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Analysis of water quality in watershed using heavy metal pollution index

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ABSTRACT

The quality of rivers and coastal is gradually deteriorating along with rapid population and socio-economic growth in the watershed to the estuary. Sampling was conducted in Semarang city rivers and Demak district rivers, Central Java Province, Indonesia, at four different stations according to geography and designation: river basins, estuaries, and rivers affected by industrial and domestic waste. Research time is August - October 2023 during the dry season. The research method uses descriptive analysis to determine the variables to be studied based on the research results in the field. River and coastal pollution levels are measured using the Heavy Metal Pollution Index method, with several water quality parameters measured, such as BOD, COD, Ammonia, TDS, TSS, and Total Coliform. In contrast, the heavy metal parameters measured are Cd, Ni, Zn, Cu, and Pb. The heavy metals and water quality parameters analyzed guided by Government Regulation of the Republic of Indonesia Number 22 of 2021 class 2. Water quality and heavy metal analysis use the Heavy Metals Pollution Index (HPI). HPI is an assessment method that shows the influence of individual heavy metal compounds on overall water quality. The results show that the status of non-metal water quality in terms of HPI analysis shows that Sampling Station (SS) 1 is 224.30 (unsuitable for drinking), SS 2 is 645.98 (unsuitable for drinking), SS 3 is 320.09 (unsuitable for drinking), SS 4 is 252.09 (unsuitable for drinking), and metal parameters in terms of HPI analysis show that SS1 is 26.43 (good), SS2 is 2345.84 (unsuitable for drinking), SS3 is 26.43 (good), and SS4 is 12.64 (excellent). The conclusions from these four research areas indicate that the status of water quality, according to the HPI is unsuitable for drinking, however, indications of heavy metals in 2 areas are still tolerable, namely good and excellent. The decline in water quality in the research area is caused by domestic and industrial waste polluting the waters. In conclusion, this river area requires further management from the collaboration of various stakeholders.

Introduction

Rivers are public waters essential in maintaining biodiversity, mostly fish aquatic ecosystems. The river consists of an upstream area at the top and a downstream area at the bottom and finally empties into the sea. Resulting in changes in the structure and function of coastal ecosystems, exceptionally shallow coastal areas (Shaik, *et al*., 2015). Because they are locations where poisons occur, coastal/estuary areas are susceptible to pollution. The dilution and sedimentation processes, which are regulated by water depth and flow speed, have an impact on the occurrence of heavy metals in estuaries (Wahwakhi, Kusmana, and Iswantini, 2017; Akbar & Rahayu, 2023).

This pollution overload can be caused by eutrophication that occurs in water areas. Excessive anthropogenic inputs (especially nitrogen, phosphate, and silicate) to coastal areas have increased manifold over the last three to four decades. Increased intake of inorganic nitrogen to waters can lead to the growth of aquatic organisms, for example, phytoplankton, changes in species composition, and possible proliferation of harmful

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algae. The accumulation of pollutants will settle to the bottom of the waters as sediment, while organisms will absorb biological pollutants (Nurjanah, *et al*., 2017). Decreased water quality and heavy metal contamination in waters are hazardous. Water pollution in rivers is due to the continuous discharge of domestic and industrial waste without treatment, which causes a decrease in water quality (Pathirana, *et al*., 2019), and is contaminated with heavy metals.

The distribution of heavy metals in water, sediments, and fish is a major factor in forming sources of pollution in aquatic ecosystems (Kumar, *et al*., 2019). Heavy metal toxicity is hazardous because it enters the food chain (Jacques, *et al*., 2017), and causes health problems (Natasia, *et al*., 2010). Heavy metals accumulated in fish can threaten human health by consuming contaminated fish and pose a significant danger after continuous exposure (Leung, *et al*., 2014). Growth rate, metabolic rate, sensitivity factors, and physiological needs for metals influence heavy metal concentrations. Effects of heavy metals: brain damage, decreased IQ, changes in the shape and size of red blood cells resulting in high blood pressure (Kristianingrum, Sulistyani, and Larastuti, 2022).

Our previous research on the Semarang coastal resulted in an analysis of Cu concentration: 0.11 mg/L (Ujianti, *et al*., 2018b), with a quality standard of 0.02 mg/L and Pb in fish of 0.68 (Ujianti, *et al*., 2018a), determining with SNI quality standard: 0.3 mg/L. Another research concluded the Banjir Kanal Barat (BKB) River in Semarang City produces TSS, nitrate, and phosphate pollution, which exceeds the assimilation capacity of the river estuary for various pollutants, which causes water pollution. With a water quality index of 51.94, the waters of the BKB estuary are considered highly polluted by TSS, nitrates, and phosphates (Haeruddin, Purnomo, and Febrianto, 2019).

