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Research Article

Pollutant Burden on Pollution Sources in the Wai Batu Merah Watershed, Sirimau District, Ambon City

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ABSTRACT

This study aims to identify sources of pollution and determine the magnitude of the potential pollution load from pollutant sources in the Wai Batu Merah watershed, Sirimau District, Ambon City. The method for identifying sources of pollution is carried out by using saturated or census sampling methods, calculating pollutant loads using direct methods for *point source pollutant sources* and indirect methods for *non-point sources* . The direct calculation method uses wastewater discharge data and the results of wastewater quality analysis results from measurements directly at the *point source pollutant wastewater treatment plant (WWTP)*. The wastewater sampling technique uses the *grab sampling method.* While the indirect method uses *effluent factors and supporting data from non-point* source pollution sources that have been identified in the Wai Batu Merah watershed. The results showed that the pollutant sources found in the Wai Batu Merah watershed were *point sources* originating from hotel and health facility activities and *non-point sources* originating from domestic activities from residential areas, agricultural and livestock businesses, *non-point source* land (forest and open land), micro, small and medium enterprises (MSMEs), small scale industries and waste. The dominant pollutant source in the Wai Batu Merah watershed comes from domestic *non-point sources. The highest point source* pollution loads for BOD, COD and TSS parameters in the Wai Batu Merah watershed came from hotel activities in segment 6 with the contribution of each parameter of 17.82 kg/day, 23.82 kg/day and 0.029 kg/day. Meanwhile, the highest *non-point source* pollution load for BOD, COD and TSS parameters came from non-point source waste in segment 6 with the contribution of each parameter of 2825.3 kg/day, 3884.8 kg/day and 2684.03 kg/day.

Keywords: *Effluent Factor, Non-Point Source, Point Source, Pollutant Load, Pollutant Source, Wai Batu Merah Watershed*

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Introduction

Rivers are flowing open waters that get input from all the wastes of various human activities in residential, agricultural and industrial areas in the surrounding area (Payus et al., 2022). The input of waste into the river will result in changes in physical, chemical and biological factors in the waters. This change can deplete essential materials in the waters so that it can disrupt the aquatic environment (Ismail, 2017). The condition of the water supply from the buffer zone is affected by activity and the behavior of its inhabitants (Jayanthi, 2018).

Increasing the rate of population growth will affect the increase in human needs for residential areas, especially in urban areas. The need for water in Indonesia is increasing in line with population growth which continues to increase rapidly, especially in large and medium cities (Meutia et al., 2022). As a consequence, domestic waste generated from household waste is also increasing (Sri et al., 2021).

Based on the water quality status report in the 2020 statistical report on water quality, air and land cover from the Directorate General of Pollution Control and Environmental Damage, it is known that the status of water quality in the Wai Batu Merah Watershed for 2016 – 2020 is in a heavily polluted condition (Lawrencia et al., 2023).

Based on the water quality status data, if no solution is found to solve the pollution problem in the Wai Batu Merah watershed, even if it continues it will affect the surrounding environment, both biotic and abiotic environmental components and other impacts that are derivative on the Wai Batu Merah watershed. and the people who live in it (Achmad et al., 2022).

In determining the polluted condition of a watershed, it is not only determined by the comparison of the quality standards of water quality and pollution level. Based on the Regulation of the Minister of State for the Environment of the Republic of Indonesia Number 1 of 2010 concerning the management of water pollution control, in addition to being determined by the results of water quality in comparison with quality standards, pollution in a waters can be determined by conducting an inventory and identification of sources of water pollution to determine the magnitude of the pollution load where the load Water pollution is the amount of a pollutant element contained in water or waste water (Suriadikusumah et al., 2021).

According to the Regulation of the Minister of State for the Environment of the Republic of Indonesia Number 01 of 2010 concerning Procedures for Controlling (Nurhasanah et al., 2021) Water Pollution, identification of water pollutant sources is an activity of collecting data and information needed to find out the causes and factors that cause a decrease in water quality (Edi Minarno et al., 2022).

Identification activity is an activity that continuous. This is caused by a pollutant source The identified water always develops over time depending on the dynamics of development, economic growth, social and cultural aspects of the local community (Lestari, 2018). However, in fact, the development of identification activities often limited by time and resource constraints (Gusti Wibowo et al., 2023). Based on this, it is necessary to determine the sources of pollutant contributing to the pollutant and the amount of pollutant load in the Wai Batu Merah watershed which will later be used as a monitoring point in efforts to manage river pollution in the Wai Batu Merah watershed (Juwana & Nugroho, 2019).

This study aims to identify sources of pollution and determine the magnitude of the potential pollution load from pollutant sources in the Wai Batu Merah watershed, Sirimau District, Ambon City.

Methods

Study Locations and Research Procedures

This research was conducted in the Wai Batu Merah watershed in Sirimau District, Ambon City (Figure 1). Administratively, the Wai Batu Merah watershed is located in Sirimau District. Before carrying out the identification process, a river segment will be divided into 6 segments representing monitoring locations (Rezagama et al., 2020).

Segment division is carried out to divide the sampling area where the results are expected to represent the study population (Purwono et al., 2019). The division of river segments will be carried out by dividing the area of the Wai Batu

Merah watershed using mapping software (Arc.GIS 10.6) by 6 segments (Figure2).

The collection of data on pollutant sources was obtained from direct survey results using the saturation sampling method or census which is guided by the Regulation of the Minister of State for the Environment of the Republic of Indonesia Number 1 of 2010 concerning the management of water pollution control. to identify pollutant sources, both point sources and non - point sources in the Wai Batu Merah watershed (Negoro et al., 2021). point source and non-point source pollutants in the Wai Batu Merah watershed. To calculate the potential pollution load, there are 2 methods, namely direct and indirect measurement methods (IC-WRMIP, 2015). The direct calculation method uses data on the content and discharge of waste water from measurements in the field. Potential pollution load that can calculated using this direct method is the potential pollution load originating from industry, hotels, lodging, health facilities, MSMEs and domestic sources that have WWTP (Point Source).

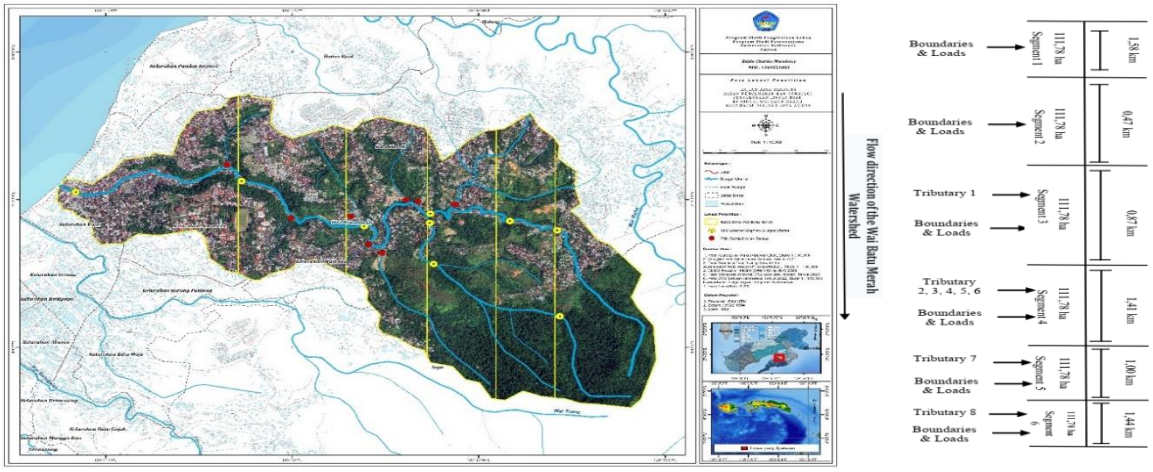

Figure 1. Map of Research Locations and River Segmentation in the Wai Batu Merah Watershed

While the indirect calculation method using the *effluent factor*, is used to estimate the pollution load from pollution sources which are difficult to measure the quality and quantity directly. Generally used to estimate the amount of pollution load from industry, hotels, inns, health facilities, MSMEs and domestic ones that do not have WWTPs (Mar'atusholikha et al., 2020).

Apart from that, as supporting data in determining pollutant sources in the Wai Batu Merah watershed, questionnaires and structured interviews will be distributed. Questionnaires will be distributed to each member of the local environmental unit (SLS) and key figures in villages/kelurahans that are included in the Batu Merah watershed (Syuhada et al., 2023). Apart from that, the distribution of questionnaires and interviews will also be carried out at related environmental institutions (Rosanka et al., 2021).

