

Original Research Article

Pepe Boyolali River: Analysis of Water Quality Using the Pollution Index Method

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Abstract

This study uses the pollutant index method to determine the form of river utilization by the surrounding community and the level of river water pollution. The research method used in this study is qualitative and quantitative analysis. Qualitative descriptive analysis method is used to analyze the form of river utilization by the community. Analysis of river water quality used quantitative method which refers to the Decree of the Minister of Environment 115/2003 concerning Determination of Water Quality Status using the Pollution Index (PI) method. The results of the analysis show that the community uses the Pepe River as a source of water and rainwater storage, waste disposal sites, fishing grounds, drainage channels, and agricultural irrigation. So that it has the potential to experience water pollution due to the entry of domestic-industrial waste. Based on PI, the flow of the Pepe River is proven to be lightly polluted, with the results of several parameter measurements showing results above the quality standard. Therefore, one of the recommendations that can be applied to overcome these problems is to develop the concept of Community-Based Development by involving the active role of all society levels in planning and implementing river management and development activities.

Keywords: Water quality; water pollution; pollution index method; Pepe River

1. Introduction

In recent decades environmental problems have become a global issue widely discussed in various parts of the world because it is considered a significant threat (Nugroho, 2018). These problems arise due to climate change, the extinction of natural resources due to unsustainable production and consumption patterns, and environmental degradation due to various anthropogenic activities carried out by humans (Nainggolan et al., 2019). Similar to other countries in the world, currently, Indonesia is still unable to escape the shackles of existing environmental problems. In Indonesia, environmental problems have become a significant problem that until now has not found an optimal solution (Masruroh, 2018). One of the environmental problems that are being faced by major cities in the world, including Indonesia, is the problem of environmental pollution. Environmental pollution, in general, can be defined as the inclusion of a substance in concentrations exceeding it carrying capacity and carrying capacity, which can cause negative impacts on the environment, society, and economy. Environmental pollution, in general, can be divided into three: water pollution, soil pollution, and air pollution. Although in Indonesia there have been many policies set by the government to overcome the pollution problem, in fact, the problem of pollution, especially the problem of water pollution, continues in Indonesia, even though when viewed from the benefits provided by water is one of the natural resources that have a somewhat important role in meeting the basic needs of living things and as a very national asset valuable

(Chowdhary et al., 2018). A body of water is said to experience pollution if there is a decrease in water quality characterized by physical, chemical, and biological changes. The decline in water quality in urban areas has become a trend that occurs in the world (Wessells and Lejano, 2017). Pollution in water has an impact on various things. For example, it impacts the optimality of function, decreases aesthetic value, and can affect health. Therefore, the protection and preservation of aquatic ecosystems should be a priority that must prioritize (Nitis and Firdaus, 2019).

One of the sciences related to water pollution is Limnology. Limnology is a science that studies the characteristics of inland waters through various water quality observation activities and activities that can then affect water quality changes. One of Indonesia's inland waters with a high potential for water pollution is the Bengawan Solo River (Widyastuti et al., 2018). Bengawan Solo is one of the longest rivers on Java Island that flows from the Sewu Mountains and passes through various urban areas until it eventually empties into the Java Sea in the north of Surabaya, with a river length of more than 600 km. Its existence flows in the middle of the urban area, which then results in the Bengawan Solo River having the potential for water pollution due to anthropogenic activities carried out by humans, both pollution due to domestic waste disposal, industrial activities, agricultural activities, and livestock activities (Mujib et al., 2022). Disposing of various types of waste due to anthropogenic activities directly into river bodies without being treated first in the Wastewater Management Installation (WWTP) can then adversely affect the survival of aquatic organisms. It could disrupt human health (Barus, 2020).

One of the tributaries of the Bengawan Solo River that has the potential to experience water pollution is the Pepe River (Ulfi Hanum et al., 2022). Pepe River is a subsidiary of the Bengawan Solo River, which is located in the west and flows from west to east through Surakarta before it finally empties into the Bengawan Solo River. The Pepe River is also the administrative boundary between Surakarta and Boyolali Regency. Its location that divides the densely populated area and dense industrial activities makes the Pepe River have a high potential to experience a decrease in water quality due to the high anthropogenic activity carried out. Anthropogenic activity may produce garbage or waste, which is then discharged into the Pepe River water body.

