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Regional Case Study

Water Quality Measurements with TSS, TDS, Total Phosphate, Nitrate, Total Coliform Parameters in the Garang Water Shed

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Abstract

Massive industrial and urban development can cause changes in the quality of river water, one of which is the Garang Watershed, located in Central Java Province. This river is situated in Kendal Regency (upper and middle) and Semarang City (middle and lower). This research examined the Garang River's water quality conditions, divided into four sub-basins: Garang Hilir, Garang Hulu, Kreo and Kripik. The parameter assessed in this research is TSS, TDS, Total Phosphate, Nitrate, and Total Coliform Parameters with a total of ten sampling location points were determined based on several criteria using GPS and the SNI 6989.57:2008 sampling method. TSS and TDS concentrations in March-April were observed to be high, especially at sampling point 10. In contrast, total phosphate concentrations were elevated at sampling points 2, 3, and 9; Nitrate values were observed to be high at sampling point 3 in March and sampling point 5 in April; Total coliforms were high at sampling points 1, 3, and 4, all of these is possibly due to domestic waste and the use of fertilizer by agricultural activities. This sampling quality assessment shows a close relationship between human activities and agricultural activities in river water quality, especially in the Garang River.

Keywords: TSS; TDS; total phosphate; nitrate; watershed

1. Introduction

With a population of 1,659,975 and a 0.22% growth rate from 2020 to 2022, Semarang City will be the capital of Central Java in 2022. The expansion of towns and industrial usage of land can be impacted by a high population. Domestic and non-domestic trash production rises along with the growth of settlements and industry (Schilling, Jha, Zhang, Gassman, & Wolter, 2008). The quality of water entering the watershed can be impacted by changes in land use. One of the watersheds in Central Java Province is the Garang Watershed. Its administrative boundaries include Semarang Regency in the higher part, Kendal Regency in the upper and middle parts, and Semarang City in the middle and lower parts. There are four sub-watersheds that make up the Garang watershed: the Upper Garang Sub-watershed, Kripi*k* Sub-watershed. Upstream and downstream, the Garang watershed plays a critical role in ecosystem health (Basuki et al., 2022). The downstream Garang watershed is used as a source of raw water for PDAM

Semarang City and a flood control canal known as the West Flood Canal, whereas the upstream Garang watershed plays a significant role in accommodating runoff. With a storage capacity of 20,400,400 m3 and a reduction in flood discharge of 170 m3/second, the Jatibarang Reservoir in the Kreo sub-watershed also functions as a flood control in the Garang watershed. Water from the Kreo River and the Garang River, which contain a variety of organic and inorganic chemicals and may impact water quality, enters the Jatibarang Reservoir. According to, the Garang watershed has the potential for both floods and drought depending on the amount of water that is delivered from the southern section to the northern part during the months of January and February. The Kreo River, Kripik River, and Garang River all have impaired water quality status in the upstream, middle, and downstream portions of the Garang watershed.

2. Materials

The Garang watershed, which is separated into the four sub-basins of Garang Hilir, Garang Hulu, Kreo, and Kripik, was sampled at ten distinct sites. These sampling locations were chosen based on a number of criteria, such as their upstream and downstream positions, prospective land uses, closeness to populations, proximity to agricultural operations, and convergence places of many sub-basins (Angela, Javier, Teresa, & Marisa, 2015). After being collected, the samples were taken to the lab for analysis, where factors like the amounts of total dissolved solids (TDS), total phosphate, nitrate, and coliform bacteria were checked.

In conducting water sampling in the Garang watershed, several supporting tools are needed, including the Global Positioning System (GPS) which is used to determine the position of sampling coordinates, water sampler to assist the water collection process, containers form of sterile jerry cans with a volume of 1 liter equipped with labels as storage of water samples for physical and chemical parameters, roll meters to measure the width and depth of the river, and buckets to collect water from sources that are difficult to reach. In addition, a cool box is also needed for sample storage so that the condition of the sample does not change and is durable (Mikhail et al., 2011). There are also several parameter measuring devices that must be provided to measure several parameters directly, including a digital pH meter for measuring pH, thermometer for measuring temperature, nephelometer for measuring water turbidity, and DO meter used to measure dissolved oxygen parameters. In addition to the parameters, river flow velocity must also be measured through a current meter (Cummins, 1962). In this case, sampling was carried out 10 times with different location coordinates. Based on the 10 sampling points determined, 5 times were taken.

Point 1 is situated upstream in Dusun Lempuyangan, Garang Sub-upper stream, was selected due to the limited human activity along the river and resulting minimal pollution. Point 2 is located in Suwaktu, Bandarjo Village, West Ungaran Sub-district, was chosen for its proximity to residential areas, those represent a location exposed to sewage. Poin 3 found on Jl. Tanah Putih II, Pudakpayung, Banyumanik District, offers a mix of forest and plantation land, allowing for natural self-purification processes. Point 4 on Jl. Gunungpati Raya, Gunung Pati District, shares a similar residential proximity, indicating sewage presence. Point 5 is located in Sukorejo Village, features nearby agricultural activities and contribute to sewage exposure. Point 6 is situated in Jombon, Medono Village, Boja Sub-District, is an upstream location with minimal pollution due to limited activities. Point 7 is located in Gunung Pati District, the condition is similar from Pint 4 with residential proximity. Point 8 is located in Sadeng, downstream from the Jatibarang dam. Point 9 serves as a meeting point for the Garang Hulu, Kreo, and Kripik Rivers. The last is point 10 which located in downstream of The Garang watershed near Yos Sudarso Bridge. This point is representing accumulation of pollutants flowing from upstream to downstream.

