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# Water Quality Analysis using Pollution Index Method in Klampok Sub-watershed, Semarang Regency, Indonesia

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## Abstract

The Klampok Sub-watershed flows in the Semarang Regency, Central Java, Indonesia, located in the upstream part of the Jragung Watershed, used as a source of irrigation. Klampok Sub-watershed experiences environmental pressures in the form of decreasing water quality because of various human activities. For this reason, this study aims to determine the changes in the water quality and pollution index of the Klampok Sub-watershed in 2016 and 2020. The water quality observations were carried out in 2020 utilizing the Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Zinc (Zn) and Copper (Cu) parameters. The laboratory analysis results were compared with water quality standards based on Government Regulation Number 22 of 2021 and the status of water quality based on the pollution index method under the Decree of the Minister of the Environment Number 115 of 2003. The study results showed a change in the quality and index of water pollution in 2016 and 2020. The study results revealed a decrease in the value of water quality on the parameters BOD, COD, Zn and Cu, which indicated that the water quality was improving. Moreover, the Klampok Sub-watershed pollution index decreased in 2016 and 2020 so that the Klampok Sub-watershed had quality criteria for lightly polluted water to moderately polluted to lightly polluted at each sampling point. Therefore, several efforts to control pollution and management of the Klampok Sub-watershed, such as community outreach, water quality monitoring and industrial compliance, are expected to improve so that the Klampok Sub-watershed's sustainability can provide various benefits to the community.

**Keywords:** Klampok Sub-watershed; pollution index; wastewater; water monitoring; water quality

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## INTRODUCTION

Water is a source of life and an essential need as the population increases in socio-economic need levels, giving rise to environmental problems caused by a decrease in the water resource quality (Jin et al., 2018; Varol, 2020). In addition, the increase in land cover and land use, which is influenced by the growth of urban areas and deforestation apart from landscape characteristics such as topography, climate, geology, soil properties, atmospheric deposition and water catchment areas, leads to river water quality degradation (Lintern et al., 2018).

In this case, surface water is grouped into rivers, runoff, swamps and lakes (Poedjiastoeti et al., 2017). Specifically, watersheds as service

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providers for supplying human water needs are required to be managed to maintain water availability (Larasati et al., 2021). It makes the clean water problem a concern in the Sustainable Development Goals.

Furthermore, domestic needs of drinking water and clean water, irrigation water for agriculture, and industrial and tourism make up the main water needs, resulting in pollution due to water resources experiencing anthropogenic pressure (Sallata, 2015; Lutz et al., 2016). There is also a decrease in water quality at a certain level so that it does not function according to its designation, indicated as water pollution. River pollutant sources are classified into a point and non-point sources, in which one pollutant source originating from a certain location is called a point source, while pollutants from runoff processes in an area are called non-point sources (Anwar et al., 2018; Wicaksono and Jayanto, 2021). For example, point sources come from industrial waste outlets, drainage channels and domestic sewage treatment plants (IPAL) outlets, including integrated households, hospitals and hotels. Meanwhile, non-point sources originate from agriculture, animal husbandry, mining and households without waste treatment installations (Environmental services of Semarang Regency, 2016; Hajimi et al., 2020).

In addition, wastewater sources are categorized into domestic and non-domestic wastewater (Putri et al., 2019; Céspedes-Bernal et al., 2021). Domestic waste comes from settlements, offices, restaurants and markets, producing liquid waste, namely toilet wastewater (black water) in the form of human waste and non-toilet wastewater (greywater) in the form of water used for bathing, washing, kitchen and detergent foam (Pangestu et al., 2017; Al Kholif, 2018; Rahayu et al., 2018). Greywater flowing directly into surface water bodies without any treatment can cause eutrophication. Eutrophication is an event of the rapid growth of algae on the water body surface due to the high content of organic matter. It can reduce water quality due to decreased dissolved oxygen levels in water bodies (Purnawan et al., 2019).

Meanwhile, non-domestic waste comes from industry, fisheries, agriculture, animal husbandry, transportation and others (Yendri and Ardinata, 2020). Concerning this, the impact of industrial waste is dangerous if proper waste treatment procedures are not carried out (Chen et al., 2020). Heavy metals sourced from industrial activities, mining and fertilizers can produce hazardous and toxic materials, such as chromium, cadmium, mercury, lead and copper (Cu), causing health problems for humans and aquatic life biota if they enter rivers, which have attracted universal attention (Xu et al., 2018; Pratiwi, 2020).

On the other hand, waste originating from agricultural activities using metal-containing organic and inorganic fertilizers, such as zinc (Zn), Cu, iron-cobalt, lead and manganese as micronutrients can pollute rivers by entering runoff containing heavy metals through the process of washing the soil into rivers (Adesiyan et al., 2018; Wulan et al., 2020).

In this regard, Semarang Regency is one area with a relatively good development process in Central Java Province; based on the research analysis results, this regency has several economic sectors, in which from the results of the relative ranking of the leading sectors, the leading sectors ranked first are the manufacturing, agriculture, forestry, fishery, trade and construction sectors (Sundaro, 2021). The economic growth accompanied by increased income would impact the environment quality since it is accompanied by increased use of natural resources and environmental pollution, either solid, liquid, or air waste (Febriana et al., 2019).

