

# Analysis of water quality on several waters affected by contamination in West Sumbawa Regency

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**Abstract.** This study reports the result of water quality in several waters in West Sumbawa Regency. The load of waste input from anthropogenic activity becomes an indication of the decrease of water quality in West Sumbawa Regency Waters. The existence of illegal mining activities around the water has the potential to cause water pollution. Sample of water were collected on April 2017 in four location such as Sejorong 1, Sejorong 2, Tongo, and Taliwang. Sample were analyzed as insitu and exsitu parameters. The result of this research showed that Sejorong 2 have the highest value of pollution index but generally four site on West Sumbawa Regency Waters were categorized lightly contaminated. Concentration of heavy metal cadmium at four locations exceed the water quality standard for fisheries and drinking water. However, the trophic classification using TSI and TRIX of all location was oligotrophic water.

## 1. Introduction

Nowadays, the quality of surface water is an important concern. Waters such as rivers become water bodies that receive pollution input. Surface water is the area which most widely receives natural processes such as soil erosion, precipitation rates, and weathering processes, as well as anthropogenic activities such as industry. Rivers are land water resources essential for domestic activities, so control and reliable information is needed for effective management [1].

Batu Hijau area of West Sumbawa is an area that has a good biological and non- biological potential. The rivers located in the Batu Hijau area have an important economic value for the community be it for daily life, irrigation, or fishing for consumption [2].

Nowadays, pollution has become increasingly problematic in our daily life [3]. Along with the high potential of natural resources in the region of West Sumbawa, many industries have also been established there. The number of companies in the region have numbered to 625 industries covering textile, paper, chemical, petroleum, coal, plastics, metal goods, machinery and equipment, food, tobacco, and other processing industries [4]. The presence of acid mine overflow from the gold mining industry in West Sumbawa has the potential to decrease water quality. According to Onodera [5] the existence of various industrial activities causes various contaminants that can enter the waters. Phiri [6] said that these contaminants can interfere and harm the life of aquatic biota.

Based on information from people who live around the river, dead biota can often be found which include fish, shrimp, and crabs. The biota are suspected to be poisoned due to the contaminants that flow into the river [7,8]. This is an important concern that needs to be studied, especially regarding the description of water quality, quality status, and determination of trophic classification in West Sumbawa Regency waters due to the problem of pollution. This is one of the monitoring efforts to

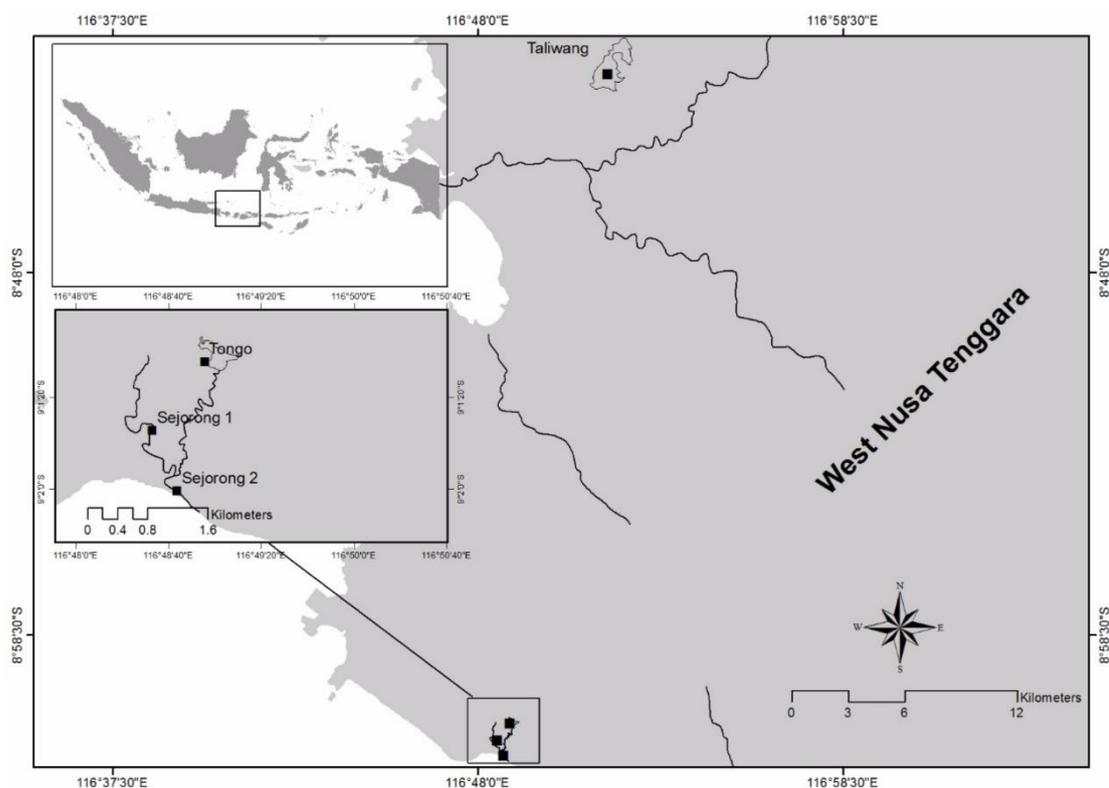


prevent the occurrence of water quality degradation in these waters which is an important habitat of various biota with great ecological and economical value for food consumption. The aim of this study is to analyze the water quality status and trophic classification of the West Sumbawa Regency waters.

## 2. Methodology

### 2.1. Monitoring site

The study was conducted in April 2017 in several water sites in the West Sumbawa regency (figure 1). The research locations consist of 4 stations, namely Sejorong 1, Sejorong 2, Tongo, and Taliwang. Sejorong 1 is a river, Sejorong 2 is the estuary of the river, while Tongo and Taliwang are small lakes and tend to resemble stagnant waters. These four locations are indicated to be affected by anthropogenic activities, especially gold mining.



**Figure 1.** Map showing the water quality monitoring sites on several waters in West Sumbawa Regency waters.

The condition of West Sumbawa waters is shown by figure 2



Sejorong 1

Water bodies are narrower, tend to be shallow, greenish water color



Sejorong 2

More rapid currents, the most shallow point, the color is brown water, close to the mouth of the river



Tongo

brownish green water color, the existence of fishing activity



Taliwang

Conditions tend to be stagnant water, overgrown with aquatic plants (water hyacinth), presence of fishing activities by boat, and fishing, water color brownish green

**Figure 2.** Conditon of sampling locations.

### 2.2. Monitored parameters and analytical methods

Water quality parameters measured consist of physical, chemical and biological parameters. The water samples taken were surface water samples. Water samples were measured in situ and some were prepared and analyzed exsitu at the Institute for Research and Standarization of Surabaya and Nutrition Laboratorium, Faculty of Public Health at Airlangga University (table 1).