Combined with water quality, discharge data is also required which is obtained based on the rating curve. Water discharge is controlled by flow rate and the cross-sectional area. Rating curve is a graph which shows the correlation flow rate with water level. Therefore, water discharge of Garang watershed can be determined at each water level interval.

3. Analytical Methods

3.1. Sampling Methods

In this study, the sampling technique utilized was in accordance with SNI 6989.57:2008 (Harahap, Siregar, & Aramiko, 2023), which is a set of standardized guidelines for proper sampling procedures. This standard outline specific instructions on where to collect samples, the methods for collecting them, and how to handle the samples differently based on the particular test parameter being investigated. SNI 6989.57:2008 plays a crucial role in ensuring the reliability and consistency of the data gathered during the research. It provides clear and standardized procedures for selecting sampling points within the Garang watershed and specifies the appropriate methods to collect the samples (Fang et al., 2005). Furthermore, the standard offers guidance on how to treat the samples differently depending on the specific parameter being tested, which is essential to maintain the integrity of the data and obtain accurate results. By adhering to the guidelines outlined in SNI 6989.57:2008, the researchers can minimize potential sources of error in the sampling process and ensure that the collected data is representative of the environmental conditions in the Garang watershed (Setyaningsih, Hadiyanto, & Putranto, 2022). This standardization enhances the scientific rigor of the study and allows for meaningful comparisons and analysis of the test results across different parameters.

3.2. Laboratory Test Methods

3.2.1 TSS

In this investigation, Total Suspended Solids (TSS) were determined using the gravimetric testing methods described in SNI 6989.3:2019. The filter medium was moistened with distilled water to start the operation (Monmaturapoj, 2008). A particular volume of the test sample was then quantitatively extracted and added to the filter media after being forcefully agitated until homogeneity was attained. Then filtration was aided by applying a vacuum. After filtering, the filter medium underwent a series of three separate 10 ml rinses with distilled water. The filter media was carefully moved to a weighing medium, often a Petri plate, after the rinse procedures were finished (Yousef & Carlstrom, 2003). After that, this assembly was put through an hour-long 103°C oven drying process. After the drying process was finished, the filter medium was allowed to cool in a desiccator until room temperature was reached, and then its weight was determined. By dividing the difference between the weight of the filter medium before and after the test sample was added by the volume of the test sample used in the procedure, the determination of TSS was calculated (Desai et al., 2009).

3.2.2. TDS

The method employed for testing Total Dissolved Solids (TDS) is the gravimetric approach in accordance with SNI 6989.27:2019. This testing procedure involves initially stirring the test sample until it achieves homogeneity. A specific volume of the test sample is then quantitatively withdrawn and introduced into a filter, where it is subjected to suction using a pump (Watson, Chow, & Frazier, 1999). The filtrate produced by the filtration procedure is then put into a vaporizer cup, where it is heated in an oven to cause it to evaporate. The vaporizer cup is placed in a desiccator to cool when the evaporation process is complete. The cup's weight is measured after cooling. By dividing the difference between the weight of the filtrate and the volume of the test sample used in the method, TDS is calculated.

3.2.3. Total Phosphate

According to SNI 6989-31:2021, the total phosphate analysis uses a spectrophotometric procedure that incorporates ascorbic acid reduction. This examination covers a concentration range of 0.15 mg P/L to 1.3 mg P/L and is carried out at a specific wavelength of 880 nm. Using peroxydisulfate, phosphorus compounds present in the test sample are broken down to produce orthophosphate as part of the total phosphorus testing technique (Ma, Yuan, Zhou, & Yuan, 2017). Following the orthophosphate testing procedure, this orthophosphate is subsequently measured. By dividing the content of the test sample (Cp) by a dilution factor (f), one can determine the total phosphate concentration. This technique essentially breaks down the phosphorus compounds in the sample, turns them into orthophosphate, and then measures the orthophosphate level. This computation, which include both the sample content and the dilution factor, yields the total phosphate concentration.

3.2.4. Nitrate

The UV-Visible spectrophotometer method with cadmium reduction is used in the nitrate testing procedure in accordance with SNI 6989.79:2011. In order to do this test, the test sample must have a pH that falls between 7 and 9, which is accomplished by adding either sodium hydroxide (NaOH) or hydrochloric acid (HCl). By deducting the concentration of nitrite-nitrogen (NO2-N) after it has passed through the reduction column from the concentration of NO2-N before to this reduction column procedure, the determination of nitrate levels is obtained (Kamphake, Hannah, & Cohen, 1967). Nitrate levels in the sample can be measured thanks to this subtraction. The quantification of nitrate levels in the sample is made possible by this subtraction.