The Klampok Sub-watershed is one of the sub-watersheds of the Jragung Watershed, where the Jragung Watershed is in the northern part of Central Java, a part of the Jratunseluna River area (Setyawan and Susilo, 2017). The Klampok Sub-watershed is located upstream of the Jragung Watershed. According to the Regional Regulation of Central Java Province Number 15 of 2014, the Jragung Watershed is included in a watershed whose carrying capacity is maintained, where land conditions, quality, quantity and continuity of water, socio-economic, investment in water construction and utilization of regional space are appropriate. The Klampok River is used as water for technical and non-technical irrigation of agricultural land (Siregar et al., 2016).

Administratively, the Klampok Sub-watershed is in Semarang Regency, Central Java and flows along Bandungan, Bergas, Bawen and Pringapus Sub-districts. On the other hand, environmental pressures caused by residential, agricultural, industrial, trade, hotel and government activities can cause decreased water quantity and quality

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in the Klampok Sub-watershed (Environmental services of Semarang Regency, 2016). Hence, it is necessary to pay attention to the use of the land around the Klampok Sub-watershed to minimize the potential for environmental pollution causing water quality degradation in this area.

According to the research of Siregar et al. (2016), the analysis results of Klampok River water showed that the contents of the Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Cu and Zn parameters had exceeded the value of class II quality standards. Monitoring river quality is vital to prevent and control river pollution, which is beneficial for the community and policymakers as environmental information to improve water quality management (Sutadian et al., 2018; Solo, 2020). For this reason, this study aims to assess the water quality of the Klampok Sub-watershed in 2016 and 2020 based on the pollution index method. The study can provide information on the water quality status in the Klampok Sub-watershed as a management measure for the protection and preservation of the Klampok Sub-watershed Semarang Regency, Central Java, Indonesia.

## MATERIALS AND METHOD

### Selection of the study areas

This research was conducted in the Klampok Sub-watershed, Semarang Regency, Central Java, Indonesia, in August 2020. The Klampok Sub-watershed is located between 110°20'45.528” to 110°33'24.882” East Longitude and 7°11'12.513” to 7°8'27.491” South Latitude. The sampling locations were in Bergas and Pringapus Sub-districts, Semarang Regency, Central Java (Figure 1) and purposive sampling was carried out with identified pollutant sources (Table 1).

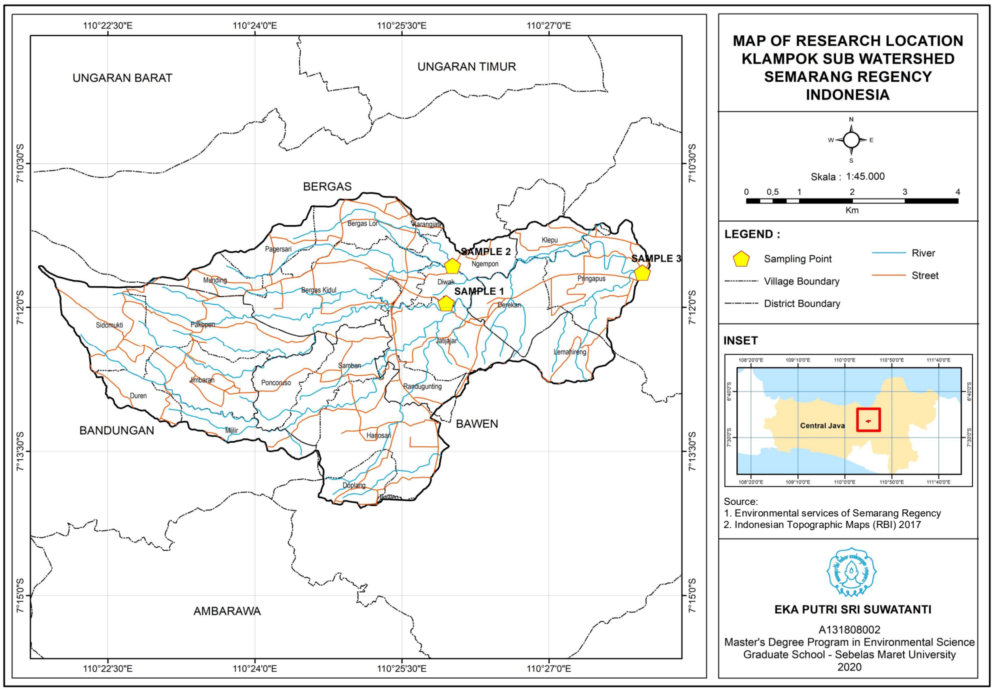

Figure 1. Sampling point at Klampok Sub-watershed

Table 1. Pollution source of the Klampok Sub-watershed

| Sampling point | Pollution source |
|---|---|
| 1 | Settlements, agriculture, business and industry, fisheries, animal husbandry and tourist attractions |
| 2 | Settlements, agriculture, business and industry, fisheries, animal husbandry and tourist attractions |
| 3 | Settlements, agriculture, business and industry, animal husbandry, fisheries, hospitals and tourist attractions |

