

ANALYSIS OF THE PREDICTED VOLUME OF DOMESTIC HOUSEHOLD WASTE IN THE COMMUNITIES OF DAS BILA AND ITS IMPACT ON THE SILTATION OF LAKE TEMPE

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ABSTRACT

The substantial waste production in the Bila watershed poses a severe threat to the area. This not only negatively affects the environment but also leads to sediment buildup in Lake Tempe. Managing the lake's health entails not solely addressing the lake itself, but also evaluating the impact within the encompassing river basin. This research examines the anticipated waste volume that could potentially contribute to sedimentation in Lake Tempe. The approach taken employs spatial analysis, utilizing a 20-meter buffer surrounding the water body. This buffer represents the zone within which the population is assumed to dispose of waste into the river. The accuracy of the findings was verified through interviews with residents residing within this 20-meter radius. The predominant source of the waste responsible for sedimentation is inorganic in nature, as it doesn't undergo natural decomposition. The study's projection suggests that by 2031, the cumulative volume of waste-triggered sedimentation will reach 1408.63 cubic meters. Addressing the burgeoning waste issue in the Bila watershed is paramount to preserving the integrity of Lake Tempe. By adopting a comprehensive perspective that encompasses both the lake and its surrounding river basin, effective strategies can be devised to mitigate sedimentation and ensure the longevity of this crucial ecosystem.

Keywords: *waste volume, sedimentation, Lake Tempe, spatial analysis, inorganic waste*

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INTRODUCTION

Lake siltation is a frequently encountered issue in various regions of Indonesia. One of the primary factors causing this siltation is household domestic waste. People dispose of their waste in rivers for several reasons, such as habit, lack of environmental awareness, and convenience (Yang et al., 2022). Improper waste disposal in rivers can lead to waste accumulation, hinder water flow, pollute the water, and disrupt river ecosystems (Deshpande et al., 2021). In some cases, such as disposing of diapers in rivers, the reasons behind such actions by the community might stem from misconceptions about child health (Kushwaha, 2022). To address this problem, cooperation between the government, communities, and environmental organizations is necessary to raise awareness about the detrimental effects of disposing of waste into rivers and encourage behavioral change among the public.

DAS Bila is a river basin located in three regencies in South Sulawesi, namely Enrekang Regency in the upstream area, Sidrap Regency in the middle area, and Wajo Regency in the downstream area of the river basin. Interestingly, this river basin flows into Lake Tempe, which is currently facing significant siltation issues and frequent flooding (Salam et al., 2020). The DAS Bila region generates a large amount of household domestic waste daily, which has the potential to contribute to the siltation in Lake Tempe (Zamzani et al., 2022). However, the lack of supporting literature regarding this statement presents a barrier to taking more in-depth actions regarding waste in the DAS Bila region (Noor & Ngabito, 2018). Nevertheless,

researchers have conducted field documentation showing the condition of DAS Bila, filled with waste in areas around the bridges that cross the river, as depicted in Figure 1.



Figure1. Dokumentation of River Trash Piles

Certainly, this poses a significant threat to both the river basin (DAS) and its estuary, Lake Tempe. The overflow flooding that occurred in early 2023 revealed the presence of trash piles that entered the affected residential areas along the shores of Lake Tempe (Hasyim, 2016), as evidenced in Figure 2.



Figure 2. Documentation of Trash Piles from the Overflow of Lake Tempe

Based on the literature review that has been compiled and considering the evident environmental impacts on DAS Bila, which potentially contribute to the siltation of Lake Tempe, this article aims to analyze the projected volume of household domestic waste that could potentially cause the siltation of Lake Tempe (Haerunnisa et al., 2017).

METHOD

The main method used in this study will employ a spatial approach. The spatial approach is utilized to justify the number of settlements and houses in the DAS Bila area. It also facilitates the calculation of the number of houses considered to dispose of waste in water bodies (rivers). In detail, the research steps can be seen in the research framework depicted in Figure 3.

