The Diversity of Tolerant Fish in the Coastal Waters of Lusi Island Sidoarjo Regency

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Abstract. One of the government’s effort in overcoming the Lapindo mudflow is to drain mud through the Porong River to form sediments which over time form an artificial island called Lusi Island. As a result of the mud accumulation in the waters of the Lusi Island region can reduce the waters quality and existing organisms diversity. The purpose of this research was to described the diversity of fish that are tolerant in the Coastal Waters of Lusi Island Sidoarjo Regency, explained the relationship between the diversity index of fish and water quality in the Coastal Waters of Lusi Island Sidoarjo Regency, explained the relative abundance index of tolerant fish in the Coastal Waters of Lusi Island Sidoarjo Regency, and know the water quality in the Coastal Waters of Lusi Island Sidoarjo Regency based on the diversity of fish. This research was did in November 2019 - February 2020. The type of research was observational research. Accumulation of sample fish and physical chemical quality of the waters were taken at five station. Identification fish of water based on morphological characteristics. The diversity index was analyzed according to the Shannon-Wiener index. The relative abundance index was analyzed based on the Odum Abundance. The result revealed that there were eleven species belonging to nine family. The relation between water quality and fish diversity index showed a positive relation which the bigger value of water quality was also followed by the bigger value of fish diversity index. The highest relative abundance index is in Mystus nigriceps fish species with 50% percentage and the lowest is Ethmalosa fimbriata with 3% percentage. The value of fish diversity in the Coastal Waters of Lusi Island Sidoarjo Regency is 2.31 which included in the uncontaminated category. So, it can be concluded the relation of fish diversity index with the physical and chemical quality of the water in the territorial waters of Lusi island Sidoarjo Regency is classified as not polluted, because the value of H > 2.0 which according to Lee, Wang & Kuo is included in the uncontaminated category.

1. Introduction

One of the mudflow phenomena that was becoming a big disaster until now is the Lapindo Mudflow in Sidoarjo. Until now, the government seems to has not yet succeeded in stopping the mudflow or managing the social impact well enough [1]. One of the problem was the disposal of mud which contain of heavy metals just flowed into the Porong River. In November 2006, the government took the initiative to start disposing Lapindo Mud into Porong River through an outlet about 20 km from the headwaters of the river to the deep sea in the Madura Strait in hope that the Porong River water discharge could drain the Sidoarjo Mudflow [2].

Then, in 2011 the Sidoarjo Mud Handling Agency dredged the Sidoarjo mud sediment then flowed through the Porong River until it formed in the mouth of the estuary. Over time, the flow of mud through the Porong River formed an artificial island of 94 hectares which was later named Lusi Island [2]. As the result of the mud sediment presence in the Porong River, it can cause a decrease in
water quality and affect the presence of organisms because not all organisms in the river are tolerant of environmental stresses, but rather have tolerance limits. There will be a decrease in abundance or even absence if the organism is intolerant of an aquatic environment. In addition, according to Fachrul [3], intolerant organisms can be used as indicators of clean and normal water quality in an aquatic environment.

Water quality can be used as a benchmark reflecting the quality of the aquatic environment, so that it can affect the organisms that are in it. Water quality can be measured from biological, physical and chemical parameters. Biological parameters as one of the parameters of water quality need to be considered because it directly affects the impact of a pollution that occurs. Biological parameters can be measured by the biomonitoring method. Biomonitoring is a method to determine water quality biologically by looking at the presence of bioindicator groups [4]. Biological indicators are groups of organisms that presence or behavior can be related to environmental conditions, including types such as plankton, benthos and nekton [5]. Nekton is an organism that can move actively on its own accord, such as fish, amphibians, large aquatic insects [6]. Fish is one of the aquatic organisms that is susceptible to environmental changes. Each fish species has a different habitat character to be able to live and breed. The structure of the fish community will have changes or disturbance if the water quality is disturbed. Changes in fish diversity can be used as a bioindicator of pollution [7].