**Table 1.** Water quality parameters, units and analytical methods as measured during April 2017 on West Sumbawa Regency waters.

Parameters	Units	Method	Handling	Notes
<b>Physical Parameters</b>				
Temperature	°C	Termometer (Hg) / (APHA, AWWA, WEF 2005)		<i>In situ</i>
Transparency	meter	<i>Secchi disk</i> /Visual (APHA, AWWA, WEF 2005)		<i>In situ</i>
Turbidity	NTU	HACH 2100 AN Turbiditymeter Handbook		<i>Ex situ</i>
TDS	mg/L	SNI 06-6989.27-2005		<i>Ex situ</i>
TSS	mg/L	SNI 06-6989.3-2004		<i>Ex situ</i>
<b>Chemical Parameters</b>				
Salinity	‰	Refractometer (APHA, AWWA, WEF, 2005)		<i>In situ</i>
pH		pH meter		<i>In situ</i>
Alkalinity	mg/L	Standard Methods 20 th edition 1998	Cooling	<i>Ex situ</i>
Dissolved oxygen	mg/L	DO meter		<i>In situ</i>
BOD	mg/L	SNI 06-6989.72 : 2009	Cooling	<i>Ex situ</i>
Ammonia	mg/L	SNI 06-6989.30-2005	H <sub>2</sub> SO <sub>4</sub> , pH <2	<i>Ex situ</i>
Nitrate	mg/L	SNI 06-2480-1991	H <sub>2</sub> SO <sub>4</sub> , pH <2	<i>Ex situ</i>
Nitrite	mg/L	SNI-06-6989.9-2004	H <sub>2</sub> SO <sub>4</sub> , pH <2	<i>Ex situ</i>
Orthophosphate	mg/L	Standard Methods 20th edition 1998	Cooling	<i>Ex situ</i>
Phosphate total	mg/L	Standard Methods 20th edition 1998	Cooling	<i>Ex situ</i>
Lead (Pb)	mg/L	SNI- 06-6989.46-2005	HNO <sub>3</sub> , pH < 2	<i>Ex situ</i>
Cadmium (Cd)	mg/L	SNI- 06-6989.38-2005	HNO <sub>3</sub> , pH < 2	<i>Ex situ</i>
Copper (Cu)	mg/l	SNI- 6989.66-2009	HNO <sub>3</sub> , pH < 2	<i>Ex situ</i>
<b>Biological Parameters</b>				
Chlorofil a	mg/L	Aseton extract	Nathio-sulfat, dark condition	<i>Ex situ</i>
Phytoplankton	sel/m <sup>3</sup>	Microscope	lugol	<i>Ex situ</i>

### 2.3. Data analysis

#### 2.3.1 Pollution index

All parameters of water quality were compared to river water quality standards using the quality standard of Indonesia [9]. The results obtained were then discussed descriptively for all observation stations. The quality status of the environmental quality of Sungai Tongoloka was calculated by the using pollution index. The pollution index was used to determine the level of pollution relative to the allowed water quality parameters [10]. The pollution index has an advantage in determining pollution levels at a point at one observation. The pollution index value results are then evaluated to determine the status of the water quality (table 2).

$$IP : \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_M^2 + \left(\frac{C_i}{L_{ij}}\right)_R^2}{2}} \quad (1)$$

IP : Pollution index  
 Ci : Concentration of water quality parameters (i)  
 Lij : Standard of water quality parameters  
 (Ci/Lij)M : Maximum value Ci/Lij  
 (Ci/Lij)R : Mean value Ci/Lij

**Table 2.** Evaluation of pollution index value [10].

Value	Water Quality Status
$0 < \leq 1.0$	Good
$1.0 < \leq 5.0$	Lightly contaminated
$5.0 < IP \leq 10$	Poluted moderately
$IP > 10$	Heavily polluted

### 2.3.2 Trophic Classification using Trophic State Index (TSI)

Trophic classification of the water was calculated based on several parameters that affect productivity in accordance with the calculation Trophic state index (TSI) [11]. TSI is based on three parameters namely total phosphate concentration (TSI-P), chlorophyll-a concentration (TSI-Chl-a) and Secchi disk depth value (TSI-SD). From these three parameters were obtained the value of TSI which is the average result of the value of TSI-P, TSI Chl-a and TSI-SD. Trophic classification based on Carlson Trophic state index (TSI) calculation is as follows:

$$TSI-SD = 10 \left( 6 - \frac{\ln SD}{\ln 2} \right) \quad (2)$$

$$TSI-Chl-a = 10 \left( 6 - \frac{2,04 - 0,68 \ln Chl-a}{\ln 2} \right) \quad (3)$$

$$TSI-TP = 10 \left( 6 - \frac{\ln \frac{48}{TP}}{\ln 2} \right) \quad (4)$$

$$\text{Average of TSI} = \left( \frac{TSI-SD + TSI-Chl-a + TSI-TP}{3} \right) \quad (5)$$

SD = Secchi *disk* (m)  
 Chl-a = Chlorofil-a ( $\text{mg}/\text{m}^3$ )  
 TP = Total phosphate ( $\text{mg}/\text{m}^3$ )

Here is the category of trophic classification based on TSI Carlson (table 3).