The coastal areas of Central Java, especially Demak and Semarang, need good management. Previous studies mentioned research on water quality management in Demak using the hydrodynamic simulations method (Wisha and Ondara, 2017), heavy metal lead and cadmium pollution using the water pollution index method. Coliform abundance utilizing the density of the coliform bacteria method (Tjahjono and Suwarno, 2018), the SNI method 2897-2008 was used to analyze coliform bacteria density (Safitri, Widyorini, and Jati, 2018). Several water quality studies in Semarang: using the National Sanitation Foundation – Water Quality Index Method (Syafrudin, *et al*., 2023), preliminary water quality survey (Budiyono, *et al*., 2015), water quality status (Suwatanti, Maridi, and Suntoro, 2022), GIS method with descriptive analysis (Ihsan, *et al*., 2022). Some of the research investigations above have yet to use the Heavy Metal Pollution Index (HPI) method, so the HPI method in this research article needs to be carried out to provide an overview of water quality management in Semarang and Demak.

Research on preventing waste disposal in aquatic ecosystems has become the primary research in environmental science. Because the effects are substantial and natural, for example, they can change aquatic organisms' community structure and function. The mixing of physicochemical aspects and pollutants that enter these waters can cause a decline in water quality and marine resources and, in the long term, will affect humans as consumers of fishery products. This research was carried out at four sampling stations, which are river watersheds. Currently, there are several land uses in the watershed at the research location. The watershed's upper reaches are hills, gardens, moors, and rice fields for residents. Industrial, residential, and agricultural areas dominate the central watershed. The downstream area is dominated by land use: irrigation, agricultural land, ponds, and settlements. Watershed to coastal must be managed synergistically and sustainably because heavy metal pollution is worrying. A coastal management system must be implemented to ensure the survival of aquatic organisms, the fisheries sector, and society (Muthmainnah, Atminarso, and Makmur, 2015). Based on the description, this research aims to determine the level of river pollution and advise the government regarding river area management, water quality, and heavy metals. This research analyzes water quality and heavy metals in coastal areas using the Heavy metal pollution index approach, which aims to determine the level of water pollution so that we can define the next steps for its management.

Materials and Methods

Location and time of research

Sampling Station 1

Sampling station 1 is on the river in front of the waste disposal area in the industrial area in Genuk District, Semarang City (06° 57'24.59 S; 110°27'20.0 E). The condition of the waters in this area is influenced by domestic waste in the surrounding area and industrial waste behind it. The water looks brown and has a depth of around 1-2 meters. The substrate in this area is dominated by mud, and very few plants are on either side of the river, so the temperature is hotter. It is located on the side of the

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 13, Number 2, Page 201-211

Semarang-Demak highway and is exposed to waste from the fumes of passing motor vehicles.

Sampling Station 2

Sampling station 2 is located on the river near the village area in Sayung Subdistrict, Demak Regency (06° 56'31.1 S; 110°23'52.87 E). The condition of the waters in this area is influenced by domestic waste in the surrounding area. The water looks brown and has a depth of around 1-2 meters. The substrate in this area is dominated by mud, and very few plants are on either side of the river, so the temperature is hotter. It is located on the side of the Semarang-Demak highway and is exposed to waste from the fumes of passing motor vehicles.

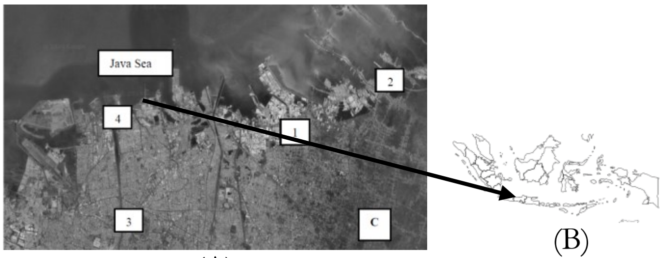
Sampling Station 3

Sampling station 3 is located in the Banjir Kanal Barat River, Semarang City (06° 59'14.9 S; 110°24'8.83 E). This river is located in front of the village and office area. In the afternoon, this river becomes a tourist spot for relaxing and a place to sell snacks for the local community. The condition of the waters in this area is influenced by domestic waste in the surrounding area. The water looks brown and has a depth of around 1-3 meters. The substrate in this area is dominated by mud. On either side of the river, there are plants, thus allowing the entry of water flows containing pesticides and agricultural fertilizers, which can affect water quality and aquatic ecology. According to fishermen and residents, the fish dominating this area is wild Tilapia (*Oreochromis* sp.).

Sampling Station 4

Sampling station 4 is located downstream of the Banjir Kanal Barat River, Semarang City (06° 57'17.6 S; 110°23'52.8 E), which borders directly on the Java Sea, so this area is an estuary/estuary area that is still influenced by water input from the freshwater area and the sea. The water looks brown and has a depth of around 1-4 meters. The substrate in this area is dominated by mud and sand. Land use in sampling station 4 is settlements, rice fields, gardens, rivers, barren land, and ponds. In downstream areas bordering residential areas, residents' lots still exist, allowing the entry of water flows containing pesticides and agricultural fertilizers, which can affect water quality and aquatic ecology. According to fishermen and residents, the fish dominating this area is barramundi (*Lates* sp.).

