Heavy Metal Pollution And Water Quality assessment In Belik River Yogyakarta

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Abstract. Nowadays, surface water pollution, particularly in the river, is a serious problem which happens in the worldwide, i.e. wastewater. The wastewater may contain of heavy metals which can be harmful to the human body. Belik River is a river that passes through Yogyakarta city. The river is potentially experience pollution from domestic waste, industrial waste, and hospital waste. The purpose of this research is to find the initial condition of metal exposure in Belik River and its effect on some water quality parameters, such as Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), TSS, TDS, pH, Electric Conductivity, Salinity, Iron (Fe), Copper (Cu), and Lead (Pb) were tested in this research. The result shows that physical and chemical parameter of water quality in Belik river such as TSS and BOD exceed the water quality standard (WQS) (Class II), but for the other parameters were under WQS. The heavy metal was found under the ASS detection for Pb and Cu, meanwhile the Fe concentration was below the WQS.

1. Introduction

The river is one of the most important resources in the life system [11]. River in an urban area is potentially polluted due to untreated water from domestic and industrial waste, that enters the river water [8]. Various kinds of human activities and industrial activities around the river contribute to the pollutant that enters the rivers directly or indirectly through surface runoff and effluent [13]. It can contain heavy metals that are harmful to the environment due to its toxicity, especially when it enters the water bodies and consumed by humans, animals, and plants [3]. The heavy metals are subjective to subsurface runoff from industrial, domestic, agriculture, animal farm, hospital and hotel waste [10].

Heavy metals contamination is a serious problem for ecology. Some metals, such as Fe and Cu are micronutrients that can be toxic for living organism at higher concentration [9]. It can cause damage to aquatic organisms and can have adverse effects on human health as well, such as kidney failure and metabolic disorders [1]. In the aquatic environment, the heavy metal can be found in the sediment and natural water, as suspense or diluted in the water. Iron (Fe), Copper (Cu), and Lead (Pb) can be found in waters. Lead poisoning causes the respiratory problem, metabolic, and immune systems of the body. And another side effect such as reduce intelligence in children. Copper can cause kidney failure, red blood cell damage [17].

Belik watershed is located in the Sleman regency, D.I. Yogyakarta Province, Indonesia with a total catchment area of 6.8 km\textsuperscript{2}. Its land use and land cover is dominated by built-up area. In 2013, a reservoir was built to revitalize Belik river. The increasing of population has resulted in the development of built-up area in Sleman regency, as well as in Belik Watershed. The main river length
is 6.93 km. the average slope of the watershed is 0.053 and classified as flat topography. Its type of peak discharge was fast moving floodwaters but rapidly subsides. The condition of drainage density is 1.01 km / km², which is classified as moderate density [15].

In addition, the Belik watershed passes through the city of Yogyakarta has potential pollution of domestic waste and Lead (Pb) from the city. Therefore, this study aims to determine the water quality condition of Belik River and envisage the heavy metal status and the influence of morphometry in the Belik River.

2. Methods

2.1. Study Area

Belik Watershed is located in urban area of Daerah Istimewa Yogyakarta Province, between 7˚45’28” LS - 7˚49’3” LS and 110˚22’33” BT - 110˚23’24” BT. Administratively, Belik watershed covers two districts/cities namely Sleman District and Yogyakarta City. Belik River is the main river of Sub-watershed Belik. Belik River is a river which originates in Dusun Karangwuni, Caturtunggal, Depok Sleman. This river passes through East of Sagan village, Klitren and Danukusuman then enter the Gajahwong river which end in the Opak River.

