Organic Matter Concentrations in Morosari River Estuary, Sayung, Demak, Central Java

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Abstract. This study was carried out to determine the concentration of organic matter in the Morosari River estuary, Sayung Demak. The study was conducted in January and February 2017. Water sampling was conducted at three stations (St.1 = residential area, St.2 = high density mangrove area, St.3 = low density mangrove area) and each station was divided into 3 point substations. The results showed that the concentration of organic material at estuary, through BOD measurement was 1.9 - 2.13 mg/L (January) & 1.10 - 1.34 mg/L (February); COD 17.3 - 22.67 mg/L (January) & 11.57 - 17.67 mg/L (February); TSS 223,33 - 277,00 mg/L (January) & 301,00 - 546,67 mg/L (February); TDS 377,67 - 603,67 mg/L (January) & 292,67 - 431,67 mg/L (February) and TOM 11,83 - 13,35 mg/L (January) & 17,10 - 19,91 mg/L (February). In general, the concentration of organic matter in the estuary has not exceeded the quality standard set by Decree of the Minister of Environment No. 51 of 2004 on the Quality Standard of Sea Water, so that the waters of the Morosari River estuary can be said to have not been contaminated with organic matter and still suitable for the life of the organisms.

1. Introduction
Morosari River Estuary is a water area located in Sayung Subdistrict, Demak Regency, which borders Semarang City. Geographically the area is adjacent to the port and Kaligawe Industrial Area, Genuk District, Semarang City. River estuary is an area of active meeting between water masses from land and sea, with land boundaries covering parts of inland water especially submerged in water which is still affected by sea characteristics, such as salinity, tides and sea water intrusion [1]. River estuaries can also be said to be fertility agents in coastal areas [2]. This is because the river mouth has high productivity and the addition of organic substances or the flow of nutrients from river flows and sea water [3]. The existence of organic matter greatly affects the distribution of organisms in it [4]. Organic material contained in waters is a parameter of the fertility of these waters [5].

According to [6] Article 71 and 95 concerning the Spatial and Regional Planning of Demak Regency stated that Sayung Subdistrict was included in the regional strategic area with the designation as an industrial area, trade, urban settlement, and marine tourism activities. Around the Morosari River estuary waters, including areas that are widely used for various economic activities, such as leather tanning industry, settlements, mangrove areas, tourism, fishing and pond cultivation, such as shrimp and fish ponds. The activity is believed
to have the potential to increase the burden of waste input containing organic material carried by the flow of the Sayung River from upstream to the mouth of the Morosari River.

Organic material is a material that is complex and dynamic, derived from the remains of organisms such as plants and animals as well as waste products in the environment that are undergoing overhaul by microorganisms [7]. This material continues to experience changes in shape because it is influenced by physical, chemical and biological factors [8] [9]. Decomposition of organic matter is affected by several factors including residual composition, temperature, pH, availability of nutrients and oxygen [10].

Organic materials in the waters will experience a decomposition process by decomposing organisms into inorganic materials as important nutrients that are needed by organisms in the waters [11] [12]. These nutrients will be used in the production process by water producers and will determine primary productivity in these waters [12].

Total organic material or Total Organic Matter (TOM) of a water consists of dissolved organic matter, particulate organic matter, and colloid [4]. Dissolved organic material is <0.5 μm and non-dissolved organic material is > 0.5 μm [13] [4]. Organic substances in dissolved form generally have higher levels compared to other forms of organic matter, only around 1/5 of the non-dissolved organic material consists of living cells [14]. According to [4] the highest concentration of dissolved organic matter is found on the surface of the waters and especially nearshore waters (areas with the highest levels of productivity, there is a river flow and gets input from the atmosphere).

Sources of organic matter dissolved in the waters come from the land, namely from human activities such as household waste, industry, settlement, livestock, agriculture and fisheries, decay of dead organisms, phytoplankton, zooplankton excretion and other animals [4] [14].

Suspended solids are all solids (sand, mud, and clay) or particles suspended in water and can be a living component (biotic) or an abiotic component [4]. Living components such as phytoplankton, zooplankton, bacteria, fungi, and dead (abiotic) components such as detritus and inorganic particles [4].