Sampling at stations 1-4 was carried out in the month August - October 2023 during the dry season. The sampling station in this research is presented in the Figure 1.



(A)

Figure 1. Figure 1. Study area: Location of Semarang City and Demak Regency Sampling station 1-4 (A), the map of the Indonesia (B),

Sample collecting

Water quality and heavy metals

Water quality and heavy metal samples were taken at sampling locations 1-3, while snapper samples were taken at station 4, the Java Sea estuary. Water samples were taken from river water, 5 litres of which were taken and put into a sample bottle and then taken to the laboratory for analysis directly on the day the sample was taken. All samples were analyzed at the Center for Standardization and Industrial Pollution Prevention Services. Water quality testing methods are presented in Table 1.

Table 1. Test Method of Water Quality Parameters

No	Water Quality Parameters	Unit	Test Method
1	BOD	mg/L	SM 5210 B, 23rd Edition: 2017
2	COD	mg/L	SM 5220 D, 23rd Edition: 2017
3	Ammonia	mg/L	Mu 2.05 (Discrete Photometry)
4	TDS	mg/L	SM 2540 A,C, 23rd Edition : 2017
5	TSS	mg/L	SM 2540 A,D, 23rd Edition : 2017
6	Total Coliform	MPN/100mL	SM 9221 B, 23rd Edition: 2017
7	Cd	mg/L	SM 3113 B, 23rd Edition : 2017
8	Ni	mg/L	SM 3111 B, 23rd Edition : 2017
9	Zn	mg/L	SM 3111 B, 23rd Edition : 2017
10	Cu	mg/L	SM 3113 B, 23rd Edition : 2017
11	Pb	mg/L	SM 3113 B, 23rd Edition : 2017

Data analysis

Referring to previous research, the heavy metals and water quality parameters analyzed in this study are TDS, TSS, BOD, COD, ammonia, and total coliform, Cd, Ni, Pb, Cu and Zn (Widyastuti, Jayanto, and Irshabdillah, 2021). The heavy metals and water quality parameters analyzed guided by Government Regulation of the Republic of Indonesia Number 22 of 2021, Concerning Implementation of Environmental Protection and Management Regarding River Water Quality Standards, class two is used, which is water that is intended to be used for infrastructure/facilities. Water recreation, freshwater fish cultivation, animal husbandry, water for irrigating crops, and other uses that require the same water quality as those uses. Water quality was also assessed for the occurrence of heavy metals in the analyzed water samples. Furthermore, the results were analyzed using the Heavy Metals Pollution Index (HPI). The methodology of HPI calculation can be found elsewhere: Al-Arab River, Basrah-Iraq (Al-Hejuje, Hussain, and Al-Saad, 2017), Ganga River (Matta, *et al.*, 2020), Code River Indonesia (Widyastuti, Jayanto, and Irshabdillah, 2021), Podhale Region Southern Poland (Wątor and Zdechlik, 2021), Euphrates River Iraq (Kamel, Al-Zurfi, and Mahmood, 2022), Islamabad (Ahmed, *et al.*, 2023). The HPI values (Wątor and Zdechlik, 2021), were calculated using the formula (1) below:

$$HPI = \frac{\sum_{i=1}^{n} Wi.Qi}{\sum_{i=1}^{n} Wi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

where: Wi is a weight unit (1/Si). Qi is the sub-index of the i-th parameter, and n is the number of observed parameters. The HPI values were then categorized into five levels of water qualities: excellent (0–25), good (26–50), poor (51–75), bad (76–100), and unsuitable for drinking (> 100) (Bora and Goswami, 2017).

Results

TDS

Sampling station 1 (SS1) is in the river close to the industrial area in Genuk sub-district, Semarang City. The TDS at the SS1 is 626 mg/L; and the SS3 is 268 mg/L, which does not exceed the class 2 quality standard of 1000 mg/L. The TDS at the SS2 is 18270 mg/L; SS4 is 13,136 mg/L which exceeds the class 2 quality standard of 1000 mg/L. (Figure 2).