**Table 3.** Category of trophic classification based on TSI Carlson.

TSI	Fertility Status
<30-40	Oligotrof
40-50	Mesotrof
50-70	Eutrof
70-100+	Hipereutrof

### 2.3.3 Trophic Classification using TRIX

The parameters chosen in the TRIX index determination were dissolved inorganic nitrogen (DIN), dissolved inorganic phosphate (DIP / PO<sub>4</sub>), chlorophyll-a (Chl-a), and saturation level (% O<sub>2</sub>). On the determination of the TRIX index using the formula Vollenwieder [12] shown as follows.

$$\text{TRIX} = (\text{Log} [\text{Chl-a} \times \% \text{sO}_2 \times \text{DIN} \times \text{DIP}] + 1.5) / 1.2 \quad (6)$$

% O<sub>2</sub> (saturation level) = (DO/DO<sub>i</sub>) × 100 % , DO<sub>i</sub> (saturation oxygen) = 14.62 – 0,37(T°C) + 0,0045(T°C)<sup>2</sup> – 0,097(Salinity) + 0,002(T°C)(Salinity) + 0,0003 (Salinity)<sup>2</sup>, (Weiss 1970), DIN(Dissolved Inorganic Nitrogen) = NH<sub>3</sub> + NO<sub>2</sub> + NO<sub>3</sub>, DIP(Dissolved Inorganic Phosphate) = PO<sub>4</sub>

## 3. Results and discussion

### 3.1. Physical Parameters

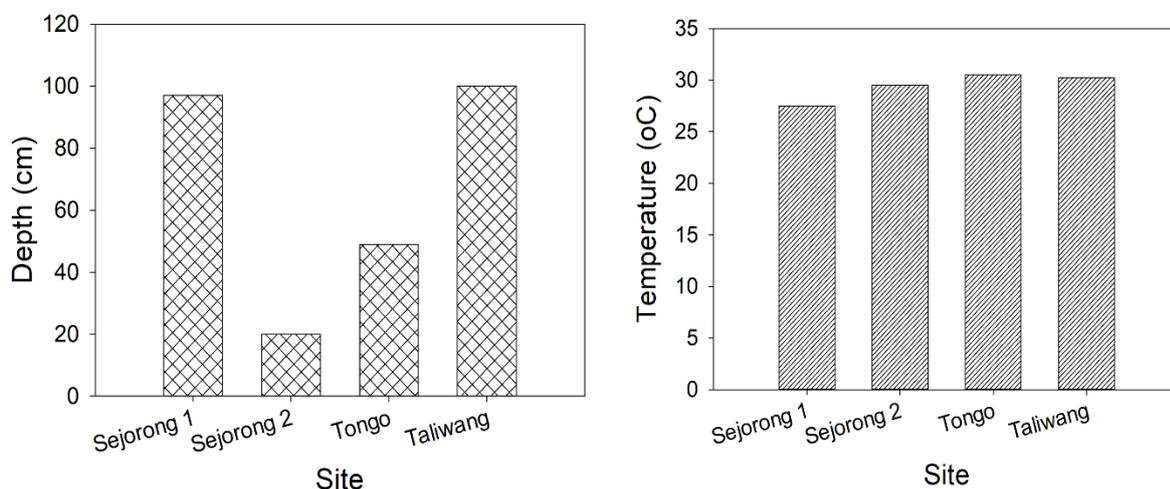
The physical parameters are shown on figure 3. According to Goldman [13], temperatures are parameters that play a role in controlling aquatic ecosystems that may affect other physical, chemical, and biological parameters. This is related to the metabolic system of aquatic biota. Temperatures on West Sumbawa Regency waters range from 27.5-30.5°C.

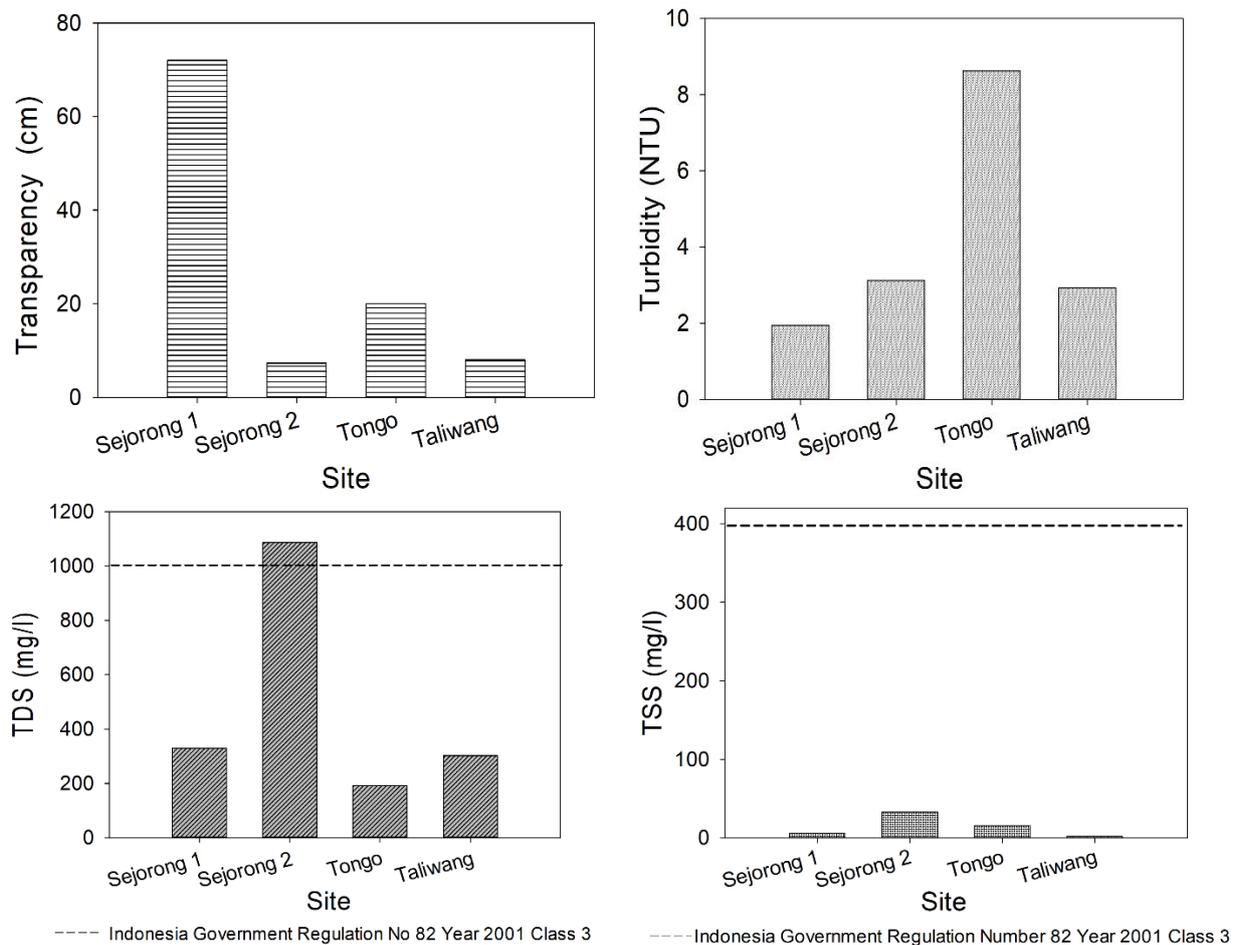
Based on field observations, Sejorong 2 is the most shallow station among all of the stations (20 cm), while Taliwang has the deepest depth (100 cm). The color of the waters describe the content of substances that exist in the waters. The color of the waters at Sejorong 1 station is greenish and odorless, while in Sejorong 2 is brown but also odorless. The Tongo station tends to be brownish-green and odorless, Taliwang station is brownish-green and smells fishy.

