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To cite this article: J Y Walalangi et al 2020 IOP Conf. Ser.: Earth Environ. Sci. 441 012125

View the article online for updates and enhancements.
Composition analysis of organic and inorganic waste and the impacts of coastal city in Palu-Central Sulawesi

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Abstract. Organic and anorganic waste in Palu city has exceeded the capacity of the service and the existing waste management facilities so that waste piling up in landfills while (TPS), and locations of residential areas around the watershed that eventually the waste to the sea. Comprehensive research is needed to formulate the management of such waste. It is given because the higher the level of human activity residing in the city of Palu, has brought the issue of marine pollution in the Palu bay, namely through the waste dump along the Watershed (DAS) Palu which empties into the sea. It can be seen through the rubbish heaps of the sea at low tide, be it in the estuaries and bays along the coast of Palu. So far, the management of coastal waste less attention than the waste in the city. It is time for the attention given to the coastal environment is given the function of these coast systemic interplay of other ecosystems. Integrated management and the sustainable coastal environment will preserve it so that its function will be maintained properly and as intended. The success of this integrated waste management depends on community participation, as the main producer of waste.

1. Introduction
Waste management in Indonesia is a national issue. Waste management in Palu city has not been solved. Who is due to several factors, among others, limited and unbalanced land availability with an increase in the volume of landfills. The government does not yet have a professional waste management planning system, community participation in waste management is still low, and the application of appropriate technology for processing waste into the material is not yet applied worth [1].

Waste accumulation in the river area and coastal environment (intertidal zone) has implications for the declining quality of the aquatic environment. The impact of this has resulted in the declining quality of the health of the people living in coastal areas [2,3]. The development of trade in coastal cities, especially the city of Palu, has led to urbanization. This facility activity produces organic and inorganic waste which finally puts pollution pressure on the Palu coastal bay waters. The volume and diversity of waste can be a burden on society because it causes various negative impacts. Waste dumps
in urban areas, especially in Palu City, have exceeded the service capacity and facilities for waste management. So that waste has accumulated in Temporary Disposal Sites (TPS) and is located in river streams around residential areas, which finally reaches the coast and the sea [4]. Based on these facts, this study aims to a). Analyze the composition of organic and inorganic waste in Palu City Bay. b). Analyze the quality of the waters of the Palu City Bay and c). Analyze the impact of the Palu Bay coastal pollution.

The complexity of pollution problems after the earthquake and tsunami natural disasters in the Palu Bay coastal area last year requires a comprehensive study to compare conditions to waste management in coastal areas before and after the disaster. Anthropogenic activities related to social structures in diverse coastal areas make this region has a high level of vulnerability to pollution. It gives theoretical consequences that the analysis using the Principle Component Analysis approach becomes relevant to be used to monitor the dynamics of the correlation of marine waste with the quality of waters that has a systemic impact on the coast of the Palu City bay. Scientific analysis is needed on waste management in watersheds and on the coast of Palu City.

2. Material and methods

2.1 Research and sampling sites for marine waste

The study conducted along the coast of Palu City and Palu River secondary data information from the location investigated in advance collected as consideration for preliminary surveys and field research. During the study, primary and secondary data also collected that were considered necessary (reports of other research results). The preliminary survey is intended to determine the sampling station and technical aspects of the research by observing locations.

Based on the objective, the boundary of the research location is the coast of Palu City (intertidal). A sampling of organic and inorganic waste is carried out in the intertidal section of the coast. A sampling of wastes (organic and inorganic) deposited in intertidal areas is carried out using the "quadrant sampling" method [2] Figure 1. A sampling of waste in intertidal areas is determined in advance by drawing the length of the sampling line (line transect) 30m with a 2m x 2m quadrant size while the distance between one quadrant and another is 1m. The trash for each quadrant is placed in a sack and labeled with a location. The rubbish in the sack is sorted by type (organic/inorganic) and weight for each research location to get absolute density and relative density data.

![Figure 1. Laying and Collecting Quadrant Sampling](image-url)

2.2 Identification of water samples

Water sample identification is carried out in two parts of the Palu River, namely the part with 0 PSU salinity and the part with more than 0 PSU salinity (Effendi, 2003). Location points ± 500 m from the coast and also in parts that have a salinity of more than 0 PSU at 3 location points ± 100 m from the coastline.
intertidal area and each taken on the left, center and right for the river and sea (KA1-KA3 = Location of river water samples and KB1-KB3 = Location of seawater samples). This was done to see how big the difference between water quality parameters in the two sections, as shown in Figure 5. The results of this water sampling were analyzed at the Natural Resources and Environmental Analysis Laboratory of the Faculty of Agriculture, Tadulako University, Palu.