Suspended solids (Total Suspended Solid) were suspended material (diameter > 1μm) which was held in millipore sieve with a pore diameter of 0.45 μm [15]. This suspended solid is the place where heterogeneous chemical reactions take place, and serves as the earliest precipitating material [16]. Suspended solids (TSS) can inhibit the ability of the production of organic substances in a waters and the penetration of sunlight into the surface and deeper parts of the water does not take place perfectly [17].

In contrast to suspended solids, Total Dissolved Solid (diameter < 1μm), ie solids in water that can pass through filters with a pore size of 0.45 μm, including carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions [15]. Similar to TSS, high or too low TDS can affect the growth of aquatic organisms [17].

According to the Ministry of Environment in the field of Environmental Pollution Control (2014) The percentage of the amount of organic material entering the river body is 60% domestic waste, industrial activities 36% and 4% from other sources. According to [18], domestic wastes, livestock and industrial wastes that are discharged into the river affect the decrease in water quality. The water quality reduction parameters can generally be seen based on the concentration of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) found in river waters [19]. Organic matter can be in the form of proteins, amino acids and urea [4]. These organic materials can be decomposed by microorganisms into more
complex compounds into ammonia (NH₃), ammonium compounds (NH₄⁺), nitrite (NO₂⁻), nitrate (NO₃⁻) [20]. The nitrogen compound is strongly influenced by the concentration of free oxygen in water, when low nitrogen oxygen will move towards ammonia while when high oxygen levels nitrogen moves to nitrate which is the end of nitrogen oxidation in water [21]. According to [4], the decomposition process in the water body tends to be detrimental because most of its products (NH₃, H₂S, and CH₄) can directly interfere with fauna life, while other products (nutrient) even though it reaches a certain concentration is beneficial, but if the nutrients continue to increase (eutrophication) will become polluters that reduce water quality. According to KLH LON-LIPI (1993), waters with BOT content smaller than 10 mg/L are categorized as clean waters. The biodegradation level of organic wastes in the waters can be identified through measurements of BOD, COD, and waste pH, while the physical parameters to determine the content of organic and inorganic materials from liquid waste is by measuring the value of the content of Total Suspended Solid (TSS) and Total Dissolved Solid (TDS) [10].

The results of the study [22], at the Sayung river estuary, Demak, the content of organic sediment is quite low, and this condition is closely related to the abundance and diversity of macrobenthos in it. Based on the regression test obtained correlation coefficient value 0.9 < r ≤ 1.0, which proves the existence of a very strong relationship. Reinforced by [23] and [24], that the estuary waters of the Sayung River belong to oligotrophic waters, thus affecting the amount of organic matter. Based on the phosphate content of the Sayung river waters, Demak belongs to mesotrophic and eutrophic waters. [24].

This study aimed to determine the concentration of organic matter and conditions of organic matter pollution in the Morosari River estuary waters, Sayung Subdistrict, Demak Regency through physical and chemical parameters.

2. Research Methods

The research material was water samples taken from the Morosari river estuary waters, Sayung Subdistrict, Demak Regency. Water sampling was carried out twice, in January and February 2017, the aim was to find out the content of organic material in the Morosari, Demak river estuary waters in two different time periods. Water samples taken were surface water with a depth of ± 1 meter [25]. Water sampling was carried out in three stations (station 1 = residential area; station 2 = high density mangrove area; station 3 = medium density mangrove area) and each station has three sampling points as repetition. The distance between stations was ± 150 m. The method of determining the location of the station based on purposive sampling method. Determination of the coordinates of each station using the Global Positioning System (GPS) (Figure 1). The collection of 5000 ml of water samples was taken from each substation using polyethylene bottles [21]. Water sampling for BOD and COD measurements using a 250 ml volume winker bottle [21]. Methods of taking water samples in accordance with SNI 6989.57-2008. Each sample bottle was labeled according to the sampling location, then put into a cool box for analysis in the laboratory. Determination of concentration of aquatic organic matter through measurement of physical and chemical parameters. The method used for BOD5 analysis (SNI.6989.72: 2009); COD (SNI 6989.73: 2009); BOT (SNI.06–6989.22-2004); Ammonia (APHA 4500 NH3) [26]; Nitrite (SNI.06-6989.9-2004); Nitrates (Brucin Sulfate, APHA, 2005) [26]; TSS (SNI 06-6989.3-2004); and TDS (Potentiometry). Analysis of water samples was carried out at the Health Laboratory Center, Semarang. As supporting data, measurements of water quality parameters in situ include pH, temperature, salinity, dissolved oxygen (DO), clarity, and depth which were
carried out together with water sampling. Daily and monthly rainfall data from the Meteorology, Climatology and Geophysics Agency (BMKG) Semarang in 2017 were also carried out as supporting data. All measurement data were analyzed descriptively, and the results will be interpreted through tables and graphs and the results of the analysis were compared with quality standards according to [27] concerning Sea Water Quality Standards for Marine Biota.

