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Analysis of Waste Increase by Waste Type in Indonesia

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Abstract. This project aims to visualize waste bank data in Indonesia using Tableau, focusing specifically on cities and regencies with the highest waste accumulation. The motivation behind this topic is the increasing cases of dengue fever (DBD) caused by accumulating waste, which serves as breeding grounds for Aedes aegypti mosquitoes. Through this visualization, we hope to raise public awareness about the importance of waste management, especially non-biodegradable waste. The data used in this project was obtained from the National Waste Management Information System (SIPSN). The visualization results indicate that Java Island has the highest amount of waste compared to other islands, with organic waste reaching 1,731 tons and inorganic waste amounting to 604 tons. These findings emphasize the urgency of better waste management in Java and the importance of collaborative efforts to reduce waste, in order to prevent disease spread and maintain a healthier environment.

Keywords: Visualization, Waste, Java Island, DBD.

1. Introduction

Waste is material or items that are no longer used or considered useless by their owners, and thus discarded. Waste can consist of the remnants of human activities or natural processes generated by households, industries, agriculture, and various other activities.(Thürer et al., 2017) These unused materials or items have three different compositions: organic, inorganic, and hazardous (B3). Organic waste is waste that can naturally decompose, such as food scraps, branches, animal waste, leaves, etc.(Mudiyanselage & Herat, 2021) Inorganic waste is a type of waste derived from non-biological materials that are difficult or unable to decompose naturally by microorganisms due to their complex chemical composition. This waste usually originates from human-made materials or natural materials that have undergone chemical processes such as plastic, bottles, glass, metal fabric, etc. (S. Gonawala & Hemali, 2017) Meanwhile, hazardous waste (B3) is a type of waste containing hazardous and toxic substances that can endanger human health and the environment. This waste requires special handling to avoid contamination risks, such as medical waste, chemicals, electronics, and toxic waste. (Yurnalisdel, 2023)

The accumulation of waste is certainly a problem. According to data, the global waste generation reached 20 billion tons in 2017 with an estimated increase to 46 billion tons by 2050. (Maalouf & Mavropoulos, 2023) This indicates that waste generation on Earth is increasing due to insufficient waste management. According to the Environmental Protection Agency (EPA), the United States became the number one waste generator country in 2018 with a figure of 292.4 million tons, (EPA- United States Environmental Protection Agency, 2020) followed by China with a generation of 222.8 million tons in the same year. Meanwhile, according to the World Bank Report, Indonesia produced 3.2 million tons of plastic waste in 2018 (World Bank, 2018). This is an important concern because waste generation has many adverse effects on the environment and living beings. (Karaeva & Magaril, 2023)

According to data from the past 10 years, from 2010 to 2019, the Indonesian population was affected by nearly 113,087 (Arisanti & Suryaningtyas, 2021) cases of dengue fever caused by environmental pollution due to waste that contaminates the environment. This pollution occurs due to the lack of infrastructure to manage waste properly, resulting in waste from various areas not being managed properly. However, in 2012, as reported on the Ministry of Finance's website in an article titled "*Penguatan Pengelolaan Sampah melalui Pendekatan Reduce Reuse Recycle (“3R”) menuju Indonesia Bersih*," the Indonesian government began efforts by implementing the 3R program, namely Reduce, Reuse, and Recycle. (Listiningrum et al., 2023) This policy is implemented to increase the initiative and awareness of the importance of waste management. One example is not using single-use plastic bags, (Khatulistiani et al., 2023) replacing them with cloth bags or other reusable shopping bags, or not using plastic straws and replacing them with stainless steel straws. (Sunandar, 2020)

Although the changes may not be significant, this movement has an environmental impact, reducing pollution and improving public health. Waste management activities carried out by the Indonesian government significantly contribute to achieving the Sustainable Development Goals (SDGs). These efforts are primarily related to SDG 11 titled "Sustainable Cities and Communities" and SDG 12 titled "Responsible Consumption and Production." SDG 11 emphasizes the importance of reducing per capita environmental impacts from cities, including effective urban waste management. Meanwhile, SDG 12 emphasizes the importance of managing chemicals and all waste throughout their life cycles in an environmentally friendly manner.