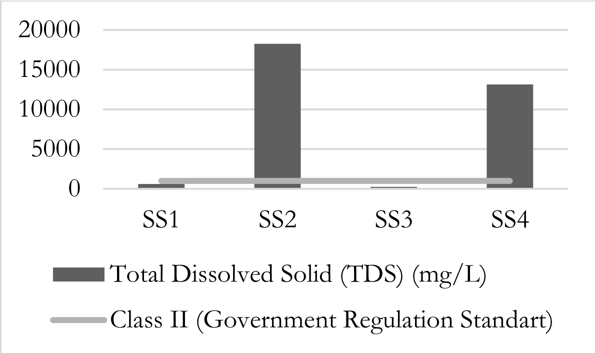


Figure 2. TDS water quality parameter graph

TSS

The TSS at the SS1 location is 38 mg/L; SS3 is 11 mg/L; SS4 is 15 mg/L which does not exceed the class 2 quality standard of 50 mg/L, furthermore it does not exceed class 2 quality standards. The TSS content in SS2 is 63.00 mg/L, exceeding the class 2 quality standard of 50 mg/L. Sampling stations in higher areas (SS3) have lower (Figure 3).

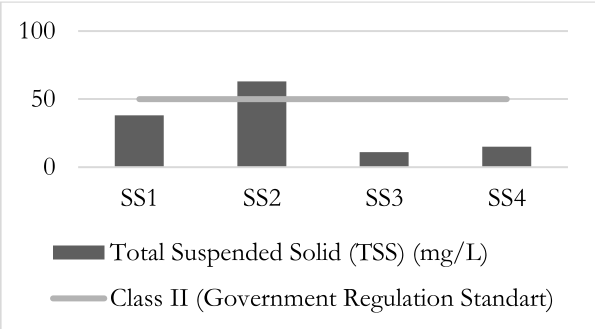


Figure 3. TSS water quality parameter graph

BOD

The BOD content in SS1 is 26.43 mg/L; SS2 is 26.43 mg/L; SS3 is 5,524; SS4 is 9.54 mg/L. BOD content is exceeding the class 2 quality standard of 3 mg/L (Figure 4).

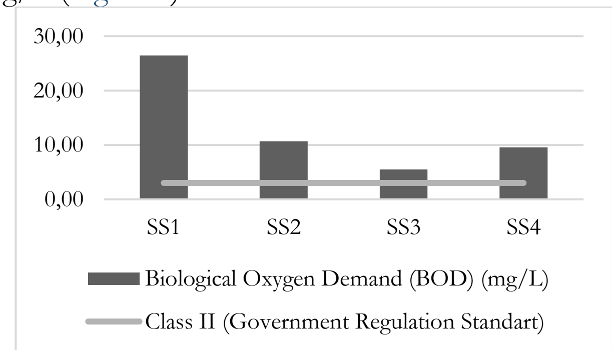


Figure 4. BOD water quality parameter graph

COD

The COD content in SS1 is 30.22 mg/L; SS2 is 76.38 mg/L; SS4 is 43.15 mg/L which exceeds the class 2 quality standard is 25 mg/L (Figure 5).

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 13, Number 2, Page 201-211

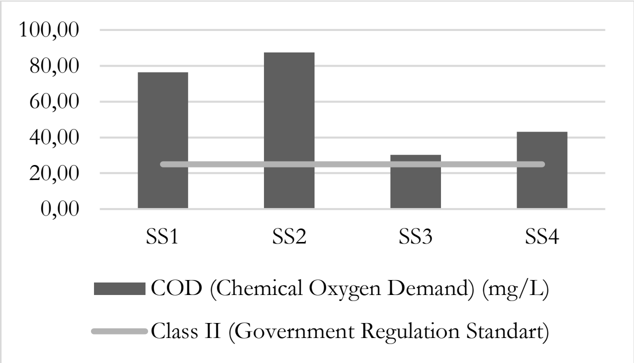


Figure 5. COD water quality parameter graph

Ammonia

Ammonia in SS1 is 0.36 mg/L; SS2 is 1.33 mg/L; SS3 0.664 mg/L; SS4 is 0.498 mg/L which exceeds the class 2 quality standard, 0.2 mg/L (Figure 6).

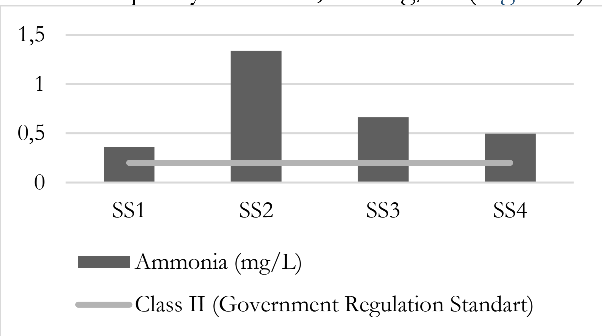


Figure 6. Ammonia water quality parameter graph

Microbiological Parameters

The total coliform content in SS1 is 2500 MPN/100 mL; SS2 is 2700 MPN/100 mL; SS3 is 2300 MPN/100 mL; SS3 is 26 MPN/100 mL. The total coliform content in, does not exceed the class 2 quality standard is 5.000 MPN/100 mL (Figure 7).