Data analysis

Source of Pollution

Data resulting from the identification of sources of pollution will be classified based on the Regulation of the Minister of State for the Environment of the Republic of Indonesia No. 1 of 2010, concerning guidelines for the management of water pollution, namely *Non Point Sources* (NPS) in the form of domestic waste, agriculture, animal husbandry, micro, small and medium enterprises, small scale industries and other sources whose waste flows in integrated channels or has WWTP (Wastewater Disposal Installation) and *Point Sources* (PS) in the form of industrial waste water or other sources that have an WWTP (Wastewater Disposal Installation) (Haryanto, 2018).

Based on the results of the identification of the divided river segments, a mapping of the distribution of pollutant sources in the Wai Batu Merah watershed will be carried out using mapping software (Arc. GIS 10.6).

Pollution Load

Point Source Pollutant Load

point source pollution load will be calculated based on the inventory guidelines and identification of water pollutant sources in Attachment I to the Regulation of the Minister of State for the Environment of the Republic of Indonesia Number 01 of 2010 with the following equation:

I,i = Ci x V x OpHrs /1 ,000,000

Information :

I,i = the i-th pollutant load/emission, kg/year

Ci = concentration of pollutant type i in wastewater discharge, mg/L (monitoring data in the field)

V = wastewater discharge flow rate, L/hour

OpHrs = number of operating hours per year, hours/year

1000,000 = conversion factor, (mg to kg)

Non-Point Source Pollutant Load

Potential Pollution Load in Domestic/Residential Areas

The potential for domestic/residential pollution loads can be calculated using the following equation (Indonesian Water Environment Agency - Center for Research and Development of Water Resources, 2015):

PBP = Population x Effluent Factor x α x Ek ratio.

Information :

PBP = Potential domestic pollution load (Kg/Day)

Population density = Population per unit area (people)

Effluent factor = *Effluent factor* (gr/person/day) (**Table 1**)

α = Load Transfer Coefficient (Delivery Load) (**Table 2**)

Eq ratio = City equivalent ratio (Discharge Load) (**Table 3**).

Table 1. Effluent factors for domestic pollutant sources

Sources of Water Pollution	Effluent Factor (g/person/day)		
	BOD	COD	TSS
Unprocessed Liquid Waste	53	101.6	38
Use Septic Tanks	12,6	24,2	18

Table 2. Load Transfer Ratio (Delivery Load)

No.	Settlement Distance from River (m)	A
1	0 – 100	1
2	100 – 500	0.85
3	> 500	0.3

Table 3. City Equivalent Ratio (Discarge Load)

No.	Segment Existence	Ek ratio
1	City	1
2	Suburbs	0.8125
3	Outback	0.625

Livestock Pollutant Load Potential

The potential pollution load from livestock can be calculated by the equation (Indonesian Water Environment Agency - Center for Research and Development of Water Resources, 2015):

PBP = Number of Livestock x Effluent Factor x 20%

Information: PBP = Potential livestock pollution load (kg/day)

Potential Agricultural Pollution Load and Other Uses

The potential pollution load for agriculture and other land uses will be used in the equation (Indonesian Water Environment Agency - Center for Research and Development of Water Resources, 2015).

PBTN Per Planting Season = Land Area x Effluent Factor x 1%

PBTN (kg/day) = PBTN per growing season / Number of days of growing season

PNPS (Forest or built-up land) = Land Area x Effluent factor x 1%

Table 4. Livestock Effluent Factor (Generation Load)

g/livestock/day	Cow	Buffalo	Horse	Pig	Sheep	Goat	Chicken	Swan	Duck
BOD	292	207	226	128	34,1	34,1	2.36	2.46	0.88
COD	717	530	558	362	92.9	92.9	5.59	6,67	2,22

Table 5. Agricultural Effluent Factors

Parameters (kg/ha/planting season)	Ricefield	Palawija	Other Plantations Mixed Farmland
BOD	225	125	32.5
TSS	0.46	2,4	1,6

Note: The COD parameter value is obtained from the BOD x 1.5 parameter value

Table 6. Effluent Factors for Other Land Uses

Parameter	Forest (kg/ha/day)	Built-up Area (kg/ha/day)
BOD	9,32	15,34

Information: The COD parameter value is obtained from the BOD x 1.5 parameter value
Information:
PBTN = Potential Agricultural Pollution Load (Kg/day)
PBPS = Potential Pollution Load for Other Land Uses (Kg/day)

Potential Pollution Burden of Hotels and Health Facilities

Potential Pollution Load for Hotels and Health Facilities can be calculated by the equation (Indonesian Water Environment Agency - Center for Research and Development of Water Resources, 2015):
PBP Hotel = Number of rooms x Effluent Factor
Health Facility PBP = Number of Mattresses or beds x Effluent Factor
Information :
PBP = Potential Pollution Load (Kg/day)

Potential Pollution Burden of Small Scale Industry and Micro, Small and Medium Enterprise Activities

Pollution Load Potential for Small Scale Industries and micro, small and medium enterprises will be calculated based on the effluent factor approach. The potential pollutant load for small-scale industries will refer to the equation approach from the Directorate General of Pollution Control and Environmental Damage, Ministry of Environment and Forestry of the Republic of Indonesia (2015) in Table 8. Meanwhile, micro, small and medium business activities are divided into laundry businesses, workshops, restaurants, car/motorcycle washes and the food industry.

Pollution loads from micro, small and medium business activities that do not have WWTPs will be calculated based on the effluent factor approach from several journals on similar activities as written by Aminatun et al (in Susilowati et al., 2020) for laundry pollution loads in Table 9, Sumadi for pollution loads workshop in Table 10, Mardianto et al (in Dwiyitno, Sturm, Januar, & Schuhen, 2021) for restaurant pollution loads and the resulting discharge taken from the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 68 of 2016 in table 11 , Setiawan et al (in Surya et al., 2023) for car/motorcycle washing pollution loads in Table 12, for pollution loads from the food industry in Table 13.

Potential Garbage Pollution Load

Garbage Load

The total waste load per district is calculated using the following formula (Directorate General of Pollution Control and

Environmental Damage, Ministry of Environment and Forestry of the Republic of Indonesia, 2015): Waste load (kg/day) = Weight of waste/person/day x populationIf the data is in volume units, the weight of the waste is calculated using the formula.

Table 7. Hotel and Health Facilities Effluent Factors

Source of Pollutants	*Effluent* Factor _		
	BOD	COD	TSS
Health Facilities (Per bed/mattress)	123	169,125	116.85
Hotel/Inn (per room)	55	75,625	52,25

Table 8. Factors Effluent Small Scale Industry

Type of activity	Pollution Load (kg/day)		
	BOD	COD	TSS
Soybean Processing	50	110	80
Tapioca Processing	3.34	10.30	4.67

Table 9. Laundry Pollution Load

Type of activity	Concentration (mg/L)			Discharge (L/day)	Pollution Load (kg/day)		
	BOD	COD	TSS		BOD	COD	TSS
laundry	560	1084	182	6566	3.68	7.12	1.20

Table 10. Potential Workshop Pollution Load

Type of activity	Concentration (mg/L)			Discharge (L/day)	Pollution Load (kg/day)		
	BOD	COD	TSS		BOD	COD	TSS
Workshop	-	88.6	47	200	-	0.01777	0.0094

Table 11. Potential Restaurant Pollution Load

Type of activity	Concentration (mg/L)			Discharge (L/day)	Pollution Load (kg/day)		
	BOD	COD	TSS		BOD	COD	TSS
Restaurant	118.64	603	312	100	0.0118	0.0603	0.0312

Table 12. Potential Car/Motorcycle Washing Pollution Loads

Type of activity	Concentration (mg/L)			Discharge (L/day)	Pollution Load (kg/day)		
	BOD	COD	TSS		BOD	COD	TSS
Car/Motorcycle Wash	44.52	82.54	46	2450	0.11	0.2	0.11

Table 13. Potential Pollution Load in the Food Industry

Type of activity	Concentration (mg/L)			Discharge (L/day)	Pollution Load (kg/day)		
	BOD	COD	TSS		BOD	COD	TSS
Food industry	392.5	188.5	371.5	640	0.25	0.12	0.24

Waste weight (kg) = specific gravity (kg/l) x waste volume
Specific gravity of organic waste = 0.61 kg/l (Kastaman, 2006).