Source: Environmental services of Semarang Regency, 2016

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### Methods of collecting data

The data needed in this study were primary and secondary. The primary data were collected through observation and measurement of water quality. The water sampling technique was under the Indonesian National Standart Agency 6989.57 (2008) regarding Surface Water Sampling Methods. Sampling was carried out by the instant sample (grab sample) method. The water sample was put into a sample bottle and stored in a cool box containing ice cubes for preservation, to be subsequently brought and analyzed to the Environmental Laboratory, Environmental service, Semarang Regency, Central Java, Indonesia. The methods for analyzing water quality parameters are presented in Table 2.

Table 2. Methods for measuring water quality

| Parameter | Unit | Method |
|---|---|---|
| TSS | mg $l^{-1}$ | SNI 6989.3-2004 |
| BOD | mg $l^{-1}$ | IKM 27 |
| COD | mg $l^{-1}$ | SNI 6989.2:2009 |
| Nitrate | mg $l^{-1}$ | IKM 07 |
| Zn | mg $l^{-1}$ | IKM 10 |
| Cu | mg $l^{-1}$ | IKM 14 |

Secondary data in this study included the water quality analysis results in the 2016 Klampok Sub-watershed, obtained through the final report document of Kajian Daya Dukung dan Daya Tampung Sungai Klampok (Environmental services of Semarang Regency, 2016).

### Data analysis

The results of water sample testing were then compared using river water quality standards according to Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. Also, the test analysis results were then compared with the test results in 2016. The water quality status could be measured using the Storage and Retrieval of Water Quality data System (STORET) method and the pollution index based on the Decree of the Minister of the Environment Number 115 of 2003.

The pollution index method was employed to determine the parameters causing low water quality status to implement proper management using a single data analysis, which is efficient in time and cost in determining water quality status. This study used the analysis of the pollution index method according to the Decree of the Minister of the Environment Number 115 of 2003 Appendix II on determining the water quality status, which is useful as information on the river pollution level. The calculation of the water quality status of the Klampok Sub-watershed in 2016 and 2020 utilized the pollution index method, using the formula in Equation 1. Status classification is based on score criteria in several water quality ranges as presented in Table 3.

$$\mathrm{PIj} = \frac{\sqrt{\left(\frac{\mathrm{Ci}}{\mathrm{Lij}}\right)^2 \mathrm{M} - \left(\frac{\mathrm{Ci}}{\mathrm{Lij}}\right)^2 \mathrm{R}}}{2} \tag{1}$$

Where; Lij = concentration of the water quality parameters stated in the water quality standard (i); Ci = concentration of water quality parameters survey results; Plj = pollution index for designation (j); (Ci/Lij)M = maximum value Ci/Lij; (Ci/Lij)R = average value Ci/Lij.

Table 3. Classification of water quality status based on pollution index method

| Score | Criteria |
|---|---|
| $0.0 \leq \mathrm{PIj} \leq 1.0$ | Good quality |
| $1.0 \leq \mathrm{PIj} \leq 5.0$ | Lightly polluted |
| $5.0 \leq \mathrm{PIj} \leq 10$ | Moderately polluted |
| $\mathrm{PIj} > 10$ | Extremely polluted |

## RESULTS AND DISCUSSION

### Water quality in the Klampok Sub-watershed

Changes in water quality in the Klampok Sub-watershed were observed with primary data from laboratory analysis in 2020 for parameters TSS, BOD, COD, Nitrate, Zn and Cu, which were then compared with secondary data from water quality analysis in 2016. The test results indicate that the water is polluted if it exceeds the maximum quality standard for river water quality according to Government Regulation Number 22 of 2021.

TSS was used as one of the important water quality parameters. TSS can disrupt the aquatic ecosystem of the photosynthetic process due to the obstruction of incoming sunlight so that the photosynthesis process is hampered and this affects temperature and turbidity (Patel et al., 2020; Rodríguez-Martínez et al., 2021). The TSS content results from the Klampok Sub-watershed are shown in Figure 2 that there was a change in the TSS content in 2016 and 2020. The increase

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in the TSS content in the last four years was seen at each sampling location point. TSS value in Klampok Sub-watershed in 2016 was 0.16 to 0.34 mg $l^{-1}$ and increased by 4.05 to 15.55 mg $l^{-1}$ in 2020. The highest increase in TSS value was at point 3, which was 0.34 to 15.55 mg $l^{-1}$. It remained within the class II quality standard based on the TSS level. Changes in land cover conditions can affect fluctuations in TSS content (Parwati and Purwanto, 2017). Changes in the increase in TSS content that affect surface runoff dissolving into water bodies are suspected of changes in requirements and land use in the Klampok Sub-watershed area. This result is similar to that of Lusiana et al. (2020) that the TSS content in the Brantas River, Malang City, was below the quality standard, where the TSS value was influenced by the amount of sediment in the water body carried by surface runoff and open land around the water body. The high content of TSS also occurs in the Sani River, Pati Regency, Central Java at 19 to 108 mg $l^{-1}$ due to the input of sediment and solids in the river body (Mailisa et al., 2021).