By focusing on good waste management, Indonesia seeks to create a healthier environment for humans and other living beings. Effective waste management helps reduce the release of hazardous substances into the air,(Faridawati & Sudarti, 2021) soil, and water, thereby preventing environmental pollution and improving the quality of life for society. These efforts also support sustainable and inclusive development, which is the main goal of the SDGs.

Waste management is a critical issue that requires serious attention from all parties, including the government, society, and the private sector. By raising awareness of the importance of waste management and implementing effective policies, such as the 3R program, Indonesia can reduce waste generation and its environmental impact. These steps not only help achieve sustainable development goals but also ensure that future generations can enjoy a clean and healthy environment.

2. Related Work

The first study, titled “Assessment of Reuse, Recycle, and Recoverable Potential of Solid Waste,” conducted by Dawit et al. (2019), provides a comprehensive analysis of the waste generated by Haramaya University (HU). According to the study, the total waste production at HU amounts to 2,608.56 kg/day. The composition of this waste is predominantly organic material, constituting 57.31% of the total waste, which presents a significant opportunity for composting. In addition to organic waste, paper waste accounts for 16.26%, and fines make up 10.98%. This detailed breakdown highlights the potential for waste management practices that focus on recycling and composting.

The study further elaborates on the recyclable portion of the waste generated at HU. Annually, the university produces 169.45 tons of recyclable paper and cardboard, 59.49 tons of recyclable plastic materials, and 11.82 tons of recyclable metals, specifically cans. This data underscores the substantial potential for improving waste management systems at the university through targeted recycling initiatives.(Dawit et al., 2019)

On the other hand, a separate study titled *"INTEGRASI DATA SAMPAH SEBAGAI UPAYA MEWUJUDKAN ZERO WASTE MANAGEMENT: STUDI KASUS DI KOTA BANDUNG,"* conducted by Khairunisa and Safitri (2020), examines the efforts to achieve zero waste management in the city of Bandung through the implementation of Waste Banks. This study reports that in 2015, the contribution of 5,244 Waste Banks to waste reduction was relatively minimal, at just 0.01%. However, there was a notable increase in their effectiveness over the following years. In 2016, the contribution of Waste Banks to reducing waste rose to 0.14%, demonstrating a growing awareness and participation in waste management activities. By 2017, the impact of Waste Banks had increased significantly, with their contribution to waste reduction reaching 1.7%.

This substantial growth reflects the success of community-based waste management initiatives in Bandung and underscores the importance of such programs in achieving broader environmental sustainability goals. The comparative analysis of these two studies highlights different aspects and strategies of waste management, illustrating both the challenges and the potential solutions for effective waste reduction and recycling in various contexts.(Khairunisa & Safitri, 2020)

3. Method

In this research endeavor, the researchers have adopted a methodological approach that impeccably aligns with their research objectives, namely harnessing secondary data available through the National Waste Management Information System, a steadfast and authoritative repository sanctioned by the government. Through the utilization of this invaluable dataset, the researchers have been afforded unfettered access to a treasure trove of information delineating the intricate tapestry of waste generation patterns across the diverse provinces and municipalities dotting the Indonesian archipelago, spanning the temporal expanse from 2019 to 2023. Within this expansive dataset lie a plethora of dimensions, encompassing not only the quotidian and annual metrics of waste generation, quantified in metric tons, but also the primary founts from whence this waste emanates, ranging from domiciles and office complexes to bustling marketplaces and beyond.

Nevertheless, the researchers are confronted with a formidable challenge—namely, the disaggregated and fragmented nature of the dataset—which necessitates assiduous consolidation and meticulous processing to synthesize a holistic and comprehensive portrayal. To surmount this obstacle, the researchers have opted to employ the Python programming language in conjunction with the versatile Jupyter Notebook as their toolkit of choice, endowed with the requisite potency and adaptability requisite for orchestrating the seamless amalgamation and expedient processing of the dataset. Beyond the mere amalgamation of disparate data points, the researchers have also undertaken the arduous task of scrutinizing each data row with a discerning eye, vigilantly identifying and rectifying any instances of missing values. Such vigilance is imperative, as the presence of missing values may engender deleterious ramifications, impeding the accuracy and fidelity of subsequent data analyses and interpretations.