Garbage is not handled

The weight of untreated waste is calculated using the following formula: Weight of

untreated waste (kg/day) = % of untreated wastex Trash load

Garbage Pollution Burden

Research conducted by Inegi and Semarnap in Fadly (in Lee et al., 2020) states that 1 kg of organic waste has a BOD value of 2.82 gr. This value represents the BOD load of the waste. Calculation of potential waste load is calculated by the following formula: Waste BOD load (kg/day) = Waste (kg/day) x (2.82/1000). The COD value is calculated using assuming COD = 1.375 x BOD, while TSS = 0.95 x BOD

Total Pollution Load

Pollution load recapitulation is carried out in several stages as follows (Directorate General of Pollution Control and Environmental Damage, Ministry of Environment and Forestry of the Republic of Indonesia, 2015):
Total Water Pollution Load = BP Industry + BP + BP Micro, Small and Medium Enterprises + BP domestic + BP livestock + BP non-point source land + BP Garbage
Information : BP = Pollution Load

Results and Discussion

Results of Identification of Sources of Pollution in the Wai Batu Merah Watershed based on the research results, it is known that the sources of pollutant originating from waste disposal by various types of activities are classified as point sources and non-point sources in the Wai Batu Merah watershed based on the guidelines of the Regulation of the Minister of State for the Environment of the Republic of Indonesia No. 1 of 2010 concerning guidelines for the management of water pollution control. The results of this study were also supported by analysis of secondary data and interviews with the head of the local environmental unit, Village and urban village officials in the Wai Batu Merah watershed, other types of activities in the Wai Batu Merah watershed and agencies in charge of process control and management. environmental pollution.

Based on the results of the identification of pollutant sources, the pollutant sources that dominate the Wai Batu Merah watershed are non-point sources, especially those from domestic sources (residential areas) which are spread over 6 segments in the Wai Batu Merah watershed. In addition, pollutant sources were also found coming from other non-point sources in the form of sources from agricultural and livestock businesses, non-point sources of land (forests and open land), micro, small and medium enterprises (MSMEs), Small Scale Industries and pollutant sources originating from waste generation.

The point sources found at the research location are in the form of point sources for hotel activities and other health facilities that have an WWTP (Wastewater Treatment Plant). The point sources are the Grand Avira Hotel in the Rijali Village and the Waihoka Village Health Center. Both of these sources use WWTP (Wastewater Management Installation) in the processing of the domestic wastewater produced, so that they are classified as point sources. For other point sources, such as large industries, they were not found at the research location. The results of the identification of pollutant sources divided by river segmentation in the Wai Batu Merah watershed are described as follows:

Source of Pollutant Segment 1 of the Wai Batu Merah Watershed

Based on the results of research and interviews with the head of the local environmental unit adjacent to the river in the Wai Batu Merah watershed, the pollutant sources found in segment 1 are dominated by non-point sources in the form of domestic sources originating from community settlements. Apart from domestic non-point sources, there are also non-point sources originating from agricultural businesses in the area of RT 006 RW 017 Batu Merah Village with an area of 0.05 Ha which is cultivated by one family. The agricultural commodities cultivated are secondary crops with types of plants, namely cassava, pineapple and other tubers such as taro and sweet potato.

Non-point sources in segment 1 based on the results of the delineation of the boundaries of the Wai Batu Merah watershed and the boundaries of the local environmental units (RT and RW) in Table 14. Then the domestic non-point sources in segment 1 are dominated by the activity of domestic waste from the people of Batu Merah Village with a total

population of 5661 people with an area of 0.435 km^2. The local environmental unit with the highest population in segment 1 of the Wai Batu Merah watershed is in RT 005 RW 017 with a total of 1776 people while the lowest is in RT 012 RW 017 with a total of 663 people while the local environmental unit with the widest area is in segment 1 of the Wai Batu watershed Red is RT 012 RW 017 with an area of 0.215 km^2 while the lowest is RT 004 RW 017 with an area of 0.011 km^2.

Pollutant Sources Segment 2 of the Wai Batu Merah Watershed

Pollutant sources found in segment 2 are non-point sources originating from agricultural, livestock and domestic non-point sources originating from community settlement activities. Non-point agricultural sources come from agricultural activities in the area of RT 004 RW 016 Negeri Batu Merah which are cultivated by 3 families with an agricultural land area of 0.05 ha per family

The agricultural land of the agricultural land owner RT 004 RW 016 is located in the Arbes Forest area and RT 009 RW 018 respectively. The agricultural commodities cultivated are secondary crops with plant types namely cassava, pineapple and other tubers such as taro and sweet potato. In addition, agricultural activities were also found in the area of RT 008 RW 017 Batu Merah Village which was cultivated by 3 families with an agricultural land area of 0.02 ha per family. The agricultural commodities cultivated are secondary crops with types of plants, namely cassava, pineapple and other tubers such as taro and sweet potato. Apart from agricultural sources, the pollutant source was also found from the livestock business in segment 2 RT 008 RW 017 Batu Merah Village which is cultivated by 4 families. The type of livestock cultivated is pigs with a total of 25 pigs per household.

Whereas for domestic non-point sources in segment 2, as shown in Table 15, it is dominated by the activities of domestic exiles from the people of Batu Merah Village with a total population of 2091 people with an area of 0.181 Km^2. The local environmental unit with the highest population in segment 2 of the Wai Batu Merah watershed is in RT 001 RW 019 with a total of 696 people while the lowest is in RT 006 RW 019 with a total of 291 people while the local environmental unit with the widest area is in segment 2 of the Wai Batu Merah watershed is RT 008 RW 017 with an area of 0.190 km^2 while the lowest is RT 001 RW 019 with an area of 0.027 km^2.

Table 14. Total population and area Local Environmental Units in Villages in Segment 1 of the Wai Batu Merah Watershed.

No.	Name of Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
1.	Batu Merah	RT 003 RW 017	942	0.040
		RT 004 RW 017	1611	0.011
		RT 005 RW 017	1776	0.068
		RT 006 RW 017	669	0.101
		RT 012 RW 017	663	0.215
Amount			**5661**	**0.435**

Source: Data from Batu Merah Village and the delineation results of the Wai Batu Merah watershed, 2023

Table 15. Total population and area Local Environmental Unit on Villages in Segment 2 of the Wai Batu Merah Watershed

No.	Name of Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
1.	Batu Merah	RT 008 RW 017	540	0.190
		RT 001 RW 019	696	0.027

No.	Name of Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
		RT 003 RW 019	564	0.062
		RT 006 RW 019	291	0.070
Amount			**2091**	**0.181**

Source: Data from Batu Merah Village and the delineation results of the Wai Batu Merah watershed, 2023

Source of Pollutants Segment 3 of the Wai Batu Merah Watershed

Pollutant sources found in the segment are non-point sources originating from agricultural, animal husbandry, MSME business activities and non-point sources originating from domestic sources in community settlements. Agricultural sources are in the area of RT 008 RW 017 Batu Merah Village which is cultivated by 1 family with an agricultural land area of 0.02 ha. The agricultural commodities cultivated are secondary crops with types of plants, namely cassava, pineapple and other tubers such as taro and sweet potato. The pollutant source from the livestock business in segment 3 comes from a pig farm operated by 6 families in the area of RT 008 RW 017 Batu Merah Village with 25 pigs per family.

Apart from that, livestock business is also found in the area of RT 004 RW 016 Batu Merah Village with 15 goats as the type of livestock. Sources originating from micro, small and medium enterprises (MSMEs) were found to be in the area of RT 004 RW 016 Batu Merah Village, namely 3 workshop units, a restaurant and a car wash. Types of MSME pollutant sources in segment 3 can be seen in table 16. Meanwhile, domestic non-point sources in segment 3, as shown in Table 17, are still dominated by residents from Batu Merah Village with a total population of 7,743 people with an area of 0,770 km^2. The local environmental unit with the highest population in segment 3 of the Wai Batu Merah watershed is in RT 004 RW 016 with a total of 4230 people while the lowest is in RT 009 RW 018 with a total of 189 people while the local environmental unit with the widest area is in segment 3 of the Wai Batu watershed The red one is RT 003 RW 016 with an area of 0.329 km^2 while the lowest is RT 008 RW 018 with an area of 0.007 km^2.

