Profile of organic material source and environmental condition in the sediment of Badek and Mewek River, Malang, Indonesia

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Abstract. The sediment characterizations and water quality in the Badek and Mewek River are observed to know the origin of organic materials and environmental conditions in those rivers. The total carbon of the sediment was analyzed using a total carbon analyzer, while total nitrogen was measured by using the indophenol blue method. Total bacterial number in the sediment was estimated using the slow stirring method. Dissolved oxygen (DO) of water was analyzed using Winkler Method, chemical oxygen demand (COD) was analyzed using a dichromate-titrimetric method, and the pH of the water was measured using pH meter. The result showed a C/N ratio of around 20, indicating that organic materials in the Badek and Mewek River might be coming from the mixing of aquatic origin and terrestrial sources. Badek River showed a higher C/N ratio indicating a more substantial influence of terrestrial organic material compared to Mewek River. The total bacterial number in the sediment of Badek River might be related to the low water quality in that river.

1. Introduction

A river ecosystem is one of the aquatic ecosystems with dynamic characteristics influenced by its water flow. Interaction between microorganisms and other aquatic environmental components becomes an interesting topic to be studied. The biogeochemical cycle in the aquatic ecosystem involves several kinds of microorganisms, such as bacteria and archaea. However, about 70% of microorganisms in the sediment are bacteria. These bacteria are involved in the decomposition of organic materials, including organic carbon and organic nitrogen, to obtain inorganic materials through various mechanisms. The disruption of this mechanism may cause instability mineralization in the river ecosystem. The input of pollutants to the river may, which is caused by anthropogenic activities, causes degradation of water quality in the river [1].

Badek and Mewek River is one of 20 rivers located in Malang City. These rivers play an important role in the aquatic ecosystem in Malang City. However, the increase of human activities around the river might cause environmental degradation regarding the pollutant input to the river. Some factors causing the environmental degradation on these rivers are the disposal of domestic and industrial wastes. The environmental condition of the Mewek River is influenced by domestic activities, while both domestic and industrial activities influence Badek River. It causes different characteristics of water and sediment properties in both rivers. The high loading of this waste may increase the
accumulation of suspended materials in the sediment [2]. Therefore, it is crucial to perform an effort to recover the environmental quality of those rivers.

For recovering a river's conditions, it is essential to observe the characteristic of its environment. Analysis of the sediment properties is crucial to be performed to know the sediment condition. The main reason to perform this way is whether sediment plays an important role in the nutrient cycle in the river environment. Organic carbon and nitrogen are needed by the bacteria to perform these biogeochemical processes. Carbon is known to be used as energy for several aerobic bacteria (genus Bacillus, Pseudomonas, etc.) during the bacterial respiration [3,4], while nitrogen is used by α, β, and γ Proteobacteria during denitrification process [5,6]. Therefore, it is crucial to observe the characteristic of sediment in the Badek and Mewek River and to investigate the relation between the total bacterial number with carbon and nitrogen. The information provided from this study can be used as consideration of environmental management by the policymaker in Malang City, Indonesia.

2. Materials and methods

2.1. Site location and sediment sampling

Sediment sampling was carried out in Badek and Mewek River, Malang City, East Java Province, Indonesia, from July to August 2017. The sediment sample was taken from 3 different sites on Badek River (SB1, SB2, and SB3) and Mewek River (SM1, SM2, and SM3) (Figure 1). The sediment sample was taken from the bottom of the river by using Ekman Grab and kept in a plastic bag. The samples, then, were kept in a refrigerator until analysis.

![Figure 1. Site location.](image_url)

2.2. Measurement of TC, TN, and total bacterial number of sediment

Measurement of total carbon (TC) in sediment was performed using a total carbon analyzer as applied in [7]. Total nitrogen (TN) of the sediment sample was measured using the indophenol blue method after digested in a Kjeldahl digester [8]. The digestion in the Kjeldahl used a combination of H₂SO₄ and H₂O₂ as oxidizer and CuSO₄ as a catalyst. This process was out at 420°C for 1.5 hours. The extracted sample was filtered by using filter paper no 6 (ADVANTEC). It was mixed with an indophenol solution and a sodium hypochlorite solution. The TN value was provided from absorbance read at 635 nm using a UV visible spectrophotometer. The total bacterial number in the sediment was analyzed using the slow stirring method [9]. A slow agitation was applied to mix the DNA extracted
buffer and sediment sample and separate the nucleic acid from its rough material. Several steps of DNA extraction using chloroform-isoamyl alcohol was applied to obtain the environmental DNA of bacteria. The bacterial number was estimated based on their DNA band intensity in a 1% gel agarose electrophoresis.

2.3. Measurement of water quality
The water quality measured in this study was: Dissolved oxygen (DO), Chemical Oxygen Demand (COD), and water acidity (pH). The DO of the water sample was analyzed using iodometric titration in the Winkler Method (SNI: 06 6989.14-2004). A water sample was mixed with MnSO$_4$, alkali-iodide azide, and sulfuric acid solution (in equal volume, 2 mL) in a 300 mL Winkler bottle. Next, this solution was titrated using N$_2$S$_2$O$_3$ solution and starch indicator until it reaches a color change. The COD of water was analyzed using a dichromate-titrimetric method (SNI 6989.73:2009). The pH of the water was measured using a pH meter.