This article is focused on discussing the use of rivers by the surrounding community and knowing the level of water pollution in the Pepe River, Sawahan Village, Ngemplak District, Boyolali, Central Java. Sawahan Village is one of the areas directly adjacent to Surakarta City, which affects this village by the characteristics of the urban environment. Sawahan is one of the areas in Boyolali with the highest population compared to other regions. Based on population density data from the Central Statistics Agency of Ngemplak District in 2021, the total population in the Sawahan Village area reached 11,437 people with an overall area of 2,658 km², which means that the population density in Sawahan Village reached 4,302 people/km². These results then made Sawahan Village occupy the first position with the highest population density in Ngemplak District. Compared to the population density in 2015, the population density in 2021 in Sawahan Village has increased to 1,032 people/km². The high population density in Sawahan Village then impacts economic growth in the region. The high economic growth in Sawahan then impacts anthropogenic activities carried out by the community, such as the number of residential areas, factories, shops, restaurants, home industry, and other businesses in this village.

The high level of activities carried out by the community will undoubtedly have an impact on the sustainability of the aquatic ecosystem in the region, including freshwater aquatic ecosystems, namely the Pepe River, which flows on the periphery of its territory as well as is the boundary line of the administrative area of Sawahan Village with Palangan Village, Colomadu District, Karanganyar Regency and Banyuanyar Village, Banjarsari District, Surakarta City. The pollution of the Pepe River water flowing in Sawahan Village can even be concluded just by looking at the situation without conducting research. For example, many piles of garbage are found in river bodies, the amount of industrial waste discharged into river bodies, etc. However, measuring the value of water characteristics in rivers is necessary to provide factual data, which is expected to become written elevator material to raise public awareness so that it can transmit better behavior toward the Pepe River.

Determination of water quality using the Pollutant Index value can be helpful as an evaluator and mitigation material to overcome the problem of river water quality degradation by entering various pollutant loads into a body of water. The method used to determine the status of water quality is to use the Polluter Index method. Analysis using the Pollutant Index to determine the level of water quality in the Pepe River is a novelty in this study. According to (Marganingrum et al., 2013), the Pollutant Index method is a reasonably straightforward calculation method to calculate the pollution level relative to the water quality standards set according to its designation. In that regard, this research was conducted to determine the form of utilization of the Pepe River by the surrounding community and to determine the value of the physical and chemical character of water to determine the level of pollution from the Pepe River in Sawahan Village.

2. Methods

The research method used was a combination of qualitative and quantitative descriptive analysis methods. The data collection techniques are direct data collection in the field, interviews, and documentation of field conditions. Data collection is directly carried out in the Pepe River, which flows in Sawahan Village. Water quality measurements were carried out in-situ with an air temperature of around 32-33 °C. Field data collection were collected to measure several water quality parameters using the Horiba U-50 Series Multi-Parameter Water Quality Meter. The data taken are temperature, turbidity, pH, ORP, conductivity, TDS, DO, and salinity. The data obtained was then analyzed based on the Decree of the Minister of Environment Number 115 of 2003 concerning Determination of Water Quality Status, one of the methods used to determine the level of pollution relative to several parameters of water quality is the Pollution Index (PI) method. Data collection through interviews was carried out through a semi-structured interview technique that refers to a series of open-ended questions to dig deeper into information. The interviews were aimed at the communities around the river that were traversed with the main question points in the form of social and economic conditions. Documentation of field conditions is directly used to provide an overview of the actual state of the Pepe River in Sawahan Village.

The study was conducted in October 2022. This research was conducted in a subsidiary of the Bengawan Solo River, the Pepe River, which flows and becomes the administrative boundary between Sawahan Village, Ngemplak District, Boyolali Regency, and Palangan Village, Colomadu District, Karanganyar Regency and Banyuanyar Village, Banjarsari District, Surakarta City. The measurement location includes five sampling points which can be seen in **Table 1**.

Table 1. Water quality test sampling location

Measurement Location	Coordinate Point	
	S	E
Point A	07°31.800'	110°47.608'
Point B	07°32.013'	110°47.755'
Point C	07°32.011'	110°48.035'
Point D	07°31.905'	110°48.212'
Point E	07°32.079'	110°48.435'

3. Result and Discussion

3.1 Pepe River Utilization Analysis

Sawahan is one of the villages in Ngemplak District, Boyolali Regency, within the Urban Fringe area because it is directly adjacent to Surakarta City. Urban Fringe then caused Sawahan Village to become one of the villages in Boyolali Regency, which was affected quite strongly by the characteristics of the urban environment. Based on the administrative map of Sawahan Village, there is a reasonably large river flow which then becomes the administrative boundary between Sawahan Village and Palangan Village, Colomadu District, Karanganyar Regency, and Banyuanyar Village, Banjarsari District, Surakarta City. The river that is the administrative boundary between Sawahan Village and the two areas is the Pepe