3.2.4 Total *Coliform*

The procedure for total coliform measurement calls for the use of a two-bag membrane for filtering, which is the standard procedure for measuring coliforms as a reference standard that consistently detects membrane incubation in selected media. In addition to that, there is a fast method that is an alternative option with two that enables the detection and containment of E. coli in a period of time of (213) hours. In the example that uses this membrane, it has the capability to kill bacteria (Bahar & Ren, 2013). According to standard methodology, a single membrane is placed in a medium to allow for selection of those that contain lactose before being incubated at a temperature of 36 °C for 213 hours.

3.3. Internet of Things (IOT)

The Internet of Things (IoT) idea aims to increase the benefits of constant internet connectivity. It incorporates the ability to connect diverse machines and equipment using networked sensors and actuators in order to collect data and perform independent tasks. This enables machines to operate freely based on recently acquired information (Efendi, 2018). IoT is primarily focused on things that can communicate data over a network without requiring human-to-human or human-to-computer interaction. Machine-to-machine (M2M) communication has so far been intimately linked to the Internet of Things (IoT), particularly in industries like manufacturing, electricity, oil, and gas. IoT goods, often known as intelligent or "smart" systems, are created with M2M communication capabilities (Giri, Dutta, Neogy, Dahal, & Pervez, 2017). Smart labelling, smart meters, and smart grid sensors are some examples. Thing speak, an open-source IoT application for the internet-based archiving and retrieval of data from sensors, is one of the platforms frequently used for IoT. Data gathering, visualization, and analysis are made easier by Thing speak when done on the cloud. Its main responsibility is to continuously update the data by gathering sensor-generated information and reading that information from the sensors.

4. Result And Discussion

4.1. TSS Parameters

4.1.1. Upper Garang Sub Watershed

In March, the discharge moving from the upstream garang subdas to the downstream garang has an increasing value at points 07, 11, and 15, while in April, due to rainy conditions, the value of the discharge in this subdas flow can only be displayed at points 8 and 14, making it impossible to physically measure the river because of its rapid flow. While in April the TSS concentration showed a significant value at points 2, 3, and 9 at 14:00 sampling after rain, the flow from the upstream garang subbasin to the downstream garang in March showed a large value at point 10 at 11:00 and 15:00. Forests, settlements, and farmland are the main land uses at points 2, 3, and 9, whereas settlements and industrial land are the main land uses at point 10 (Lin & Ho, 2003). The high TSS content may be caused by soil erosion, including soil erosion from domestic and agricultural activities that enters rivers. The high TSS value, which is also brought on by an increase in turbidity value, might be impacted by erosion.

4.1.2. Kripik Sub Watershed

The amount of discharge that travels from the chip subdas upstream to the downstream garang has a tendency to rise in March. It tended to rise in March, despite a decline in the discharge at point 5 during the observation period. At location 5 throughout the observation period. whereas in April, the value of the sub-basin flow discharge. Due to the weather, this can only be seen at point 5 at 8 a.m. So that it is impossible to gauge the river physically due to its rapid flow. Although the river's extensive morphological circumstances may be to blame for the drop in discharge at point 5, the fact that the point is in a lowland ensures that neither the river flow there nor the river's overall flow are excessive. Point is not too tunggi, which results in a low discharge value there. Modest worth. Additionally, the dominance of agricultural land use may be the reason for the decline in discharge at point 5, which results in a low value of discharge there. Domination of land usage in agricultural areas, resulting in the taking of the amount of river water used there for irrigation of agriculture and other domestic purposes other domestic requirements (Mutiga, Mavengano, Zhongbo, Woldai, & Becht, 2010). Total Suspended Solids (TSS) concentration in the flow from subdas kripik to garang hilir increased noticeably in March, especially at point 10. The highest TSS value for April, on the other hand, was recorded at point 5, specifically around 14:00 while it was raining. While point 10 is mostly made up of residential settlements, point 5 is distinguished by mixed dryland agricultural. The high TSS levels in the water are a result of soil erosion brought on by both home and agricultural operations, which is the cause of the elevated TSS concentration. The elevated TSS concentrations that were observed are the outcome of this occurrence (Gasperi et al., 2014).

4.1.3. Kreo Sub Watershed

At 07:00, 11:00, and 15:00 in March, the discharge flowing from the upper Kreo subbasin downstream to Garang showed an increase trend. However, because to the rainy weather in April, only point 6 at 08:00 and 14:00, as well as point 7 at 08:00, were able to record discharge data for this subbasin. The high river flow brought on by these weather conditions made it impossible to take any physical measurements (Groffman et al., 2006). In March, the flow from the Kreo sub-basin to Garang downstream had particularly high Total Suspended Solids (TSS) concentrations at points 7 and 10 at 07:00 and 11:00 and 15:00, respectively. At points 7 and 9 at 8:00 in April, as well as at points 7 and 8 at 14:00, the TSS concentration showed elevated values. While most of the land use at points 7, 8, and 9 is mixed dryland agriculture, point 10 is distinguished by settlements and industrial zones. The increased turbidity levels in the river, which result from increased soil erosion from domestic and agricultural activities, are to blame for the elevated TSS concentrations (Olalekan, Adewoye, Sawyerr, & Raimi, 2023).