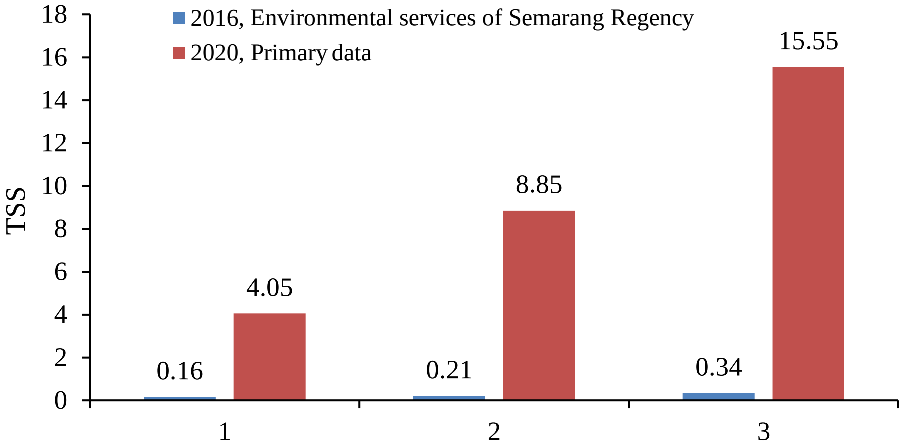

Figure 2. TSS values of Klampok Sub-watershed in 2016 and 2020

Meanwhile, BOD was utilized in aquatic biochemistry and ecotoxicology related to the amount of dissolved oxygen in the ability of microorganisms to decompose organic compounds, including pollutants, under aerobic conditions (Smagin et al., 2018; Nugraha et al., 2020). BOD is an indicator of the level of water and wastes pollution by organic matter, which significantly affects the capacity of river water biodegradation (Yustiani et al., 2021). The value of the BOD content indicated that the river body had been polluted by organic waste (Djoharam et al., 2018) which came from residential, industrial, agricultural, fisheries, animal husbandry, tourism and hospital activities around the Klampok Sub-watershed. The BOD concentration results from the Klampok Sub-watershed showed that it was above the class II quality standard, both in 2016 and 2020 (Figure 3). The BOD concentration in 2016 exceeded the river class quality standard at each sampling point, which was in the range of 32.9 mg $l^{-1}$ to 55.5 mg $l^{-1}$. In 2020, the BOD content decreased in value at each sampling point compared to the BOD content in 2016. The Klampok Sub-watershed BOD concentration in 2020 met the class IV quality standard for points 1 of 10.4 mg $l^{-1}$ and 2 of 9.6 mg $l^{-1}$. The value of the BOD class III quality standard shown at sampling point 3 was 3.3 mg $l^{-1}$. The BOD content decreased at sampling point 3 since sampling location point 3 was the accumulation of pollution points from points 1 and 2 and had a longer distance than the previous sampling point. The pollutant had been reduced by increasing the distance of the river flow so that the number of pollutants received was smaller at the receiving location of the pollution accumulation than at the previous sampling locations (Lusiana et al., 2020).

Changes in BOD content in 2016 and 2020 were due to the improvements in water quality with measures to control river pollution in the Klampok Sub-watershed. One of them was a socialization program appealing to the community not to pollute the river by throwing household waste in the river. This program can minimize the pollution of BOD values originating from residential activities in the Klampok Sub-watershed. Household wastes such as household waste, paper waste, wash water and food waste are some of the sources of pollution, with high BOD and COD values, thereby reducing the value of water quality in Kali Asin Semarang (Kurnianti et al., 2020).

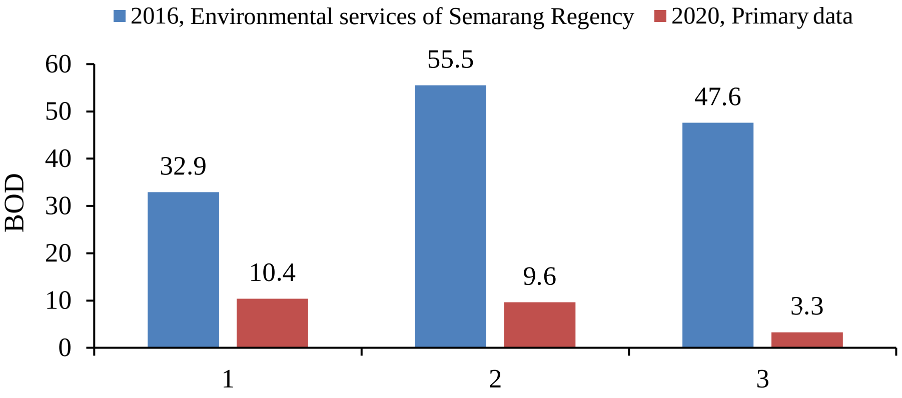

Figure 3. BOD values of Klampok Sub-watershed in 2016 and 2020

The observation results of a decrease in BOD content in the Klampok Sub-watershed are also similar to those of Novita et al. (2020) that there was a decrease in the BOD value in the Bedadung River from 2016 to 2019, respectively, which was influenced by the ability to reduce organic pollutants, signifying that there was an improvement in water quality in the Bedadung River.