Table 16. Micro, Small and Medium Enterprises (MSMEs) which are classified as pollutant sources in Segment 3 of the Wai Batu Merah Watershed

No.	MSME owners	Types of MSMEs
1	Adelia Motor	Workshop
2	ATL Motors	Workshop
3	Batu Putih	Workshop
4	Padang Ampera Restaurant	Restaurant
5	Dua Bersaudara	Car wash

Table 17. Total population and area Local Environmental Units in Villages in Segment 3 of the Wai Batu Merah Watershed

No.	Name of Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
1	Batu Merah	RT 003 RW 016	336	0.329
		RT 004 RW 016	4230	0.109
		RT 005 RW 016	252	0.087
		RT 001 RW 018	546	0.015
		RT 004 RW 018	321	0.060
		RT 005 RW 018	825	0.081

No.	Name of Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
		RT 008 RW 018	1044	0.007
		RT 009 RW 018	189	0.082
Amount			**7743**	**0.770**

Source: Data from Batu Merah Village and the delineation results of the Wai Batu Merah watershed, 2023

Pollutant Sources of Segment 4 of the Wai Batu Merah Watershed

Pollutant sources found in segment 4 are non-point sources originating from domestic residential activities and 1 point source originating from health facilities, namely the Waihoka Health Center. Soya Village, Batu Merah Village and Waihoka Urban Village are part of the domestic non-point sources in segment 4 of the Wai Batu Merah watershed. In Table 18, the total population in segment 4 is 6852 people with an area of 0.763 Km^2. The largest population is in Batu Merah Village, 83% of the total population in segment 4. The local environmental unit with the highest population in segment 4 of the Wai Batu Merah watershed is Batu Merah Village, namely RT 004 RW 021 with a total of 1107 people, while the lowest is in the Waihoka Urban Village, namely RT 002 RW 04 with a total of 135 people. While the local environmental unit with the widest area in segment 4 of the Wai Batu Merah watershed is in Batu Merah Village, namely RT 002 RW 013 with an area of 0.121 km^2 while the lowest is also in Batu Merah Village, namely RT 003 RW 021 with an area of 0.00004 km^2.

Pollutant Sources of Segment 5 of the Wai Batu Merah Watershed

Pollutant sources found in segment 5 are dominated by non-point sources in the form of livestock businesses and domestic non-point sources originating from residential communities. The source of livestock contaminants in segment 5 is in the area of RT 003 RW 014 Batu Merah Village which is managed by 6 families. The type of livestock being cultivated is chicken with a total of 15 chickens per family. In addition, in the same local environmental unit area, there is one family that runs a goat farming business with a total of 14 goats.

Meanwhile, domestic non-point sources in segment 5 of the Wai Batu Merah watershed as shown in Table 19 are dominated by residents of Batu Merah Village, Waihoka and Amantelu Urban Villages. The total population in segment 5 is 11,454 people with an area of 1,170 km^2. The local neighborhood unit with the highest population in segment 5 of the Wai Batu Merah watershed is Batu Merah Village, namely RT 006 RW 009 with a total of 912 people, while the lowest is in the Waihoka Urban Village, namely RT 002 RW 03 with a total of 93 people. Meanwhile, the local environmental unit with the largest area in segment 5 of the Wai Batu Merah watershed is in Amantelu Urban Village, namely RT 005 RW 05 with an area of 0.135 km^2 while the lowest is in Waihoka Village, namely RT 003 RW 02 with an area of 0.00001 km^2.

Table 18. Total population and area Local Environmental Units in Villages and Urban Village in Segment 4 of the Wai Batu Merah Watershed

No.	Name of Village and Urban Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
1	Soya	RT 01 RW 07	219	0.13
		RT 02 RW 07	195	0.03
		RT 04 RW 07	168	0.02
2	Batu Merah	RT 002 RW 013	624	0.121
		RT 003 RW 013	591	0.094
		RT 001 RW 016	339	0.054

No.	Name of Village and Urban Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
		RT 002 RW 016	627	0.064
		RT 002 RW 018	627	0.001
		RT 006 RW 018	594	0.027
		RT 001 RW 021	651	0.044
		RT 003 RW 021	537	0.00004
		RT 004 RW 021	1107	0.026
3	Waihoka Urban Village	RT 004 RW 02	204	0.060
		RT 002 RW 04	135	0.011
		RT 003 RW 04	234	0.081
Amount			**6852**	**0.763**

Source: Soya and Batu Merah Village and Waihoka Urban Village data and the delineation results of the Wai Batu Merah watershed, 2023

Table 19. Total population and area Local Environmental Units in Villages and Urban Village in Segment 5 of the Wai Batu Merah Watershed

No.	Name of Village and Urban Village	Name of Local Environmental Unit	Number of Population (people)	Area (km ^{2})
1.	Batu Merah	RT 001 RW 009	696	0.095
		RT 002 RW 009	552	0.018
		RT 003 RW 009	618	0.011
		RT 004 RW 009	717	0.067
		RT 005 RW 009	585	0.049
		RT 006 RW 009	912	0.026
		RT 007 RW 009	312	0.019
		RT 008 RW 009	531	0.057
		RT 010 RW 009	402	0.019
		RT 001 RW 013	582	0.076
		RT 003 RW 014	417	0.097
		RT 001 RW 015	291	0.006
		RT 006 RW 016	450	0.117
2.	Waihoka Urban Village	RT 001 RW 01	168	0.022
		RT 002 RW 01	171	0.024
		RT 003 RW 01	183	0.047
		RT 001 RW 02	267	0.009
		RT 002 RW 02	165	0.013
		RT 003 RW 02	186	0.00001
		RT 001 RW 03	393	0.063
		RT 002 RW 03	93	0.007
		RT 003 RW 03	234	0.017
		RT 004 RW 03	201	0.014
		RT 005 RW 03	459	0.023
		RT 001 RW 04	198	0.007
3.	Amantelu Urban Village	RT 003 RW 04	276	0.053
		RT 003 RW 05	522	0.070
		RT 004 RW 05	339	0.003
		RT 005 RW 05	396	0.135
		RT 006 RW 05	138	0.006
Amount			**11454**	**1,170**

Source: Data from Batu Merah Village, Waihoka and Amantelu Urban Villages and the delineation results of the Wai Batu Merah watershed, 2023

Pollutant Sources of Segment 6 of the Wai Batu Merah Watershed

Pollutant sources found in segment 6 are non-point sources originating from livestock activities, SMEs, Small Scale Industries and non-point sources originating from domestic activities in community settlements. Apart from that, one point source was also found that came from hospitality activities, namely the Grand Avira Hotel in Rijali Urban Village. The non-point source livestock business segment 6 comes from chicken farms managed by 6 families in the area of RT 002 RW 014 Batu Merah Village with 15 chickens for each 5 families while 1 other family with a total of 135 chickens.

Sources originating from micro, small and medium enterprises (MSMEs) are located in 3 areas of the local environmental unit (SLS), namely RT 001 RW 001 and RT 003 RW 001 in Batu Merah Village and RT 02 RW 02 in Rijali Urban Village. The types and number of MSME pollutant sources in segment 6 can be seen in Table 20. Whereas non-point sources originating from small-scale industries, are in 2 local environmental unit areas, namely in the area of RT 003 RW 001 in Batu Merah Village and RT 02 RW 02 in Rijali Urban Village. The source of the pollutant comes from small-scale industries, namely soybean processing and tapioca processing. Types of Small Scale Industry pollutant sources in segment 6 can be seen in Table 21. For non-point sources originating from domestic activities can be seen in Table 22. Batu Merah Village, the Urban Villages of Amantelu, Karang Panjang and Rijali are part of the domestic non-point source segment 6 of the Wai Batu Merah watershed. The total population in segment 6 is 30,129 people with an area of 1,205 km^2. The local neighborhood unit with the highest population in segment 6 of the Wai Batu Merah watershed is in Rijali Urban Village, namely RT 03 RW 01 with a total of 3792 people, while the lowest is in Batu Merah Village, namely RT 002 RW 014 and Amantelu Urban Village, namely RT 003 RW 02 with a population 96 souls each. Meanwhile, the local environmental unit with the largest area in segment 6 of the Wai Batu Merah Watershed is in the Amantelu Urban Village, namely RT 003 RW 014 with an area of 0.097 km^2 while the lowest is in the Village, namely RT 003 RW 03 with an area of 0.000007 km^2.