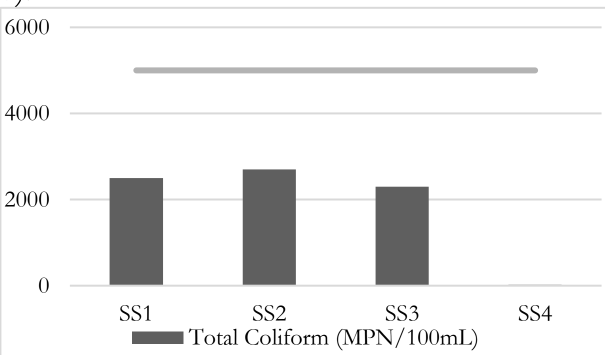


Figure 7. Total coliform water quality parameter graph

HPI

The results of the Heavy Metal Pollution Index (HPI) analysis, viewed from the non-metal aspect at SS 1, are 224.30, which means unsuitable for drinking. The results of the Heavy Metal Pollution Index (HPI) analysis, viewed from the non-metal aspect at SS 2, are 645.98 which means unsuitable for drinking. The results of the Heavy Metal Pollution Index (HPI) analysis, viewed from the non-metal aspect at SS 3, are 320.09 which means unsuitable for drinking. The results of the Heavy Metal Pollution Index (HPI) analysis, viewed from the non-metal aspect at SS 4, are 252.09 which means unsuitable for drinking.

Heavy Metals

Ni

The heavy metal parameters measured and analyzed in this research are Cd, Ni, Cu, Pb, and Zn. In SS1-SS4, the heavy metal parameter Ni is <0.030 mg/L, not exceeding the class 2 quality standard of 0.05 mg/L (Figure 8).

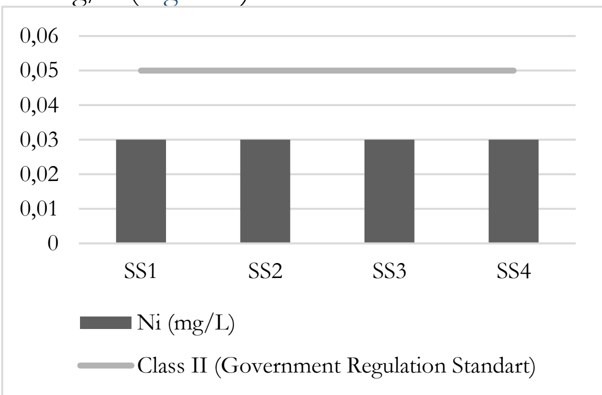


Figure 8. Ni heavy metal parameters graph

Cu

In SS1-SS4, the heavy metal parameter Cu is < 0.001 mg/L, not exceeding the class 2 quality standard of 0.02 mg/L (Figure 9).

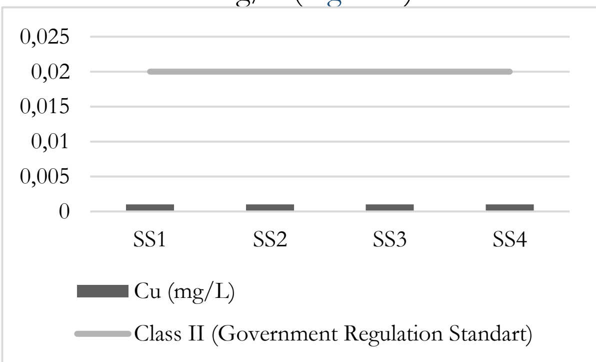


Figure 9. Cu heavy metal parameters graph

Pb

In SS4, the heavy metal parameter Pb is <0.0030 mg/L, not exceeding the class 2 quality standard of 0.03 mg/L. In SS1-SS3, the heavy metal parameter Pb is <0.03 mg/L, the same as the class 2 quality standard of 0.03 mg/L (Figure 10).

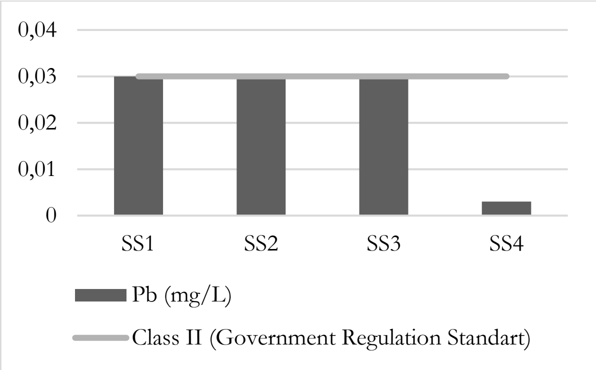


Figure 10. Pb heavy metal parameters graph

Zn

In SS1-SS4, the heavy metal parameter Zn is <0.009 mg/L – 0.016 mg/L, not exceeding the class 2 quality standard of 0.05 mg/L (Figure 11).