Furthermore, COD was employed as an indicator of water quality parameters to measure organic pollutants in water bodies (Meng et al., 2018; Ruben et al., 2018). COD is a level of oxygen consumed during the decomposition of organic matter and oxidation of inorganic chemicals (Sutadian et al., 2018). On the other hand, it is necessary to describe the level of pollution, which plays a vital role in controlling pollution levels and managing waters (Prambudy et al., 2019). From the observation results, the COD concentration from the Klampok Sub-watershed in 2020 showed a decrease in value compared to the COD concentration in 2016. The COD content of the Klampok Sub-watershed in 2016 at each sampling point was in the range of 60 to 100 mg $l^{-1}$. The decrease in COD concentration in the Klampok Sub-watershed occurred in 2020, in the range of 8.186 to 23.69 mg $l^{-1}$. This incident aligns with Hashim et al. (2021) results, which reported a decreasing COD trend was experienced at all Bernam River Basin stations, Malaysia.

In addition to the socialization program for the community, there was a Klampok Sub-watershed management program in terms of industrial activities providing COD and BOD pollution values from industrial activity waste. Monitoring and supervision of industrial compliance in waste management were carried out as a form of stakeholder collaboration, namely the Environmental services of Semarang Regency and the industry, to prevent water pollution in the Klampok Sub-watershed. This program was one of the factors in decreasing COD and BOD concentrations in the Klampok Sub-watershed. The decrease in COD and BOD content in the Klampok Sub-watershed in 2020 was due to the ability of microorganisms to degrade organic matter in waste. The reduction in BOD and COD levels was caused by a decrease in organic matter levels accompanied by a reduction in the need for oxygen to decompose organic matter (Turista, 2017).

Megasari et al. (2012) found that the decrease in COD was caused by the activity of microorganisms in degrading organic compounds by adding activated sludge to the beverage industry wastewater treatment process. The addition of bacteria provided a COD removal of 81.78% in tapioca waste (Febriningrum and Nur, 2021). It is also similar to the study of Wifarulah and Marlina (2021) that there was a decrease in COD concentration in the Widuri River, Yogyakarta, which was caused by the decomposition process by microorganisms. The decomposition process is assisted by macrozoobenthos, one of the aquatic biotas that live relatively sedentary and interact with

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waste in aquatic waste. It plays a role in helping the decomposition process of organic material into small pieces, making it easier for microbes in the decomposition process (Mar'i et al., 2017).

Sources of COD can be natural organic matter in water bodies and organic matter caused by domestic and industrial waste disposal activities and the entry of plant and animal decomposition runoff through the rain (Peng and Li, 2021). Based on the COD content, in class IV, the pollution level in 2020 decreased compared to 2016. These results show that all sampling points were in class II with points 1 and 2 corresponding to class II and point 3 corresponding to class I, which were still below the 25 mg l$^{-1}$ (Figure 4).

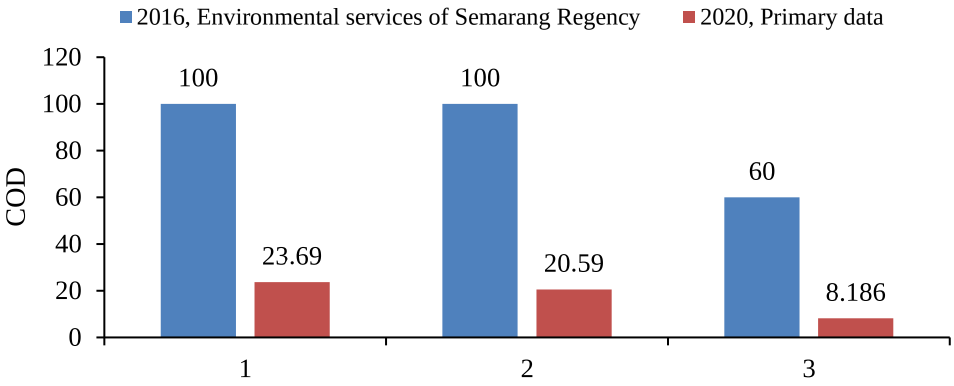

Figure 4. COD values of Klampok Sub-watershed in 2016 and 2020

The nitrate content in the waters is influenced by the intake of nitrate, a macronutrient that regulates primary productivity in the euphotic area of the river body. Nitrates are sourced from household and agricultural, and domestic waste (Elviana and Monika, 2019). These compounds have stable properties but are very soluble in water and are important for aquatic plants and algae as nutrients for growth (Harjito et al., 2018).