Table 20. Micro, Small and Medium Enterprises (MSMEs) which are classified as pollutant sources in Segment 6 of the Wai Batu Merah Watershed

No.	MSME owners	Types of MSMEs	MSMEs Location
1.	Adela Laundry	Laundry	RT 001 RW 001 Batu Merah Village
2.	Warung Tempel	Restaurant	RT 02 RW 02 Rijali Urban Village
3.	Warung Beta Mardika	Restaurant	RT 02 RW 02 Rijali Urban Rijali
4.	UD. Dewi	Food Processing	RT 003 RW 001 Batu Merah Village
5.	UD. Tanto	Food Processing	RT 003 RW 001 Batu Merah Village
6.	UD. Sumber Rejeki	Food Processing	RT 003 RW 001 Batu Merah Village
7.	CV. Hilyah Bakery	Food Processing	RT 001 RW 001 Batu Merah Village

Source: Research Results, 2023

Table 21. Types of Small Scale Industrial Pollutants in Segment 6 of the Wai Batu Merah Watershed

No.	Small Scalle Industrial owners	Small Scalle Industrial type
1	UD. Chandra	Processing of Soybeans
2	CV. Sarwo Abadi	Processing of Soybeans
3	UD. Riska	Processing of Soybeans
4	UD. Iskandar	Processing of Soybeans
5	UD. Mie Basah Fa'i	Tapioca Starch Processing

Source: Research Results, 2023

Table 22. Total population and area Local Environmental Units in Villages and Urban Village in Segment 6 of the Wai Batu Merah Watershed

No.	Name of Village and Urban Village	Name of Local Environmental Unit	Number of Population (Person)	Area (Km ^{2})
1	Batu Merah	RT 001 RW 001	387	0.009
		RT 002 RW 001	462	0.008
		RT 003 RW 001	579	0.008
		RT 004 RW 001	1737	0.011
		RT 001 RW 002	579	0.005
		RT 002 RW 002	1173	0.001
		RT 001 RW 003	537	0.010
		RT 002 RW 003	258	0.007
		RT 003 RW 003	294	0.010
		RT 004 RW 003	333	0.031
		RT 001 RW 004	354	0.003
		RT 002 RW 004	345	0.006
		RT 003 RW 004	477	0.008
		RT 002 RW 006	510	0.021
		RT 003 RW 006	282	0.028
		RT 004 RW 006	1227	0.004
		RT 005 RW 006	390	0.019
		RT 006 RW 006	480	0.058
		RT 001 RW 008	765	0.006
		RT 002 RW 008	486	0.007
		RT 003 RW 008	354	0.027
		RT 004 RW 008	405	0.037
		RT 005 RW 008	420	0.024
		RT 001 RW 014	249	0.009
		RT 002 RW 014	96	0.026
		RT 003 RW 014	294	0.097
		RT 004 RW 014	270	0.026
2	Amantelu Urban Village	RT 001 RW 01	402	0.078
		RT 002 RW 01	231	0.031
		RT 003 RW 01	543	0.024
		RT 001 RW 02	351	0.007
		RT 002 RW 02	546	0.010
		RT 003 RW 02	96	0.014
		RT 004 RW 02	228	0.010
		RT 001 RW 03	135	0.007
		RT 002 RW 03	240	0.007
		RT 003 RW 03	186	0.006
		RT 001 RW 04	252	0.085
		RT 002 RW 04	231	0.029
		RT 001 RW 05	405	0.043
		RT 002 RW 05	240	0.054
		RT 003 RW 05	522	0.070
		RT 001 RW 06	444	0.011
		RT 002 RW 06	678	0.020
3	Karang Panjang Urban Village	RT 01 RW 01	243	0.031
		RT 02 RW 01	228	0.020

No.	Name of Village and Urban Village	Name of Local Environmental Unit	Number of Population (Person)	Area (Km ^{2})
		RT 03 RW 01	189	0.006
		RT 04 RW 01	279	0.0004
4	Rijali Urban Village	RT 03 RW 01	3792	0.001
		RT 04 RW 01	1599	0.037
		RT 01 RW 02	231	0.006
		RT 02 RW 02	297	0.013
		RT 03 RW 02	672	0.011
		RT 04 RW 02	885	0.018
		RT 01 RW 03	264	0.000011
		RT 02 RW 03	354	0.000284
		RT 03 RW 03	480	0.000007
		RT 01 RW 05	261	0.001
		RT 02 RW 05	303	0.011
		RT 03 RW 05	240	0.017
		RT 04 RW 05	339	0.020
Amount			**30129**	**1.205**

Source: Data from Batu Merah Village, Waihoka and Amantelu Urban Villages and the delineation results of the Wai Batu Merah watershed, 2023

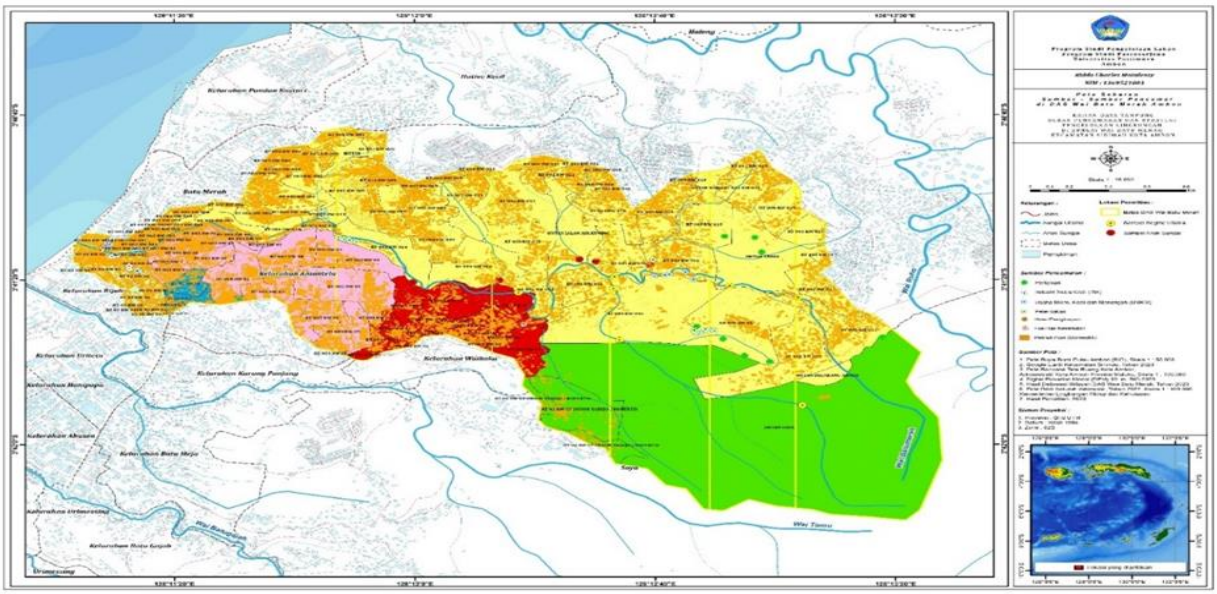

Figure 2. Pollution Load in the Wai Batu Merah Watershed

Pollutant Load Segment 1

Based on the results of the identification of pollutant sources, it is known that segment 1 is dominated by sources of pollution from non-point sources . Based on the data in table 23 , it is known that the total contribution of pollutant load in segment 1 for BOD parameters is 108.38 kg/day, COD is 149.98 kg/day and TSS is 95.72 kg/day. The non-point source with the largest pollutant load contribution in segment 1 of the Wai Batu Merah watershed is the non-point source of waste with a pollutant load contribution for the BOD parameter of 65.48 kg/day with a contribution of 60.42%, COD of 90.03 kg/day with a contribution of 60.03 % and TSS of 62.20 kg/day with a contribution of 64.98% (Prihatiningsih, Kusuma, Suharyanto, & Leksono, 2019).

While non-point The source with the lowest pollutant load contribution is non-point source agriculture with a pollutant load value for the BOD parameter of 0.004 kg/day with a contribution of 0.004%, COD of 0.01 kg/day with a contribution of 0.01% and TSS of 0.0001 kg/day with contribution of 0.0001%.When connected with the results of identifying pollutant sources, the contribution of pollutant sources that contribute to waste in segment 1 is from the Batu Merah Village which is dominated by settlements and open areas. Domestic waste originates from households where a number of waste is disposed of into sewers or public waters (Purwendah & Periani, 2019).