River. Its location that divides dense residential areas and dense industrial activities then causes a high potential for water pollution in the surface water body. The existence of water pollution in the Pepe River flow in Sawahan Village can even be concluded invisibly through physical observation of the situation and conditions that exist along the river flow due to the entry of various types of garbage and polluting waste by domestic community activities, industrial activities, and other economic activities. A river should be a body of water capable of providing optimal environmental services for humans and other living things. (Saputri and Arsi, 2019) mentioned that with the increasing number of residents and the increasing number of settlements on the outskirts of the river, the condition of the river had decreased water quality. The change in the pattern of agricultural land use to non-agricultural land is also one of the factors that cause changes in hydrological conditions in a river basin area (Agustiningasih and Sasongko, 2012). In addition, the behavior of community use of rivers is also one of the factors that cause changes in the quality of water. (Suryadi et al., 2016) stated that humans play a crucial role in the environment, where all behaviors can impact and influence the environment. People's behavior can shape environmental conditions, and environmental conditions can also shape people's behavior patterns. Therefore, community behavior can be one of the bases for analysis in knowing the sources of pollution that causes degradation or deterioration of environmental conditions.

Like other rivers, the Pepe River is used by the surrounding community to meet needs in terms of water and other natural resources. In addition to having a function as the city's main drainage, the Pepe Hilir River in Surakarta City is also used for tourism and educational purposes. With careful Development planning, the plan can be achieved optimally, and the river can become a beautiful area free from waste. However, the potential possessed by the Pepe River has yet to be fully utilized by several areas passed by the river flow, including the flow of rivers flowing in Sawahan Village. Because of its location in a densely populated area, the Pepe River flow in Sawahan Village has a high potential for pollution. Some forms of utilization carried out by the community around Sawahan Village for the flow of the Pepe River are:

1) As a water source and rainwater reservoir

The Pepe River is one of the surface water bodies that holds enough water to be used by the surrounding community as a water source. The Pepe River will empty into the Bengawan Solo River, which is then used as a source of clean water for the surrounding community through a Water Treatment Plant (WTP) which processes the water of the Bengawan Solo River into drinking raw water to then be ready to be distributed to consumers. In addition, rivers also connect with groundwater, which is generally used by the community as a source of clean water to meet daily needs. (Yuniar et al., 2022) said that based on the elevation of the water surface, rivers and groundwater could show a relationship that affects each other, one of which is the relationship between groundwater flowing into rivers and groundwater that receives flow from rivers. Most of the people of Sawahan Village generally still use groundwater as a source of clean water to meet their daily needs. Therefore, the Pepe River in Sawahan Village is directly or indirectly used by the surrounding community to fulfill clean water resources.

2) As a waste disposal site

Apart from being a water source, some people in Sawahan Village consider the river a landscape or waste disposal site where many riverside communities throw garbage and waste from activities carried out into it. Several factors affect the behavior of the community in throwing garbage into the river, namely internal factors such as lack of public knowledge about waste management, lack of public awareness about environmental cleanliness, habitual factors of throwing garbage in river bodies, and external factors such as the lack of availability of waste disposal facilities around the river and the absence of strict law enforcement and sanctions for people who throw waste into the river (Suherdiyanto and Prihadi, 2021). Generally, communities around the riverbank collect solid waste from household activities which are then disposed of on the outskirts of the river without going through the sorting and processing process first. Likewise, liquid waste generated from daily activities such as waste from Washing Baths and Latrines (MCK) directly flows through paralog pipes into the river. In addition, waste from industrial activities,

animal husbandry, and other economic activities is also discharged directly into the river or through paralog pipes. Various types of waste entering the water body affect pollution and decrease water quality.

3) As a fishing ground

The Pepe River that flows in Sawahan Village is also used by a small part of the surrounding community for fishing activities. Generally, the fishing activity carried out is fishing using fishing gear with ordinary worm baits that are relatively safe for the sustainability of the river. However, what needs special attention is the condition of the Pepe River waters that have been affected by domestic waste, and industrial waste can affect catches and can endanger health if consumed. To maintain the sustainability of the Pepe River ecosystem, fishing activities in destructive ways, such as fishing with explosives (fish bombs) and using toxic materials, are not allowed to be carried out. Fishing activities in such destructive ways can have a high potential for ecosystem damage and cause disruption and even death of various fish species and other species in these waters. Therefore, to suppress the existence of fishing activities in destructive ways by a group of irresponsible individuals, it is necessary to participate in the local community carrying out supervision and reporting if they encounter destructive fishing activities to fisheries supervisors or local law enforcement officials.