Information:
A1-A4 = East Palu District
B1-B4 = District of West Palu
C1-C4 = River
KA1-KA3 = River Water Samples
KB1-KB3 = Seawater Samples

Figure 2. Sketch of the Waste and Water Sampling Model

2.3 Data analysis
Data processing of Palu City bay water quality uses Principal Component Analysis (PCA). To find out the amount (slice), weight and composition of the rubbish that is found on the coast of Palu City based on the number of residents who live in river and coastal areas which are potential sources of pollutants that dump their waste directly into rivers or to the coast, without being treated first first. Then the data obtained will be analyzed using the equation below [2]:

1. Absolute density (number of pieces of waste) =

\[
\frac{\text{Number of pieces of waste in each category}}{\text{Area size (m}^2\text{)}}
\]

2. Absolute density (waste weight) =

\[
\frac{\text{Weight of waste pieces in each category}}{\text{Area size (m}^2\text{)}}
\]

3. Relative density (number of pieces of waste) =

\[
\frac{\text{Number of pieces of waste in each category}}{\text{The total number of pieces of waste in all categories}} \times 100\%
\]

4. Relative density (waste weight) =

\[
\frac{\text{Weight of waste pieces in each category}}{\text{Total weight of pieces of waste in all categories}} \times 100\%
\]

3. Results and discussion
3.1 Results
The impact of development activities in various sectors in the Palu City area is the generation of organic and inorganic waste that is increasing in number, both in quantity and type. In this study, the data values of organic and inorganic waste are then averaged both from the number of pieces and the weight of waste that has been collected. For more details, please note in Table 1 and Table 2.

Table 1. Average Value of Organic Waste

<table>
<thead>
<tr>
<th>Number</th>
<th>Weight</th>
<th>Number of</th>
<th>Weight</th>
<th>Number</th>
<th>Weight</th>
</tr>
</thead>
</table>

3
Table 2. Average Value of Inorganic Waste

<table>
<thead>
<tr>
<th></th>
<th>Number of Pieces</th>
<th>Weight (g)</th>
<th>Number of Pieces</th>
<th>Weight (g)</th>
<th>Number of Pieces</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>30</td>
<td>618.53</td>
<td>B1</td>
<td>216</td>
<td>7109.46</td>
<td>A1</td>
</tr>
<tr>
<td>C2</td>
<td>84</td>
<td>1094.9</td>
<td>B2</td>
<td>290</td>
<td>3677.68</td>
<td>A2</td>
</tr>
<tr>
<td>C3</td>
<td>38</td>
<td>1858.4</td>
<td>B3</td>
<td>250</td>
<td>7062.62</td>
<td>A3</td>
</tr>
<tr>
<td>C4</td>
<td>27</td>
<td>271.23</td>
<td>B4</td>
<td>209</td>
<td>209</td>
<td>A4</td>
</tr>
<tr>
<td>∑</td>
<td>44.75</td>
<td>960.76</td>
<td></td>
<td>241.25</td>
<td>4514.69</td>
<td></td>
</tr>
</tbody>
</table>

Information:
C1-C4 = River Location
B1-B4 = Coastal Location of West Palu District
A1-A4 = Coastal Location of East Palu District

Figure 3. Graph of Average Number of Pieces (units) (a) and Average Amount Weight (g) Organic Waste.
Two factors affect water quality, namely natural factors and human activity factors [5]. Natural factors can occur when water reaches the earth, infiltration into the soil or flowing on the surface of the soil. The chemical composition of soil or rock through which the water will contribute to how the water quality, because during the movement of water occurs naturally dissolving [6]. The condition of the quality of the waters of the Palu River and on the coast of Palu City Bay can be seen in the following Table 3 and Table 4.