The value of the nitrate content of the Klampok Sub-watershed in observations in 2020 increased compared to the content in 2016 (Figure 5). The nitrate content in 2020 ranged from 1.1 mg l$^{-1}$ to 2.8 mg l$^{-1}$, while the nitrate content in 2016 ranged from 0.009 mg l$^{-1}$ to 0.16 mg l$^{-1}$. In this case, the increase in nitrate concentration in 2020 is due to residential activities and agricultural fertilizers and pesticides around the Klampok Sub-watershed area. According to Effendi (2003), water eutrophication can occur if nitrate levels exceed 0.2 mg l$^{-1}$, triggering the rapid growth of algae and aquatic plants. Tungka et al. (2016) have recorded that nitrate concentration of 0.6 to 2.2 mg l$^{-1}$ affected the appeal of phytoplankton HABs at the estuary of the Banjir Kanal river of Semarang.

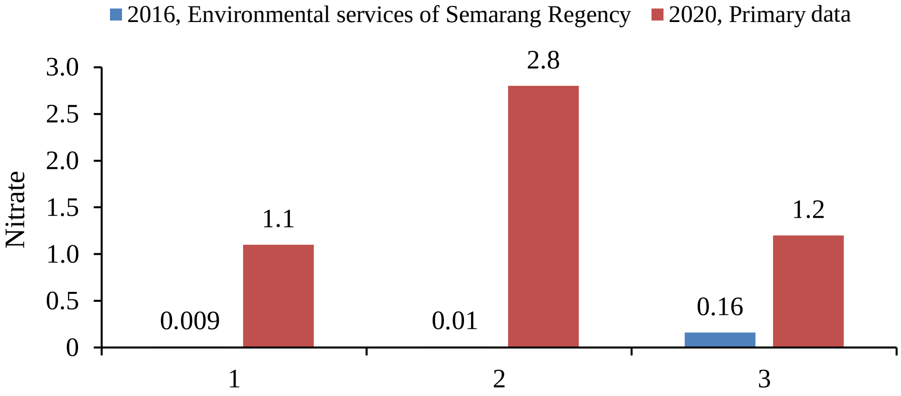

Figure 5. Nitrate values of Klampok Sub Watershed in 2016 and 2020

The results of this study are similar to those of Adriani et al. (2020) which revealed that the nitrate concentration in the Silandak River with the location of the highest nitrate

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concentration came from densely populated areas. Sari and Wijaya (2019) mentioned that densely populated locations contributed to the highest nitrate concentration, where domestic waste generated resulted in an increase in nitrate in the water. It is also similar to Putri et al. (2019) that it was allegedly due to domestic and agricultural activities in the use of fertilizers when there was a process of erosion and agricultural land erosion, causing dissolved nitrate to enter river bodies and becoming a contributor to the increase in nitrate concentrations. The nitrate contents in the Klampok Sub-watershed in 2016 and the observation results in 2020 were still at class II quality standard, below the value of 10 according to Government Regulation Number 22 of 2021.

Zn is sourced from weathering of rocks, volcanic eruptions, forest fires, soil erosion containing Zn and the anthropogenic activities of Zn-heavy metal from mining activities, use of fertilizers, pesticides, wood preservatives, anti-corrosion materials, pigment processing industries and thermal power industries (Borah et al., 2018; Patty et al., 2018). The Zn content in the Klampok Sub-watershed in 2016 was in the class IV quality standard which exceeded the class II quality standard, indicating that the water quality of the Klampok Sub-watershed has been polluted by Zn content. The Zn content in 2016 was 0.1 mg $l^{-1}$ at each observation point. The high content of heavy metals in the Klampok Sub-watershed can be attributed to business and industrial activities (Environmental services of Semarang Regency, 2016). Chemical fertilizers and pesticides used in agricultural activities contributed to Zn content in the Klampok Sub-watershed.

In previous research, Siregar and Kiswiranti (2019) stated that the Zn content in the Klampok River ranged from 0.13 to 0.16 mg $l^{-1}$ and was in the class IV quality standard. These results are in line with Halang and Susanti's (2019) research that the Zn value of the waters of Alalak River, Barito Kuala Regency, has exceeded the environmental quality standard. It is thought to originate from anthropogenic activities that can produce heavy metal waste, such as traditional market activities, sales of chemical fertilizers, ship dock activities and diesel fuel sales.

In addition, consuming water with a high Zn content can cause health problems, such as nausea, vomiting, stomach cramps, anemia, pancreatic disorders, skin inflammation and arteriosclerosis (Jamshaid et al., 2018). Changes in Zn content at each observation point could be seen in the observation results made in 2020, which ranged from 0 to 0.04 mg $l^{-1}$ (Figure 6). However, the Zn content was not found at point 3, which is suspected that the Zn content was deposited in the sediment. Suyatno et al. (2021) affirmed that heavy metals are easy to bind and settle, so they accumulate in sediments; therefore, sediment has a higher heavy metal content than water. The concentrations of heavy metals in sediments were higher at 3 to 5 times than those in water (Kusmana et al., 2018). It is also shown in the change in the value of the Zn quality standard for the Klampok Sub-watershed in 2020, which was already in class II, with a value below 0.05 mg $l^{-1}$. The Environmental service of Semarang Regency monitors river water quality as a preventive measure against pollution, including metal content in Semarang Regency waters.

