Analysis of River Water Quality in Manado City: Challenges and Environmental Management Efforts

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Abstract: This study analyzed river water quality in Manado City with the aim of identifying challenges and related environmental management efforts. Water samples were taken from various major rivers in the city area, and water quality parameters such as physics, chemistry, and biology were analyzed. Results showed significant variations in river water quality, with some rivers experiencing degradation due to industrial activities, agriculture, and domestic waste.

Some parameters, such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), and coliform bacteria content showed high levels of organic pollution. The concentration of heavy metals also exceeds the set quality standards. The main challenges in managing the river environment in Manado City are rapid industrial growth and inadequate waste treatment infrastructure.

Effective management efforts include improving waste management systems, enforcing environmental regulations, and implementing environmentally friendly technologies. Public education is also needed to raise awareness of the importance of keeping the river clean. This research provides insights for the government and stakeholders in preserving water resources and river ecosystems. With these steps, it is hoped that the environment and communities in Manado City can face the challenges of river water pollution in a sustainable manner.

Keywords: Quality Analysis, River Water, Physical parameter, BOD, COD, Coliform

1. Introduction

Manado City is the capital of North Sulawesi Province which has a population in 2015 of 425,634 people and in 2021 as many as 453,179 people [1] With increasing population growth, it is also followed by the increasingly complex problems faced by the Manado city government, in clean water supply, waste management [2].

It is directly bordered on the north by North Minahasa district, on the east by North Minahasa and South Minahasa, on the south by Minahasa district, and on the west by the Sulawesi Sea as shown in Figure 1. Manado city has 11 sub-districts and 87 sub-districts and villages [1].

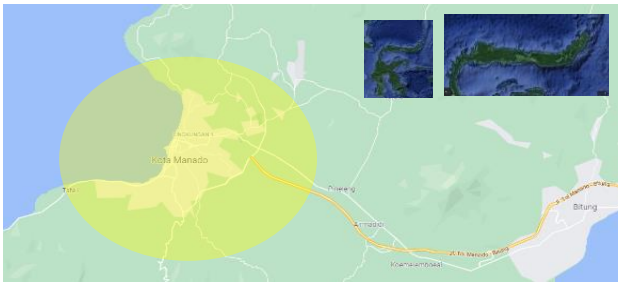

Figure 1. City of Manado

The condition of river water quality standards in Manado City, Indonesia, is very important to understand in order to identify problems and potential impacts on the environment and local communities. There are 5 rivers flowing in Manado City, namely Tondano River, Tikala River, Sario River, Bailang River and Malalayang River [3].

River water in Manado City plays an important role in the lives of local communities. Apart from being a source of clean water for daily needs such as drinking, bathing, and cooking, river water is also used for agriculture, fisheries, and industrial activities. In addition, the natural beauty of the river is a tourist attraction in this city.

Along with urban and industrial growth, river water quality in Manado City has the potential to decline due to pollution. Some of the factors that can cause a decline in river water quality include:

- Industrial waste: If industrial waste is not treated properly before being discharged into the river, it can cause water pollution and harm to the living organisms in it.
- Discharge of household waste: If household waste management systems are inadequate, they can pollute river water.
- Agriculture: Excessive use of fertilizers and pesticides can pollute river water through surface and soil runoff.
- Livestock farming: Most people who keep livestock dispose of animal waste that flows into the nearest river/water body. River water pollution can cause various negative impacts, both on the environment and human health. Some of these impacts include [4]:
- Ecosystem damage: Pollution can cause harm to flora and fauna in river ecosystems, causing food chain disruption and biodiversity.
- Public health: Contaminated water can cause diseases such as diarrhea, cholera, and skin diseases, which in turn can affect the overall health of the community.
- Reduced drinking water quality: River water pollution can also impact the quality of drinking water for the community, which will affect their health.

To address this issue, the city government, environmental authorities, and local communities need to take serious measures to address and monitor the problem. Some of the measures that can be taken include [5]:
- Sewage treatment: Industrial and household effluent treatment should be prioritized to ensure that the effluent discharged into the river is purified first.
- Afforestation and conservation: Greening and conservation programs should be enhanced to preserve natural resources associated with rivers, such as forests in watersheds.
- Public education: Public education and awareness on the importance of keeping rivers clean and the impacts of pollution need to be improved.

To maintain the sustainability of rivers, holistic environmental management and conservation efforts are needed. This includes strict enforcement of environmental regulations, effective waste management, protection of forests and watersheds, and public education on the importance of keeping rivers clean [6].