4) As a drainage channel and agricultural irrigation

Based on Boyolali Regency Regional Regulation Number 9 of 2011 concerning the Boyolali Regency Regional Spatial Plan for 2011-2013, it is stated that the Pepe River is one of the springs that can be used for the Development of drainage channels / primary drainage networks to irrigate agriculture. However, the Solo - Kertosono (Soker) toll road construction project since 2012 has made the irrigation and drainage canals in Sawahan Village not function as they should. Irrigation canals used by farmers for irrigation of rice fields sourced from the Pepe River are indicated to be polluted by domestic waste and industrial waste. In addition to the potential to be polluted due to the use of Pepe River water, irrigation flows also have the potential to carry agricultural waste, which is also the cause of the decline in the quality of the Pepe River. Therefore, to minimize the potential for deterioration, it is necessary to maintain and manage irrigation flows to avoid bringing pollutant sources into the river.

3.2 Analysis of the Physical and Chemical Quality of Water in the Pepe River Flow Sawahan Village

The sapling of the Bengawan Solo River, namely the Pepe River, which flows along Sawahan Village, is indicated to have pollution, which invisibly shows relatively poor conditions with the discovery of a lot of garbage and various types of waste entering it. However, to prove this hypothesis, field studies must be conducted to analyze whether indications of pollution in the river flow occur. (Haris and Yusanti, 2018) stated that pollution in the water could be analyzed through a series of assessments of water quality, including physical, chemical, and biological parameters. Water quality assessment along the Pepe River flowing in Sawahan Village is expected to be written elevator material to raise public awareness of river sustainability. This study's water quality analysis is limited to measuring physical and chemical parameters. The data used to analyze water quality is from field observations using the Horiba U-50 Series Multi-Parameter Water Quality Meter tool. The field data collection was carried out in October 2022, with data collection locations covering 5 location points along the Pepe River. The first step in collecting data for water quality analysis on the Pepe River flowing in Sawahan Village is to calibrate the tool automatically using equated water first. After calibration of the tool, measurements are made of several water quality parameters. The parameters measured include measurements of physical parameters such as temperature and turbidity as well as chemical parameters such as Power of Hydrogen (pH), Oxidation Reduction Potential (ORP), conductivity, Total Dissolve Solid (TDS), Dissolved Oxygen (DO), and salinity.

Measurements of some of these parameters can be done automatically using the Horiba U-50 Series Multi-Parameter Water Quality Meter tool just by dipping the tool into a river water body in seconds. After the tool is dipped into a river water body, the measurement results will be automatically

displayed on the tool display. The measurement results obtained from the five points are then compared with the applicable water quality standards to determine the physical and chemical conditions of the Bengawan Solo River tillering flow, namely the Pepe River, which flows in Sawahan Village. The Pepe River flowing in Sawahan Village will be emptied into the Bengawan Solo River so that the water in the river flow is then allocated at least following the classification and designation of its parent river, the Bengawan Solo River. The Bengawan Solo River is generally used as a source of clean water for the surrounding community through a WTP that treats Begawan Solo River water into drinking raw water, which is then ready to be distributed to consumers. Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management stipulates that water intended as drinking raw water and others is included in class I. Therefore, to find out how the water quality conditions in the Pepe River flow in Sawahan Village can be done by comparing the results of measuring the physical and chemical parameters of water with quality standards of water class I that have been set nationally. The results of water quality measurements at five points along the Pepe River flow in Sawahan Village can be seen in **Table 2**.

Table 2. Water quality in pepe river sawahan village

Parameters	Unit	Measurement Location					Quality Standards (Grade 1)
		Point A	Point B	Point C	Point D	Point E	
Temperature	°C	29.22	29.11	28.97	28.87	29.21	Deviation 3
Turbidity	NTU	161.33	102.7	181	135.47	130.33	25
pH	-	3.97	5.12	5.62	6.44	5.45	6 – 9
ORP	ORPmv	346.33	211	178.67	154	152	-
Conductivity	µs/cm	0.05	0.32	0.27	0.22	0.43	-
TDS	g/L	0.03	0.21	0.16	0.13	0.23	1
DO	mg/L	8.93	11.6	9.33	10.72	9.65	Minimal 6
Salinity	ppt	0.02	0.15	0.13	0.10	0.17	0.5

These parameters describe the condition of the Pepe River in Sawahan Village. Explanation of each parameter is discussed in the following section.