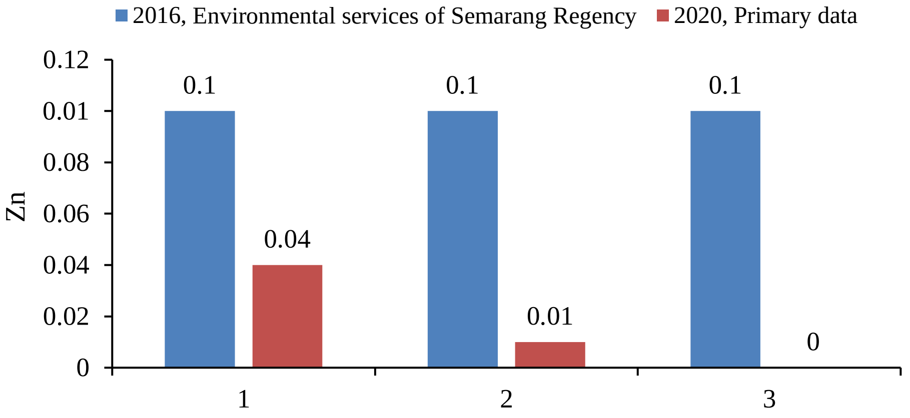

Figure 6. Zn values of Klampok Sub-watershed in 2016 and 2020

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The following parameter, Cu, is a metal element found in nature, both naturally and non-naturally. Naturally, Cu is sourced from natural events, such as erosion of mineral rocks and Cu particulates or dust in the air layer, which then experiences precipitation (Yudo, 2006). Meanwhile, non-naturally, Cu comes from anthropogenic activities, such as industrial activities, metal and electricity manufacturing, mining and agriculture (Rehman et al., 2019).

The Cu content of the Klampok Sub-watershed in 2016 was in the class IV quality standard so that it had exceeded the class II quality standard value, which was 0.02 mg $l^{-1}$ at each observation point, for point 1 of 0.1 mg $l^{-1}$, point 2 of 0.08 mg $l^{-1}$ and point 3 of < 0.1 mg $l^{-1}$. Class IV quality standards for Cu parameters are also shown in the observation results of Cu parameters in 2020, which were in the range of 0.05 to 0.080 mg $l^{-1}$ (Figure 7). Meanwhile, the standard value of the Cu parameter for class IV is 0.2 mg $l^{-1}$. Based on the analysis results, Cu has polluted the Klampok Sub-watershed.

This research aligns with research by Firmansyah (2019) that the concentration of total Cu in the waters of the Porong River estuary in Sidoarjo has exceeded the normal concentration threshold value of Cu in the waters. Economic development in downtown and suburban areas causes a higher amount and intensity of pollutant emissions of heavy metals in rivers than in areas with low anthropogenic activity and land use (Zeng et al., 2020; Kumar et al., 2021).

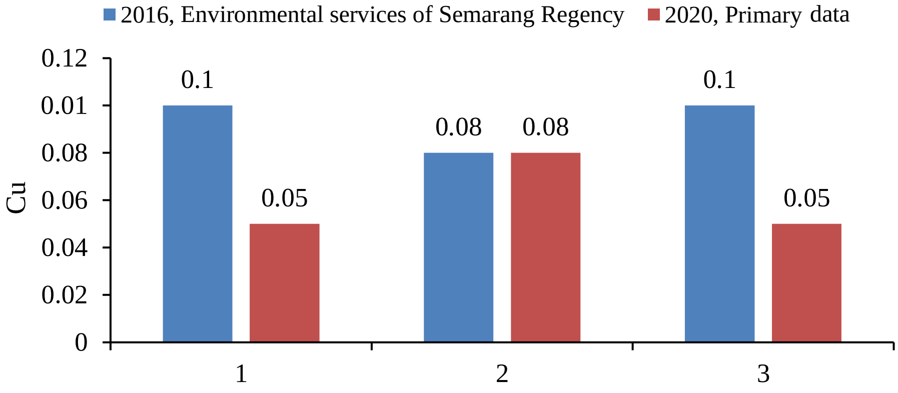

Figure 7. Cu values of Klampok Sub-watershed in 2016 and 2020

In the Klampok Sub-watershed, Cu content was attributed to agricultural activities using fertilizers and pesticides. Related to this, pesticides and fertilizers in agricultural activities are some of the sources of Cu content in waters, which can pollute river water through surface runoff (Pandey and Singh, 2017; Naggar et al., 2018). Agricultural waste can be reduced by the participation of farmers in reducing runoff in the nutrient load in river bodies (Bradford et al., 2020). Business and industrial activities also had an important role in the high content of heavy metals in the Klampok Sub-watershed, apart from pollution due to natural activities, one of which was the erosion process of mineral rocks entering water bodies (Environmental services of Semarang Regency, 2016).