![Figure 1. Map showing location of the study site](image)

3. Result and Discussion

3.1. Water Quality Measurement Results

The results of measurements of water quality in the Morosari river estuary waters, Sayung sub-district, Demak Regency are presented in Table 1.

| Station | pH  | Temperature (°C) | Salinity (ppt) | DO (mg/l) | NH₃ (mg/L) | NO₂ (mg/L) | NO₃ (mg/L) |
|---------|-----|------------------|----------------|-----------|-----------|------------|------------|
| J F J F | 30-31 | 28.5 | 3.22 | 4.83 | 1.9 | 0.4 | 0.1 | 0.0 | 1.7 | 2.3 |
| I 7 6-7 | 29.0 | 6-7 | 4.20 | 6.28 | 1 | 4 | 0 | 2 | 7 | 8 |
### Water Quality

| Station | pH (°C) | Temperature | Salinity (ppt) | DO (mg/l) | NH₃ (mg/L) | NO₂ (mg/L) | NO₃ (mg/L) |
|---------|---------|-------------|----------------|-----------|------------|------------|------------|
| J       | F       | J           | F              | J         | F          | J          | F          |
| I       | 31-     | 29.5        | 2.90           | 5.40      | 1.8        | 0.4        | 0.1        | 0.0        | 1.6        | 1.9        |
| II      | 8.5     | 6           | 5              | 6-7       | 5-6        | 5.07       | 6.68       | 5          | 6          | 0          | 1          | 0          | 7          |
| III     | 30.     | 30-         | 2.50           | 4.67      | 2.7        | 0.7        | 0.1        | 0.0        | 1.0        | 1.6        |
|         | 5-      | 30.5        | -              | -         | 5          | 2          | 1          | 1          | 2          | 9          |

**Quality Standard**: 7-8.5<sup>*)</sup> 28-32<sup>*)</sup> 0-34<sup>*)</sup> > 5<sup>*)</sup> 0.3<sup>*)</sup> 0.06<sup>*)</sup> 0.008<sup>*)</sup>  

Source :<sup>*)</sup> [27]  
Note : J= January  
F= February

### 3.2. BOD₅ (Biological Oxygen Demand) Measurement Results

The measurement results of the average concentration of BOD₅ (Biological Oxygen Demand) at the mouth of the Morosari River, Sayung Subdistrict, Demak in January were higher, ranging from 1.90 to 2.13 mg / L compared to February 2017 which ranged from 1.10 to 1.34 mg / L (Figure 2).

![Figure 2. Average concentration of BOD5 in Morosari River Estuary, Sayung District,](image-url)
Demak Regency

The high concentration of BOD$_5$ in January was thought to be the number of decomposer microorganisms that used dissolved oxygen (DO) in the waters to decompose organic materials derived from domestic waste, industry, fisheries, mangrove litter. This was supported by the results of dissolved oxygen measurement (DO) in these waters in January which was lower, ranging from 2.50-5.07 mg/L compared to February, which was 4.67-6.68 mg/L. According to [2], mangrove litter is the largest contributor to organic matter easily decomposed in the waters. In general, the measurement results of BOD$_5$ at the Morosari river estuary have not exceeded the quality standard according to [27] concerning Sea Water Quality Standards of 20 mg/L.