1) Temperature

Temperature is one of the determining factors for water quality which has a crucial role in water. It is because the temperature is directly a limiting factor in affecting the survival of the organisms in it and indirectly affects the oxygen content in the water (Azizid Daroini et al., 2020). Government Regulation of the Republic of Indonesia Number 22 of 2021 states that the river water temperature in class 1 has a quality standard deviation of 3 from the average temperature. (Rahadi et al., 2019) stated that if the deviation of 3 from the average temperature is $\pm 3^{\circ}\text{C}$ from the natural temperature of the water. In contrast, if the average temperature of river water is 25°C , then the temperature quality standard in class 1 is in the range of $22\text{-}28^{\circ}\text{C}$. The results of measuring water temperature in the Pepe River flow in Sawahan Village at point A to point E, respectively, are 29.22°C , 29.11°C , 28.97°C , 28.87°C , and 29.21°C . Based on these results, it can be known if the temperature at the five measurement points exceeds the predetermined quality standards. It can be influenced by external factors such as industrial and dense population activities. In addition, the low level of vegetation of plants around the river flow can also be one of the factors that trigger an increase in temperature in the waters of the Pepe River (Haris and Yusanti, 2018). The increase in temperature in these waters can affect the chemical properties of the waters, such as an increase in viscosity, an increase in the rate of chemical reactions, an increase in evaporation, a decrease in the solubility of gases in water, and an increase in oxygen consumption. It, of course, can affect the survival of aquatic organisms in it (Djoharam et al., 2018).

2) Turbidity

Turbidity is a condition where water is in a turbid or non-clear state due to the accumulation of a significant enough number of suspended solids particles in the water. The suspended solids generally come from sludge, fine fibers, soap, oil, etc. Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 stipulates that the quality standard for turbidity of water media for hygiene and sanitation purposes is 25 NTU. The results of measuring the water turbidity in the Pepe River flow in Sawahan Village from point A to point E, respectively, are 161.33 NTU, 102.7 NTU, 181 NTU, 135.47 NTU, and 130.33 NTU. Based on the results of these measurements, it can be seen that the turbidity value of the water in the Pepe River flowing in Sawahan Village at the five measurement points exceeds the predetermined quality standards. One of the factors that may cause the high results of turbidity measurements in the Pepe River is the large number of domestic and industrial activities that discharge waste directly into the river without going through the treatment process first. Based on Table 2, it can be known if Point C shows the highest measurement results compared to other measurement points. The high turbidity value at point C is likely due to the location of the measurement point in residential and industrial areas, which allows for high waste disposal activities in the area. The high value of turbidity can cause inhibition of penetration of sunlight entering the river body. It will directly impact reducing the oxygen concentration in the waters, interfering with the sustainability of aquatic organisms in it (Wulandari et al., 2020). In addition, the high value of turbidity can also disrupt the environment's aesthetics.

3) The power of Hydrogen (pH)

pH is the amount of hydrogen ion content in water. The small number of hydrogen ions in water indicates the water's acidity level. Government Regulation of the Republic of Indonesia Number 22 of 2021 stipulates that the pH quality standard in river water bodies is between 6 to 9. Based on the measurements that have been made, the pH values obtained in the Pepe River flow in Sawahan Village at point A to point E, respectively, are 3.97, 5.12, 5.62, 6.44, and 5.45. Based on the results of these measurements, it can be seen that the average pH value at the five measurement points does not meet the established quality standards, precisely at points A, B, C, and E. At these four points, the results of measuring the pH value are acidic and below the quality standard. One of the factors that are suspected of causing the low pH value is because points A, B, C, and E are in dense residential areas and close to the tofu industry, which allows for the disposal of solid waste and liquid waste directly into the river without passing the treatment stage first. (Pradana et al., 2019) stated that if the pH value is outside the standard range set, it can cause damage to the aquatic ecosystem. In addition, pH values outside this range in river water also trigger reduced levels of dissolved oxygen which directly affects the decrease in oxygen consumption and disruption of aquatic organism growth.

