Waste management system on Badung River area in Bali

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Abstract. The issue of waste is still a serious problem in Denpasar, Bali. Low levels of public awareness make the city view worse. Badung River, which passes through residential areas, is always filled with garbage every day. This uncontrolled waste production is caused by shipments of waste from the Upper and Middle parts of the Badung River catchment area and the level of public awareness that is still lacking in the environment. The origin of the contents of the garbage in the Badung River comes from human activities and nature. Research on this waste problem uses questionnaires by taking samples in the survey area based on 8 locations taken from the tributary meeting to the Badung River. This research shows that the implementation of good policies improves good behaviour compared to the implementation of policies in poor categories. The solid waste management system in the Badung River catchment area is the same, which is divided into waste generation, storage, collection, transfer disposal and waste disposal. So that it can be seen that solid waste management systems, such as the sorting process and the 3R (reduce, reuse, and recycle), are still very little attention to the community around the Badung River catchment area.

1. Introduction

1.1. Background
The river is one of the sources of water that humans and other living creatures can use to meet their biological needs. Rivers are spread in various places, both rural and urban. One of the biggest rivers that cross the city of Denpasar is Badung River. The river which is located in the center of the busiest city, its existence is still worrying, besides supporting the creation of the beauty of the city, Badung River is still a source of city problems. In various corners of Tukad Badung there is still a pool of garbage floating, the Badung River has been used as a waste dump for some people or city residents who lack environmental discipline.

Garbage is a sight that is still found along the river that crosses Denpasar City. Plastic waste, household waste, and dead animals are often found floating in the current. The garbage comes from upstream and is carried downstream. Some of the garbage is stuck on the banks of the river, so the river cleaning staff needs to be taken. Residents outside the catchment area also contribute to the dirty Badung River. The government needs to exercise more control to maintain the cleanliness of the river. Need education in the community so as not to throw garbage into the river. A few years back the Badung River had experienced siltation, so when the rainy season arrived the river often overflowed [1]. Based on the preliminary survey and the final report of the Bali-Penida, River Basin Department (BWS), problems were identified along the Badung River catchment area, including the conditions of 3rd Jurang River at Nuansa Kori street is near residential areas so it is prone to waste, the condition of Badung River at Ken Dedes street saw that the river had begun to have garbage, the condition of
Campuhan River, Badung River, Jurang River, at Maruti street the condition of the river began to have garbage and the residential area seemed to be slum, the condition of Badung River at Gajah Mada street - Pulau Buru street – Diponogoro street the condition of the river began to have garbage, the condition of Badung Main River, at 1st Pulau Biak street and 2nd Pulau Biak street, the condition of the river with garbage and residential areas seemed to be slum, and the condition of Badung River at Taman Pancing street, Pemogan, South Denpasar, the condition of the river with garbage and residential areas seems to be slum [2].

Although various efforts have been made, one of them is to install a garbage trash rack to reduce the volume of waste carried in the river, but it is not effective because the volume of waste is increasing. Lack of public awareness and coordination between agencies involved and other bad natural phenomena that might occur certainly can have a big influence on the environment, natural scenery, conservation of coastal waters, water availability can even cause more severe ecosystem damage along Badung River. If this condition is allowed to continue, then it is not impossible that there will be inconvenience in carrying out city activities, damage to scenery and tourism assets, the water crisis and even the extinction of ecosystems which are certainly not wanted by all parties. The integration of the handling program needs to be prepared and matured and applied well in order to create a clean, safe, sustainable and beautiful ecosystem. Identification of the amount of waste generation and community behavior in disposing of garbage is very necessary in order to develop a waste management model and this arrangement becomes more important to do besides because Denpasar is the provincial capital because the Badung River is planned as one of the city's tourist attractions.

1.2. Research purposes
The objectives of this study are:
1) Analyzing the amount of waste generation that occurs in settlements along the Badung River Catchment Area;
2) Designing the right waste management system to overcome the problem of waste in the Badung River Catchment Area.

2. Literature Review

2.1. Definition of garbage
Waste is material that has no value or is not valuable for ordinary or primary purposes in fabrication or use of damaged or defective goods in manufacturing or excessive or rejected material or waste. In Law No.18 concerning Waste Management it is stated the definition of waste as the rest of human daily activities and / or from natural processes in the form of solids [3].