By undertaking these meticulously orchestrated endeavors, the researchers are poised to unearth a veritable trove of insights pertaining to the intricate dynamics undergirding waste management practices throughout the Indonesian archipelago. Armed with these insights, the researchers stand primed to uncover latent trends and patterns clandestinely nestled within the vast expanse of the dataset, thereby furnishing a robust foundation upon which to scaffold further analyses and inquiries. Such endeavors are poised to yield substantial dividends, furnishing invaluable contributions to the corpus of knowledge surrounding waste management imperatives and affording invaluable insights that may inform the formulation of efficacious policies and strategies for the future.

This research also employs the SEMMA methodology, a framework that simplifies the prediction of variables related to data mining projects. SEMMA's structured approach facilitates a clear understanding of the processes involved in managing data mining endeavors. SEMMA comprises five distinct phases: Sample, Explore, Modify, Model, and Assess. (Ahmad, 2022)

This sample initiates a research effort that explores the complex patterns of waste generation across Indonesia, utilizing data mining techniques to gain valuable insights. The foundation of this research lies in secondary data sourced from the National Waste Management Information System (SIPSN), a comprehensive repository managed by the government. The data exploration phase began with a thorough examination of the SIPSN dataset, which revealed a wealth of information covering waste generation from various sources, including households, offices, and public areas. In addition, the dataset also provides a detailed breakdown of waste composition, distinguishing between organic and inorganic waste streams. After modifying Recognizing the potential impact of missing values on the integrity of the analysis, the researchers carefully addressed this data quality issue. Using appropriate imputation techniques, they ensured that the dataset was free of missing values, thus improving the reliability of subsequent analyses. And modeling Harnessing the power of trend line analysis, the researchers embarked on a journey to uncover the temporal patterns of waste generation across Indonesia. By fitting trend lines to the data, they were able to identify underlying trends and predict the future trajectory of waste generation. Finally, to validate the accuracy of the trendline model, a rigorous evaluation process was conducted.

4. Result and Discussion

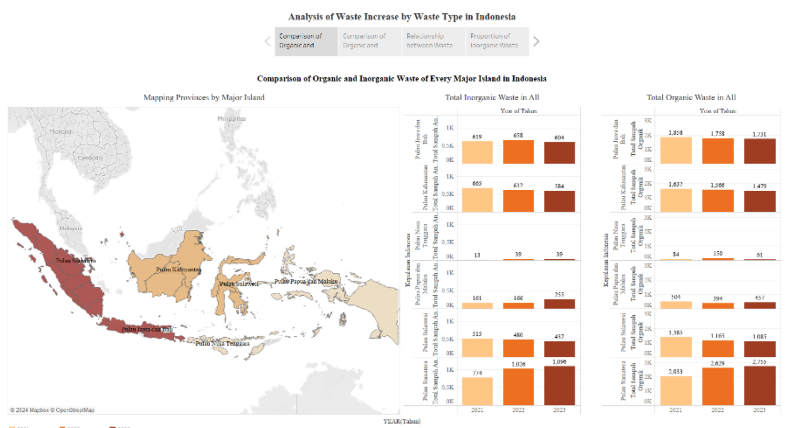

Figure 1. Visualization of a Map of Indonesia Based on the Total Organic and Anorganic Waste

This visualization provides an overview of the comparison of organic and inorganic waste in Indonesia. This map can be used to see the provinces that have high levels of organic and inorganic waste, as well as to see the comparison between the two. Each island has a different color, which is based on the severity of its annual waste generation. The browner the color of an island, the more severe and higher the amount of annual waste it has. Each island has comparable values, namely total organic waste and total inorganic waste.

The comparison of organic and inorganic waste is divided into three time periods, namely 2021, 2022, and 2023. Each time period has different colors ranging from light orange, orange, and brown.

Based on Figure 1, the reader can see that the islands that have the highest annual waste generation to severe levels are Sumatra Island and Java and Bali Island. Meanwhile, Nusa Tenggara Island and Papua and Maluku Island have the least waste generation due to the light brown color shown in the maps. In addition, readers can also get information related to the comparison of organic and inorganic waste per island through the visualization bar on the side.