During this time the diversity and abundance of existing fish and its relation to water quality of Lusi Island waters is still unknown because no research has been done before and the lack of information from the parties such as related agencies or local people. According to Hendrata [8], fish can be used as a bioindicator of the waters quality because fish is one of the aquatic biota that is able to show reactions to physical changes or changes in water pollutants dissolved at certain limit concentration. The intended fish reaction, among others; show swimming behavior and movements, show body color and so on, as well as changes in respiratory activity [7].

Based on Purnomo and Rachmadiarti’s research [9] conducted on the East Coast of Sidoarjo, Lapindo Hot Mud caused changes in environmental factors in aquatic ecosystems and aquatic organism life, from the nine species of fish divided into eight genus and eight families, there were Anabantidae and Belontiidae families which have an additional respiratory organ characteristics that enable them to live in a lack of oxygen condition in contaminated waters by Lapindo Mud and the Channidae family which have a primitive labyrinth.

Thus, the purpose of this research was to describe the diversity of fish species that were tolerant in the coastal the Lusi Island waters of Sidoarjo Regency, explain the relationship between the diversity index of fish species with water quality in the coastal waters of Lusi Island region of Sidoarjo Regency, explain the relative abundance index of fish species that are tolerant in the coastal waters of Lusi Island region of Sidoarjo Regency, and know the water quality in the coastal waters of Lusi Island region of Sidoarjo Regency based on the fish diversity index.

2. Method
The subjects of this research were fish and water quality in Lusi Island waters, Sidoarjo Regency. The objects of this research were the diversity and abundance of fish and chemistry water quality in the waters of the Lusi Island, Sidoarjo Regency. The research site was visualized in Figure 1.
2.1. Research Procedure
In this study, the research procedures carried out in three stages, including the preparation, the implementation, and the final stage.

The implementation stage included measurements of physical quality of water. Physical and chemical quality of water measurements were carried out at five samplings. Then the fish sampling was done by spreading gill nets thrown to the bottom of the water.

The final stage was carried out when the data of research obtained then processed and analyzed in Ecology Laboratory of Biology Department FMIPA UNESA. Fish identification is based on the Fish Identification Book by Saanin [10]. For water quality identification was based on government quality standards in Government Regulation No. 82 of 2001 about Water Quality Management.

2.2. Sampling Design
Determination of physical and chemical water quality sampling was done by purposive sampling. There were five stations which covered three observation areas, namely the upstream, middle and downstream sections. Each station had two repetitions, namely the edges and middle.

Fish sampling was done by putting gill nets at each station. The position of the gill net after being put will unfold vertically because it was equipped with a float and sinker. The position of the gill net will be left unfolded in the water for a while, ± 30 minutes, then the gill net was pulled back to count the obtained catches. Then take a picture of each type of fish caught and then identified based on the book "Taksonomi dan Kuntji Identifikasi Ikan" [10]. The water quality parameters measured were physical and chemical parameters.

2.3. Data Analysis
Data analysis in this research was done by using descriptive analysis, which was a technique in describing the obtained data so that it was obvious and can be distinguished from one another.

The diversity index can be calculated using the Shannon-Wiener Index formula as follows:

\[ H' = - \sum \frac{ni}{N} \ln \frac{ni}{N} \]

Note:
\( H' \): Shannon-Wiener diversity index
\( ni \): One particular species found
\( N \): The number of individuals found
Then, the species diversity index in a water can be used to determine the level of water pollution according to Lee, Wang and Kuo [11], that is, “>2 = Not Polluted”; “1.6-2.0 = Lightly Polluted”; “1.0-1.5 = Moderately Polluted”; “<1.0 = Heavely Polluted”

Meanwhile, fish abundance can be calculated using Relative Abundance (RA) formula based on Odum [6] as follows:

$$RA = \frac{n_i}{N} \times 100\%$$

Note: RA = Relative Abundance (%)

$\text{n}_i$ = One particular species found

$\text{N}$ = Total number of individuals found

Calculation of relative abundance using the RAlf formula is also based on the provisions of Katamihardja and Satria, that is, “<25% = Relatively Rare”; “25–50% = Relatively Medium”; “>50% = Relatively High.”