Waste is the remainder of a business and / or activity which is solid or semi-solid in the form of organic matter or an organic which can be decomposed or non-biodegradable which is considered to be useless and disposed of into the environment [4].

Solid waste or waste includes objects in the form of plastic, aluminum, iron, cans, bottles / glass / glass, and so on. While liquid waste is the seepage of liquid from the decay of waste and can contaminate soil and river water. Groundwater pollution, for example caused by the content of e-coli bacteria and heavy metals [5].

In order to reduce the volume of waste on the surface of the earth, it is necessary to classify and know the sources of waste. This waste classification activity can indirectly sort waste into rubbish that can still be utilized and disposed of.

2.2. Classification and source of waste
Classification of waste and its sources is very necessary in the planning of solid waste management systems, especially in the operational technical subsystem, especially in terms of management and final waste disposal. Based on the 2006 Solid Waste Management Guidelines the Directorate General
of Cipta Karya, Directorate of Environmental Sanitation and Settlements Development, divides the waste classification as follows [6]:

1) Types of waste
Based on the chemical properties of the elements of formation, there are 2 categories of waste types, namely:
   a. Organic waste, which is waste that contains organic compounds and is composed of elements of carbon, hydrogen, oxygen and nitrogen. For example, leaves, wood, paper, bones, food scraps, vegetables and fruits;
   b. Inorganic waste, which is waste that does not contain organic compounds, generally this waste is very difficult to decompose by microorganisms. For example, glass, aluminum cans, dust, metal. The character of waste is strongly influenced by the level of population growth, economic growth and prosperity and lifestyle of urban communities [7].

Based on the shape:
   a. Solid waste: all waste materials other than human waste, urine and liquid waste;
   b. Liquid waste: the liquid material that has been used then is not needed again and thrown into a landfill [8].

Specific waste is household waste or garbage of a household type which because of its nature, concentration and/or amount requires special handling, including, garbage containing B3 (hazardous and toxic materials such as used batteries, used toner, etc.), garbage containing B3 waste (medical waste), disaster-related waste, debris, waste that is technically not yet able to be processed, garbage that arises in a period such as human waste [9].

Industrial waste in the form of chemicals that are often toxic requires special treatment before disposal. This waste comes from the entire production process (chemical materials / pieces of material), treatment and packaging of products (paper, wood, plastic, cloth / cloth that is saturated with solvents for cleaning) [10].

2) Waste sources
The source of the waste can be classified as follows:
   a. Garbage from settlements;
   b. Waste from agriculture and plantations;
   c. Waste from the rest of the building and construction;
   d. Trash from trade and offices;
   e. Waste from industry.

2.3. Factors affecting waste
Waste, both in quantity and quality, is strongly influenced by various activities and living standards of the people. Some important factors that affect waste include: 1) Total population. It is easily understood that the more residents, the more garbage. Even this waste management is racing against the rate of population growth; 2) Socio-economic situation. The higher the socio-economic condition of the community, the more the amount of waste per capita is disposed of every day. The quality of the waste is increasing, which is non-organic or cannot rot. Changes in the quality of this waste depend on the material available, the applicable regulations and public awareness of the waste problem. Even this increase in welfare will increase construction and renewal activities for buildings, transportation will increase with the consequence of increasing volume and type of waste.

Technological advancements will increase the number and quality of waste, because the increasingly diverse use of raw materials, the way packaging and manufacturing products are increasingly diverse can affect the amount and type of waste. This population factor can be the most influential factor in determining community behaviour in disposing of garbage in the surrounding environment.
2.4. Waste management

Operational techniques for handling urban waste include the basics of planning for activities: Waste disposal, garbage collection, waste removal, garbage transportation, processing and recycling of waste, and final waste processing.

The maximum sorting and recycling activities are carried out from the garbage collection to the final waste disposal. Operational techniques for urban waste management consisting of storage activities up to the final disposal of waste must be integrated by sorting from the source.