2. Material and Methods

2.1. Material

River water quality is an important parameter to measure the cleanliness and suitability of river water for various human and environmental purposes. River water quality assessment includes various aspects, such as physical, chemical, and biological parameters, which can provide an overview of the condition of the river environment. River water quality can be affected by various factors, including human activities such as industry, agriculture, and domestic waste. Increasing pollution and climate change are serious challenges in sustainably maintaining river water quality [7].

Physical parameters include water temperature, turbidity, flow velocity, and sediment levels. Chemical parameters include pH, dissolved oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and concentrations of heavy metals and other contaminants. Meanwhile, biological parameters include coliform bacteria analysis and biological indices to assess the presence of living organisms in the water. River water quality

management involves efforts to control and reduce pollution and restore river ecosystems. Enforcement of environmental regulations, implementation of effective waste treatment technologies, and active community participation are essential in maintaining the sustainability of river water quality [8].

The results of research that have been conducted on one of the rivers flowing in the city of Manado, namely the Sario river, show that the value of E. coli and Total Coliform contaminants is above the threshold of the applicable standards [9].

In Malaysia, the influence of urbanization and modernization resulted in the most severe problems faced by Malaysia and adversely affected the sustainability of water resources. For this reason, the Department of Environment Malaysia has classified the water quality index based on 5 classifications [10] as follows:

Table 1. Water Quality in Malaysia

Parameter	Unit	Class				
		I	II	III	IV	V
Ammoniacal Nitrogen	Mg/L	< 0.1	0.1 – 0.3	0.3- 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	Mg/L	< 1	1 – 3	3 – 6	6 – 12	>12
Chemical Oxygen Demand	Mg/L	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	Mg/L	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7	6 – 7	5 – 6	< 5	> 5
Total Suspended Solid	Mg/L	< 25	25 – 50	50 – 100	150 – 300	> 300
Water Quality Index		< 92.7	776.5-92.7	51.9-76.5	31-51.9	< 31

In Indonesia, the Government has issued Government Regulation of the Republic of Indonesia no. 82 of 2001 on water quality management and water pollution control and later supplemented by Minister of Environment and Forestry Regulation of the Republic of Indonesia no. P.68/Menlhk/Setjen/Kum.1/8/2016 on domestic wastewater quality standards. In this regulation, the quality standard of domestic wastewater that is safe to be discharged into water bodies is stipulated. Table 2. Domestic Wastewater Quality Standard, showing the threshold values of the quality standard.

Table 2. Domestic Wastewater Quality Standard

Parameter	**Unit**	**Maximum Content**
pH		6 – 9
BOD	Mg/L	30
COD	Mg/L	100
TSS	Mg/L	30
Oils and Fats	Mg/L	5
Ammoniac	Mg/L	10
Total Coliform	amount/100 ml	3000
discharge	L/person/day	100

Classification of water quality based on Government regulations no. 82 of 2001, is set into 4 (four) classes:

- Class one, water whose designation can be used for clean water or drinking water, and or other designations that require the same water quality as these uses.
- Class two, water whose designation can be used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops, and or other designations that require the same water quality as these uses

- Class three, water whose designation can be used for freshwater fish farming, animal husbandry, water for irrigating crops, and or other designations that require the same water as these uses
- Class four, water whose designation can be used for irrigation, crops, and or other designations that require the same water quality as these uses.

2.2. Methodology

The methodology used in this research is:

- Observation research method.
The technical implementation of this observation method is by conducting reviews, field measurements, and taking water samples.
- Water testing method in the laboratory.
For water testing, using methods based on the American Public Health Association (APHA) standard can be seen in Table 3. Water Testing Method

Table 3. Water Testing Method

No	Test Description	UoM	Result	GRL	Method Reference	Rem Q
1	Total Suspended Solids	mg/L	< 1	n/a	APHA-2540-D(2017)	Q
2	Turbidity	NTU	4.2	n/a	APHA-2130-B(2017)	Q
3	pH	n/a	8.12	n/a	APHA-4500H+.B(2017)	Q
4	Fecal Coliform	MPN/100mL	160000	n/a	APHA-9221.E(2017)	Q
5	Total Coliform	MPN/100mL	>160000	n/a	APHA-9221.B(2017)	Q
6	Biological Oxygen Demand	mg/L	< 2	n/a	APHA 5210-B(2017)	Q
7	Chemical Oxygen Demand	mg/L	< 10	n/a	APHA 5220-D(2017)	Q
8	Dissolved Oxygen	mg/L	7.54	n/a	APHA-4500O-G(2017)	Q