4) Oxidation Reduction Potential (ORP)

ORP is the level of water's ability to kill the bacteria contained in it. (Putri et al., 2017) stated that the ORP value in water can also be used to determine the level of water cleanliness and its ability to destroy contaminants. Therefore, measuring the ORP value in a body of water is also carried out to determine the number of microorganisms in the water. The ORP content in the water that is used as raw water is not explicitly required in drinking water quality. The higher the ORP value in water, the faster it takes to kill the bacteria in it will be faster, so the waters with the highest ORP values show the best water quality and vice versa. The results of measuring ORP values on the Pepe River flow in Sawahan Village from point A to point E were 346.33 mV, 211 mV, 178.67 mV, 154 mV, and 152 mV. Based on the results of these measurements, it can be known if the highest ORP content is found at point A, with a value of 346.33 mV. The results then show that based on the ORP content value, the water quality at point A is much better than at other measurement points. s. Based on (Putri et al., 2017), the upstream and downstream points differentiate the ORP values obtained. Point A is located in the upstream area so when compared to other points it is a differentiating factor and makes the ORP value at point A the highest.

5) Conductivity

Conductivity is the ability of a substance to conduct electric current. The magnitude of the conductivity value in water is directly proportional to the concentration of dissolved electrolyte ions. These dissolved ions generally come from dissolved salts or other inorganic compounds. The higher the conductivity value in water, the higher the electrolyte ion content, and vice versa. Hindayani and Hamim (2022) mentioned that conductivity is one of the indicators in determining the quality of drinking water to show the amount of dissolved metal content in the water that can harm health if consumed and potentially cause a decrease in water quality. The conductivity value in water will also affect the quality of a water body, where the higher the conductivity value, the worse the water quality (Setyaningrum and Agustina, 2020). The results of measuring the value of water conductivity in the Pepe River flow in Sawahan Village at point A to point E, respectively, are 0.05 $\mu\text{s/cm}$, 0.32 $\mu\text{s/cm}$, 0.27 $\mu\text{s/cm}$, 0.22 $\mu\text{s/cm}$, and 0.43 $\mu\text{s/cm}$. Based on these results, it can be known if the highest water conductivity value is found at point E. High water conductivity value can be influenced by the entry of ions from community anthropogenic activity waste, for example, the disposal of laundry waste and tofu industrial liquid waste which is discharged directly into the river without passing the treatment stage first (Fitriani et al., 2019; Hindayani and Hamim, 2022).

6) Total Dissolve Solid (TDS)

TDS can be interpreted as a solubility of a solid substance in water. TDS is the accumulation of all organic and inorganic substances in water in molecular suspension, ionization, and micro-granular form. Government Regulation of the Republic of Indonesia, Number 22 of 2021, stipulates that the maximum quality standard for TDS content in river water bodies is 1 gram/L. Results of measuring the TDS value in the Pepe River flow in Sawahan Village successively at point A to point E are 0.03 g/l, 0.21 g/l, 0.16 g/l, 0.13 g/l, and 0.23 g/l. Based on these results, it can be seen that the TDS content in the Pepe River flow in Sawahan Village has stayed within the set quality standards. Point E shows the highest TDS value measurement results compared to other points. It is thought to be caused by the influence of suspended materials derived from domestic waste discharges and industrial waste, which then enter river waters. One of the wastes suspected of affecting the high value of TDS is tofu and tempeh liquid waste which generally contains organic and inorganic materials that are pretty high so that if the waste enters the waters, it can increase the TDS content in water. If the amount exceeds the quality standards, it can cause water damage, such as increased turbidity, which can interfere with the continuity of the photosynthesis process and increase toxicity to organisms' aquatics (Ananda et al., 2018). If the TDS content in water is high and exceeds the quality standard, then the water is not suitable for use as a source of raw water because it can pose a risk of health problems if consumed.

7) Dissolved Oxygen (DO)

DO is one of the most critical parameters in water quality analysis by showing the amount of oxygen in the water. (Aruan and Siahaan, 2017) stated that DO is the amount of dissolved oxygen in a body of water that plays a vital role in the survival of aquatic organisms, especially in carrying out biochemical activities such as supporting respiration, reproduction, and fertility activities. The dissolved oxygen content can also be used as an indicator of pollution in water where waters with high DO levels indicate that the water conditions are in good condition and suitable for use for raw water needs. In contrast, if the DO level is low, the waters are polluted and have decreased quality. Government Regulation of the Republic of Indonesia, Number 22 of 2021, states that the quality standard for DO content in rivers is at least 6 mg/L. Results of measuring the value of DO levels in the Pepe River flow in Sawahan Village successively at point A to point E are 8.93 mg/L, 11.6 mg/L, 9.33 mg/L, 10.72 mg/L, and 9.65 mg/L. Based on the results of these measurements, it can be known if based on DO levels at the five measurement locations carried out along the Pepe River flow in Sawahan Village showed quite good results with DO value levels at all five measurement points already exceeding the minimum limit of DO levels set, which exceeded 6 mg/L.