Waste management at the city level, sources of waste from city activities that are considered special, such as protocol roads, city parks, important agencies, trade centres, and the like are served by door-to-door systems, where garbage is collected and transported by trucks garbage to the final processing site. The principle of waste processing and recycling puts forward the use of waste as a resource so that the waste that has to be disposed of to landfill becomes less. The success of these processing and recycling efforts will depend on the sorting of waste starting from the source, on communal containers, on collecting and transporting facilities, so that the waste to be transported to the processing site has been sorted according to type or composition.

3. Research methods

3.1. Research design

The research method used is descriptive quantitative method, namely research that aims to make a systematic, factual and accurate description of the facts and characteristics of a particular object of research, while qualitative research is research that departs from data, utilizing existing theories as explanatory material, and ends with a theory. Analysis methods in this study include:

1) Identification of waste generation and community behaviour in disposing of garbage in the Badung River catchment area to find out the source, and the cause of the increasing volume of waste.

2) Planning waste management model based on the results of identification of waste generation and community behaviour in disposing of garbage.

The analysis carried out in this study did not use an analysis with a standard theoretical basis because until now there has been no standard solid waste management theory. However, in this study an evaluation of existing waste management was carried out as well as the analysis of generation and characteristics of waste and community behaviour in disposing of waste used in the concept of 3R (reuse, reduce, and recycle)-based waste management in the Badung River catchment area.

3.2. Data collection methods

The data collection methods to be carried out in this study are as follows:

1) Primary Data

The primary data collection methods carried out in this study are as follows:

a. Observation, namely the technique of collecting data by making direct observations in the field at predetermined locations. This method is used to determine the existing condition of the Badung River stream area and map the survey area based on 8 river arms taken from the tributary meeting to the main river, namely Badung River based on a preliminary survey and identified waste to determine the population and number of samples, and to find out Existing garbage in the survey area.

b. Questionnaire, which is collecting data using a format that is distributed to respondents who aim to obtain primary data. This method is used to identify community behaviour in disposing of waste at the location of the object of research by distributing questionnaires to residents (households) in the area along the Badung River catchment area, divided into 3 (three) survey locations, namely, the upstream and middle areas identified in the preliminary survey the presence of garbage.

c. Interviews, namely collection techniques on respondents, by holding communications directly. This method is used to identify the initial waste problems that occur along the Badung River catchment area by interviewing environmental experts, hydrologists and authorities.

2) Secondary Data
And the secondary data collection method carried out in this study is a literature study / literature study that is by collecting the data needed to identify problems and analysis. The collection of secondary data includes regional conditions, existing waste management, population data, socio-economic, institutional, regulatory, community participation and physical data.

3.3. Identification of waste generation

Methods of taking and measuring samples of generation and composition of waste based on SNI 19-3964-1994. The purpose of this method is to obtain the amount of waste generation used in waste planning and management. Examples of waste generation are garbage taken from selected picking locations, to measure its volume and weigh its weight and measure its composition; while the composition of the waste component is the physical component of waste such as food scraps, papers, wood, textile, rubber-leather, plastic, non-ferrous metals, glass and others (e.g. land, sand, stone, ceramics).

4. Research results

4.1. Condition of the Badung river catchment area

Badung River has a watershed area of 52,497 km² and a length of 19,601 km, all of which is entirely located in the area of Badung Regency and Denpasar City. This river has the type as a Main River. Badung River crosses dense areas in Denpasar City. Badung River is a watershed system that occupies the city of Denpasar in its upstream and middle parts, while the downstream is the boundary between the Badung Regency and the City of Denpasar. The Badung River tributaries are all in Denpasar, namely Jurang River, Langan River, Medih River, Urang River and Rarangan River. This river is included in a large river in Bali which empties into the Bali Sea. In the lower reaches of the Badung River there is the Estuary Nusa Dua Reservoir [2].

4.2. Areas identified for waste along the Badung River

From the results of field search (final report of the Engineering Consultant of PT Parama Krida Pratama), along Badung River, several common problems occurred, namely:

1. The condition of the building in the form of a retaining wall with stone pairs has begun to break down;
2. There is a narrowing of the river at some point;
3. Buildings in the River Side Area;
4. Disposal of garbage into the river;
5. The operational pattern of garbage control buildings is not optimal.