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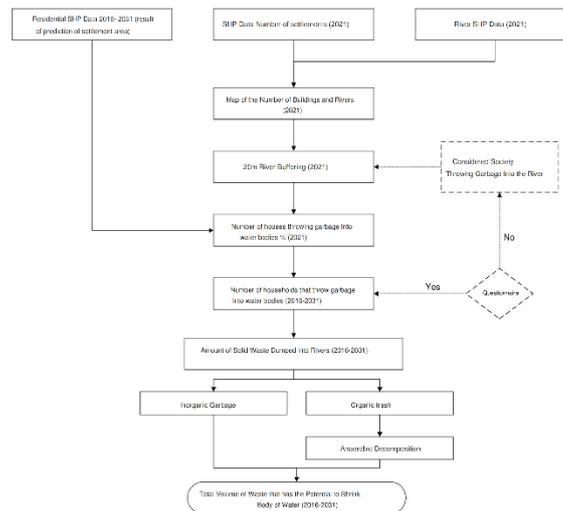


Figure 3. Research Framework

The Shapefile Data for Settlements from 2016 To 2031

The data was obtained from previous analyses that have shown an increase in the extent of settlements over the years. The data on settlement extent is available spatially and qualitatively. The qualitative representation of settlement extent in DAS Bila is presented in Table 1.

Table 1. Watershed Residential Areas in 2016-2031

Year	Residential Area (ha)
2016	808,56
2017	808,56
2018	808,56
2019	808,56
2020	836,46
2021	844,92
2022	853,2
2023	1127,16
2024	1232,73
2025	1386,09
2026	1435,23
2027	1570,77
2028	1623,51
2029	1957,23
2030	2007,18
2031	2193,66

Source: Land Use Prediction Analysis

The Shapefile Data for the Number of Settlements in 2021

This shapefile data is provided as open source on the internet, and it is widely used in digital applications that utilize maps as their operational foundation. The data we obtained was sourced from the website EarthExplorer, downloaded in the form of an SHP file, and its clear representation can be seen on the map in Figure 4.

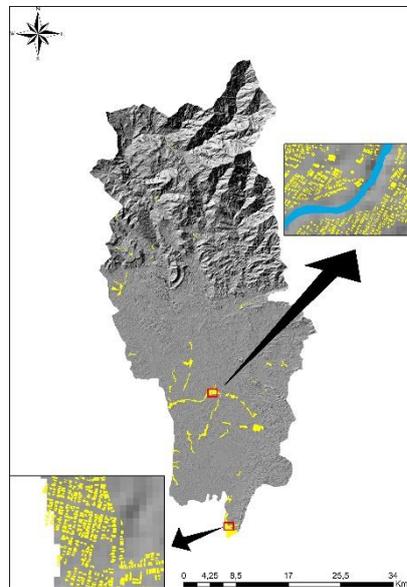


Figure 4. Map of the Number of Settlements

The Shapefile Data for Rivers.

This data is crucial in determining the number of houses that dispose of waste into the river. The essence of this map is to display the river network within the DAS area.

Map of Building Density and Rivers

This map displays the locations of settlements and river networks in a single map, which is important for identifying the points where settlements intersect with river flows.

River Buffering of 20 Meters

After obtaining the points where settlements intersect with river flows, in this step, a buffer zone is created by extending 20 meters outward from the riverbanks. Houses within this 20-meter buffer zone are considered as houses that dispose of waste into the water bodies (rivers). The distance of 20 meters is an approximation to determine the number of houses that engage in such waste disposal since census data on the number of households still disposing waste into the river is unavailable.

The Number of Houses that Dispose of Waste in Water Bodies (%)

This data represents the percentage obtained from the existing conditions, indicating the proportion of houses that dispose of waste into the river (within the 20-meter buffer zone) compared to the total number of houses.

The Number of Houses Disposing Waste into Water Bodies (2016-2031)

These values are derived from the percentage (%) values obtained in the previous stage. This is important to perform because the analysis of the number of houses is not extended until 2031. The data on the number of houses is only available for the existing period.

The Amount of Waste Generated and Disposed into the River

This stage involves calculating the cumulative waste generation assumed to enter the water bodies. To determine the amount of waste generated per household, conversion factors are used based on the values specified in Table 2.

Table 2. Waste Generation Conversion Factors

Constant	Value	Unit	Source
Household Waste Generation	292	Kg/House	Ministry of Environment and Forestry (2021) -Landfill in Wajo Regency.
The density of Household Waste	300	Kg/m ³	Ministry of Environment and Forestry (2021) -Landfill in Wajo Regency.