8) Salinity

Salinity is one of the parameters used in water quality analysis that shows the amount of dissolved salt in water. The river is one of the freshwater waters where it generally has a low salt content. (Fitriani et al., 2019) stated that water could meet clean water needs if the salinity value is less than 0.5 ppt (parts per thousand). The results of measuring the salinity value of water in the Pepe River flow in Sawahan Village at point A to point E, respectively, are 0.02 ppt, 0.15 ppt, 0.13 ppt, 0.10 ppt, and 0.17 ppt. Based on the results of these measurements, it can be seen that the salinity value in the Pepe River flow in Sawahan Village has stayed within the predetermined quality standards. It then shows that the dissolved salt content in the Pepe River in Sawahan Village is low (Fitriani et al., 2019).

3.3 Analysis of Water Quality Status in the Pepe River Flow Sawahan Village

Analysis of water quality status can be carried out using several methods. Referring to the Decree of the Minister of Environment Number 115 of 2003 concerning the Determination of Water Quality Status, one of the methods that can be used to determine the pollution level relative to several water quality parameters is the Pollution Index (PI) method. According to (Marganingrum et al., 2013), the Pollution Index method is a reasonably straightforward calculation method to calculate the pollution level relative to the water quality standards set according to its designation. Determination of water quality using the Pollution Index value can be helpful as an evaluator and mitigation material to overcome the problem of river water quality degradation by the influx of various pollutant loads. The calculation of the Pollution Index value can be done using the calculation formula below.

$$PI_j = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)M^2 + \left(\frac{C_i}{L_{ij}}\right)R^2}{2}} \quad (1)$$

Where: PI_j is Pollution Index according to its designation (j), C_i is the concentration of water quality parameters (i), L_{ij} is the concentration of water quality parameters (i) listed in the water quality standard (j), M is maximum, R is average.

Table 3. presents the standard status of river water quality based on the Decree of the Minister of Environment Number 115 of 2003. Furthermore, the results of calculating the status of water quality at five measurement locations along the Pepe River in Sawahan Village, Ngemplak District, Boyolali Regency are presented in **Table 4.**

Table 3. Pollution index categories

Pollution Index Score	Quality Status
0 ≤ PI ≤ 1.0	Good
1.0 < PI ≤ 5.0	Lightly Polluted
5.0 < PI ≤ 10	Moderately Polluted
PI > 10	Heavily Polluted

Table 4. Calculation of the value of water pollution index in the Pepe River flow Sawahan Village

Measurement Location	Ci/Lij		PI Score	Quality Status
	Max	Std. Deviation		
Point A	5.04	0.64	3.59	Lightly Polluted
Point B	4.07	0.60	2.90	Lightly Polluted
Point C	5.30	0.90	3.80	Lightly Polluted
Point D	4.67	0.78	3.35	Lightly Polluted
Point E	4.58	0.79	3.29	Lightly Polluted