4.2. TDS Parameters

4.2.1 Upper Garang Sub Watershed

At 07:00, 11:00, and 15:00 in March, the flow from the upper reaches of the Garang sub-basin downstream showed an increasing trend in discharge values. The discharge data for this subbasin could only be gathered at points 1 and 2 at 08:00 in April due to a lot of rain. Physical measurements were not possible because of the huge increase in river flow brought on by this heavy downpour (Jarvis, 2007). The stream from the upper Garang sub-basin to the downstream Garang showed consistently higher values for Total Dissolved Solids (TDS) concentration. Both at 08:00 in April and at 15:00 in March, point 10's peak TDS value was noted. In the Garang watershed, Point 10 is located downstream and primarily comprises residential land use. TDS refers to dissolved and colloidal materials in the form of chemical compounds and other things that aren't filtered by filter paper with a 0.45 m diameter. Anthropogenic variables originating from home and waste-related impacts can be blamed for the increased TDS value at point 10.

4.2.2. Kripik Sub Watershed

In general, March sees an increase in the water flow from the upper Kripik subbasin to the downstream Garang. It's crucial to remember that over the observation time, the discharge specifically at point 5 has decreased. On the other hand, due to severe rains in April, the river flow was too vigorous for physical measurements, and the discharge data for this subbasin are only available for point 5 at 08:00. The considerable structural characteristics of the river can be blamed for the decrease in discharge at point 5. The river flow at this location is rather low because it is in a lowland environment, which leads to a lower discharge value (De Doncker et al., 2009). Furthermore, the area's predominant usage of agricultural land could have an impact on the drop in discharge at point 5. This is due to the fact that a portion of the river's water is diverted for residential and agricultural irrigation, which lowers the area's discharge value. Total Dissolved Solids (TDS) levels have consistently risen in the water flow from the Kripik subbasin to the downstream Garang. Point 10 is where the TDS concentration peaks, at both 08:00 in April and 15:00 in March. Point 10 is characterized by a predominance of residential land use and is situated downstream in the Garang watershed. According to TDS refers to dissolved and colloidal components, such as chemical compounds and other substances, that are not filtered by paper with a 0.45 m diameter (Crittenden, Trussell, Hand, Howe, & Tchobanoglous, 2012). Human activities, particularly home and waste-related factors, are to blame for the high TDS levels at point 10.

4.2.3. Kreo Subwatershed

At 07:00, 11:00, and 15:00 in March, the water flow from the upper Kreo sub-basin downstream to Garang showed an increasing trend in discharge. However, due to a lot of rain in April, only point 6 at 08:00 and 14:00, as well as point 7 at 08:00, were able to capture discharge data for this sub-basin. Physical measurements were not possible because of the huge increase in river flow brought on by this heavy downpour. The water flow from the Kreo sub-basin to the downstream Garang exhibited higher values for Total Dissolved Solids (TDS) content in both March and April. The farthest downstream monitoring point, Point 10, regularly showed a high TDS concentration. Point 10's high TDS concentration is a result of the region's predominant land use, which is populated by settlements and industrial land. TDS is defined as dissolved and colloidal materials in the form of chemical compounds and other substances that are not filtered by paper with a 0.45 m diameter (Dupré, Gaillardet, Rousseau, & Allègre, 1996). Rock weathering, soil runoff, and anthropogenic effects in the form of both home and industrial waste are some of the causes of the elevated TDS levels at this time.

4.3. Total Phosphate Parameters

4.3.1. Upper Garang Sub Watershed

The discharge values from the upper Garang sub-basin's water flow downstream increased in March at 07:00, 11:00, and 15:00. The discharge data for this subbasin could only be captured at points 1 and 2 at 08:00 in April due to a lot of rain. Physical measurements were not possible due to the huge increase in river flow brought on by this heavy downpour. In March, at points 1 and 2 at 7:00 and 14:00, the Total Suspended Solids (TSS) concentration in the water flow from the upstream Garang to the downstream Garang showed high values, primarily because of wet conditions. At points 2, 3, and 9 at 14:00 in April, the concentration of total phosphate revealed high levels. While secondary dryland forest predominates at points 2, 3, and 9, woods, villages, and agriculture predominate at points 2, 3, and 9. Total phosphate, the amount of phosphorus, whether it is present as dissolved or particulate matter, organic or inorganic. As a result, the total phosphate concentration of fluids with significant quantities of organic matter should also be determined. The breakdown of organic waste from residential and industrial sources, such as detergents, as well as runoff from agricultural areas that employ fertilizers, can also be sources of phosphorus (Khan & Mohammad, 2014).