Transparency is visually determined and measured using a Secchi disk [13]. Transparency is one of the parameters that can be used to estimate the total turbidity of the waters due to organic or inorganic waste [11, 12]. Therefore, this technique can be used to predict the primary productivity of waters associated with the status of trophic classification. Sejorong 1 has the highest transparency value among other stations (72 cm) while Sejorong 2 has a low transparency value (7.3 cm) and Taliwang (8 cm).

The value of TDS for Sejorong 1, Tongo, and Taliwang has not exceeded the water quality standard based on [9] Class 1 regarding drinking water quality standard and Class 3 on the quality standard for fishery activities (1000 mg/L), while Sejorong 2 has exceeded the standard quality (1086 mg / L).

The TSS value describes the total of suspended solids in the water. TSS values range from 2-33 mg / L. Sejorong 2 has the highest TSS value of 33 mg/L. However, for the four stations the TSS value is still below the quality standard for fishing activities (400 mg / L).

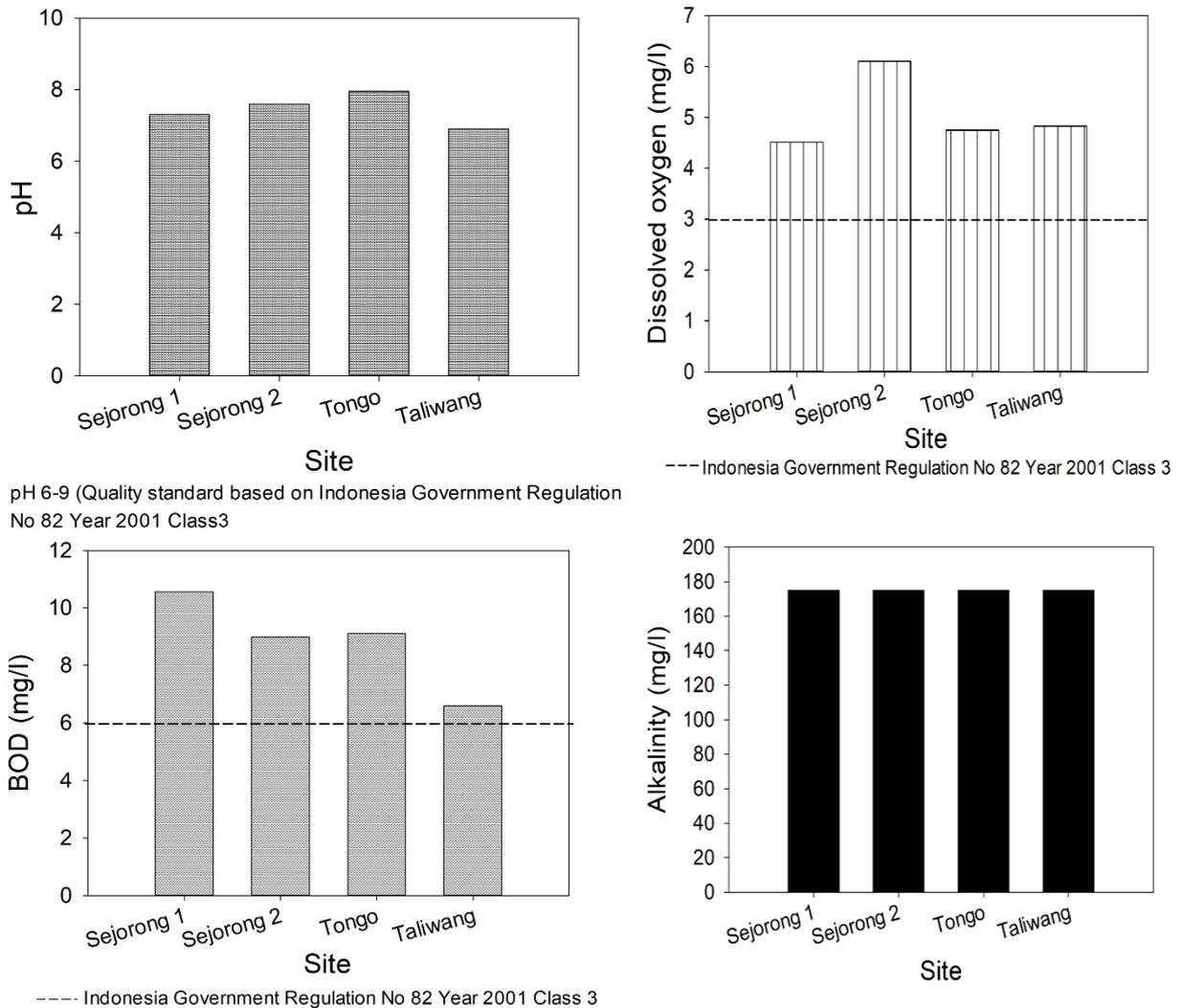




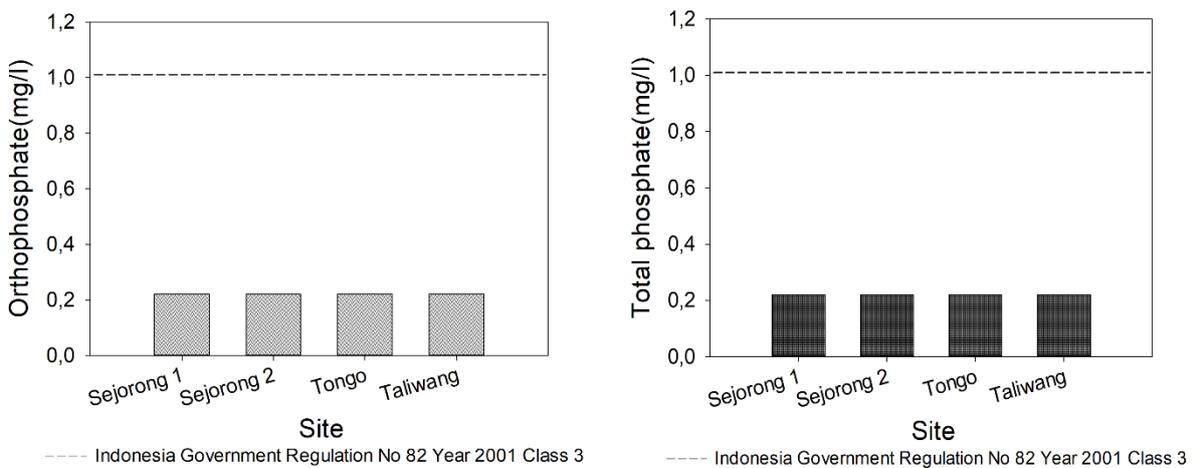
**Figure 3.** Physical parameter on West Sumbawa Regency waters.