Based on the results of interviews with the surrounding community, it is known that the condition of waste management in this area is very apprehensive where as much as 50% of the amount of waste generated is disposed of in the river area and another 50% is accommodated in public waste disposal sites which are close to the large water bridge which is close to segment 2. Based on this information, it can be seen that there is a link between the behavior of disposing of garbage from the community and the amount of pollutant load originating from the leachate produced by the waste. When leachate reaches a water source, it can cause pollution to the water source (Aljaradin & Peerson, 2012).The decomposition process of organic waste will produce waste water which is often called

Table 23. Pollutant Load and the Contribution of Pollutant Sources from Non - Point Sources in Segment 1 of the Wai Batu Merah Watershed

No.	Source Type *Non-Point Source*	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	35.28	32.55	48.52	32.35	33.52	35.02
2	Agriculture	0.004	0.004	0.01	0.01	0.0001	0.0001
3	Farm	-	-	-	-	-	-
4	*Non-Point Source* land	7.62	7.03	11.42	7.61	-	-
5	MSMEs	-	-	-	-	-	-
6	Small Scalle Industrial	-	-	-	-	-	-
7	Rubbish	65.48	60.42	90.03	60.03	62.2	64.98
Total		**108.38**	**100**	**149.98**	**100**	**95.72**	**100**

Source: Analysis Results, 2023

Leachate. Leachate contains organic and inorganic chemicals as well as a number of pathogenic bacteria, which have the potential to cause pollution to river water and the environment, and humans. Leachate contaminants are carried by the movement of water through the soil, contaminating soil, groundwater and river water. Putra et al (in Surya et al., 2023) stated that leachate contains very high concentrations of pollutants, one of which is BOD and COD.

The lack of public awareness of the disposal of domestic waste and garbage has contributed to the pollutant load, especially non-point source solid waste and domestic waste in the segment 1 area of the Wai Batu Merah watershed.

Pollutant Load Segment 2

Based on the results of the identification of pollutant sources, it is known that segment 2 is dominated by sources of pollution from non-point sources . In Table 24, it can be seen that the total contribution of pollutant load in segment 2 for BOD parameters is 27.57 kg/day, COD is 48.12 kg/day and TSS is 13.15 kg/day. non-point source with the largest contribution to pollutant load in segment 2 of the Wai Batu Merah watershed is a domestic non-point source (settlements) with a contribution of pollutant load to the BOD parameter of 11.76 kg/day with a contribution of 42.66%, COD of 16.17 kg/day with contribution of 33.60% and TSS of 11.17 kg/day with a contribution of 89.94%.

Deficiencies in domestic waste management and the prevailing human behavior indirectly dispose of organic and inorganic waste as well as solid and liquid waste into water bodies, have increased the level of water pollution and reduced water quality (Nguyen et al., 2022).

Meanwhile, the non-point source with the lowest pollutant load contribution was non-point source agriculture with a pollutant load value for the BOD parameter of 0.007 kg/day with a contribution of 0.03%, COD of 0.01 kg/day with a contribution of 0.02% and TSS of 0.0001 kg/day with a contribution of 0.001%.

The low contribution of pollutant load in segment 2 is caused by the high forest standing dominated by Arbes (Air Besar) area which causes the self-purification process to occur. Although this process did not significantly reduce river quality parameters in the segment 2 area of the Wai Batu Merah watershed. Naturally, water systems are capable of carrying out a self-purification process or can be interpreted as the ability of the environment to recover or return to its original state from the pollution load that has entered. This ability explains why river water quality tends to be good when it reaches downstream.

Table 24. Pollutant Load and Contribution of Pollutant Sources from Non - Point Sources in Segment 2 of the Wai Batu Merah Watershed

No.	Source Type *Non-Point Source*	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	11.76	42.66	16.17	33.60	11.17	84.94
2	Agriculture	0.007	0.03	0.01	0.02	0.0001	0.001
3	Farm	6.4	23.21	18.1	37.61	-	-
4	*Non-Point Source* land	7.32	26.55	11	22.82	-	-
5	MSMEs	-	-	-	-	-	-
6	Small Scalle Industrial	-	-	-	-	-	-
7	Rubbish	2.08	7.54	2.86	5.94	1.98	15.06
Total		**27.57**	**100**	**48.12**	**100**	**13.15**	**100**

Source: Analysis Results, 2023

Pollutant Load Segment 3

non-point sources . In Table 25, it can be seen that the total contribution of pollutant load in segment 3 for BOD parameters is 60.52 kg/day, COD is 84.9 kg/day and TSS is 50.55 kg/day. Non-point sources with the largest contribution to pollutant load in segment 3 of the Wai Batu Merah watershed are domestic non-point sources (settlements) with a contribution of pollutant load to the BOD parameter of 38.67 kg/day with a contribution of 63.89%, COD of 53.18 kg/day with contribution of 62.64% and TSS of 36.74 kg/day with a contribution of 72.68%. The high load of domestic pollution is influenced by the contribution of pollutant sources from domestic non-point sources (settlements) from the headwaters of the Wai Batu Merah river in Batu Merah Village which accumulates and the contribution of pollutant from the surrounding tributary areas which are generally dominated by high residential areas. with the condition that the domestic sewage channel leads directly to the river.

Sources of water pollution originating from domestic waste generally come from residential areas. Liquid waste water originating from the results of human activities enters the waters through runoff originating from agricultural, residential and urban areas (Sinaga et al., 2020).

While the non-point source with the lowest pollutant load contribution is the non-point source agriculture with a pollutant load value for the BOD parameter of 0.013 kg/day with a contribution of 0.02%, COD of 0.02 kg/day with a contribution of 0.02% and TSS of 0.0002 kg/day with a contribution of 0.0004%.

Table 25. Pollutant Load and Contribution of Pollutant Sources from Non - Point Sources in Segment 3 of the Wai Batu Merah Watershed

No.	Source Type *Non-Point Source*	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	38.67	63.89	53.2	62.64	36.74	72.68
2	Agriculture	0.013	0.02	0.02	0.02	0.0002	0.0004
3	Farm	0.1	0.17	0.28	0.33	-	-
4	*Non-Point Source* land	7.26	12.00	10.9	12.83	-	-
5	MSMEs	0.12	0.20	0.79	0.93	0.17	0.34
6	Small Scalle Industrial	-	-	-	-	-	-
7	Rubbish	14.36	23.73	19.7	23.25	13.64	26.98
Total		**60.52**	**100**	**84.9**	**100**	**50.55**	**100**

Source: Analysis Results, 2023

Pollutant Load Segment 4

Based on the identification of pollutant sources, it is known that segment 4 is dominated by sources of pollution from non-point sources. In addition, this segment was found to be a point source of health facility activities, namely the Waihoka Health Center. In Table 26, it can be seen that the total contribution of pollutant load in segment 4 for BOD parameters is 104.47 kg/day, COD is 144.47 kg/day and TSS is 93.08 kg/day. The non-point source with the largest pollutant load contribution in segment 4 of the Wai Batu Merah watershed is the non-point source of waste with a pollutant load contribution for the BOD parameter of 65.09 kg/day with a contribution of 62.30%, COD of 89.5 kg/day with a contribution of 61.95 % and TSS of 61.84 kg/day with a contribution of 66.44%.

While the pollutant source with the lowest contribution to the pollutant load is the point source of health facilities with a pollutant load value for the BOD parameter of 0.0008 kg/day with a contribution of 0.001%, COD of 0.0017 kg/day with a contribution of 0.001% and TSS of 0.000017 kg/day with a contribution of 0.00002%.

Based on the results of interviews with the community around segment 4, it is known that the habit of residents living in the river area of disposing of waste directly into the river is 60% of the total community living around the tributary in segment 4. Based on this information, the high non-point pollution load The source of waste in segment 4 of the Wai Batu Merah watershed is caused by the accumulated waste pollutant load from segment 3 and the contribution of the waste pollution load from the surrounding tributary areas.