The high BOD$_5$ concentration in the three stations is also related to the nitrification process. The nitrification process of organic materials derived from domestic, industrial and mangrove litter that falls in the waters will be described by decomposers. According to [20], organic nitrogen (protein) from the waste will be degraded into Ammonia (NH$_3$), nitrite (NO$_2$) and nitrate (NO$_3$). This is evident from the results of laboratory analysis found that the concentrations of Ammonia (NH$_3$), Nitrite (NO$_2$) and Nitrate (NO$_3$) measured in January from the three study locations were above the quality standard, which ranged from 1.85 to 2.75 mg/L, 0.10 - 0.11 mg/L and 1.02 - 1.77 mg/L. Whereas sea water quality standards for the concentration of Ammonia (NH$_3$), Nitrite (NO$_2$) and Nitrate (NO$_3$) according to [27] were equal to 0.3 mg/L, 0.06 mg/L and 0.008 mg/L.

Based on the measurement results of nitrate content, the Morosari river estuary waters belong to the quite fertile class. According to [28] oligotrophic (low fertility) water types if they have a nitrate content of 0-1 mg/L, mesotrophic (moderate fertility) 1-5 mg/L, and eutrophic (high fertility) if they contain between 5-50 mg of nitrate/L.

3.3. COD (Chemical Oxygen Demand) Measurement Results

Based on the results of the study, the average COD concentration obtained in January 2017 ranged between 17.33 - 22.67 mg/L and in February 2017 ranged between 11.57 - 17.67 mg/L (Figure 3).

According to [29], the COD concentration can be affected by the degradation of organic and inorganic materials derived from community activities around the river and the waste produced by the industry is not treated properly.
Excessive COD concentration in a waters is the same as BOD concentration which will affect the decrease in dissolved oxygen concentration (DO) and pH, so that it will affect the decline in water quality. A further consequence is that the productivity of aquatic resources also declined. The difference between COD and BOD values is a description of the amount of organic material that is difficult to decompose in the waters. According to [30], COD describes the total amount of oxygen needed to oxidize organic materials chemically, both of which can be degraded biologically or difficult to degrade biologically into CO₂ and H₂O. The COD value is inversely proportional to the DO value which means that the higher the COD value the DO value will be low. In accordance with the results of DO measurements at the study site in January the results were lower when compared to DO in February. However, the COD value in the January and February 2017 measurements still met the class IV quality standard according to [31] which is 100 mg / L.

3.4. **TSS (Total Suspended Solid) Measurement Results**

TSS consists of minerals and organic particles in the water column [32]. The measurement results of TSS concentrations at the mouth of the Morosari River, Sayung Subdistrict, Demak Regency in January ranged from 223.33 to 277.00 mg / L and February 2017 ranged between 301.00 - 546.67 mg / L (Figure 4).

The average concentration value of TSS in February was higher than January, presumably influenced by rainfall. According to data reported by BMKG Semarang (2017), rainfall in February was categorized as high, namely 319 mm, while January was 210 mm (medium category). The high rainfall causes the input of suspended materials from the land carried by the river to go to the estuary more. This is in accordance with the statement [33], that the cause of the high TSS one of them is influenced by the intake of material from the land carried through the river flow. Also explained by [34], TSS will increase due to soil erosion caused by rain.
Figure 4. Average TSS concentration in Morosari River Estuary, Sayung District, Demak Regency.

The source of TSS that enters Morosari river estuary waters, including all solid substances (sand, mud and clay) or suspended particles in water and can be biotic components such as phytoplankton, zooplankton or abiotic components such as detritus and particles other organic matter carried from upstream to downstream of the river mouth. In general, the value of TSS in the morosari river estuary waters has not exceeded the quality standards set by [27], which is 400 mg / L. With the exception of February sampling at Station 1, TSS exceeded the quality standard, this is presumably due to its location close to residential areas so that the highest input of TSS originates from the mainland and the more sea-level TSS concentration decreases due to dilution by rainwater.