Inorganic and Organic

This stage is a classification of the characteristics of organic waste and inorganic waste that have been calculated from previous data. To classify the characteristics of organic and inorganic waste, the conversion values are used in Table 3.

Table 3.3. Trash Characteristic Conversion Value

Constant	Value	Unit	Source
Wood/Branches Constant	17,34	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Food Residue Constant	41,03	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Paper/Cardboard Waste Constant	7,20	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Plastic Constant	17,02	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Metal Constant	2,10	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Glass Constant	2,90	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Rubber/Leather Constant	6,40	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency
Other Constant	2,11	%	Ministry of Environment and Forestry. (2021) - Landfill in Wajo Regency

Anaerobic Decomposition

This process involves the decomposition of organic waste mass and volume that enters the water bodies. Naturally, organic waste undergoes anaerobic decomposition in the water bodies (Carlos-Pinedo & Wang, 2022; Sasaki et al., 2013). To determine the appropriate

decomposition rate, decomposition factors are used for each type of organic waste, as presented clearly in Table 4.

Table 4. Anaerobic Decomposition Rates for Organic Waste

Constant	Value	Unit	Source
Decomposition Constant for Food Residue Waste	60	%	(Nordin et al., 2020)
Decomposition Constant for Wood/Branches Waste	50	%	(Besserer et al., 2021)
Decomposition Constant for Paper/Cardboard Waste	70	%	(Hidayat et al., 2019)

The Total Volume of Waste that Potentially Causes Water Body Siltation

This is the final stage of calculating the total volume of decomposed organic waste and the inorganic waste considered as potential contributors to water body siltation (Pandey, 2022).

RESULTS AND DISCUSSION

The Number of People Disposing of Waste.

The purpose of buffering is to classify the types of communities that dispose of waste into the water bodies and those that do not. This aims to separate the number of communities that dispose of waste and then calculate the amount of waste generated from such disposal. The 20-meter buffering from the water bodies is an approximation to determine the communities that dispose of waste in the water bodies and those that do not. The basis for this distance determination comes from the research conducted by (Afifa Maharani et al., 2023), which showed that 100% of communities within that radius disposed of waste.

To perform the 20-meter buffering classification, a spatial analysis approach is used. After overlaying the maps of settlements and rivers, a 20-meter buffer is applied along the water body edges. The settlements within or intersecting the buffer line are considered communities that dispose of waste in the water bodies, while those outside the buffer line are communities that manage waste through means other than disposing of it in the water bodies (Sumantri & Cordova, 2011). Figure 5. shows the results of buffering in one example where settlements and river networks intersect.



Figure 5. Buffering Analysis (20m)

The yellow line indicates the 20m buffer line, while the green polygon represents all settlements in DAS Bila, the blue polygon represents the river, and the red polygon represents the houses within the 20m buffer zone. The result of the spatial analysis shows that 0.15% of the total houses in DAS Bila are households that dispose of waste in the water bodies.

The Result of Calculating the Volume of Waste that Potentially Causes Water Body Siltation.

The calculation of the number of houses can be done based on the settlement extent in Table 1., which is then divided by the average building area to obtain the number of buildings each year from 2016 to 2031. The clear results of the calculation of the number of buildings are listed in Table 5.

Table 5. Number of Houses in DAS Bila

Years	Number of Houses (houses)
2016	93.156,71
2017	93.156,71
2018	93.156,71
2019	93.156,71
2020	96.371,16
2021	97.345,86
2022	98.299,82
2023	129.863,61
2024	142.026,65
2025	159.695,74
2026	165.357,31
2027	180.973,29
2028	187.049,63
2029	225.498,55
2030	231.253,44
2031	252.738,38

The total number of houses for each year will be multiplied by the constant value of 0.15% obtained from the 20-meter buffering in the previous stage. The result of multiplying 0.15% by the number of houses will give the number of houses considered to dispose of waste in the water bodies (Hasanah et al., 2019). Once the houses that are considered to dispose of the waste are obtained, the calculation of waste generation volume is done using the conversion values in Table 2. resulting in the total waste volume.

The next step involves classifying the waste into organic and inorganic categories. In this classification stage, the conversion values in Table 3. are used. Inorganic waste includes plastic, metal, glass, rubber/leather, and other types of waste, while organic waste consists of wood/branches, food residue, and paper/cardboard. The calculation results of the volume based on each waste classification are clearly presented in Figure 6.