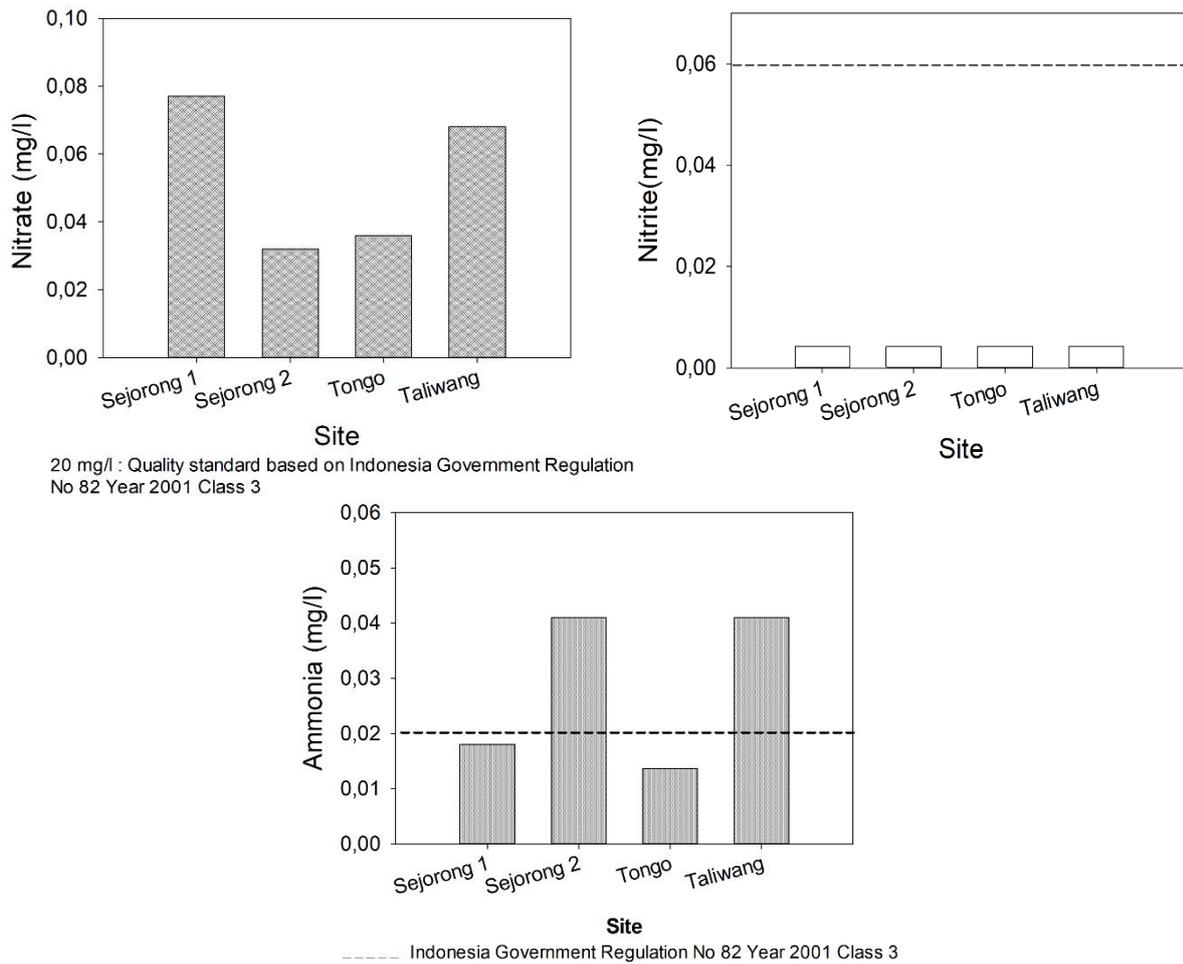
### 3.2 Chemical parameters

The chemical parameters of water quality are shown by the figure 4,5 dan 6. The degree of acidity is influenced by the process of photosynthesis and respiration. The pH values at the study sites ranged from 6.9-7.95. Overall pH value is still in the range of drinking water quality standards and fishery activities. Oxygen values range from 4.51-6.1 mg / L. The oxygen content value at the four stations meets the quality standard for fisheries activities (minimum 3 mg / L).