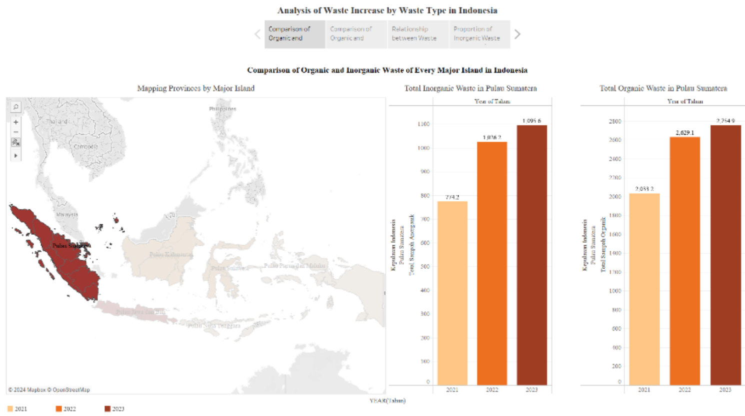

Figure 2. Visualization of Sumatera Island Based on Total Organic and Anorganic Waste

Furthermore, the dashboard is interactive, where readers can tap on any of the island maps. Based on the results of map visualization, especially on the island of Sumatera, it shows that the total Organic and Inorganic waste is based on three year divisions, namely 2021, 2022, and 2023.

Based on the bar chart above, it can be seen that every year Sumatra Island experiences an increase in the amount of waste. In 2021, the total inorganic waste reached 774.2 tons and increased by 32.55% to 1,026.2 tons in 2022. This increase continued until the end of 2023 but not as high as last year, with a total increase of 6.76% so that the waste reached 1,095.6 tons.

Meanwhile, the total organic waste in 2021 was 2,033.2 tons and increased by 32.4% to 2,629.1 tons in 2022. This increase continued until the end of 2023 but not as high as last year, with a total increase of 6.8% so that the waste reached 2,754.9 tons.

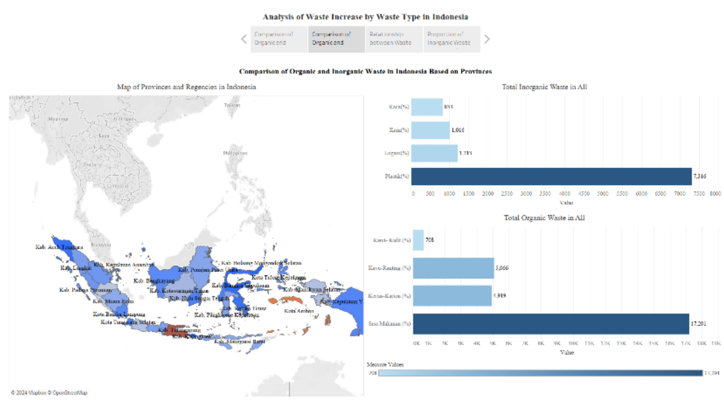

Figure 3. Visualization of Comparison of Organic and Inorganic Waste in Indonesia based on District/City

The second visualization displays the comparison between organic and inorganic waste owned by each district/city in Indonesia. From the visualization, readers can find out the organic and inorganic waste composition of each district/city. The organic waste composition consists of the percentage of Glass, Fabric, Metal, and Plastic waste. Meanwhile, inorganic waste consists of the percentage of leather-leather, wood-twigs, paper-cardboard, and food waste.

Coloring of visualization maps based on the amount of waste generation in each district/city. The more the amount, the darker brown the color of the area on the map will be. Meanwhile, the less waste, the more blue the color will be. Like maps, the coloring of organic and inorganic waste barcharts is also based on the amount of waste per type. The more waste the type has, the darker blue the color of the bar will be. This applies vice versa.

Based on Figure 3, readers can see that Banyuwangi district has the highest annual waste generation rate in Indonesia. This is shown by the dark brown color on the Banyuwangi district map. Meanwhile, areas such as Southeast Aceh and Karangasem are colored light blue, which means that these two districts are included in the districts that have less waste generation.