According to Komariyah and Sugito (2011), the characteristics of puskesmas wastewater that have hospitalizations are almost entirely similar to hospital wastewater. So that the health facilities waste can also be categorized as hospital waste. Based on the results of the study, the point source of the Waihoka Health Center does not have inpatient facilities. This results in a smaller pollutant load

Table 26. Pollutant Load and Contribution of Pollutant Sources from Point Sources and Non - Point Sources in Segment 4 of the Wai Batu Merah Watershed

No.	Types of Pollutant Sources	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	32.88	31.47	45.22	31.30	31.24	33.56
2	Agriculture	-	-	-	-	-	-
3	Farm	-	-	-	-	-	-
4	*Non-Point Source* land	6.5	6.22	9.75	6.75	-	-

No.	Types of Pollutant Sources	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
5	MSMEs	-	-	-	-	-	-
6	Small Scalle Industrial	-	-	-	-	-	-
7	Rubbish	65.09	62.30	89.5	61.95	61.84	66.44
8	*Point Source* – Health Facilities	0.0008	0.001	0.0017	0.001	0.000017	0.00002
Total		**104.47**	**100**	**144.47**	**100**	**93.08**	**100**

Source: Analysis Results, 2023

Pollutant Load Segment 5

Based on the identification of pollutant sources, it is known that segment 5 is dominated by non-point sources of pollution. In Table 27, it can be seen that the total contribution of pollutant load in segment 5 for BOD parameters is 615.57 kg/day, COD is 859.87 kg/day and TSS is 587.13 kg/day. The non-point source with the largest pollutant load contribution in segment 5 of the Wai Batu Merah watershed is the non-point source of waste with a pollutant load contribution for the BOD parameter of 523.66 kg/day with a contribution of 85.07%, COD of 732.41 kg/day with a contribution of 85.18 % and TSS of 506.03 kg/day with a contribution of 86.19%. Meanwhile, the non-point source with the lowest pollutant load contribution was non-point source livestock with a pollutant load value for the BOD parameter of 0.25 kg/day with a contribution of 0.04% and COD of 0.63 kg/day with a contribution of 0.07%.

Based on the results of interviews with the surrounding community in the segment 5 area, it is known that as many as 60% of the people who live in the river area dispose of waste directly into the river. Based on this information, the high non-point source pollution load of waste in segment 5 of the Wai Batu Merah watershed is caused by the accumulated waste pollutant load from segment 4 and the contribution of the waste pollution load from the surrounding children's areas. In general, pollutant sources enter rivers through tributaries and open channels and/or directly through runoff. The high concentration of these water quality parameters is probably caused by the large number of community activities that dispose of waste water at the riparian of tributaries (Rosanka et al., 2021).

Table 27. Pollutant Load and Contribution of Non - Point Source Pollutants in Segment 5 of the Wai Batu Merah Watershed

No.	Source Type *Non-Point Source*	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	85.37	13.87	117.39	13.65	81.1	13.81
2	Agriculture	-	-	-	-	-	-
3	Farm	0.25	0.04	0.63	0.07	-	-
4	*Non-Point Source* land	6.29	1.02	9.44	1.10	-	-
5	MSMEs	-	-	-	-	-	-
6	Small Scalle Industrial	-	-	-	-	-	-
7	Rubbish	523.66	85.07	732.41	85.18	506.03	86.19
Total		**615.57**	**100**	**859.87**	**100**	**587.13**	**100**

Source: Analysis Results, 2023

Pollutant Load Segment 6

Based on the results of the identification of pollutant sources, it is known that segment 6 is dominated by sources of pollution from non-point sources, besides that in this segment a point source was found from hotel activities,

namely the Grand Avira Hotel in Rijali Urban Village.

In Table 28, it can be seen that the total contribution of pollutant load in segment 6 for BOD parameters is 3223.15 kg/day, COD is 4604.35 kg/day and TSS is 3186.97 kg/day. The non-point source with the largest pollutant load contribution in segment 6 of the Wai Batu Merah watershed is the non-point source of waste with a pollutant load contribution for the BOD parameter of 2825.3 kg/day with a contribution of 87.66%, COD of 3884.78 kg/day with a contribution of 84.37 % and TSS of 2684.03 kg/day with a contribution of 84.22%.

While the non-point source with the lowest pollutant load contribution is non-point source land with a pollutant load value for the BOD parameter of 4.49 kg/day with a contribution of 0.14% and COD of 6.73 kg/day with a contribution of 0.15%.

the non-point source pollutant load of waste in segment 6 which causes a high pollution load for the BOD, COD and TSS parameters is not only caused by waste originating from segment 6 itself, but also the contribution of accumulated waste from segment 1 to segment 5 which is then buried in segment 6 as well as contributions from other sources such as non-point source micro, small and medium enterprises (MSMEs) and non-point source small scale industries which are spread across segment 6 in the Wai Batu Merah watershed.

Segment 6 is the segment with the highest residential area (60.36 Ha or 35% of the total area of the Wai Batu Merah Watershed) compared to the other segments. With the area of settlements and the high number of businesses and activities from MSME entrepreneurs and small-scale industries, offset by a lack of concern and awareness of the community and entrepreneurs around the Wai Batu Merah watershed who carry out domestic waste disposal activities consisting of graywater and blackwater waste and direct waste to the river body will make a high contribution in increasing the pollutant load which results in exceeding the pollutant load carrying capacity in the Wai Batu Merah watershed.

Garbage is waste generated from activities/businesses if it enters the environment without being processed first. The volume of solid waste and liquid waste that enters the river will increase along with the increase in population and activities by the community (Meutia et al., 2022).

With a relatively high residential area, the potential for waste and domestic waste generation from the community in the river will also be higher. A fixed area with an increasing population will cause more and more waste to be generated (Achmad et al., 2022).

Table 28. Pollutant Load and Contribution of Pollutant Sources to Non - Point Sources in Segment 6 of the Wai Batu Merah Watershed

No.	Source Type *Non-Point Source*	Pollutant Load (kg/day) and Amount of Contribution					
		BOD	Percentage (%)	COD	Percentage (%)	TSS	Percentage (%)
1	Domestic (Residential)	185.32	5.75	254.82	5.51	176.05	5.52
2	Agriculture	-	-	-	-	-	-
3	Farm	-	-	-	-	-	-
4	*Non-Point Source* land	4.49	0.14	6.73	0.15	-	-
5	MSMEs	4.7	0.15	7.72	0.17	2.22	0.07
6	Small Scalle Industrial	203.34	6.31	450.3	9.73	324.67	10.19
7	Rubbish	2825.3	87.66	3884.8	83.94	2684.03	84.22
8	*Point Source* – Hotels	17.82	0.55	23.82	0.51	0.029	0.001
Total		**3240.97**	**100**	**4628.19**	**100**	**3187**	**100**

Source: Analysis Results, 2023

Conclusion

From the research results, it can be concluded :

1. Based on the identification results, the pollutant sources in the Wai Batu Merah watershed are point sources originating from hotel and health facility activities and non-point sources originating from domestic activities from residential areas, agricultural and livestock businesses, non-point source land (forests and open land), micro, small and medium enterprises (MSMEs), small scale industries and waste. The dominant pollutant source in the Wai Batu Merah watershed comes from domestic non-point sources.
2. Point source pollution loads for BOD, COD and TSS parameters in the Wai Batu Merah watershed came from hotel activities in segment 6 with the contribution of each parameter of 17.82 kg/day, 23.82 kg/day and 0.029 kg/day. Meanwhile, the highest non-point source pollution load for the BOD, COD and TSS parameters came from non-point source waste in segment 6 with the contribution of each parameter of 2825.3 kg/day, 3884.8 kg/day and 2684.03 kg/day.

Suggestion

1. Further research is needed to identify pollutant sources and calculate the potential pollutant load in the rivers in Ambon City. So that it can be used as a basic reference for in-depth studies for the Ambon City Government in the context of developing data and determining pollution management strategies for watersheds in Ambon City.
2. The Environmental Service is obliged to increase monitoring efforts that focus on pollutant sources and pollution load contributions that focus on the local environmental units (RT and RW) as well as on the location of businesses and or activities around the Wai Batu Merah watershed.