3. Results and Discussion

From the research that has been done, the species of fish that was found in the waters of the Lusi Island consisted of nine families including Polynemidae (Eleutheronema tetradactylum), Engraulidae (Stolephorus sp.), Mugilidae (Valamugil engeli and Liza parmata), Gerreidae (Gerres filamentosus), Chanidae (Chanos chanos), Clupidae (Sardinella gibbosa and Ethmalosa fimbriata), Bagridae (Mystus nigriceps), Leiognathidae (Leigonathus sp.), and Cynoglossidae (Cynoglossus cynoglossus).

About the fish diversity index at each station in the Lusi Island Region Waters was presented in Table 1.

| No. | Station | Fish Diversity Index (H’) |
|-----|---------|---------------------------|
| 1.  | Station 1 | 1.39                      |
| 2.  | Station 2 | 1.56                      |
| 3.  | Station 3 | 2.12                      |
| 4.  | Station 4 | 2.27                      |
| 5.  | Station 5 | 2.32                      |

3.1. Physical-Chemical Water Quality in the Waters of Lusi Island, Sidoarjo

An elucidation of the average of physics-chemical quality in the waters of the Lusi Island Region was presented in Table 2.

| Station | Temperature (°C) | Depth (m) | Water Clarity (cm) | Flow Velocity (m/s) | Turbidity (NTU) | Salinity (%) | DO (mg/L) | CO₂ (mg/L) | pH | BOD (mg/L) |
|---------|------------------|-----------|--------------------|---------------------|-----------------|--------------|------------|------------|----|------------|
| 1       | 27.2             | 1.8       | 0.22               | 0.2                 | 18.3            | 19.4         | 12.3       | 0.6        | 8.3| 6.5        |
| 2       | 27.7             | 1.8       | 0.23               | 0.4                 | 20.0            | 22.6         | 13.0       | 0.6        | 8.2| 8.9        |
The results of physico-chemical parameters measurement in Lusi Island

| Station | Temperature (°C) | Depth (m) | Water Clarity (cm) | Flow Velocity (m/s) | Turbidity (NTU) | Salinity (%) | DO (mg/L) | CO₂ (mg/L) | pH | BOD (mg/L) |
|---------|-----------------|-----------|--------------------|-------------------|-----------------|--------------|------------|------------|----|------------|
| 3       | 28.4            | 2.1       | 0.26               | 0.3               | 60.0            | 26.2         | 13.0       | 1.1        | 8.5| 15.9       |
| 4       | 28.9            | 1.2       | 0.23               | 0.1               | 34.8            | 28.2         | 21.1       | 1.4        | 8.1| 9.7        |
| 5       | 30.1            | 1.6       | 0.26               | 0.4               | 23.0            | 30.0         | 17.2       | 1.8        | 8.4| 7.7        |
| Average | 28.5            | 1.7       | 0.24               | 0.3               | 31.2            | 25.3         | 15.3       | 1.1        | 8.3| 9.7        |
| Standard Deviation | 1.12 | 0.33 | 0.02 | 0.13 | 17.33 | 4.28 | 3.77 | 0.52 | 0.16 | 3.65 |

About the averages of highest and lowest fish relative abundance in the waters of the Lusi Island was presented in Table 3.

| No. | Family | Species                     | Station |
|-----|--------|-----------------------------|---------|
| 1.  | Bagridae | *Mystus nigriceps* | 1 | 2 | 3 | 4 | 5 |
| 2.  | Clupeidae | *Ethmalosa fimbriata* | 0% | 0% | 0% | 4.3% | 3% |

Table 3. The averages of highest and lowest fish abundance at each station in Lusi Island

From the results and research identification conducted in the waters of Lusi Island, the dominant fish family in the waters of Lusi Island was Bagridae. That was caused by the location of stations 4 and 5 were close to the river mouth which had many types of fish. In addition, according to Kimirei et al [13] river mouth areas have important functions for aquatic ecology including being a place for every phase of fish life, spawning sites [14], and foraging [15].