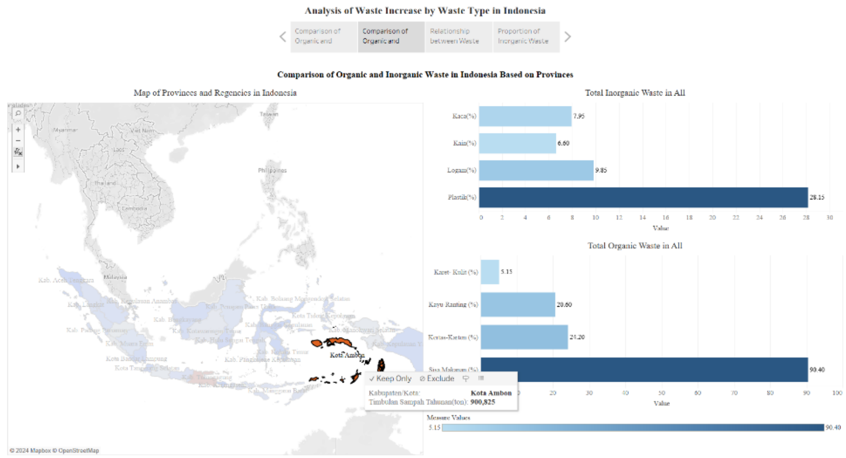

Figure 4. Visualization of Comparison of Organic and Inorganic Waste in Indonesia Based in Ambon City

One example of a district/city taken is Ambon City. Based on the dashboard above, Ambon City has both organic and inorganic waste. Inorganic waste in Ambon City consists of Glass (7.95%), Fabric (6.6%), Metal (9.85%), and Plastic (28.15%). Meanwhile, organic waste in Ambon Regency consists of Rubber-leather (5.15%), Wood-twigs (20.6%), Paper-cardboard (24.2%), and food waste (90.4%).

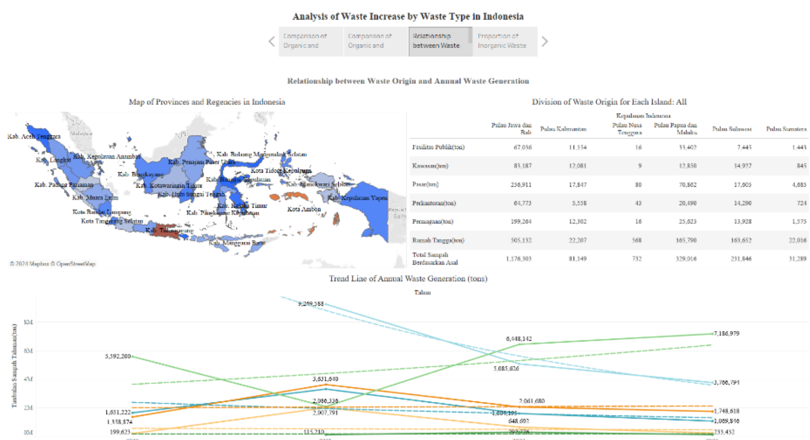

Figure 5. Visualization of Relationship between Waste Origin and Annual Waste Generation

Trend line shows the trend pattern of annual waste generation in Indonesia within a certain period of time (in the figure, from 2012 to 2021). This trend line helps to see the overall pattern of increase or decrease in annual waste generation. Meanwhile, the Mapping shows the distribution of waste generation per province and district/city in Indonesia. This mapping uses different colors to show the level of waste generation in each region. This helps to see which areas have high waste generation and which areas have low waste generation. And the table shows the proportion of waste per waste type in Indonesia and the total waste generation by waste source. This table helps to see what type of waste is generated the most and where the waste comes from.