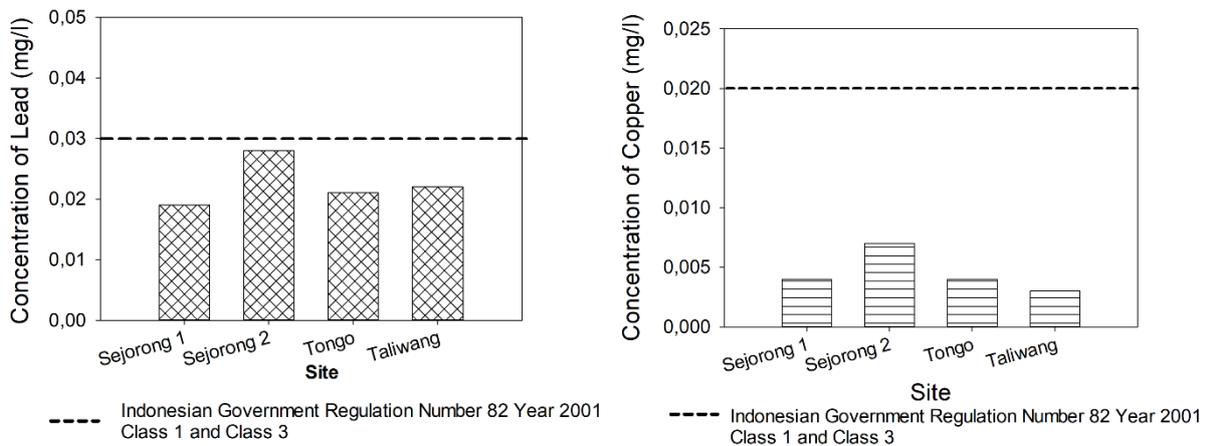


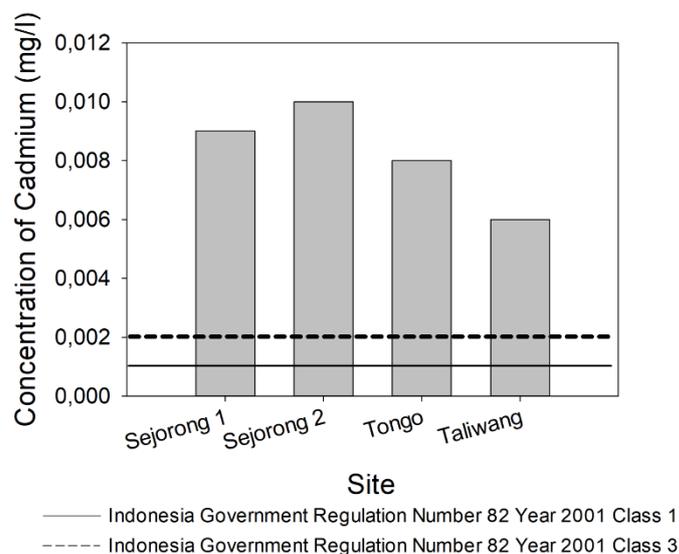
**Figure 4.** Chemical Parameter pH, DO, BOD, and Alkalinity on West Sumbawa Regency waters.





**Figure 5.** Chemical parameters orthophosphate, total phosphate, nitrat, nitrit, amonia on West Sumbawa Regency waters.





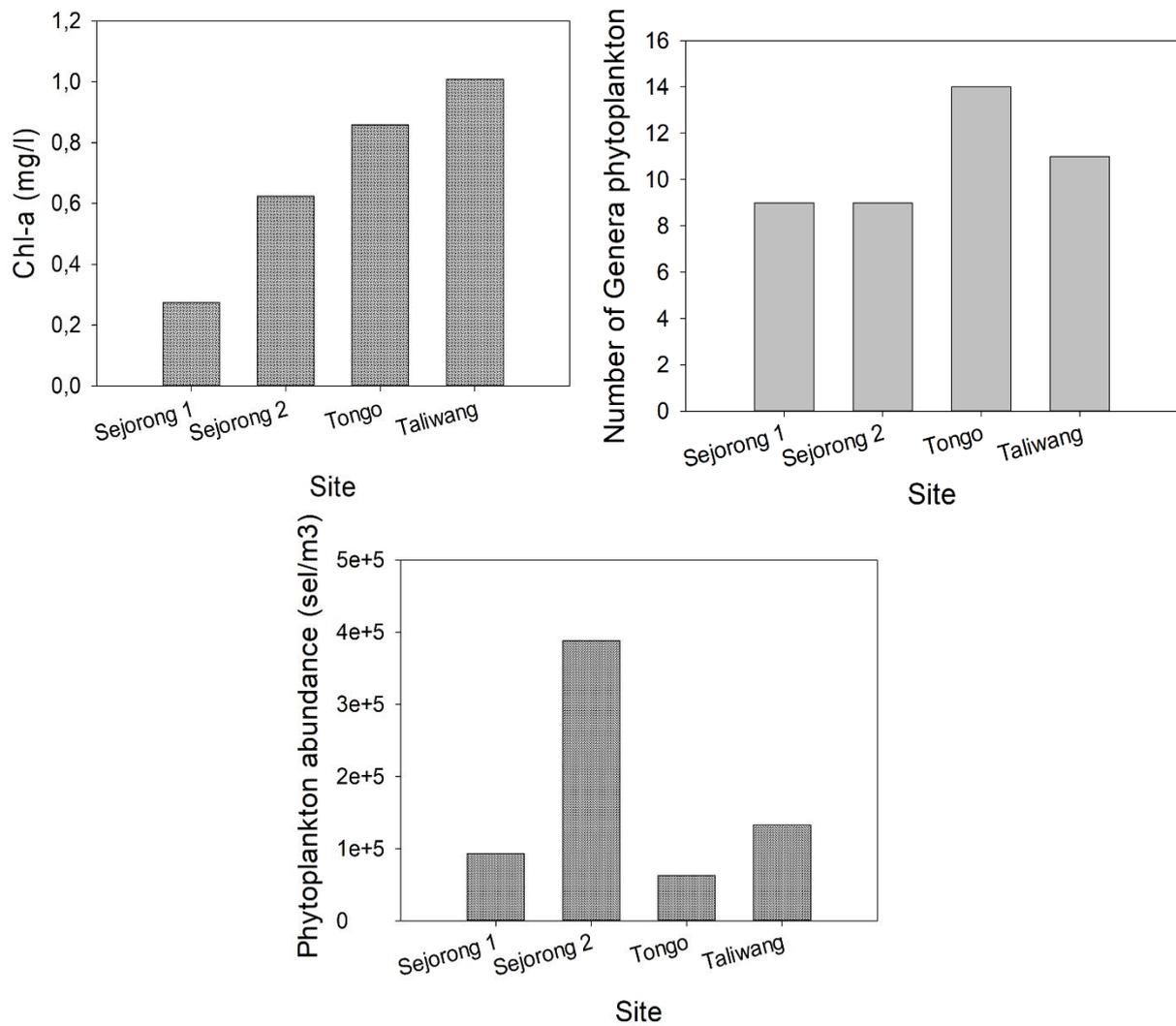
**Figure 6.** Concentration of Heavy metal on West Sumbawa Regency waters.

The value of alkalinity in all four stations had the same tendency value which was 175.05 mg  $\text{CaCO}_3$  / L. BOD values obtained from the results ranged from 6.6 to 10.57 mg / L. The BOD value for all stations exceeded the good quality standard for fishery which is 6 mg/L. Phosphorus is one source of nutrients in the water. The total value of phosphate and orthophosphate in all four stations is <0.22 mg / L. The total value of phosphate and orthophosphate is still below the standard for fisheries (1 mg / L) and the quality standard of drinking water (0.2 mg / L).