Table 3. Results of Analysis of Water Quality Parameters in the Palu River

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Units</th>
<th>Analysis Results</th>
<th>Quality Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Temperature</td>
<td>°C</td>
<td>KA 1</td>
<td>KA 2</td>
</tr>
<tr>
<td>2.</td>
<td>Suspended Solids</td>
<td>mg/l</td>
<td>25,21</td>
<td>26,42</td>
</tr>
<tr>
<td>3.</td>
<td>BOD</td>
<td>mg/l</td>
<td>1,55</td>
<td>1,35</td>
</tr>
<tr>
<td>4.</td>
<td>COD</td>
<td>mg/l</td>
<td>3,11</td>
<td>2,75</td>
</tr>
<tr>
<td>5.</td>
<td>Turbidity</td>
<td>NTU</td>
<td>47,00</td>
<td>52,00</td>
</tr>
<tr>
<td>6.</td>
<td>Salinity</td>
<td>PSU</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>7.</td>
<td>NO₃ as N</td>
<td>mg/l</td>
<td>3,21</td>
<td>3,45</td>
</tr>
<tr>
<td>8.</td>
<td>NH₃-N</td>
<td>mg/l</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>9.</td>
<td>NO₂-N</td>
<td>mg/l</td>
<td>0,02</td>
<td>0,03</td>
</tr>
</tbody>
</table>

Table 4. Results of Analysis of Water Quality Parameters on the Coastal Gulf of Palu City

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Units</th>
<th>Analysis Results</th>
<th>Quality Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>KB 1</td>
<td>KB 2</td>
</tr>
<tr>
<td>1.</td>
<td>Suhu</td>
<td>°C</td>
<td>30,3</td>
<td>29,8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Padatan</td>
<td>mg/l</td>
<td>32,21</td>
<td>30,55</td>
</tr>
<tr>
<td></td>
<td>Tersuspensi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>BOD</td>
<td>mg/l</td>
<td>0,65</td>
<td>0,63</td>
</tr>
<tr>
<td>4.</td>
<td>COD</td>
<td>mg/l</td>
<td>1,69</td>
<td>1,71</td>
</tr>
<tr>
<td>5.</td>
<td>Turbiditas</td>
<td>NTU</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>6.</td>
<td>Salinitas</td>
<td>PSU</td>
<td>26</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>NO₃ (Nitrat)</td>
<td>mg/l</td>
<td>0,05</td>
<td>0,05</td>
</tr>
<tr>
<td>8.</td>
<td>NH₃-N</td>
<td>mg/l</td>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>9.</td>
<td>NO₂-N (Nitrit)</td>
<td>mg/l</td>
<td>0,03</td>
<td>0,05</td>
</tr>
</tbody>
</table>

Source: Sea Water Quality Standard Kep.51/MENLH/2004

The impact of organic and inorganic waste on the quality of main river waters and the coast of Palu City can be made in one of the ways, namely by using Principal Component Analysis or better known as PCA technique. Principal Component Analysis (PCA) is one of the ordination techniques that project the dispersion of multi-dimensional data matrices so that relationships can be found between variables and relationships between objects.

The analysis of the main components in Figure 5, explains the water quality characteristics of the parameters of temperature, TSS, BOD, COD, turbidity, salinity, nitrate, nitrite, and waste. PCA results show that valuable information on the center axes on the two main axes 1 and 2 with the contribution of each axis by 75% and 16% for a total of 91%.
3.2 Discussion
Table 1 showed the average value of organic waste for the number of pieces (units) at the river location C1 = 51, C2 = 77, C3 = 21 and C4 = 21. The coastal locations of the West Palu Subdistrict are B1 = 147, B2 = 107, B3 = 337 and B4 = 145. The number of pieces at the coastal location in the East Palu District were A1 = 3463, A2 = 2445, A3 = 2052 and A4 = 1038. While for the amount of weight (g) organic waste for the research location in the watershed C1 = 2266.5 g, C2 = 4677.2 g, C3 = 2333.4 g and C4 = 3488.6 g. The location of the coast of West Palu District had the weight of organic waste is B1 = 6499.25 g, B2 = 6582.38 g, B3 = 11368.62 g and B4 = 10730.31 g. The locations of the coastal districts of East Palu were A1 = 18014 g, A2 = 14619 g, A3 = 12340 g and A4 = 8392.3 g.

Based on these data, the average value of the highest amount of organic waste is in the A1-A4 location of 2249.5 g, and the lowest value of organic waste is in the Palu City river location, 42.5 g. While for the highest average weighted pieces of waste there is a coastal location in West Palu
District, 8795.14 g followed by A1-A4 locations weighing 13341 g and C1-C4 were weighing 3191.4 g.