These results are also similar to those of Suyatno et al. (2021) that the high content of Cu metal in the water in the West Flood Canal River, Semarang City, Central Java, was caused by various community activities, such as settlements, tourism objects, fishing ponds, industry and market. In addition, Mahurpawar (2015) expressed that Cu becomes toxic if the concentration is higher than the normal level; Cu can cause gastrointestinal distress (stomach pain, nausea and vomiting), anemia and even death, which can be caused by liver poisoning due to high doses.

### Water quality status of the Klampok Sub-watershed

Finally, the water quality index plays a role in determining the water quality status in describing the results of the combination of different water quality parameters to obtain water quality information (Effendi, 2016). The water quality status in the Klampok Sub-watershed was indicated by the pollution index value, obtained based on the calculation of water quality parameters. Class II status was used in the calculation of the Klampok Sub-watershed pollution index. The class II quality standard status signifies that water whose designation can be used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops and/or other designations, requires the same water quality as detailed in the Government Regulation Number 22 of 2021.

The parameters of TSS, BOD, COD, Nitrate, Zn and Cu were chosen because they were considered to describe the effects of various anthropogenic activities in the Klampok Sub-watershed. In 2016, the pollution index value of the Klampok Sub-watershed at three sampling points was in the range of 4.831 to 5.598, with a light-polluted to moderately polluted status (Table 4). Moderately polluted status was shown at sampling points 2 and 3 due to the high concentrations of BOD, Zn and Cu parameters. Anthropogenic activities contributed to high parameter concentrations in the Klampok Sub-watershed water body. In 2020, the calculation results of the pollution index of the Klampok Sub-watershed ranged from 2.193 to 3.028, meaning that it had a lightly polluted status at each sample point. Changes in the value of the Klampok Sub-watershed pollution index can be seen in Table 3. The calculation results of the value of the 3-point pollution index decreased even more due to the absence of Zn content.

Table 4. Water quality status calculation of the Klampok Sub-watershed in 2016 and 2020

| Sampling point | Pollution index | | Quality status | |
|---|---|---|---|---|
| | 2016 | 2020 | 2016 | 2020 |
| 1 | 4.831 | 2.806 | Lightly polluted | Lightly polluted |
| 2 | 5.598 | 3.028 | Moderately polluted | Lightly polluted |
| 3 | 5.338 | 2.193 | Moderately polluted | Lightly polluted |

Trends in water quality status were also shown in the research of Rahayu et al. (2018) that the Cikapundung River was heavily polluted in the dry month in 2015 and moderately polluted in the dry month in 2016. Nevertheless, this result contrasts with the research of Suriadikusumah et al. (2021), in which the Cipeusing River pollution index in 2016 and 2017 was decreasing, from moderately polluted to heavily polluted.

From this study, the Klampok Sub-watershed provides economic value for the community, which is useful as irrigation water and over time, it becomes a use for water recreation that there is a location for the development of Grenjeng Waterfall tourism in Bergas Sub-district. In addition to providing economic value, the Klampok Sub-watershed needs to be maintained in its use as the final channel for anthropogenic activities around the Klampok Sub-watershed, which is feared to put pressure on water quality. Poor water quality will then contribute to the decline in public welfare and health.

Based on Hanif et al.'s (2020) research, various health problems such as scabies, diarrhea, dysentery, respiratory problems and asthma are caused by consuming polluted water in the Kapotaskha River, Bangladesh. On the other hand, the Ganga River is contaminated with heavy metals that impact the fish in the Ganga River; when consumed by humans, it is dangerous due to the concentration of heavy metals in fish's liver, gills and muscles (Maurya et al., 2019). For this reason, the best management implementation should be used to improve water quality, where interventions play a role. One form of management procedure is to use no-till and nutrition management to reduce pollutant sources (Liu et al., 2019).

Various efforts to manage and control pollution in the Klampok Sub-watershed include water quality monitoring programs, industrial monitoring programs, socialization appeals for river and environmental cleanliness, environmental service, clean river program (*Prokasih*), tree planting activities and stockfish seeds. Those activities are expected to be continuously carried out and optimized by all stakeholders to maximize the results and maintain the sustainability of the Klampok Sub-watershed.

Thus, good and wise watershed management will result in good water quality, providing sustainability for nature and the environment. In particular, improving the water quality status of the Klampok Sub-watershed signifies that various pollution control, management and conservation efforts have been carried out by stakeholders or related parties responsible for improving water quality.

## CONCLUSIONS

The water quality of the Klampok Sub-watershed experienced changes in 2016 and 2020 in terms of several parameters, including TSS, BOD, COD, Nitrate, Cu and Zn. Changes in the water quality of the Klampok Sub-watershed affected the changes in the water quality status. From this study, the water quality of the Klampok Sub-watershed has improved, becoming lightly polluted at each sampling point. Conservation is the result of the efforts made by various relevant stakeholders and these need to be maintained and improved to maintain sustainability in the future.

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