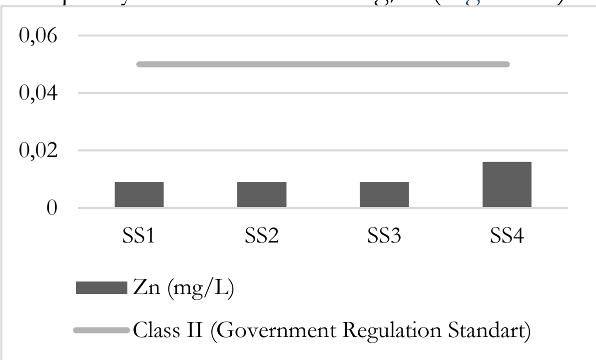


Figure 11. Zn heavy metal parameters graph

Cd

In SS1,SS3, and SS4 the heavy metal parameter Cd is <0.001 mg/L, not exceeding the class 2 quality standard of 0.01 mg/L. The Cd content in SS2 is 0.519 mg/L, which exceeds the class 2 quality standard is 0.01 mg/L (Figure 12).

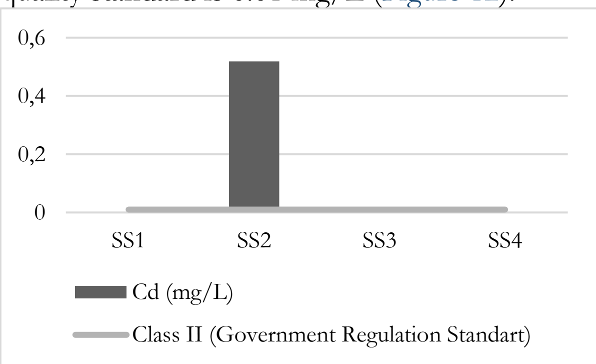


Figure 12. Cd heavy metal parameters graph

Discussion

Water Quality Parameters

TDS

The total amount of organic and inorganic substances present in a specific volume of water is measured by TDS (Yousif and Chabuk, 2023). TDS describes inorganic salts and small amounts of organic materials in aqueous solution. TDS consists of calcium, magnesium, sodium, potassium cations, carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions (Genanaw, *et al.*, 2021). SS2 gets its pollution load from domestic waste in the surrounding area and sources TDS from the presence of all dissolved salt. The high values recorded at these locations are likely due to pollution through the discharge of waste from soap and detergent factories, municipal wastewater, and sewage into rivers (Tadesse, Tsegaye, and Girma, 2018). TDS values are lower than downstream stations (SS4) due to anthropogenic activities and less land use (Al-badaii, Shuhaimi-othman, and Gasim, 2013). The high TDS at SS4 is due to agricultural waste on the watershed's right and left downstream banks, industrial waste, and domestic waste. In slow-flowing river water, suspended mud can settle to the bottom of the river, causing the suffocation of fish eggs or other benthos. The high concentration of TDS in waterways is caused by extreme anthropogenic activities along the river flow and runoff with high levels of suspended material. TDS can measure the total quantity of dissolved components in waterways (Lusiana, *et al.*, 2022). The ions and levels contributing to TDS may have ecotoxicological consequences (Weber-Scannell and Duffy, 2007).

TSS

TSS affects water turbidity; high TSS content in waters can disrupt the activities of aquatic organisms. The relationship between TSS and phytoplankton is if the TSS concentration decreases, the abundance of phytoplankton increases. Phytoplankton need sunlight to carry out photosynthesis. Cloudy water inhibits photosynthesis, inhibiting phytoplankton growth (Piranti and Wibowo, 2020). TSS are suspended minerals or sediments that move in water depending on water flow and rainfall levels (Novita, *et al.*, 2020). By lowering the quantity of light that reaches the water, high TSS levels can damage aquatic life as well as the clarity and quality of the water (U.S Environmental Protection Agency, 2023). TSS consists of mud, fine sand, and microorganisms, mainly caused by soil erosion or erosion carried into water bodies. TSS is not toxic to water, but if it is excessive, it will cause turbidity so that sunlight cannot enter the waters, disrupting photosynthesis (Hamuna, *et al.*, 2018). High TSS values can disrupt aquatic biota, disrupt fish vision, and inhibit fish breathing. The TSS value can be a crucial parameter in waters that dynamically reflects water changes. TSS is beneficial in analyzing polluted waters and domestic waste and can be used to evaluate water quality and determine the efficiency of processing units (Novita, Firmansyah, and Pradana, 2023). The steep river structure will result in soil erosion or erosion carrying mud and sand. This can result in high TSS values. The TSS value will generally be increased during the rainy season. The high TSS value is caused by erosion from both sides of the riverbank along the river and rainwater (Al-badaii, Shuhaimi-othman, and Gasim, 2013).