References

Achmad, B., Sanudin, Siarudin, M., Widiyanto, A., Diniyati, D., Sudomo, A., … Ruswandi, A. (2022). Traditional Subsistence Farming Of Smallholder Agroforestry Systems In Indonesia: A Review. *Sustainability*, *14*(14), 8631. Https://Doi.Org/10.3390/Su14148631

Dwiyitno, D., Sturm, M. T., Januar, H. I., & Schuhen, K. (2021). Influence Of Various Production Methods On The Microplastic Contamination Of Sea Salt Produced In Java, Indonesia. *Environmental Science And Pollution Research*, *28*(23), 30409–30413. Https://Doi.Org/10.1007/S11356-021-14411-6

Edi Minarno, P., Suprapto, A., & Harsono. (2022). Pollution Load Capacity Of The Larangan/Premulung River Sukoharjo Regency, Central Java Province, Indonesia In 2020. *Iop Conference Series: Earth And Environmental Science*, *1016*(1), 012029. Https://Doi.Org/10.1088/1755-1315/1016/1/012029

Gusti Wibowo, Y., Tyaz Nugraha, A., & Rohman, A. (2023). Phytoremediation Of Several Wastewater Sources Using Pistia Stratiotes And Eichhornia Crassipes In Indonesia. *Environmental Nanotechnology, Monitoring & Management*, *20*, 100781. Https://Doi.Org/10.1016/J.Enmm.2023.100781

Haryanto, B. (2018). Climate Change And Urban Air Pollution Health Impacts In Indonesia. In *Climate Change And Air Pollution: The Impact On Human Health In Developed And Developing Countries* (Pp. 215–239). Springer. Https://Doi.Org/10.1007/978-3-319-61346-8_14

Ismail, S. H. (2017). *Abundance And Diversity Of Aquatic Insects In Relation To The Physico-Chemical Parameters In Several Rivers From Bukit Merah Catchment Area*. Universiti Sains Malaysia. Retrieved From Http://Eprints.Usm.My/Id/Eprint/45488

Jayanthi, B. (2018). *Bioaugmentation And Phytoremediation Of Heavy Metal From Leachate Contaminated Soil/Jayanthi Barasarathi*. University Of Malaya. Retrieved From Http://Studentsrepo.Um.Edu.My/Id/Eprint/12040

Juwana, I., & Nugroho, D. P. (2019). The

Improvement Of Cipunagara River Quality (Bod Parameter) Based On Pollution Load Analysis Of Domestic, Agriculture, Farming And Industrial Activities. *Iop Conference Series: Earth And Environmental Science*, *361*(1), 012031. Https://Doi.Org/10.1088/1755-1315/361/1/012031

Lawrencia, D., Maniam, G., Chuah, L. H., & Poh, P. E. (2023). Critical Review Of Household Water Treatment In Southeast Asian Countries. *Wires Water*, E1640. Https://Doi.Org/10.1002/Wat2.1640

Lee, K. K., Bing, R., Kiang, J., Bashir, S., Spath, N., Stelzle, D., … Shah, A. S. V. (2020). Adverse Health Effects Associated With Household Air Pollution: A Systematic Review, Meta-Analysis, And Burden Estimation Study. *The Lancet Global Health*, *8*(11), E1427–E1434. Https://Doi.Org/10.1016/S2214-109x(20)30343-0

Lestari, F. (2018). Pollution Charges And Assimilation Capacity In Tanjungpinang Bay Area, Riau Islands Province, Indonesia. *Asian Journal Of Water, Environment And Pollution*, *15*(1), 1–7.

Mar'atusholikha, V., Firmansyah, I., & Hamzah, H. (2020). Model Dynamic Of Water Quality Index Bod-Based In Indonesia. *Journal Of System Dynamics*, *1*(1), 34–41.

Meutia, A. A., Lumowa, R., & Sakakibara, M. (2022). Indonesian Artisanal And Small-Scale Gold Mining—A Narrative Literature Review. *International Journal Of Environmental Research And Public Health*, *19*(7), 3955. Https://Doi.Org/10.3390/Ijerph19073955

Negoro, Y. A. T., Marthanty, D. R., & Soeryantono, H. (2021). Analysis Of The Green Infrastructure Implementation To The Enhancement Of Environmental Support Capacity (Case Study: Watershed Outside University Of Indonesia). *Iop Conference Series: Materials Science And Engineering*, *1098*(2), 022050. Https://Doi.Org/10.1088/1757-899x/1098/2/022050

Nguyen, L. S. P., Hian-Wui Chang, J., Griffith, S. M., Hien, T. T., Soon-Kai Kong, S., Le, H. N., … Lin, N.-H. (2022). Trans-Boundary Air Pollution In A Southeast Asian Megacity: Case Studies Of The Synoptic Meteorological Mechanisms And Impacts On Air Quality. *Atmospheric Pollution Research*, *13*(4), 101366. Https://Doi.Org/10.1016/J.Apr.2022.101366

Nurhasanah, Cordova, M. R., & Riani, E. (2021). Micro- And Mesoplastics Release From The Indonesian Municipal Solid Waste Landfill Leachate To The Aquatic Environment: Case Study In Galuga Landfill Area, Indonesia. *Marine Pollution Bulletin*, *163*, 111986. Https://Doi.Org/10.1016/J.Marpolbul.2021.111986

Payus, C. M., Nur Syazni, M. S., & Sentian, J. (2022). Extended Air Pollution Index (Api) As Tool Of Sustainable Indicator In The Air Quality Assessment: El-Nino Events With Climate Change Driven. *Heliyon*, *8*(3), E09157. Https://Doi.Org/10.1016/J.Heliyon.2022.E09157

Purwendah, E. K., & Periani, A. (2019). Implementation Of Presidential Regulation Number 83 Of 2018 Concerning Handling Of Sea Was In Order To Provide Protection And Preservation Of The Sea Environment For Indonesia. *Ganesha Law Review*, *1*(2), 18–37. Https://Doi.Org/10.23887/Glr.V1i2.52

Purwono, P., Ristiawan, A., Ulya, A. U., Matin, H. A. A., & Ramadhan, B. S. (2019). Physical-Chemical Quality Analysis Of Serayu River Water, Banjarnegara, Indonesia In Different Seasons. *Sustinere: Journal Of Environment And Sustainability*, *3*(1), 39–47. Https://Doi.Org/10.22515/Sustinere.Jes.V3i1.83

Rezagama, A., Sutrisno, E., & Handayani, D. S. (2020). Pollution Model Of Batik And Domestic Wastewater On River Water Quality. *Iop Conference Series: Earth And Environmental Science*, *448*(1), 012074. Https://Doi.Org/10.1088/1755-1315/448/1/012074

Rosanka, S., Franco, B., Clarisse, L., Coheur, P.-F., Pozzer, A., Wahner, A., & Taraborrelli, D. (2021). The Impact Of Organic

Pollutants From Indonesian Peatland Fires On The Tropospheric And Lower Stratospheric Composition. *Atmospheric Chemistry And Physics*, *21*(14), 11257–11288. Https://Doi.Org/10.5194/Acp-21-11257-2021

Sinaga, D., Setyawati, W., Cheng, F. Y., & Lung, S.-C. C. (2020). Investigation On Daily Exposure To Pm2.5 In Bandung City, Indonesia Using Low-Cost Sensor. *Journal Of Exposure Science & Environmental Epidemiology*, *30*(6), 1001–1012. Https://Doi.Org/10.1038/S41370-020-0256-9

Sri, H., Prasetyo, P., Endang, S., & Sukendah, S. (2021). Effects Of Gamma Irradiation On Phenotypic Changes In Vanda Hybrid. *Effects Of Gamma Irradiation On Phenotypic Changes In Vanda Hybrid*, *1*(1), 1–45.

Suriadikusumah, A., Mulyani, O., Sudirja, R., Sofyan, E. T., Maulana, M. H. R., & Mulyono, A. (2021). Analysis Of The Water Quality At Cipeusing River, Indonesia Using The Pollution Index Method. *Acta Ecologica Sinica*, *41*(3), 177–182. Https://Doi.Org/10.1016/J.Chnaes.2020.08.001

Surya, B., Taibe, P., Sariman, S., Hernita, H., Salim, A., Nasrullah, N., & Zubai, A. G. H. (2023). *Renewable Energy Utilization And Environmental Pollution Control In The New City Area Mamminasata Metropolitan, Indonesia*. Retrieved From Http://Localhost:8080/Xmlui/Handle/123456789/5101

Susilowati, Y., Kumoro, Y., & Nur, W. H. (2020). Integrated Water Quality Modelling For Spatial Planning. *Iop Conference Series: Earth And Environmental Science*, *483*(1), 012041. Https://Doi.Org/10.1088/1755-1315/483/1/012041

Syuhada, G., Akbar, A., Hardiawan, D., Pun, V., Darmawan, A., Heryati, S. H. A., … Mehta, S. (2023). Impacts Of Air Pollution On Health And Cost Of Illness In Jakarta, Indonesia. *International Journal Of Environmental Research And Public Health*, *20*(4), 2916. Https://Doi.Org/10.3390/Ijerph20042916