The variables that will be measured to determine water quality are:

- Physical Quality:
  - o Water temperature: using a thermometer
  - o Turbidity: can be visual and the level of turbidity is based on predetermined standards
  - o Color: visually
  - o TSS (total solid suspended)
- Chemistry
  - o pH: using litmus paper
  - o BOD5
  - o COD
  - o Heavy metals
- Microbiology
  - o Fecal Coliform
  - o Total Coliform

3. Results and Discussion

3.1. Research Results

From the research that has been carried out, data or water samples have been taken which are then tested/examined at the Manado Class 1 Environmental Health and Disease Control Engineering Center Laboratory with the results as shown in table 1. River water analysis results below:

Table 1. Results of River Water Analysis

No.	River Name	BOD (mg/l)	Total Coliform MPN/100 ml	Description
1	Malalayang River	1.2 - 2	16,000	
2	Sario River	< 2	>16,000	
3	Tikala River	1.0 - 1.2	390 - 9,200	
4	Bailang River	1.0 - 2.2	1,700 - 16,000	
5	Tondano River	1.0 - 1.4	16,000	

3.2. Discussion

The research data obtained; it illustrates that the BOD value in each river flowing in Manado City is below the threshold of river water quality standards. The quality standard for river water by applicable regulations, namely Government Regulation No. 82 of 2001 concerning water quality management and river water pollution control in Indonesia

BOD is an important indicator in determining water quality. It measures the amount of oxygen required by microorganisms to decompose dissolved organic matter in water. The higher the BOD, the greater the potential for organic pollution in water. Countries with dense populations, large industries, or inadequate sanitation systems tend to have high BOD values [11], [12].

The BOD value of each river flowing in Manado City is below the quality standard value according to existing regulations, indicating that the potential for organic pollution in water is very low.

Total Coliform and Fecal Coliform

Total coliform and fecal coliform values are important parameters in measuring water quality and environmental hygiene. They are indicators of the presence of bacteria in water that may indicate contamination by organic matter, human feces, or other waste. Thresholds for total coliform and fecal coliform values are based on health and environmental standards set by health and environmental regulatory authorities.

Total coliforms are a group of bacteria that are commonly found in natural environments, including soil and water. While not necessarily pathogenic (disease-causing), the presence of total coliform in water can indicate pollution and the potential presence of other pathogenic bacteria. Fecal coliform, on the other hand, is a subgroup of total coliform that originates from the intestines of mammals, including humans and is usually present in human feces. The presence of fecal coliform in water is a stronger indicator of human fecal contamination, which can contain harmful pathogens such as E. coli.

The thresholds for total coliform and fecal coliform values vary depending on the use of the water. For example, drinking water has stricter standards compared to surface water such as rivers or lakes that may be used for recreational activities or irrigation. Below are examples of commonly used thresholds in some environmental regulations in different countries:

1. EPA (Environmental Protection Agency) United States:
- Drinking water: Zero total coliform and fecal coliform per 100 mL.
- Surface water: Total coliform concentrations should be low, and fecal coliform counts should be very low or zero in water samples.

2. WHO (World Health Organization):
- Drinking water: Zero fecal coliform in 100 mL of water sample.
- Surface water: Total coliform concentration should be low, and fecal coliform should not be detected in 100 mL of water sample.

3. Other local or national standards: Many countries have specific standards for total coliform and fecal coliform values based on local conditions and water use. These may include different thresholds for drinking water, wastewater, and surface water.

If total coliform and fecal coliform values exceed the established thresholds, this may indicate problems in water quality and the environment, as well as potential health risks to humans. Remedial measures and further monitoring will be required to reduce contamination and keep the environment clean.

A study conducted in China (Pearl River Delta) that measured the number of pathogens in drinking water sources essential to improve water quality, found that external environmental factors are strongly associated with coliform distribution [13]. Urban pollution sources greatly affect nutrient and pathogen pollution in rivers, but river flow rates can improve water quality both in terms of nutrients and pathogens [14].

4. Conclusion

The conclusions that can be drawn from the results of this study are:

- The BOD value in each river flowing in Manado city is below the threshold of river water quality standard.
- The values for Total Coliform and Fecal Coliform are far above the threshold value which indicates that river water in Manado City is potentially harmful to human health.

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