2.2. Sampling and Data Analysis

This research using purposive sampling, based on land use and potential waste that enters the Belik River. The sampling was carried out in 8 sampling sites (Figure 1). The sampling was conducted during dry season. With the assumption, in dry season the river discharge was in a low condition, so that the pollutant loads were higher due to dilution effects in the water [8]. The laboratory test result and measured at field result were compared with water quality standard class 2 according to PP No. 82 Tahun 2001 to find out the condition of heavy metal were iron, lead, and cooper in Belik River. The other water quality parameter were compared with level pollution from Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), and Total Suspended Solid (TSS). Concentration of DO, pH, and BOD with the heavy metal in each sampling sites to see its correlations.
3. Results and Discussion

3.1. Physical Parameters of water in Belik River

The general properties of physical parameters, such as TDS, TSS, EC, Salinity, and Temperature are shown in Table 1. The results show that the electric conductivity (ES) varies from site 1 to site 8. The maximum EC value is 317 µmhos in site 8, meanwhile the lowest EC value has observed in site 3 250, 45 µmhos. The EC values represent the organic material and mineral compound in the water. Therefore, the EC value can be used as an indicator of pollutions of inorganic parameters especially dissolved minerals. The salinity values range from 150-212 ppm (Figure 2).
Table 1. Overview of physical parameters of water in Belik River

| Sampling Sites | Discharge (m³/s) | EC (µmhos) | TDS (ppm) | Salinity (ppm) | TSS (mg/L) | Temperature (°C) |
|----------------|------------------|------------|-----------|----------------|------------|------------------|
| 431973         | 1                | 0.4        | 299       | 212            | 179        | 14               | 25.4 |
| 431916         | 2                | 0.32       | 302       | 225            | 193        | 11               | 25.7 |
| 431924         | 3                | -          | 354       | 247            | 212        | 135              | 27.62 |
| 431925         | 4                | 0.39       | 250       | 178            | 150        | 74               | 26.0 |
| 431864         | 5                | 0.25       | 252       | 178            | 151        | 45               | 25.9 |
| 431838         | 6                | 0.41       | 251       | 174            | 151        | 75               | 26.1 |
| 431822         | 7                | 0.34       | 255       | 281            | 153        | 135              | 26.6 |
| 431673         | 8                | 0.21       | 317       | 182            | 154        | 39               | 26.7 |

Total Dissolved Solids (TDS) represent inorganic ions compound in the water, that comes from domestic, and industrial waste, i.e. detergent, or in natural water such as Chloride, Bicarbonate, Flouride, Sulfate, and another ions. The TDS is strongly correlated with EC. The TDS graph in Figure 3 shows a similar pattern with EC graph in Figure 2. The TDS and EC values, followed an increase from site 1 to site 3 and a decrease in site 4, meanwhile form site 5 to site 8 the pattern is not similar. Compare to the WQS Class 2, the TDS values are under the WQS limits. However, the TSS value shows high concentration in sites 3 and 7. In general, the TSS value are exceed the WQS of class 2 (50 mg⁻¹), except for site 2, 5, and 8.

3.2. Chemical Parameters of water in Belik River

The values of pH, COD, BOD, and DO are presented in Table 2. This parameter was chosen due to its sensitivity to environmental changes. Most of the pollution found in Belik River comes from domestic waste as well as home industry waste. The BOD and COD are evaluated in comparison with the heavy metal effects from wastewater treatment (Mala and Maly, 2009).
Table 2. Overview of chemical parameters of water in Belik River

| x       | y       | Sampling Sites | Discharge (ms⁻¹) | BOD (mg.l⁻¹) | COD (mg.l⁻¹) | DO (mg.l⁻¹) | pH    |
|---------|---------|----------------|------------------|--------------|--------------|-------------|-------|
| 431973  | 9141469 | 1              | 0.4              | 4.18         | 11.59        | 6.42        | 7.08  |
| 431916  | 9141420 | 2              | 0.32             | 5.12         | 8.73         | 6.30        | 7.05  |
| 431924  | 9141232 | 3              | -                | 4.77         | 28.11        | 6.09        | 7.62  |
| 431925  | 9141203 | 4              | 0.39             | 5.47         | 12.54        | 6.48        | 7.26  |
| 431864  | 9140988 | 5              | 0.25             | 2.15         | 7.46         | 6.15        | 7.96  |
| 431838  | 9140869 | 6              | 0.41             | 4.55         | 17.31        | 6.35        | 7.01  |
| 431822  | 9140784 | 7              | 0.34             | 6.6          | 15.72        | 6.57        | 6.9   |
| 431673  | 9140435 | 8              | 0.21             | 1.61         | 15.09        | 6.08        | 7.88  |