4.3.2. Kripik Sub Watershed

The discharge values from the upper Garang sub-basin's water flow downstream increased in March at 07:00, 11:00, and 15:00. The discharge data for this subbasin could only be captured at points 1 and 2 at 08:00 in April due to a lot of rain. Physical measurements were not possible due to the huge increase in river flow brought on by this heavy downpour. In March, at points 1 and 2 at 7:00 and 14:00, the Total Suspended Solids (TSS) concentration in the water flow from the upstream Garang to the downstream Garang showed high values, primarily because of wet conditions. At points 2, 3, and 9 at 14:00 in April, the concentration of total phosphate revealed high levels. While secondary dryland forest predominates at points 2, 3, and 9, woods, villages, and agriculture predominate at points 2, 3, and 9. Total phosphate, according to Effendi (2003), is the amount of phosphorus, whether it is present as dissolved or particulate matter, organic or inorganic. As a result, the total phosphate concentration of fluids with significant quantities of organic matter should also be determined. The breakdown of organic waste from residential and industrial sources, such as detergents, as well as runoff from agricultural areas that employ fertilizers, can also be sources of phosphorus (Khan & Mohammad, 2014). Particularly at point 5 at 07:00 in March and at 14:00 in April, the total phosphate concentration in the water flow from subdas kripik to garang hilir demonstrates increased levels. The presence of phosphate can be linked to a number of sources, and this region is largely known for its mixed dryland agriculture. The phosphate content is greatly increased by runoff from fertilized agricultural areas. According to phosphate can also come from the breakdown of organic waste, such as household and industrial waste found in detergents.

4.3.3. Kreo Sub Watershed

At 07:00, 11:00, and 15:00 in March, the water discharge from the upper Kreo subdas to the downstream Garang showed a rise in value. Due to high rainfall in April, the discharge data for this subdas could only be recorded at points 6, 8, 11, and 15 in addition to point 7 at 08:00. Physical measurements were impossible due to the large increase in river flow brought on by these rain-induced conditions. In the flow from the Kreo sub-basin to Garang downstream, the Total Suspended Solids (TSS) concentration showed high values in March, especially at point 7 at 07:00, 11:00, and 15:00. At points 10 at 08:00 and 7, the total phosphate content in April displayed high levels. While mixed dryland agriculture predominates in point 7, point 10 is characterized by settlements and industrial zones. Total phosphate, according to is the amount of phosphorus, whether it is present as dissolved or particulate matter, organic or inorganic. As a result, waterways with a lot of organic matter are more likely to have high phosphorus levels. The breakdown of organic waste, including waste from commercial and residential sources like detergents, can be the cause of phosphate content. Phosphorus is also heavily influenced by runoff in agricultural areas that employ fertilizers (Hart, Quin, & Nguyen, 2004).

4.4. Nitrate Parameters

4.4.1. Upper Garang Sub Watershed

At 07:00, 11:00, and 15:00 in March, the water flow from the upper Garang sub-basin to the downstream Garang showed an increase in discharge levels. However, due to high rainfall in April, the discharge data for this subbasin could only be obtained at points 1 and 2 at 08:00. Physical measurements could not be taken because of the significant increase in river flow brought on by these weather conditions.

In March, the nitrate concentration in the flow from the Garang upstream to the Garang downstream indicated a high value at point 1 at 07:00, but in April, it was reduced during sampling that was done after the rain. Secondary dryland forest land use mostly defines Point 1. Due to the presence of nitrates emanating from both the parent rock and the soil, nitrate concentrations in places with forest land use tend to be higher than at other points. vegetation in the land cover converts nitrogen into nitrate, which then ends up as nitrate content in the soil (Qi, Helmers, Christianson, & Pederson, 2011). It's crucial to remember that this analysis did not examine the nitrate concentrations in the soil or parent rock nearby; rather, it only examined pollutant parameter concentrations depending on land use at that time.

4.4.2. Kripik Sub Watershed

The movement of water from the upstream to the lower portions of the chip subdas March is often the month when Garang's discharge rises. Notably, there was a drop in discharge seen at point 5 throughout the monitoring period in March despite this general trend. In contrast, rainy weather in April made it impossible to gather physical measurements because the river flow was too fast and difficult, preventing the collection of discharge data for this sub-basin until point 5 at 08:00. The physical features of the river can be used to explain the decrease in discharge at point 5. Despite being a vast river, the discharge number is smaller since the flow is considerably lower there due to the river's placement in lowlands. The area's propensity for agricultural land usage, which diverts some of the river's water for agricultural irrigation and other domestic uses, may also have an impact on the drop in flow at point 5. This particular location's discharge is further reduced. In March, point 5 at 07:00 WIB had the greatest nitrate concentration; in April, point 5 at 14:00 WIB had the highest nitrate concentration. This area is distinguished by a mixture of residential and dryland agricultural land use. There are a number of causes for the elevated nitrate levels. First off, point 5 is a densely inhabited area, and Istiqomah reported in 2020 that residential garbage predominates there. The high level of nitrate in the water is probably a result of this. Further raising the nitrate concentration at this point is the use of fertilizers in nearby agricultural activities, which can also result in an increase in nitrate content (Sekhon, 1995).