3. Results
The result showed that TC and TN in the Badek River tend to be higher (7,900 and 380 mg/kg, respectively) than that in the Mewek River (6,700 and 350 mg/kg, respectively). The C/N ratio in the Badek River was slightly higher (C/N ratio = 21) than that in the Mewek River (C/N ratio = 17) (Table 1). In contrast, the total bacteria in the Badek River was relatively lower (3.7× 10$^8$ cells/g) compared to that in the Mewek River (4.4 × 10$^8$ cells/g). These results indicate that the input of organic materials in the Badek River is higher than that in the Mewek River. The high amount of total bacteria does not follow the high amount of carbon and nitrogen in the Badek River in the sediment. This result indicates that there is pressure on the bacteria present in the sediment of Badek River.

Table 1. TC, TN, and total bacterial number in the sediment.

| Site | TC (mg/kg) | TN (mg/kg) | C/N Ratio | Total bacteria ($\times$10$^8$ cells/g) | DO (mg/L) | COD (mg/L) | pH |
|------|------------|------------|-----------|-----------------------------------------|-----------|------------|-----|
| SB1  | 5,800      | 290        | 20        | 3.7                                     | 4.3       | 93         | 6.5 |
| SB2  | 10,500     | 470        | 22        | 3.5                                     | 4.4       | 87         | 6.6 |
| SB3  | 7,300      | 380        | 19        | 3.8                                     | 4.8       | 76         | 6.9 |
| Mean | 7,900      | 380        | 21        | 3.7                                     | 4.5       | 85         | 6.5 |
| SM1  | 5,700      | 300        | 19        | 4.3                                     | 5.1       | 32         | 7.0 |
| SM2  | 5,800      | 320        | 18        | 4.9                                     | 5.6       | 38         | 7.1 |
| SM3  | 8,700      | 440        | 20        | 4.1                                     | 5.2       | 43         | 7.1 |
| Mean | 6,700      | 350        | 19        | 4.4                                     | 5.3       | 38         | 7.1 |

The average value of DO in the water of Badek River was 4.5 mg/L. This value was slightly lower than that in the Mewek River (5.5 mg/L). The COD of water in the Badek River was higher (85 mg/L) than that in the Mewek River (38 mg/L). The pH of water in the Badek River also tends to be lower (pH 6.5) than that in the Mewek River (pH 7.1). Correlation analysis showed that there was a high correlation between total bacteria in the sediment and DO of the water ($R^2$=0.87) and COD of the water ($R^2$=0.67). These results indicate that water quality in the Badek River tends to be lower than that in the Mewek River. The amount of total bacteria in the sediment seems to be influenced by the water quality of the river.

4. Discussion
In a terrestrial-influenced river, the environmental condition usually depends on the combination of their hydrological and terrestrial characteristics [10,11,12]. The C/N ratio in the Badek River was slightly higher than that in the Mewek River. The high C/N ratio in the sediment of Badek River seems to be related to the higher allochthonous organic materials. According to Fan et al.(2017) [13],
the deposition of organic matter in aquatic environments typically comes from two different sources. The sources are living phytoplankton (autochthonous) and terrestrial plants in that surrounding area (allochthonous). The deposition of phytoplankton is characterized by higher nitrogen content resulting in the low C/N ratio (around 4 to 10) [14,15]. The other source, organic materials from the terrestrial environment, is mainly composed of lignin, cellulose, and some source of protein and amino acids [16,17]. The higher amount of organic carbon obtains a C/N ratio of more than 20 [18]. The organic materials in the sediment of Badek and Mewek River might be originated from the mixing of allochthonous and autochthonous organic material. However, since the higher value of the C/N ratio in the Badek River, it might be dominantly sourced from a terrestrial environment.

The low total bacterial number in the sediment of Badek River seems to be related to the low water quality in the Badek River. The availability of oxygen in the water is known to be the critical factor in the bacterial number and activity in the sediment of the aquatic environment [19]. Decomposer bacteria play an important role in the decomposition of organic materials in anaerobic conditions [20]. Therefore, the availability of dissolved oxygen becomes critical during this process. Inorganic materials (ammonia) are obtained through aerobic reaction, and release CO₂ as a result of microbial respiration. The high COD might also indicate the high respiration rate in the water. However, the high chemical oxygen demand in the water of Badek River (two times higher than that in the Mewek River) might indicate high demand for oxygen for a chemical reaction. Chemical substances in the Badek River could be sourced from industrial activities around the Badek River.

5. Conclusions

Organic materials in the Badek and Mewek River might be coming from mixing of aquatic origin and terrestrial sources. Badek River showed a higher C/N ratio indicating a stronger influence of terrestrial organic material compared to Mewek River. The total bacterial number in the sediment of Badek River might be related to the low water quality in that river. This information can help the policymaker in Malang City to choose Badek River as the main priority for the conservation management to provide a sustainable environment.

References

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