3.5. TDS (Total Dissolved Solid) Measurement Results

The results of the measurement of the average concentration of TDS at the mouth of the Morosari River, Sayung Subdistrict, Demak Regency in January were higher, namely between 377.67 - 603.67 mg / L compared to February 2017 ranging between 292.67 - 431.67 mg / L (Figure 5).
Total dissolved solid (TDS) of Morosary Estuary are thought to originate from inorganic and organic materials such as leaves, mud, plankton, runoff from soil, industrial and domestic waste. Based on measurement data, the average TDS concentration in January 2017 was higher than in February 2017. This was allegedly due to the high rainfall in February caused dilution, resulting in a wider distribution of TDS material, this resulted in a decrease TDS concentration for the month.

According to [15], TDS is the number of dissolved solids measuring ≤ 1 μm. A high TDS value indicates that organic waste has not been completely eroded into gas. Conversely, a decrease in the value of TDS concentration caused by smaller dissolved particles in the wastewater has gone through the methanogenic phase, so that the particles dissolved in the waste have been converted into gas form. According to [35], the methanogenic phase is the methane formation phase of organic waste by microbes in anaerobic conditions (low oxygen).

In general, the results of the measurement of TDS values at the mouth of the Morosari, Demak river in January and February 2017 have not exceeded the grade IV quality standard according to [31] which is 2000 mg / L. These conditions indicate that the waters are still safe, turbidity has not occurred, this can be seen from the results of clarity measurements at the study site at sampling time of 0.22-0.25 m (January 2017) and 0.18-0.23 m (February 2017) with a depth of 1.33-1.47 m (January 2017) and 1.34-1.56 m (February 2017).

3.6. TOM (Total Organic Matter) Measurement Results
TOM describes the concentration of total organic matter in a waters consisting of dissolved, suspended (particulate) and colloidal organic matter [4]. The measurement results of TOM concentrations at the mouth of the Morosari River in January ranged between 11.83 - 13.35 mg / L and in February 2017 ranged from 17.10 - 19.91 mg / L (Figure 6).
The TOM concentration value is thought to be influenced by rainwater dilution. Referring to the data reported by BMKG Semarang (2017), that in January 2017, Demak Regency had medium rainfall of 210 mm and in February 2017 had a high rainfall of 319 mm. The rainwater was suspected of carrying more organic material from upstream to downstream so that the TOM concentration in February 2017 was higher than in January 2017.

Total organic matter also showed the relationship with dissolved oxygen concentration (DO), which was the tendency of decreasing dissolved oxygen with increasing total organic matter. This is in accordance with the opinion [36], the condition of anoxic aquatic environments can be caused by organic loads from allochtonous sources.

The high TOM value in February was also suspected because high rainfall caused the productivity level of mangrove litter to increase, due to the low density of leaves which made the leaves easily fall into the waters. This statement was strengthened by the results of the study [37], that the highest litter production occurs during the rainy season or during high rainfall. According to [38], the factors that influence the production and decomposition rate of mangrove litter are sediment texture, salinity, soil pH, temperature, rainfall, and wind speed.

Based on the measurement of TOM, the Morosari Demak river mouth waters were categorized as not clean, because the TOM content exceeds 10 mg / L. According to LON LIPI (1993), the waters are clean if TOM is <10 mg / L. However, according to [39] it does not include polluted waters because TOM is still in the range 0.01-30 mg / L.

### 4. Conclusion

The conclusion of this study was the concentration of organic matter in the estuary waters of the Morosari, Sayung, Demak regencies based on BOD measurements was 1.90 - 2.13 mg / L (Jan) & 1.10 - 1.34 mg / L (Feb); COD 17.33 - 22.67 mg / L (Jan) & 11.57 - 17.67 mg / L (Feb); TSS 223.33 - 277.00 mg / L (Jan) & 301.00 - 546.67 mg / L (Feb); TDS 471.67 - 603.67 mg / L (Jan) & 292.67 - 431.67 mg / L (Feb) and TOM 11.83 - 13.35 mg / L (Jan) & 17.10 – 19.91 mg (Feb). In general, the value of the concentration of organic matter
parameters in the Morosari River estuary waters had not exceeded the quality standards that have been determined according to the Decree of the Minister of Environment No. 51 of 2004 concerning Sea Water Quality Standards, so that the Morosari River estuary waters can be said to have not been contaminated with organic matter and not toxic for biota.

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