4.4.3. Kreo Sub Watershed

At 7:00, 11:00, and 15:00 in March, the flow of discharge in the Kreo sub-basin, traveling downstream to Garang, demonstrates changes. Physical measurements are impossible in April since the discharge values are only accessible at points 6 and 7 between the hours of 8 a.m. and 14 p.m., respectively, due to the rainy weather. At point 6 at 7:00, 11:00, and 15:00 in March, nitrate concentrations from the kreo sub-basin to the downstream garang are noticeably high. Nitrate levels peak in April at point 9 at 8 a.m. and point 7 at 14 p.m. According to a land use analysis, point 6 is mostly covered by secondary dryland forest, whereas points 7 and 9 are mainly distinguished by mixed dryland agricultural. Nitrate levels that are elevated in agricultural land use zones may be caused by nearby residential trash or fertilizer application. Higher nitrate concentrations can be seen in secondary dryland forest areas, which may come from the parent rock and soil. Nitrate concentration in the soil can rise as a result of vegetation in the land cover converting nitrogen into nitrate. It's crucial to remember that this research only considers the pollutant parameter concentrations depending on particular land use classifications at the relevant places.

4.5. Total Coliform Parameters

4.5.1. Upper Garang Sub Watershed

March shows an increase in the volume of water flowing from the upstream garang sub-basin to the downstream garang, especially at 7:00, 11:00, and 15:00. However, due to high rains in April, the water discharge can only be seen at points 1 and 2 at 08:00, making it impossible to physically assess the river flow. In particular, at points 1 and 2 at 07:00 WIB, the concentration of total coliform in the water moving from the upstream garang to the downstream garang peaked in March. Total coliform levels were higher in April, especially at point 3 at 14:00 WIB, where a measurement of 7500 MPN/100 ml was recorded. In terms of land use, point 1 is predominantly distinguished by secondary dryland forest, whereas point 2 is predominately made up of populated areas. The discharge of domestic waste from nearby residents' activities, which introduces organic matter into the water and subsequently degrades water quality, is responsible for the elevated levels of total coliform. The elevated total coliform levels are also a result of problems with community cleanliness.

4.5.2. Kripik Subwatershed

Although there was a dip seen at point 5 during one of the observation hours, the flow rate coming from the chip sub-basin's upstream, as it goes downstream towards garang, normally sees an upward trend in March. However, due to constant rainy circumstances in April, which cause a fast-flowing river and make it impossible to take physical measurements, the discharge can only be seen at point 5 at 08:00 (King, Cambray, & Dean Impson, 1998). The physical features of the river can be used to explain the decrease in discharge at point 5. Despite being a major river, this point's water flow is very shallow due to the river's placement in the lowlands, which lowers the discharge amount. Furthermore, the prevalence of agricultural land use, which results in the diversion of river water for irrigation and other domestic uses in the area, may be related to the decline in discharge at point 5. At point 4, specifically at 11:00 am and 2:00 pm in March and April, respectively, the highest concentrations of total coliform were found. Plantation land dominates the region surrounding point 4, and organic fertilizers made from livestock waste are frequently used there. Because these fertilizers can be carried by surface runoff, the total coliform concentration in the area is noticeably high. In addition, the existence of residential zones facilitates the disposal of domestic garbage produced by neighborhood residents' activities. This discharge degrades the quality of the water and increases the quantity of total coliform by introducing organic debris into the stream. The community's general sanitation problems also contribute to the increased total coliform levels (Gwimbi, 2011). Point 4 saw the highest total coliform concentrations in both March and April, notably around 11:00 and 2:00. A substantial portion of the land at Point 4 is made up of plantations, which presents an opportunity to use organic fertilizers made from livestock dung. Because of their ability to move through surface runoff, these organic fertilizers have the potential to increase overall coliform concentrations in the area.

4.5.3. Kreo Subwatershed

March saw an increase in the volume of water flowing from the Kreo sub-basin upstream to the Garang downstream, especially at 7:00, 11:00, and 15:00. However, in April, the discharge could only be seen at points 6 and 7 at 8 a.m., 11 a.m., and 15 a.m., respectively. This was due to strong rains that caused the river's flow to significantly increase and made it impossible to take measurements. When measuring the flow from the kreo sub-basin to the downstream garang in March, significant values of total coliform content were found at points 8 at 7:00, 9 at 11:00, and 7 at 15:00. At point 9 at 8:00, point 9 at 11:00, and point 7 at 15.00 in April, comparable elevated values were reported. In terms of land use, points 7, 8, and 9 are primarily characterized by mixed dryland agriculture. The discharge of domestic waste from nearby residents' activities, which introduces organic matter and deteriorates water quality, is to blame for the high levels of total coliform. The increased total coliform levels are also a result of problems with community cleanliness (Gwimbi, 2011). Because these organic fertilizers can be transported via surface runoff, increasing concentrations in the area, their use for agricultural purposes also adds to the elevated total coliform content.