This research focuses on the waste problem, where in the field search that has been carried out along Badung River, as shown in Figure 1, it is identified at several points along the Badung River that there is garbage, among others: North Denpasar sub-district, West Denpasar sub-district and South Denpasar sub-district. [2]
4.3. Analysis of waste generation
The study was conducted on housing in the municipality of Denpasar in three sub-districts that were identified as waste through a preliminary survey, and the study was conducted for 8 consecutive days namely on 18th May – 25th May 2019 every 12.00 AM.

The collection of primary data in the form of physical characteristics of waste, the number of samples, the generation of samples and management of waste management were obtained from the results of direct research in the field and interviews. While secondary data was collected before the study was conducted, namely data relating to the location of the study area such as area, number of families, existing infrastructure that can be obtained through the Bali Central Statistics Agency (BPS) and local village government officials.

Determination of the location of waste sampling is carried out using the stratified random sampling method. The method of taking and measuring generation samples and the composition of waste are based on the SNI 19-3964-1994 method. Data processing in the form of generation analysis, composition and characteristics of waste.
As shown in Figure 2, it was seen that the composition of organic waste was greater than inorganic waste but the ratio was not too far, namely North Denpasar sub-district 50.551% organic waste and 49.449% inorganic waste, South Denpasar district 64.151% organic waste and 35.849% inorganic waste, Badung River 67.397% organic waste and 32.603% inorganic waste except in West Denpasar sub-district, inorganic waste (54.102%) is greater than organic waste (49.889%).

Whereas Figure 3 shows that the total comparison, there is a comparison that is not too far between organic waste and inorganic waste in the sub-district (53.53%: 46.47%) and there is a considerable comparison in the river (67.40%: 32.60%). Based on the type of garbage observed visually, the dominant organic waste is obtained from vegetables and wet fruits from kitchen waste. Whereas dominating inorganic waste is food packaging and plastic bags.

**Table 1. Average waste disposal.**

| Average Waste Disposal (r)     |            |            |
|--------------------------------|------------|------------|
| Housing waste                  | 11,5909    | liters/person/day |
| Waste of river waste           | 8,280      | literals/person/day |
| Name of sub-district           | Total Waste| Satuan     |
| North Denpasar                 | 186,138.803| liters/day  |
| West Denpasar                  | 155,550.330| liters/day  |
| South Denpasar                 | 254,988.949| liters/day  |
| River                          | 260.796    | liters/day  |
As shown in Table 1, the calculation results obtained the average household waste generation in the study location for unit volume is 11.5909 litre / day / day with a density of 0.0938 kg / litre (organic waste) and 0.071 kg / litre (inorganic waste). According to SNI 19-3242-1994, the rate of generation of household waste for homes is 2.20 - 2.25 litre / person / day or 0.30 - 0.35 kg / person / day. The rate of waste generation in this study is not in accordance with the applicable standards or can be said to be very high when viewed from the required values. Table 1 also shows only 0.7% - 1.1% of waste from housing and roads that are wasted into rivers. This value looks low, but if the community is not reminded of the impact, then it is likely that in the future this value will continue to increase.

4.4. Waste generation projection

The projected population is carried out using the exponential method, as shown in Table 2, the population of municipalities in Denpasar increases every year with an average annual growth of 1.89%.

Table 2. Projections of the population of each sub-district.

| No | Sub-district    | 2014 | 2015 | 2016 | 2017 | 2018 | 2020 | 2025 | 2030 |
|----|----------------|------|------|------|------|------|------|------|------|
| 1  | North Denpasar | 191  | 194  | 197  | 201  | 205  | 205  | 216  | 226  |
| 2  | West Denpasar  | 250  | 255  | 259  | 264  | 268  | 270  | 284  | 298  |
| 3  | South Denpasar | 273  | 279  | 286  | 292  | 297  | 301  | 320  | 340  |

The projected waste generation is derived from the derivation of population growth times the amount of waste per capita per day referring to the Indonesian National Standard (SNI) 19-3983-1995. Table 3 shows that the calculation of the projection of waste generation in the city of Denpasar for each sub-district for the next 10 (ten) years is calculated based on the data as follows:

1. Projected population for the next 10 years.
2. Waste generation per day in Denpasar city (11,5909 liters / person / day) and for a year multiplied by 365 days.
3. Based on the calculation of population projection, Denpasar City is still in the category of medium city classification so the amount of waste generation per capita / day is assumed to be constant, which is 11,5909 liters / person / day