BOD

SS1 is a place close to an industrial area, furthermore this is thought to have an influence. When BOD levels are high, DO decreases because bacteria absorb the oxygen in the water. As a result, fish and other aquatic species cannot survive in conditions of lack of oxygen (Islam, Hossain, and Majed, 2021). An increase in BOD can be caused by the rise in the amount of organic waste disposed (Chatanga, *et al*., 2019). BOD measures the amount of oxygen consumed by bacteria and other microorganisms during the oxidation of organic materials (Sandu, *et al*., 2023). One measure that is often used to measure the level of organic material pollution in wastewater is BOD levels. It shows how much oxygen microorganisms use in the air to oxidize organic substances in sewage during a specific time, usually five days, and at a certain temperature, usually 20^{0}C (Effendi, 2003). High BOD content is caused by the large amount of waste entering the waters from nearby pollution sources (Santiari, Nuarsa, and Suyasa, 2016). Both industrial and domestic waste can increase levels of biochemical substances and heavy metals in water. This poses significant risks to aquatic ecosystems and public health (Bashar and Fung, 2020). The difference in values between COD and BOD describes the amount of organic material that is difficult to decompose in waters. COD and BOD are essential water quality parameters to monitor in aquaculture.

COD

COD is used to assess the resistance of industrial waste and sewage to contamination and the amount of oxygen required to oxidize organic and inorganic materials in samples. High COD values are influenced by waste streams discharged into rivers. The higher the COD levels in the waters, the higher the concentration of industrial contamination containing inorganic and organic compounds, thus indicating a higher level of toxicity (Islam, Hossain, and Majed, 2021). COD is a measure of water pollution by organic substances, which can naturally be oxidized through biological processes and can cause a reduction in dissolved oxygen in water (Wibowo and Rachman, 2020). The need for BOD and COD affects aquatic microorganisms in waters and increases water acidity. Contamination of organic and inorganic materials from community activities around the river and waste produced by domestic and industrial waste that is not adequately processed causes high COD content.

Ammonia

The high ammonia content in SS1 is thought to be due to industrial waste discharge. High ammonia content is not suitable for the stability of aquatic organisms. It can cause a decrease in dissolved oxygen, which can disrupt physiological and metabolic functions such as respiration for aquatic organisms (Zhang, *et al*., 2013). Ammonia has a highly toxic effect in waters, especially on fish, mollusks, and crustaceans, which are sensitive to the presence of ammonia (Soeprobowati, *et al*., 2021). Nitrogen compounds in seawater exist in three primary forms, which are in balance, namely ammonia, nitrite, and nitrate. If oxygen is normal, then the balance will be towards nitrate. When oxygen is low, the credit will move towards ammonia. Thus, nitrate is the final product of nitrogen oxides in the sea. The ammonia value is above the required quality standard of no more than 0.3 mg/L. The increase in ammonia concentration is due to increased decomposition of plant or animal remains (Sastrawijaya, 2009). Ammonia concentrations increase due to domestic and industrial waste disposal around SS3. This is in line with research (R. Zhang, *et al*., 2012), which examined the water quality parameters of ammonia in the Hongqi River, China.

Human activities in SS4 are agriculture and community moorland, ponds, aquaculture, tourist areas, and industrial areas. Waste disposal at SS4 affects the ammonia content. Ammonia can come from urine and feces, microbiological oxidation containing organic substances, industrial wastewater, and community activities. One source of river nitrogen is fertilizer discharged from upstream agriculture into the estuary. In addition, household wastewater and industrial waste discharged into river estuaries contribute to ammonia levels in these estuary areas (Ni'am, Prasetya, and Utami, 2021).

Microbiological Parameters

E. coli in water indicates that feces have recently been contaminated. This may indicate potential disease caused by pathogens such as bacteria, viruses, and parasites. Gram-negative facultatively anaerobic bacteria do not form spores, are rod-shaped, and develop red colonies with a metallic (gold) sheen within 24 hours at 35ºC on late-type media containing lactose (American Public Health Association, 2012). The potential density of disease pathogens in wastewater can be checked using coliform bacteria such as Total Coliform (TC) and Fecal Coliform (FC) to measure water safety. TC and FC are indicators of potential disease pathogens such as bacteria and viruses. WHO (2002) confirmed TC and *Escherichia coliform* bacteria as an index of FC bacteria as the primary indicator in freshwater waste. These indicators provide an overview of waterborne diseases (Balogun and Ogwueleka, 2021). This is mainly caused by contaminated human animal waste from animal washing, septic waste, and animal waste (Divya and Solomon, 2016). The BKB river flows into the Java Sea, which is a river that flows into the open sea, so the samples obtained should be better. However, the result value showed that the fish and waters were contaminated with *E. coli* (Nasution, Julianti, and Suryanto, 2022). Contamination of these bacteria in the aquatic environment, if not managed, will be detrimental. Microbial contamination from fecal and total coliform is light and invisible water pollution and causes serious problems. In addition to other types of bacteria, each person emits 100-400 billion coliforms daily. For humans, the coli form is not dangerous. However, it is used as a sign of pathogenic organisms that are difficult to identify.