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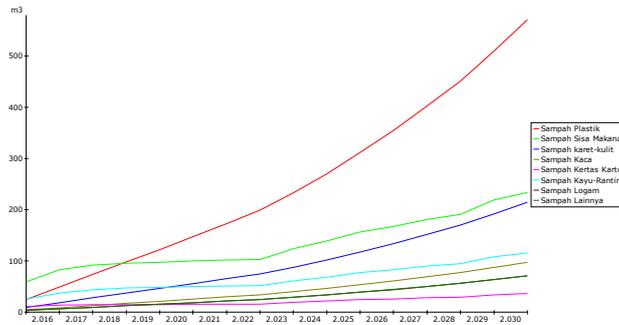


Figure 6. Result of Calculating the Volume of Waste Disposed into Water Bodies

The graph illustrates an increase in plastic waste, which initially ranked third, while food residue waste shows a decrease from its initial position as the top waste category. The increase in inorganic waste is attributed to the fact that inorganic waste does not undergo decomposition, unlike organic waste (do Carmo Precci Lopes et al., 2018; Hanies Ambarsari, 2004). The decomposition of organic waste is clearly presented in Table 4. The results of the volume calculation for waste are depicted in detail in Table 6.

Table 6. The volume of Inorganic and Organic Waste

Year	Waste (m3)							
	Inorganic					Organic		
	Plastic Waste	Rubber/Leather Waste	Glass Waste	Metal Waste	Other Waste	Food Residue Waste	Paper/Cardboard Waste	Wood/Branches Waste
2018	73,2	27,52	12,47	9,03	9,07	91,76	14,35	43,5
2019	97,6	36,7	16,63	12,04	12,1	95,52	14,63	46,61
2020	122	45,87	20,79	15,05	15,12	97,03	14,71	48,16
2021	147,24	55,37	25,09	18,17	18,25	99,66	15,09	49,8
2022	172,74	64,95	29,43	21,31	21,41	101,33	15,31	50,87
2023	198,48	74,63	33,82	24,49	24,61	102,6	15,49	51,67
2024	232,5	87,42	39,61	28,69	28,82	123,04	19,03	60,49
2025	269,7	101,41	45,95	33,28	33,43	138,89	21,45	68,14
2026	311,52	117,14	53,08	38,44	38,62	156,39	24,13	76,68
2027	354,83	133,43	60,46	43,78	43,99	166,96	25,56	82,47
2028	402,23	151,25	68,54	49,63	49,87	181,05	27,72	89,52
2029	451,22	169,67	76,88	55,67	55,94	190,53	29,04	94,68
2030	510,29	191,88	86,95	62,96	63,26	218,59	33,7	107,51
2031	570,86	214,66	97,27	70,43	70,77	233,45	35,73	115,46

The Result of Questionnaire Validation

The validation in this study involves verifying the accuracy of the 20-meter buffer that is assumed to represent 100% of households disposing of waste in the water bodies. Through interviews, it was found that the determination of the 20-meter buffer was appropriate. The main reason reported by the majority of participants for disposing of waste in the water bodies (rivers) was the lack of adequate sanitation facilities (waste bins). This finding aligns with the research conducted by (Salam et al., 2020), where their SWOT analysis of Lake Tempe highlighted significant challenges, including the lack of proper sanitation facilities and difficulties in controlling community waste management practices deeply rooted in the habit of disposing waste into water bodies. Figure 7. shows the interviews conducted with the

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community at the intersection of settlements and rivers, while Figure 7. depicts interviews conducted at a different location.



Figure 7. Interview with one of the community members disposing of waste into the river



Figure 8. Interview with one of the community members disposing of waste into the river

CONCLUSION

The analysis of the volume of domestic household waste in the communities of DAS Bila in relation to the siltation of Lake Tempe yields the following conclusions: The number of households disposing of waste into the water bodies (rivers) accounts for 0.15% of the total number of households in DAS Bila. The number of households disposing of waste will increase as the settlement extent expands. Initially, organic waste had the largest volume. However, due to decomposition, the accumulated volume primarily consists of inorganic waste, particularly plastic waste, as plastic does not undergo decomposition. Overall, the potential siltation contribution from both inorganic and organic waste amounts to 1408.63 m³ by the year 2031.

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