Table 3. Waste generation projections.

| No | Kecamatan     | 2018    | 2020    | 2025    | 2030    |
|----|---------------|---------|---------|---------|---------|
| 1  | North Denpasar| 2,334.18| 2,409.70| 2,541.04| 2,679.54|
| 2  | West Denpasar | 3,065.69| 3,170.04| 3,351.92| 3,544.24|
| 3  | South Denpasar| 3,392.32| 3,540.35| 3,801.58| 4,082.07|

4.5. Plan for the waste management system model

Operational techniques for handling urban waste include planning basics for the following activities: waste storage, garbage collection, garbage removal, garbage transportation, waste processing and recycling and final waste processing.

The maximum sorting and recycling activities are carried out from the garbage collection to the final waste disposal. Operational techniques for urban waste management consisting of storage activities up to the final disposal of waste must be integrated by sorting from the source.

The design of the system model of activities and the process of processing integrated waste can be seen in Figure 4 below.
Figure 4. Waste management system model plan.

Waste management at the city level, sources of waste from city activities that are considered special, such as protocol roads, city parks, important agencies, trade centres, and the like are served by door-to-door systems, where garbage is collected and transported by trucks to the final processing site. The principle of waste processing and recycling puts forward the use of waste as a resource so that the waste that has to be disposed of to landfill becomes less. The success of these processing and recycling efforts will depend on the sorting of waste starting from the source, on communal containers, on collecting and transporting facilities, so that the waste to be transported to the processing site has been sorted according to the type or composition [11].

Currently in Denpasar City there are at least 171 Waste Management Groups that manage waste directly in the community and provide education about waste sorting. Furthermore, the garbage collected by the Waste Management group is transported to the Temporary Shelter (TPS). And continued transportation by Department of Environment and Hygiene (DLHK) Denpasar City from Temporary Shelter (TPS) to Landfill (TPA) [12].

The processing of organic waste is by the process of incineration or burning of waste, namely the technology of processing waste that involves burning organic matter. Incineration and processing of other high-temperature waste is defined as thermal processing. Waste incineration converts waste into ash, combustion residual gas, particulates, and heat. The gas produced must be cleaned of pollutants before being released into the atmosphere. The heat produced can be used as an energy generator. This incinerator can reduce waste volume up to 95-96% [13].

While processing or recycling other inorganic waste is a waste bank. Aside from being a savior of the environment, this garbage bank also has the concept of saving money. Inorganic waste cannot decompose naturally but it needs human action to process it by recycling inorganic waste, one of which is plastic waste, also known as plastic waste. The existence of a waste bank greatly helps the local government in combating waste, especially plastic. Waste bank innovation starts from exports to collaborate with banks. This waste bank adopts an online system for garbage bank savings transaction services, where each community deposits rubbish, especially plastic waste at certain points such as the banjar hall. Waste from households that can be valued or sold are paper, bottles and plastic bags, instant noodles and drinks, and iron. The processing of other organic waste is recycled plastic food packaging products and various beverages containing aluminum foil, and manufactured goods such as pencil cases, bags and trendy bags for mothers if they want to shop at the market. At present there are 37 garbage banks in the city of Denpasar that view waste as something useful and make waste as a commodity [14]. The subsequent processing of inorganic waste is to make waste as a work of art. One of them is carried out by Potato Head in Bali, an international beach club network on Seminyak Beach, Kuta. This makes Sustainism Lab, a laboratory of its own waste processing demonstration plot and
produces more than 40-tons of waste per month. This amount is estimated to be equivalent to one hamlet, and the remaining waste disposed to landfill is only 10% [15].

Revitalization of Final Processing Sites (landfill) is planned to be built at Suwung landfill, Denpasar. Later, the waste that is here will be managed and converted into electricity through technology-based power plants that are environmentally friendly. For information on estimating the total volume of garbage in the city of Denpasar, Badung Regency, Gianyar Regency, and Tabanan Regency, known as Sarbagita, it is 1,200 tons per day. With this amount, the projected capacity of electricity generation from waste processing is 15-20 MW [16].

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