Heavy Metals

Heavy metals harm human organs. Using agricultural pesticides and fertilizers reduces surface water quality and pollutes groundwater aquifers (Rahman and Hossain, 2008). Ni is a silver-colored metal used to make stainless steel, electronics, and coinage. Ni can enter a person's body through food, drink, and air. Health problems caused by nickel include dermatitis, allergies, organ dysfunctions, and respiratory system cancer (Kinuthia, *et al*., 2020). Dissolved Cu is one of the most pervasive and toxic elements in stormwater runoff and is commonly found in rivers, estuaries, and coastal marine habitats. Cu can disrupt normal fish behavior and the development of many fish species. Cu toxicity varies depending on fish species, life stage, and water chemistry (Sommers, *et al*., 2016). Aquatic organisms more easily absorb dissolved Cu. The season and method of waste disposal can impact the variation in Cu concentrations between high and low (Wahwakhi, *et al*., 2017). Copper sulfate (CuSO4) has been widely used to control algae and some pathogens in fish farming ponds, thereby increasing the copper concentration in the water. Cu is highly toxic to fish, so concentrations that control algae or pathogens must be below the fish toxicity threshold. Cu toxicity varies depending on water chemistry, temperature, and fish species and induces various damage that can lead to fish death. The impact of Cu on the aquatic environment is complex and depends on the physiochemical properties of the water (Min, *et al*., 2014). Exposure to Pb can happen when a person consumes contaminated food or water or inhales contaminated dust particles and aerosols. Pb poisoning in humans damages the kidneys, liver, heart, brain, skeleton, and nervous system. Headaches, memory loss, and irritability are some of the early signs of Pb poisoning. Anemia and reduced hemoglobin production can result from Pb poisoning (Sobhanardakani, 2017). Non-essential metals, such as too much Cd in the diet, are bad for the kidneys, bones, and cardiovascular (Godt, *et al*., 2006). Cd is a material used in various industries, including electronics, textiles, and leather tanning, because it only occurs in small amounts in nature (Widyastuti, Jayanto, and Irshabdillah, 2021). According to an Iranian study, releasing pollutants rich in heavy metals into aquatic ecosystems is why canned fish samples had Cd levels over the Maximum Permitted Limit (MPL) (Sobhanardakani, 2017). Other research on Semarang Bay in 2018 and 2019 exceeded the water standard threshold for aquatic organisms (0.001 mg/L) (Ihsan, *et al*., 2022). HPI according to metal parameters in SS1 is 26.43 (good), SS2 is 2345.84 (unsuitable for drinking), SS3 is 26.43 (good), and SS4 is 12,64 (excellent).

After some of the results and discussion above, we can illustrate that implementing strategies in waste management, especially liquid waste, can be done using cleaner technology, public education and awareness, pollution control and law enforcement. This law enforcement needs to be more enforced by the government, for example, by monitoring and enforcing laws against violations related to waste management to ensure that existing regulations are implemented effectively and aim to protect the environment, human life and aquatic organisms. The implementation and success of this policy depends on the awareness and compliance of all parties, including industry, government and the general public, in maintaining water and environmental quality.

Conclusion

The status of non-metal water quality in terms of HPI analysis shows that SS 1 is 224.30 (unsuitable for drinking), SS 2 is 645.98 (unsuitable for drinking), SS 3 is 320.09 (unsuitable for drinking), SS 4 is 252.09 (unsuitable for drinking. Metal parameters in terms of HPI analysis show that SS1 is 26.43 (good), SS2 is 2345.84 (unsuitable for drinking), SS3 is 26.43 (good), and SS4 is 12.64 (excellent). The result can be described as suitable for drinking if HPI analysis results indicate that heavy metal concentrations are below the acceptable limits set by relevant authorities for safe drinking water and unsuitable for drinking if HPI analysis reveals that heavy metal concentrations exceed the acceptable limits for safe drinking water. In such cases, consuming the water may pose health risks due to heavy metal contamination.

At the four research locations, water quality parameters that exceeded quality standards were ammonia, BOD, and COD. Excess BOD and COD can cause a decrease in water quality because they require excessive oxygen for the decomposition process of organic material, which decreases dissolved oxygen levels. The high ammonia level in the four research areas can disrupt the nitrogen cycle in aquatic ecosystems. High ammonia levels are caused by releasing industrial waste, domestic waste, or agriculture that contains high nitrogen without adequate processing. Management of the aquatic environment can be done with good waste management practices, the use of effective waste processing technology, strict policies related to releasing waste into waters, and the implementation of sustainable agricultural practices to reduce the flow of nitrogenous waste into waters.

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