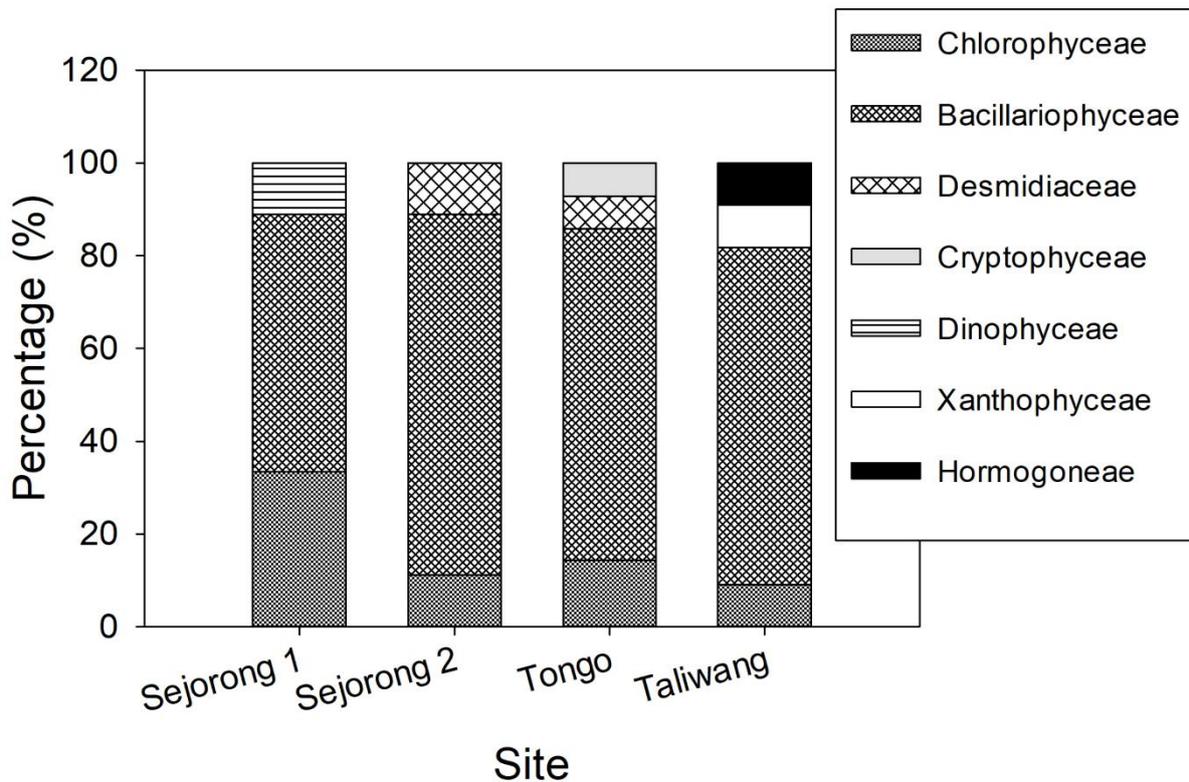
Nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ) is the main form of nitrogen in natural waters and is a major nutrient for plant and algae growth, and is a limiting factor other than phosphorus [13]. The value of nitrate in the West Sumbawa Regency waters ranged between 0.032-0.037 mg/L. The highest nitrate value was in Sejorong 1 and the lowest was in Sejorong 2. The value was still below the drinking water quality standard (10 mg / L) and the fishery quality standard (20 mg / L). Nitrite is an unstable nitrogen parameter. The presence of high nitrite potentially becomes dangerous in the waters. The nitrite value for the four stations is <0.0042. The value still had not exceeded the fishery quality standard of 0.06 mg / L. Ammonia is a part of nitrogen which can be toxic to aquatic biota if its presence is in excess in the water. Levels of ammonia in the study sites ranged from 0.0137 to 0.041 mg / L. Sejorong 2 and Taliwang had a value above the fishery quality standard.

The heavy metal content of lead in the West Sumbawa Regency waters ranged from 0.014-0.028 mg / L with Sejorong 2 having the highest levels that almost exceeded the quality standard. Copper content ranged from 0.003-0.007 mg/L. In addition to lead concentration (Pb), Sejorong 2 also had the highest copper (Cu) heavy metal concentration among the stations. Although the value is still below the quality standard, it is necessary to monitor the levels in the water so the concentration does not increase. For cadmium (Cd), concentrations at all four stations exceed the standards for drinking water (class 1) and fishery (Class 3). The cadmium concentration values ranged from 0.006 to 0.01 mg / L. The Sejorong 2 station also had the highest cadmium metal concentration compared to the other stations.

3.3 Biological parameters



**Figure 7.** Biological parameters Chlorofil a, number of genera and phytoplankton abundance on West Sumbawa Regency waters.

