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Spatial multi-parameter assessment of rivers water quality in Yogyakarta

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Abstract. El Niño-Southern Oscillation (ENSO) affects climate patterns, leading to increased temperatures, high evaporation rates, and reduced precipitation in affected regions. This affects the amount of surface flow that keeps many rivers from moving until they dry up. This is also happened in Winongo, Code and Gajahwong rivers located in Yogyakarta Province. Stagnant water can affect water quality due to immobile water pollution. This study monitors river water quality by assessing Dissolved Oxygen (DO), Potential Hydrogen (pH), and Ferrum (Fe) levels. Water samples were collected from the upstream, midstream, and downstream sections of the Winongo, Code, and Gajahwong rivers to assess water quality. This approach helps identify pollution sources, understand spatial variability, and develop effective water management strategies.. Results indicate that the Winongo River had the highest Dissolved Oxygen (DO) level of 2.4 mg/L in the downstream section. The Code River had the highest pH of 8.1 in the upstream area, while the Gajahwong River showed a stable Iron (Fe) concentration of 2.5 mg/L. According to government regulations, the water quality in all three rivers is suitable only for irrigation purposes.

1 Introduction

The El Niño-Southern Oscillation (ENSO) phenomenon represents a non-linear interaction between the ocean and the atmosphere in the tropical Pacific region [1]. The event is correlated with anomalies in sea surface temperature (SST) [2]. Which result in irregular hydroclimatic cycle patterns and, consequently, extreme climate change [3]. This impacts precipitation, temperature, and water levels [4, 5], with deficits in precipitation leading to reduced discharge in surface streams and the onset of drought in regions affected by ENSO [6].

In consideration of Indonesia's natural conditions, rivers serve as a primary source of water for the community. The region's topography, characterised by a mountainous landscape, has shaped the river's natural course. Rivers serve as the primary source of water for the socio-economic sustainability of communities [7]. They are utilized for a multitude of purposes [8], including agricultural activities, fisheries, settlements, tourism, and industrial processes[9, 10]. Additionally, rivers act as both a source of water and a conduit for waste disposal. The natural hydrological cycle of a river entails the transportation of waste to lower locations. During its journey, waste is decomposed by river currents, resulting in uniform deposition [11].

Drought conditions caused by ENSO have an impact on reducing river discharge. As a result, river currents that can reduce waste pollution will experience precipitation in one location. The lack of waste flow will result in a decrease in the quality of river water, which can interfere with community activities in utilizing river water. Improper utilization of water quality can have a negative impact.

In Indonesia, water use is classified in accordance with government regulations enacted in 2001. In evaluating water quality, it is essential to consider its physicochemical properties [12]. The assessment of water quality can be carried out on a physical level through the observation of various characteristics, including temperature, color, and turbidity. Concurrently, it is essential to ascertain the microbial content, which must be subjected to laboratory analysis. In light of the aforementioned considerations, a chemical assessment of water quality is a particularly intriguing avenue of inquiry.

The objective of this study is to ascertain the impact of river water quality as a consequence of the El Niño–Southern Oscillation (ENSO) phenomenon. The research will concentrate on the Winongo, Code, and Gajahwong Rivers in the Yogyakarta Province. However, there are restrictions on the testing of chemical parameters, specifically dissolved oxygen (DO), potential hydrogen (pH), and ferrum (Fe). The selection of these three indicators allows for the representation of various environmental factors, including biota life, waste pollution, water consumption, and cleanliness. Research using samples can only determine the value of a specific location. In contrast, this research aims to describe the water quality throughout the entire river flow. Therefore, spatial analysis is employed to gain a comprehensive understanding [13].

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2 Methodology

2.1 Study framework

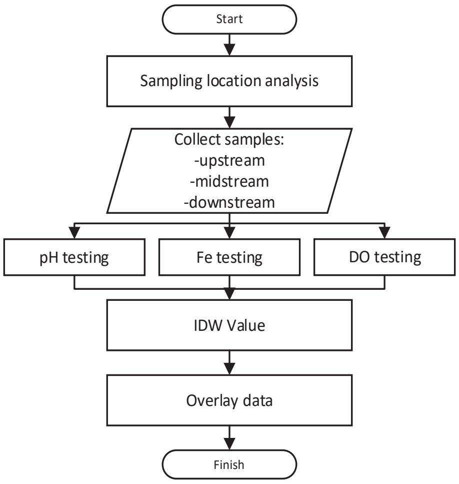

Fig. 1. Flowchart penelitian

2.2 Study area

The research was carried out in the rivers of Yogyakarta, including the Winongo, Code, and Gajahwong Rivers, as illustrated in Figure 2. The rivers were selected based on their geographical proximity to Mount Merapi and their subsequent flow into the Opak River. Additionally, human activities are prevalent along the riverbanks, which may contribute to pollution of the river flow.