Table 2 showed the average value of inorganic waste for the number of pieces (units) at the river location C1 = 30, C2 = 84, C3 = 38 and C4 = 27. The coastal locations of the West Palu Subdistrict were B1 = 216, B2 = 290, B3 = 250 and B4 = 209. The number of pieces in the coastal location of the East Palu District are A1 = 106, A2 = 151, A3 = 155 and A4 = 97. While for the amount of weight (g) organic waste for the research location in the watershed C1 = 618.53 g, C2 = 1094.9 g, C3 = 1858.4 g and C4 = 271.23 g. The location of the coast of West Palu Subdistrict had inorganic waste weight is B1 = 7109.46, B2 = 3677.68, B3 = 7062.62 and B4 = 209. The coastal locations of the East Palu District were A1 = 3423.7, A2 = 3902.3, A3 = 5932.5 and A4 = 4024.6.

The average amount of inorganic waste deposited in the intertidal area in this study based on the results of the data table above showed that the number of inorganic waste pieces is at location B1-B4, which is 241.25 pieces, then A1-A4 locations are 127.25 pieces, and C1-C4 locations are 44.75 pieces — judging from the average weight of inorganic waste the highest weight value was located at location B1-B4 with a weight of 4514.69 g which is then followed by locations A1-A4 and C1-C4 weighing 4320.8 g and 960.76 g, respectively.

The number of pieces and weight of organic waste in the East Palu District location has the highest amount. This is because of this location, there are many settlements inhabiting the coast, and there are also many culinary centers, snorkeling tours, public ports, and fish processing plants. On the other hand, in Palu Barat District has the fewest amount of organic waste. This is due to the lack of residential areas in the area; there are only a few lodging places, Galian C factories, and fish markets. On the contrary, the highest number of pieces and weight of inorganic waste in the West Palu Subdistrict location. Based on the seven compositions of inorganic waste, more types of plastic waste are found slammed with glass, fabric/textile, rubber, paper, styrofoam, and aluminum waste types.

Distribution of characteristics of physical and chemical parameters can show how much the level of pollution exists at each observation station by using Quality Standards Based on the Ministry of Environment Decree 51 of 2004 for tourism and Water Quality Standards Based on PP.RI No.82 Th .2001 Class II. The parameter value of highest suspended solids is seen at KB station 1 (32.21 mg/L) and the lowest is at KB station 2 (30.55 mg/L) whereas in river water the highest suspended solids value at station train 2 (26.42 mg/L) and the lowest value is at Railway Station 3 (25.14 mg/L).

Differences in the value of suspended residues at each station both river water and seawater are affected by wastes containing dissolved solids such as dredging or sedimentation that are washed away by run-off and settle in the coastal area [7]. The value of the suspended solids that exist at each station shows a number that is not good for the coastal area. Sedimentation in the bay mostly originates from the Palu River is very worrying. If this sedimentation is not overcome, then the threat of rob (overflow due to high sea levels at high tide) will threaten the population.

Besides, sedimentation determines the ability of water to propagate light is very important, without sunlight photosynthesis is not possible, and life at sea will not be able to survive [8, 9]. Sunlight can be absorbed quickly by seawater to reach 100 m in clear seas. States that in turbid water this ray only reaches 10 m to 30 m and for very turbid waters it only reaches 3 m. Penetration of this light will affect the type and distribution of organisms that are in the sea and the temperature of seawater. In addition to suspended solids, the average temperature for river waters in the three observation stations is around 29°C, and the temperature for sea waters is between 29-30°C. Naturally, according to seawater, quality standards can allow temperature tolerance for corals and mangrove forests can grow well in the temperature range of 28-32°C [10, 11, 12].

In addition to physical parameters, chemical parameters also affect the water quality of water. For the parameters of seawater salinity at the three observation sites ranging from 20-28 PSU. At KB station 2 with a higher number of run-offs having lower salinity compared to KB stations one and KB 3. The influx of wastewater from the mainland greatly affects the salinity of seawater. Some biota, including seagrasses, are very sensitive to changes in salinity, and even some biota will experience death if there is a drastic change in changes in salinity. Furthermore, the value for BOD5 river water
(KA 1-KA 3) ranges from 1.35 mg/l to 1.55 mg/l. Based on this category river water is still in good condition because it has not exceeded the quality standard of 3 mg/L. As for seawater, it ranges from 0.63 mg/L to 0.66 mg/L. Although not yet exceeding the standard quality of seawater, which is 20 mg/L, however the stations that must be considered are KB 1 and KB 3 stations which are public tourist attractions.