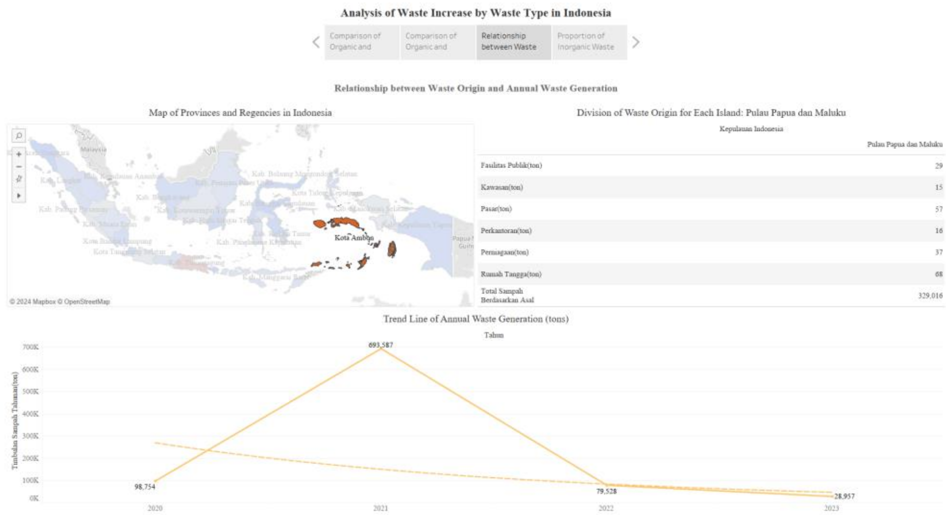

Figure 6. Visualization of Trend Line

These three elements are interrelated to provide a comprehensive picture of the waste generation situation in Indonesia. The trend line shows the overall trend, the mapping shows the geographical distribution, and the table shows the breakdown of waste types and waste sources. The annual amount of waste generation in Indonesia increased from 2012 to 2021. This can be seen from the trend line which shows an upward trend. The provinces and districts/cities with the highest waste generation are located in Java Island, namely DKI Jakarta, West Java, and East Java. This can be seen from the mapping that shows red color in the region. The most common type of waste generated by the Ambon Islands is organic waste, which is 61.16%. This can be seen from the table that shows the largest proportion of organic waste. The source of most waste is households, 37.40%. This can be seen from the table that shows the largest proportion of household waste.

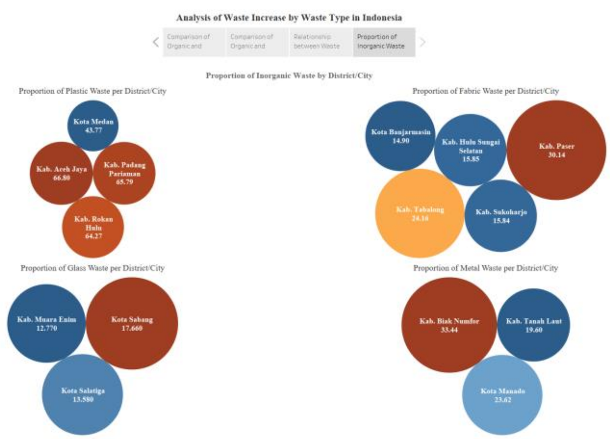

Figure 7. Visualization of Proportion Inorganic Waste by District/City

The last visualization is a bubble plot visualization that represents each Indonesian district/city in each bubble. This visualization displays information related to which districts/cities have the most inorganic waste represented by the bubble size and color. In the plastic waste bubble plot, readers can see that the bubble distribution is quite even. However, there are several districts that stand out, namely Pasangkayu District with a percentage of 109%, Gorontalo District with 98.3%, and Tabalong District with a percentage of 96.5%. Based on this information, readers can know that the most plastic waste comes from Pasangkayu, Gorontalo, and Tabalong districts, which means that these three districts need further handling and supervision from the government in dealing with the existing plastic waste problem.

The top right bubble plot displays information about which districts have the most cloth waste in Indonesia. Based on the visualization results, readers can find out that Paser Regency with a percentage of 30.14% occupies the first place as the district that has the most fabric waste in Indonesia. Then, it is followed by Tabalong Regency in the second position with a percentage of 24.16%.

In contrast to the two bubble plots above, the bottom left bubble plot displays the district with the most glass waste, namely Sabang district with a percentage of 17.66%. Meanwhile, the bottom right bubble plot displays the district with the most metal waste, which is occupied by Biak Numfor district with a percentage of 33.44% and Tanah Laut district with 29.82%. So, it can be concluded that each bubble plot represents the province in Indonesia with the most waste categories.

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