Sampling was conducted at three locations; upstream, midstream, and downstream to obtain a representative sample of the overall flow. At each location, a sample of 1 liter was collected using a plastic bottle to ensure sample quality. Water samples were taken at the water structure due to the dryness that occurred in the stream. The sampling period was from November 1-3, 2023. Which after observation, coincided with the highest SST temperature of 2.21°C.

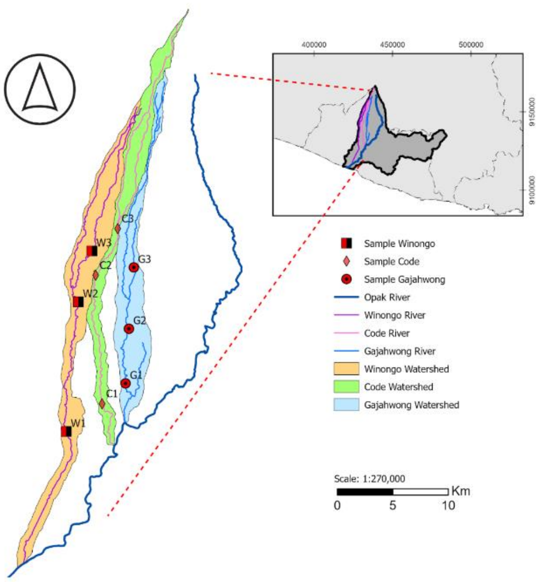

Fig. 2. Location sample taken.

2.3 DO testing

The sample will be mixed with MnSO4 and O2 reagent as much as 20 drops on each material. Then the sample is mixed which will react within 5 minutes. After the mixture becomes homogeneous add H2SO4 and let it react for 5 minutes. The sample is transferred into a conical bottle as much as 100 mL which is then titrated with Na2S2O3 until the color becomes yellow. Add 10% amylum until it changes color. Then titrate again with 1/40 N Na2S2O3 until the water becomes clear. The DO concentration is calculated using the formula 1.

$$DO = \frac{1000}{V} \times t \times f \times 0.2 \tag{1}$$

DO = Dissolve Oxygen (mg/L)
t = Number of titrations
f = Correction factor = 1
V = Sample volume (L)

2.4 pH testing

pH testing uses the help of a calibrated pH meter using pH 7.01 and pH 4.01 buffers. Calibration is carried out when the tool is inserted in each mixture by adjusting according to the pH buffer tested. pH meter is then cleaned to avoid mixing water samples and buffers. The sample water is then entered into a measuring cup as much as 100 mL. Put the tool until it shows a constant value.

2.5 Fe testing

To determine the Fe content at the initial stage, it is necessary to make an Fe standard. Prepare 3 test tubes containing 10 ml of distilled water and mixed with Fe standard solution sequentially 0, 1, and 2 drops. In each tube added a solution of (4N) H2SO4 and 0.1 N KMnO4 until the reaction changes the color of the water to purple. Then add KCN5 5 solution until the water reacts to become cloudy. Then prepare the test tube again which included a 10 mL water sample. Add as many as 5 drops of solution (4N) H2SO4, (0.1) KMnO4, KCN5. The sample water is then compared with the Fe standard solution. The Fe concentration is calculated using the formula 2.

$$Fe = \frac{1000}{V} \times \frac{n}{20} \times 0.1 \tag{2}$$

Fe = Ferrum (mg/L)
n = Number of compound droplets
V = Sample volume (L)

2.6 Spatial analyst

The addition of spatial analysis is shown to provide an overview of the values in the watershed area. The analysis used is spatial interpolation based on points using the Inverse Distance Weighting (IDW) method. The method works by utilizing a raster bounded by the watershed. Value input is done on each paramater in each river.

3 Result and discussion

3.1 DO value

Figure 3 illustrates the findings of the DO testing conducted in each river. The results obtained in Winongo River have a value of 1.7–2.4 mg/L, in Code River 1.1–2.1 mg/L, and in Gajahwong River 1.6–2.2 mg/L. The Code and Gajahwong rivers exhibit the highest values in the midstream and the lowest values in the downstream. This is a notable contrast to the results observed in the Winongo River, where the highest values are recorded in the downstream. However, Winongo River demonstrates a relatively high average value compared to other rivers.