BOD measurement is a prevalent measurement method used to check the occurrence of contamination of organic matter because in this way it is quite easy to measure the amount of oxygen molecules used by bacteria to oxidize the content of organic matter in water samples. Therefore BOD is often interpreted as the amount of oxygen in the water system needed by aerobic bacteria to decompose or remodel organic matter in water through biochemical oxidation processes by aerobic decomposition. Liquid waste produced by households contains a lot of organic matter which is characterized by high BOD in water polluted with waste [13, 14].

Furthermore, the highest value of river water nitrate content is seen at KA 2 station (3.21 mg/L) and the lowest at KA 3 station (3.18 mg/L). While the nitrate content in seawater has an average value of 0.05 mg/L at each KB station 1 to KB 3. Overall the parameters of river water quality are still useful, while for seawater the suspended solids are quite high or in other words have passed the threshold seawater quality standards for the quality of coral growth.

Correlation of each parameter (T = Temperature, TSS = Suspended, BOD, COD, SL = Salinity, NO₃, NO₂, SOP = Pieces of Organic Waste Pieces, SOB = Heavy Organic Waste, SAP = Pieces of Inorganic Waste, SAB = Heavy Inorganic Waste) is showed in Figure 5. Temperature parameters are positively correlated with salinity. States that the higher the temperature in the waters will increase salinity [15]. This is caused by increased water evaporation and lack of precipitation and vice versa. Other positive correlations can also be seen in the temperature and nitrate parameters, an increase in water temperature can increase nitrate levels in the waters because the inclusion of pollutants in the waters can change the ecological system of the water which affects the biota. Pieces of organic waste have a positive correlation with turbidity. The increase in organic waste will increase the turbidity of the waters that have an impact on pollution and penetration of sunlight into the waters, the inhibition of sunlight will reduce the productivity of the waters which have an impact on environmental quality [16, 17]. Pieces of inorganic waste are positively correlated with nitrite in the waters, an increase in inorganic waste makes the process of nitrification increase and in a state that can continuously lead to hypoxic water conditions that have an impact on decreasing water quality.

Looking at the results of the PCA analysis between the parameters in the correlation matrix of water quality characteristics, it is shown in Figure 13 that in the correlation cycle all parameters entered in a circle on the two main axes of 16% and 75% respectively produce a variation of 91%. This can be illustrated that there is indeed a correlation between water quality parameters in Palu City Bay.

This analysis showed that at the research location, there are three groups of observation stations. The first group is KA 1, KA 2, KA 3, the second group is KB1, KB3, and the last is KB 2. The remoteness of KB 2 due to this observation station was at middle river estuary, so the variable measured has a high value compared to other observation stations. For the organic waste chunk variable (SOP) in the next figure showed that this variable is a variable that greatly affects the water quality in the research location. As well as the TSS variable, which had a high correlation value; this illustrates by looking at these two variables, we could predict the condition of the water quality in the research location. KB 1 and KB 3 stations were characterized by SAP, SAB, NO₂, and NH₃ variables, while the latter group is characterized by temperature, TSS, and SOB variables.

4. Conclusion
Types of waste deposited in the Palu River and Palu City coast consist of organic and inorganic. Inorganic waste in the form of plastic scrap, rubber, paper, styrofoam, glass, fabric/textile and aluminum. Organic waste in the form of vegetable waste, fruits, leaves, coconut fiber, noodles, fish offal, fish bones, twigs/wood, shrimp shells, animal skins, peanut shells, seagrasses, eggshells and
feces. The average number of pieces (highest value) type of organic waste is on the coast of East Palu District, namely on the coast of Lere and Silae, while the average weight for the kind of organic waste is on the coast of West Palu, namely on the coast of Besusu and Talise. Ordinary pieces and weight (highest value) of inorganic waste are on the coast of West Palu sub-district. The impact of organic and inorganic waste pollution on the quality of waters in the river and coastal areas of Palu City based on the results of the Principal Component Analysis (PCA) has an interrelated correlation between water quality parameters with waste that could reduce the quality of the coastal environment of Palu City.

5. References

[1] DKPKP 2010 Data Total Infrastructure Hygiene and Gardening in Palu, Central Sulawesi (Data Jumlah infrastruktur Kebersihan dan Pertamanan Kota Palu-Sulawesi Tengah). (Palu: Palu City Department of Sanitation - Dinas Kebersihan Pertamanan Kota Palu) p 157
Acknowledgment
Thanks to the Ministry of Research, Technology and Higher Education has provided scholarship and research dissertation doctoral grants; Dean of the Faculty of Fisheries and Marine Science Brawijaya University; Head of the Environmental Laboratory Tadulako University and Rector Tadulako University who has facilitated, so that this research can do.