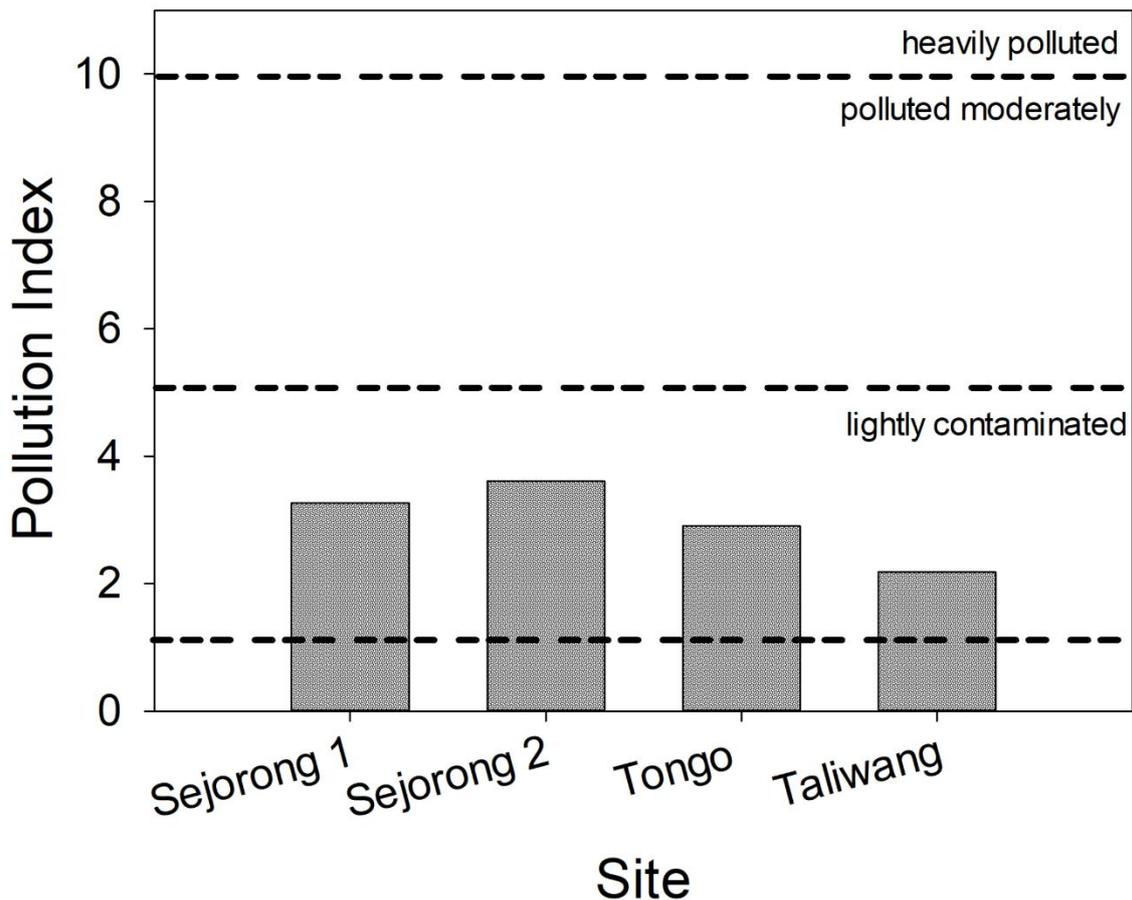


**Figure 8.** Composition of plankton on West Sumbawa Regency waters.

Chlorophyll a is a biological parameter that can predict the productivity of the water. Through chlorophyll, the biomass of phytoplankton in a waters can be known. The highest measurement of chlorophyll a was found in Taliwang Station at 1.008 mg / L and the smallest in Sejorong 1 with a value of 0.275 mg /L.

The number of plankton genera in Tongo was highest among the stations, which are 14 genera (figure 7). The highest abundance of plankton was Sejorong 2 (figure 7) due to the high abundance of *Synedra ulna* at the site. In general, the four stations were dominated by Bacillariophyceae with a range of 56-78%. The second dominant plankton was Chlorophyceae with a range of 11-33 %, while the other class was only about 7-11 % (figure 8).

Based on analysis of the pollution index, the four locations in West Sumbawa Regency waters was lightly contaminated (figure 9). However the trophic classification based on TSI and TRIX found all of locations were categorized as oligotrophic water (table 4).



**Figure 9.** Water pollution index on West Sumbawa Regency waters.

**Table 4.** Trophic classification on West Sumbawa Regency waters.

Site	TSI Carlson	TRIX	Trophic Classification
Sejorong 1	3.81	1.11	Oligotrophic
Sejorong 2	16.67	1.51	Oligotrophic
Tongo	12.55	1.37	Oligotrophic
Taliwang	17.32	1.32	Oligotrophic

The existence of pollution was due to waste from the mining industry, illegal mining, and the excess mine acid from some time ago which has affected the aquatic environment as seen from the water quality parameters. The most heavily heavy metal waste was industrial waste, due to heavy metal elements being used as raw materials in industries, fungicide catalysts and additives. Industrial waste containing heavy metals will be carried by rivers or air to the sea [14]. In general, pollution waste derives from anthropogenic activities [15].

The physical parameters especially temperatures in this area are still within the range of aquatic biota thresholds, especially freshwater. Relating to the color parameters, Sejorong 1 is still greenish. One cause is the dominant plankton of Chlorophyceae. The brown color in Sejorong 2 is due to the station being closely located to the estuary, resulting in a lot of organic matter accumulating in the area. This is proven with the lowest *t* and highest TDS and TSS, with a turbidity that is also quite high.

Taliwang also has brown water color, but with a fishy smell. This is because the station is filled with water hyacinth that is likely to die and rot in the waters, causing unpleasant odors.

Overall transparency values in Sejong 2, Tongo, and Taliwang tend to be small due to the high organic material at the site. This is in line with the high value of turbidity in the three locations. The pH value at Taliwang station is the lowest among the other locations. This is indicated from the high levels of CO<sub>2</sub> due to high respiration in these waters. However, the alkalinity value is quite high in all four locations, so the pH range is neither too low nor too high. Oxygen levels are still within optimum limits for fishery.

The content of nitrate is still below the quality standard for fishery, so in terms of nitrate it still can support fishery activities. However, the high ammonia in Sejong 2 and Taliwang indicated that the decomposition of organic material was high in those locations. The rest of the organic matter were either from faeces or dead biota and can also increase ammonia levels in the water so that the value exceeds the quality standard.

The parameters of concern due to pollution caused by mining are heavy metals. The concentration of lead (Pb) and copper (Cu) at all locations was still below the quality standard, while cadmium (Cd) exceeded the quality standard. This needs to be monitored to determine whether the levels are increasing or decreasing.

The effect of the heavy metal Pb interferes with the enzyme oxidase, as a result it will inhibit the cell metabolic system, one of which inhibits the Hb system in the bone marrow [16]. In addition to the metal Pb, Cd metal also has the potential to poison aquatic biota. According to Tarigan [17] other than harmful to organisms, Pb metal is also harmful to humans. This is because humans consume aquatic biota such as fish, etc. Shrimp organisms will experience death within 24 - 504 hours from the exposure to metal Cd in concentrations of 0.005-0.15 ppm. This is evidenced by the conditions in the field where biota is very rarely found due to the effects of mine acid exposure and illegal mining that has killed off the biota.

The biological parameters observed were chlorophyll a and plankton. The value of chlorophyll a in Tongo and Taliwang was high. This indicates that Tongo and Taliwang are very productive waters compared to Sejong 1 and Sejong 2. In addition, the number of phytoplankton genera found in Tongo and Taliwang were higher than that of Sejong 1 and Sejong 2. However Sejong 2 has the highest abundance due to the dominance of the species *Synedra ulna*.

Based on the pollution index analysis, the quality status of water quality in the four locations are classified as lightly contaminated. This is due to the parameters that have exceeded the standard. Based on the analysis of TSI and TRIX fertility rates, all stations in the West Sumbawa Regency waters are oligotrophic. This means that the waters are still clear waters and have little nutrient content.

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