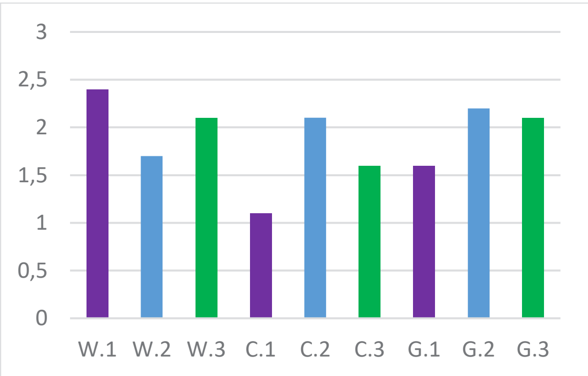

Fig. 3. Result of dissolve oxgen in each river.

The DO parameter provides an indicator of water cleanliness and can indicate ecological conditions. Low oxygen content in water can affect the quality of life of the ecosystem [14]. Fish require oxygen for life and foraging activities therefore, a reduction in oxygen levels can cause stress and a subsequent decrease in population [15]. The lack of oxygen occurs because there is no water current that provides circulation for oxygen to enter the water [16]. Therefore, water that settles without any movement can cause saturation.

3.2 pH value

The Code River has the highest value range of 7.51–8.11, while the Winongo River has a value of 7.51–7.9 and the Gajahwong River has a relatively narrow range of 7.44–7.55. The results demonstrate that the pH content in the Gajahwong River maintains a consistent value. In contrast, the Code River demonstrated a decline in the highest value in the upstream and a subsequent decrease in the downstream. However, both the Winongo River and the Gajahwong River exhibited a similar value trend, with the highest value observed in the downstream and the lowest value observed in the midstream.

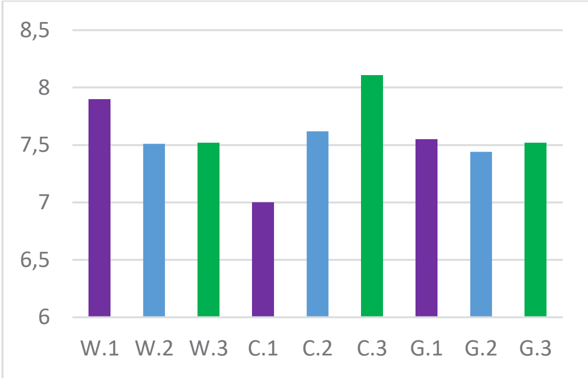

Fig. 4. Result of potential hydrogen in each river.

The pH value is a measure of the concentration of hydrogen ions (acid and alcali) in water [17]. The acidity of water is influenced by waste. Rivers with a high concentration of alkali are caused by pollution from algae derived from agricultural crops [18]. Yogyakarta region has a significant amount of agricultural land, which is consistent with the pH value obtained.

3.3 Fe value

The results of testing conducted to assess iron pollution levels are presented in Figure 5. The iron values observed in all river samples were found to be below the threshold of 0.35 mg/L. The Winongo River exhibits the highest value range of 0.25–0.35 mg/L, while the Code River has a value of 0.25–0.30 mg/L and the Gajahwong River has a similar value of 0.25 mg/L. Based on the values obtained, the Winongo River and the Code River exhibit comparable trends in Fe content, with the highest values observed in the downstream river and the lowest in the upstream river. However, the Gajahwong River displays a consistent Fe value at all sample locations, maintaining a constant value throughout.

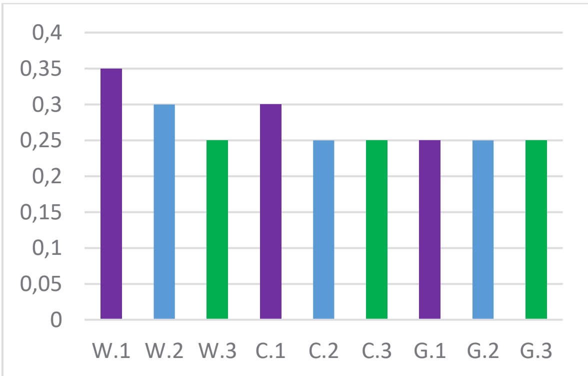

Fig. 5. Fe result graph.

The presence of metals in aquatic environments can be attributed to sedimentation processes [19]. Additionally, the exploitation of mineral resources through the use of mining activities, which often involves the use of metal tools [20], can further contribute to elevated metal concentrations in these systems. The urban environment, particularly in areas with high population densities, can also act as a source of contamination, with metal pollutants entering the city center through runoff and other forms of human-induced activities [21]. The available data indicates that the concentration of metals in the city area is considerably elevated, raising concerns about the adverse effects these pollutants may have on human health.