4.6. Storm Water Management Model

In the study of water quality analysis begins with the creation of a channel model along the Garang River Watershed using SWMM software. As shown in Figure 1, the SWMM modelling for water quality analyse was accomplished by generating 10 sub catchment, 11 junction, 8 land uses, 3 rain gages, and pollutants such as TSS, TDS, Total Phosphate, Total Coliform, and Nitrate. The type of land use has an impact on river quality since it is related to the leaching of pollutants on the land use during raining season and has varied EMC values. The EMC (Event Mean Concentration) value represents the concentration of specific pollutants contained in stormwater runoff from a particular land use type within a watershed. The value is generated from the ratio of pollutant mass to total runoff volume. Industrial and commercial land types have a higher percentage of impervious surfaces which allows for more efficient transport of pollutants and runoff. However, when open areas, forests, and land with dense vegetation cover are used, the concentration of pollutants will be lower due to the reduced impervious surface area. EMC values for TSS, TDS, Total Phosphate, Total Coliform, and Nitrate parameters in the Garang watershed were calculated at each location points.

Table 1. Composite EMC value of each parameter

Point	Month	TSS	TDS	Total Phosphate	Nitrate	Total Coliform
1	Maret	1.65	61.14	0.026	1.114	1598,46
	April	0,54	63,43	0,0067	0,06	329,51
2	Maret	16,59	174,02	0,028	0,458	2369,03
	April	213,89	127,98	0,1422	0,277	1645,58
3	Maret	24,08	155,96	0,021	0,427	1357,71
	April	226,53	112,93	0.1545	0.253	4184.88
4	Maret	16.88	103.88	0.020	2.918	4266.99
	April	212.41	71.46	0.256	0.251	3648.63
5	Maret	22.39	138.97	0.032	2.613	765.226
	April	1844.84	138.74	1.195	0.815	4209.74
6	Maret	5.00	45.06	0.017	2.897	1073.91
	April	15.51	40.41	0.013	0.064	658.18
7	Maret	18.62	109.41	0.038	0.058	2062.68
	April	4.99	76.30	0.369	0.350	3199.71
8	Maret	11.90	115.08	0.030	0.015	1752.32
	April	465.77	96.26	0.205	0.264	1050.74
9	Maret	17.66	156.86	0.034	0.350	918.87
	April	174.50	150.50	0.116	0.196	952.61
10	Maret	28.29	157.01	0.034	0.374	866.38
	April	31.43	279.04	0.071	0.134	752.85

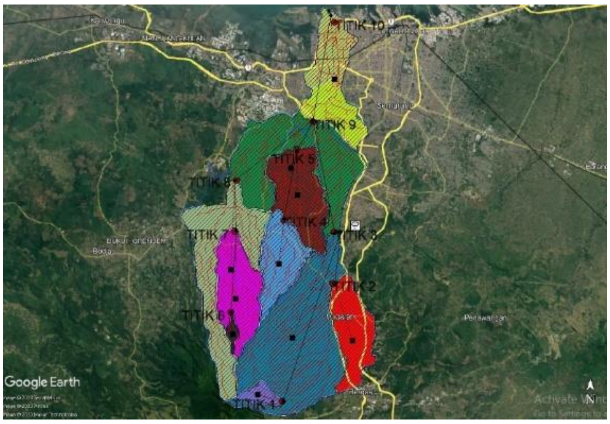

Figure 1. Garang watershed river flow model in SWMM

4.7. Model Design of Real Time Water Quality Monitoring Tool Based on Internet of Things

The Garang watershed's water quality monitoring system is designed to measure 4 parameters, including temperature, pH, turbidity, and TDS. The monitoring system is equipped with appropriate sensors which will be record the quality data every 30 minutes by microcontroller in the latte panda V1 module for processing. Water quality data will subsequently be transmitted in real time to the website over the internet. Users can get monitoring results in the form of graphs and tables through the website and can be accessed freely using mobile phones or computers.

In planning the design of monitoring tool, there are 5 sensors used, including the DS18B20 sensor which use to detect and monitor the temperature of the water, the SKU sensor: SEN1283758 serves to detect and monitor pH levels, sensor SKU: SEN0237 serves to detect and monitor dissolved oxygen levels in water, sensor SKU: SEN0244 serves to detect and monitor total dissolved solid levels, and sensor SKU: SEN 0189 serves to detect and monitor turbidity levels. Meanwhile, the microcontroller has function to processes and sends data from the sensor to master data over the internet. As a power source, the monitoring tool stores and supplies electricity using a rechargeable battery usually used for motorcycles with a voltage of 12 Volts and a current strength of 20 A (Mamun et al., 2022).