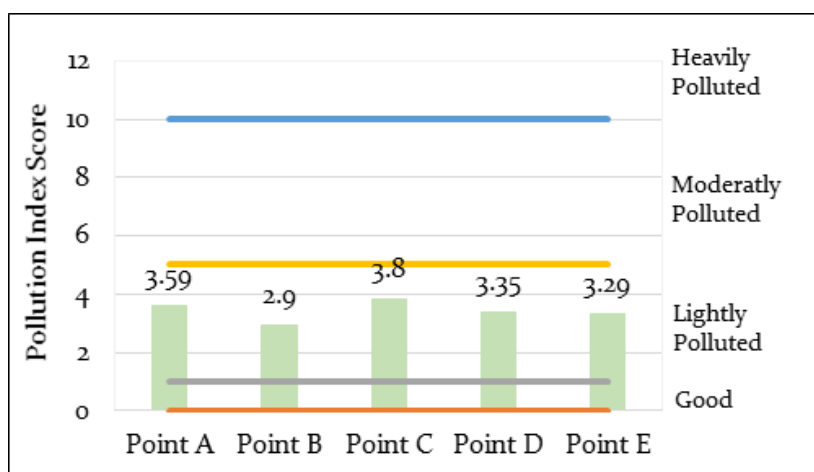


Figure 1. Graph of Pepe River pollution index in Sawahan Village

Based on the calculation results as shown in **Table 4** and **Figure 1**, it can be seen that the Pepe River flowing in Sawahan Village, Ngemplak District, Boyolali Regency, from point A to point E, is proven to have pollution with a lightly polluted quality status with the highest level of pollution found at point C with a pollutant index value of 3.8. The high pollution level is caused by measurement locations near residential and industrial areas that provide a high potential for the contribution of solid and liquid waste to river water bodies. Therefore, to prevent the worsening of these conditions, it is necessary to handle and control various sources of pollutants entering the river. The results of these calculations are expected to be used as elevator material by the local government to handle immediately so that river water quality degradation can be minimized immediately and resolved immediately.

3.4 Strategies to Maintain Pepe River Water Quality

Seeing that there are problems that cause a decrease in water quality in the Bengawan Solo River saplings, namely the Pepe River, which flows in Sawahan Village, Ngemplak District, Boyolali, the Development concept that is considered capable of being a recommendation and solution in solving these problems is through the Development of the Community-Based Development concept. Community-Based Development is an effort to combine the roles of all levels of society to maintain the ideal function of an environment through the Development of community resources in improving welfare in environmental, economic, and social aspects (Pangestu et al., 2018).

In simple terms, Community-Based Development is a development concept involving the active role of all levels of society, both civil society, the government, and academics, in planning and implementing Development and management. Three essential aspects must be considered in realizing this Community-Based concept to solve pollution problems in the Pepe River in Sawahan Village and its surroundings, namely by paying attention to the role and participation of the public, Community education, and sustainability aspects. The first aspect is public participation, where the role and participation of the community are needed to assist in planning governance and managing and supervising river areas to minimize potential pollution. Then the aspect of Community education is related to the knowledge and understanding of the community about the importance of keeping the environment clean. Furthermore, the sustainability aspect is related to activities carried out on an ongoing basis to achieve the expected results. Some solutions or recommendations that can be implemented to overcome the problem of water pollution in the Pepe River flow in Sawahan Village through the Development of the Community-Based Development concept are:

a) The Role of Society

- The community is expected to play a role in monitoring and reporting if they encounter destructive fishing activities, waste disposal activities in river bodies, and other activities that are considered to have the potential to cause water pollution to fisheries supervisors and local law enforcement officials.
- The government supports in empowering the local MSME industry through a program to provide Communal WWTP to support the management of liquid waste in densely populated settlements before it is finally disposed of in water bodies.
- Academics and the public can monitor the condition of waterways as an initial detection so that abnormal conditions that indicate water pollution can be handled immediately.
- All elements of society are expected to play an active role in supporting all environmental conservation activities.

b) Community Education

- Providing socialization to the community regarding the importance of environmental cleanliness, especially river ecosystems.
- Forming an environmentally conscious community.
- Conducting an environmental care movement campaign to convey affirmations or messages of concern for the environment in public spaces to foster a sense of concern for residents for the environment, primarily related to the waste problem.

c) Sustainability

- Carry out environmental management activities such as the Program Kali Bersih (Prokasih) regularly.
- Supervise and enforce laws and regulations from the government for irresponsible parties that cause river pollution.

4. Conclusion

The form of utilization of river water bodies by the surrounding community is one of the critical factors against whether or not a body of water is polluted. Based on the results of field observations and interviews, four forms of utilization of the Pepe River by communities around the river, especially the people of Sawahan Village, were obtained as a source of water and rainwater reservoir, a waste disposal site from domestic and industrial activities, a fishing ground, and as a source of water for drainage channels and agricultural irrigation. Various community utilization activities have high potential as a source of pollutants that cause pollution in the flowing Pepe River and become the administrative boundary between Sawahan Village and the Surakarta City area. Based on the results of the calculation of the Polluter Index value, the flow of the Pepe River in Sawahan Village has been proven to be at a level or status of lightly polluted with the results of measuring several parameters such as temperature 29.07 °C, turbidity 142.16 NTU, and DO 10.04 mg/L in average showing results above the predetermined quality standards. Therefore, one of the solutions or recommendations that can be implemented to overcome these problems is to develop a Community-Based concept by involving the active role of all levels of society in river conservation activities starting from the planning, and implementation, to evaluation stages. Three key aspects must be considered in realizing the concept of Community-Based Development-based Development, namely by paying attention to the role and participation of the public, Community Education, and sustainability aspects.

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