3.4 Variations of parameter in each river

The results of the value of each parameter that has been obtained will then be interpolated. Fig 6 shows the test results of Winongo River, Fig 7 shows the test results of Code River, Fig 8 shows the test results of Gajahwong River. Presentation of values in the form of a map greatly facilitates the delivery of information. green color will show a low value while the higher the color will turn red. The difference in values in each river is influenced by flow characteristics [22].

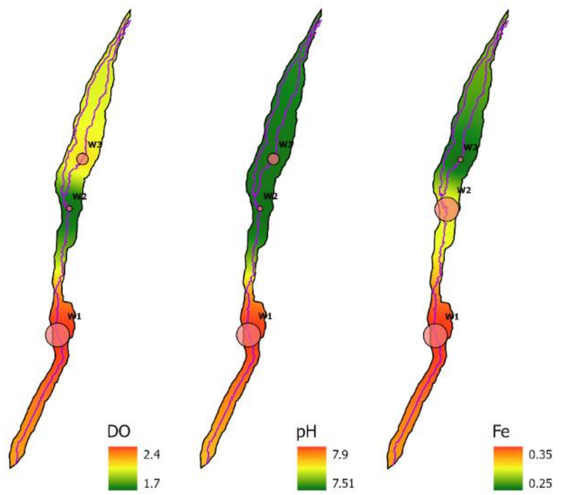

Fig. 6. Parameter interpolation in Winongo River.

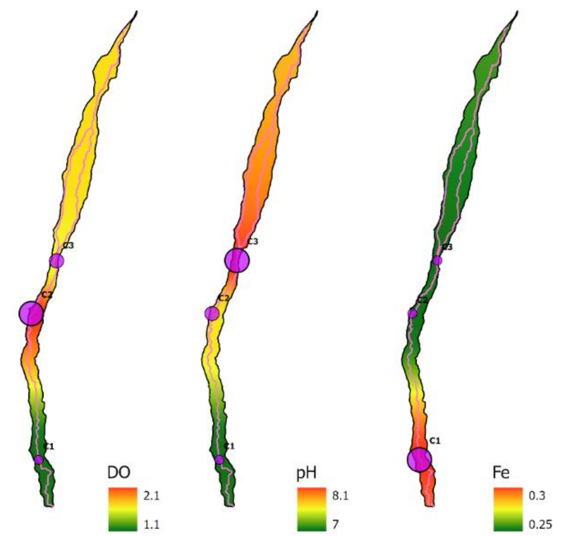

Fig. 7. Parameter interpolation in Code River.

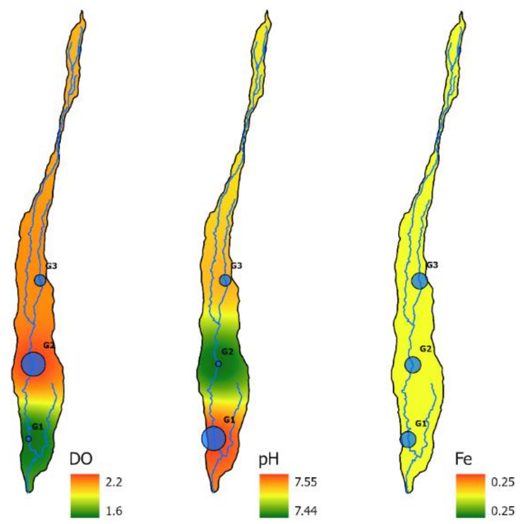

Fig. 8. Parameter interpolation in Gajahwong River.

DO and pH content have a negative correlation that affects each other [23]. High pH value should reduce the quality of dissolved oxygen in the water. However, this study found a positive correlation in several sample locations. Winongo River downstream and Gajahwong River upstream have the same value compared to other locations.

Fe content in all rivers has a tolerable value. Results obtained in each river do not have a significant difference. This is likely due to similar land use characteristics and river flow utilization.

4 Conclusions

Drought in river flow due to the ENSO phenomenon has a severe impact on water quality. In each stream there is no significant difference. This can happen because of the location of the streams that are close to each other. Decrease of water quality during drought does occur in many regions [24, 25]. Water use needs to be restricted to ensure its best priority. Water quality that can be used is limited to irrigation. However, this research has limitations in determining the purpose of water use. It is expected that further research can review other parameters to get more accurate results.

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