The water quality monitoring equipment has an LCD screen that performs similarly to a Windows 10 PC, as well as an Arduino Leonardo microcontroller, WIFI, and display record. To operate the water quality monitoring tool can be started by connecting the battery through the power socket so that it can turn on the microcontroller and LCD. The sensor is first immersed in the water before being tested for parameters until it stabilises and all sensor parameters can be read. Synchronize the data to the internet so that later the data read by the sensor will automatically be recorded in the us at database. Users can get the water quality data of the Garang river watershed via the available website after synchronising with the internet. Every 30 minutes, data readings from the device's sensors are taken and shown in the website with the form of graphs and tables that the user can download. The website contains the results of water quality readings and monitoring in the Garang watershed. There are two features on the website: home and acquisition log. Where the home tool displays a graph of water quality readings from numerous stations at that time from several locations, while the acquisition log tool includes a data display in tabular form that users can download (Beran & Piasecki, 2009).

Furthermore, to validate the data measured by the real time water quality monitoring device, data calibration is carried out by comparing the measurement results of the device for pH and temperature sensors with pH standard solutions and thermometers. The data calibration aims to determine the error value of the real time water quality monitoring sensor. In this calibration, there will be a calculation of the percentage of error value which is the result of the difference between sensor readings and actual conditions compared to the number of trials. Calibration of the pH sensor value is done by reading the pH value using standard solutions of pH 4, pH 7, and pH 9 and comparing with the pH sensor results. According to the analytical results, respectively the percentage error figures for pH 4, pH 7, and pH 9 are 0.16%, 5.95%, and 9.86%. Meanwhile, the temperature sensor is calibrated in the laboratory by comparing the sensor device's temperature measurement with a thermometer. In this study, three different temperatures of water were used: cold water, standard temperature water, and hot water. The percentage error value of the cold temperature reading is 0.64%, while the normal temperature sensor has an error percentage value of 0.72%, and the hot temperature is 1.73% (Ghahramani, Castro, Becerik-Gerber, & Yu, 2016).

There are methods or procedures in maintenance to ensure that the monitoring system used survive a long time and keep their quality. Things to consider in the operational and maintenance of real time water quality monitoring devices based on the internet of things system, particularly in monitoring temperature, pH, turbidity, and DO parameters, among others, sensor cleaning can employ ultrasonic sensors, microcontrollers should be included in a box containing silica gel to maintain humidity, when operating the tool should be avoided from direct sunlight because excessive heat can harm its operation. Furthermore, when the DO sensor is initially used, the sensor must be wetted/given a solution of NaOH solution so that it can read the DO value of water.

Several factors determine the position of the real-time water quality monitoring equipment in the Garang watershed (Syafrudin et al.). Several factors that determine the location of the tool placement include locations with water quality status whose changes significantly when sampling before and after rainfall, sites with river physical qualities that are not rocky, and locations that are easily accessible so that operators can monitor and maintain the tool more easily.

5. Conclusion

In conclusion, important trends and variables impacting water quality in the area have been shown by the investigation of numerous water quality parameters in the Upper Garang, Kripik, and Kreo sub watersheds. The Upper Garang sub watershed experienced an increasing trend in discharge in March, particularly at 07:00, 11:00, and 15:00. However, only point 1 and 2's discharge statistics were available at 08:00 due to the intense April rains. The concentrations of **Total Suspended Solids (TSS)** were noticeably high at a number of locations, including **point 10 in March** and **point 5 in April,** possibly as a result of soil erosion from home and agricultural activities. Similar to TSS, data collection of TDS parameters in **April was restricted to points 1** and 2 at 08:00 due to significant rainfall. However, the Upper Garang sub watershed showed an increasing trend in discharge in March. **Concentrations of Total Dissolved Solids (TDS) continually increased, especially at point 10, which is downstream and predominantly residential.** The phosphate parameters in the Upper Garang sub watershed, discharge values increased in March, but data gathering was constrained in April owing to rain. **In April, total phosphate concentrations were elevated at points 2, 3, and 9, most likely as a result of habitation and agricultural activity. Nitrate parameters** due to the existence of secondary dryland forest land use, point 1 in the Upper Garang sub watershed had noticeably high nitrate concentrations in March. **Nitrate levels were higher at point 5** in the Kripik sub watershed in both March and April, probably as a result of a **confluence of residential waste and fertilizer use in surrounding agricultural areas**. Nitrate concentrations in the Kreo sub watershed reached high levels at several sites in March and April, with mixed dryland agriculture making up the majority of the land use. Coliform total in March saw a rise in discharge in the Upper Garang sub watershed, but strong April rains only allowed for the collection of data at points 1 and 2 at 08:00. Due to the presence of secondary dryland forest and residential areas, **point 1's** total coliform concentrations were noticeably high in March and **point 3's total coliform** concentrations in April. Due primarily to the application of organic fertilizers on plantation land and the presence of residential areas, total coliform concentrations in **the Kripik sub** watershed peaked at **point 4** in both March and April. Total coliform levels were increased in **the Kreo sub** watershed throughout March and April as a result of mixed dryland agriculture and the discharge of domestic waste.

These results demonstrate the intricate interactions between human activity, weather, and land use on water quality metrics in the sub watersheds under study. To improve water quality and environmental sustainability in the area, mitigating variables such soil erosion, home waste discharge, and agricultural practices should be taken into account.

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