is done at the landfill. In the City of Ambon, there is a waste processing field (namely *Tempat Pengolahan Akhir Sampah* in Indonesian term), which is located in the hamlet of Toisapu Villate, Hutumuri Sub-district, Leitimur Selatan District. The figure below shows the landfill site in the city of Ambon.

The waste processing system at Toisapu Landfill is controlled landfill. Currently the area covers with about 9 hectares, and the 5 hectares are full-filled with waste. With this type of processing system, the waste compacting is done once a week. The landfill area comprises of 3 landfill blocks, the garbage block 1 and 2 are currently full, and the garbage block 3 is now reaching a height 2 meters, with a maximum capacity height of 5 to 7 meters. The landfill has an estimated maximum of the existing capacity of 47.450 tons. In addition to the garbage blocks, the landfill area also has a leachate pool for water treatment that is generated from the waste. In addition, the landfill has a development plan to add an area of 2 hectares to as the garbage block 4. Moreover, there is also an Integrated Waste Treatment Installation (namely *Instalasi Pengeolahan Sampah Terpadu* in Indonesian term) located at the landfill area. Thus, some types of waste are able to be recycled. The landfill serves City of Ambon, but District of Leitimur Selatan is not served due to the mountainous area that is difficult to reach.

Figure 5 explained the flow of waste management in the City of Ambon. Starting from household waste that is transported individually or collectively to the depot transfer near to their household area. Furthermore, wastes that are collected at the transfer depot are then transported to the landfill area by the garbage truck. In the landfill, the wastes are sorted into two, which are organic and non-organic waste, by the scavengers. Organic waste is further processed in the waste treatment installation to become compost with an average production of 20 m³ per month. Meanwhile, non-organic waste that is unable to be processed will be store at the landfill, and non-organic waste that is able to process, is processed in the waste treatment installation. Currently the non-organic waste that can be processed is processed by plastic chopping system with production as much as 3 tons per day. Then they are sent to Surabaya for further processing. In addition, there is also non-organic waste that is used to make plastic craft, which then sold at the Waste Bank. Organic and non-organic wastes that can be processed then contribute to the income of the city of Ambon.

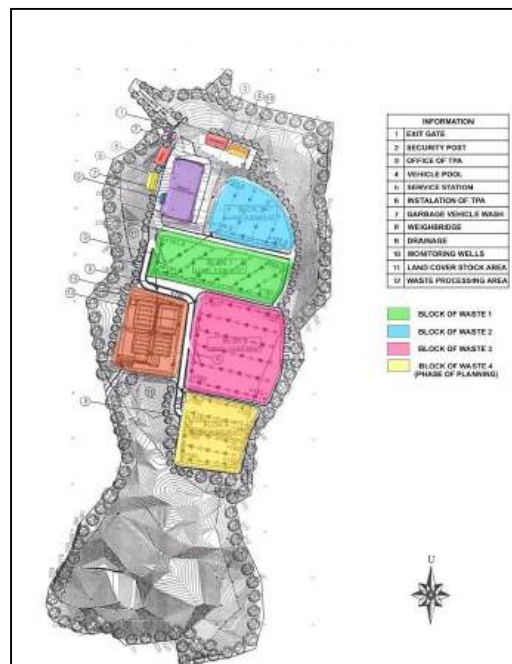


Figure 3. Plan of the landfill in the City of Ambon
 Source: IPST Kota Ambon, 2016

When compared to SNI 3242-2008, waste management in the integrated depot transfer, should be done by sorting the organic and inorganic waste. Additionally, organic waste needed to be composted of organic waste with environmental scale. Inorganic wastes also needed to be sorted according to the type of waste such as Inorganic waste that can be recycled, waste from stalls that can be sold, dangerous household waste, and residual waste. After that, selling the waste that has economic value to the city, needed to be managed in accordance with applicable regulations, and collect residual waste into the container to be transported to the landfill.

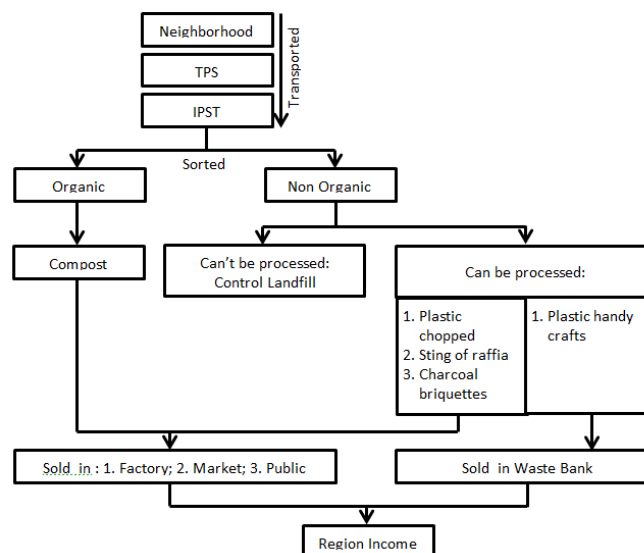


Figure 4. Waste processing flow in City of Ambon
 Source: Result of Observation and Interview with Head of IPST City of Ambon, 2016

4. Conclusions

Based on the analysis, the completeness of waste management in the city of Ambon can be considered as a good waste management system. It is because of the stages of waste management already run most likely according to the applicable standards and regulations. However, several points remain to be improved, such as the quantity and quality of personnel and infrastructure which are still limited, the waste transport operation which can be more optimal, the public which can be more supportive to the waste management and the lack of action against violations of regulations on waste disposal. In addition, expansion of the landfill area and improvement of the waste processing tools are needed, so that all kinds of process-able inorganic waste can be processed in Ambon City.

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