Biological oxygen demand (BOD) represents the amount of oxygen consumed by organic compounds in the water bodies [5]. The BOD and COD values in the urban area are influenced by wastewater treatment. Therefore, BOD is the most important parameter for the environment in the urban area, due to domestic and industrial influences [6]. BOD values continue to increase in trend at site 5 to 7. The increasing of BOD appears due to the input of domestic waste between site 5 to site 7. In general, the BOD values exceed the water quality standards (3 mg.l⁻¹), except for site 5 and 8. Chemical Oxygen Demand (COD) is an indicator used for organic activities [6]. The COD values are below the WQS, except for site 3. The COD for WQS class 2 is 25 mg.l⁻¹.

Figure 4. TSS and TDS Value in Belik River

3.3. Metal toxic in Belik River
The metals tested include Iron (Fe), Lead (Pb), and Copper (Cu). The metal parameters were chosen due to huge impact of domestic and geological influence in Yogyakarta that contain Fe from volcanic deposit. Those metals are harmful and easily to find in the environment. The ASS test results for heavy metals in Belik River UGM segment shows that the Copper (Cu) and Lead (Pb) content in the area is below the detection limit (Table 3). The values of Cu for the 8 sampling sites are <0.004 mg.l⁻¹. In drinking water, the acceptable limit of copper is 0.1 mg.l⁻¹. The effect of copper on the human body can cause kidney failure [7]. Meanwhile, Lead can come from particles carried by rain mixed by pollution or industrial waste [4]. Pb values for all sampling sites are below 0.002 mg.l⁻¹.

Fe can be detected at levels below the WQS. The acceptable limit of Iron for WQS class 2 is 0.3 mg.l⁻¹ [2]. All the samples are within the acceptable limits of WQS. Based on the data shown in Table 3, the correlation between morphometry, such as meander, perimeter, and distance, are insignificant. The heavy metal content in the Belik River, especially iron, are mostly influenced by domestic waste that directly enters the river and the geological condition or sediment bed load that contain Fe. Site 7
has the highest Fe value compared to the others due to direct input of domestic waste before the sampling sites.

### Table 3. Overview of heavy metals in Belik River

| x     | y       | Sampling Sites | Fe (mg.l\(^{-1}\)) | Pb (mg.l\(^{-1}\)) | Cu (mg.l\(^{-1}\)) | Discharge (ms\(^{-1}\)) |
|-------|---------|----------------|---------------------|---------------------|---------------------|-------------------------|
| 431973| 9141469 | 1              | 0,039               | <0,002              | <0,004              | 0,4                     |
| 431916| 9141420 | 2              | 0,038               | <0,002              | <0,004              | 0,32                    |
| 431924| 9141232 | 3              | 0,039               | <0,002              | <0,004              | -                       |
| 431925| 9141203 | 4              | 0,021               | <0,002              | <0,004              | 0,39                    |
| 431864| 9140988 | 5              | 0,008               | <0,002              | <0,004              | 0,25                    |
| 431838| 9140869 | 6              | 0,011               | <0,002              | <0,004              | 0,41                    |
| 431822| 9140784 | 7              | 0,165               | <0,002              | <0,004              | 0,34                    |
| 431673| 9140435 | 8              | 0,096               | <0,002              | <0,004              | 0,21                    |

4. Conclusion

The analyzed data of TSS and BOD were found to be above the acceptable limit of the water quality standard of class 2 according to Government regulations of Indonesia Number 82/2001 on management of water quality and control over water pollution, while the other parameters such as COD, DO, pH, TDS, Salinity, and DHL are still below the WQS of Class 2. In general, several parameters are above the limits due to direct inputs from domestic waste before the sampling points. The contents of heavy metals in Belik River that passes through Universitas Gadjah Mada shows that Lead (Pb) and copper (Cu) are below the instrument detections. Iron (Fe) were found in very small quantities and appears to be below the limit of WQS of class 2. It can be concluded that the morphometry of Belik River, plays an insignificant role in decreasing heavy metal content and self-purification in the water. However, the input of domestic waste are the major sources of pollution in Belik River.

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