Among the 5 existing stations, the highest fish diversity index was at station 5, namely 2.32. The lowest value of fish diversity index among other stations was station 1, that was 1.39. The diversity index value obtained was very low because station 1 was located farthest from a fish source which near to the estuary.

Fish species with the highest relative abundance was *Mystus nigriceps* which a percentage of 50% at station 1. Meanwhile, fish species with the lowest relative abundance was *Ethmalosa fimbriata* which a percentage of 3% at station 5. This can be caused by at station 1 having territorial waters that was located far from the Lusi Island Region, so that the waters didn’t contain any contaminants [16]. In addition, according to Sari et al [12], *Mystus nigriceps*, member of family Bagridae, has the ability to live in any environmental conditions. Adis et al [17] also explained that species which is a family of Bardrigae has an ability to live in a variety of environmental conditions.

About value of water quality in Lusi Island Region, temperature average value obtained of 27.2°-30.1°C. This is the optimum growth temperature for the fish according to the Sutisna and Sutarmanto [18] statement, the optimum growth temperature for aquatic organisms ranged between 25°C-35°C.

Lusi Island waters had depth of 1.2-2.1 meters. A good and optimal depth for aquatic organism life ranges from 1.2 to 3 meters. The deepest water of the stations was in station 3 which was located the closest to the Lusi Island that there were building facilities and infrastructure that affect the depth of waters.
The average value of water clarity of Lusi Island in each station was 0.24 meters. Nybakken and Bertness [19] explained that ideally the level of water clarity is usually more than 1 meter, if it is less than 1 meter then it is declared turbidity. In addition, fish usually respond to light stimuli between 0.5 meters [20].

Flow Velocity in the Lusi Island Area obtained an average value of 0.14-0.36 m/s which was included in the low category according to Welch and Lindell [21]. As Odum [6] stated that the flow velocity has different variations in each different part of the same water flow. This is also related to the statement from Johan and Ediwarman [22] that the flow velocity that is suitable for fish life ranges from 0.10 to 0.25 m/s.

Turbidity of Lusi Island waters obtained an average value of 18.3-60.0. The highest turbidity value was found at station 3 because at this station was close to Lusi Island where there were many activities, especially the activities of visitors or local residents. According Dongkyun et al [23], high turbidity level affects the fish life, even causes death. High turbidity level also disrupt the osmoregulation system in fish, such as breathing and visibility of aquatic organisms, and inhibition of light penetration to the water [6].

The lowest salinity value in Lusi Island waters was at station 1 which was 19.4 ‰ and the highest at station 5 which was close to estuary, that was 30.0 ‰. According to Dobson and Frid [24], the salinity range of estuary that still be tolerated is around 5-18 ‰. This is in accordance with the statement of Susana [25] which is getting farther away from the coastline, the salinity value will be higher because the volume of freshwater from the mainland will gradually mixed with the seawater.

Dissolved Oxygen (DO) levels obtained from the average of each station was 15.3 mg/L. Based on DO level criteria stated by Lee, Wang and Kuo [11], DO levels of the Lusi Island waters are included in the uncontaminated category. The statement is in accordance with Effendi [26] that a water quality is good if the water has DO levels >3 mg/L. In addition, according to Muhtadi et al [27] the oxygen content in waters that are ideal for fish life is above 6 ppm.

The averages of CO₂ value of all stations were 0.6-1.8 mg/L. These were in accordance with the statement of Prasetyawan [28] that location which nearer to the estuary, the value of CO₂ will be higher. However, the value of CO₂ in the waters of the Lusi Island area was low. The low value of CO₂ in the Lusi Island waters caused by less organic materials contained in the waters of the Lusi Island area which could increase CO₂ levels. According to Boyd [29], normally, free CO₂ levels in waters are <5 mg/L. However, free CO₂ levels of 10 mg/L still be tolerated by aquatic organisms as long as it was balanced by the availability of sufficient O₂ levels.

pH of Lusi Island waters obtained averages value of 8.1-8.5. Based on Government Regulation No. 82 of 2001 that the third-grade water quality standard is 6-9, so that the pH levels obtained from Lusi Island waters met the established quality standard and still capable of providing life support for organisms in the waters. According to Effendi (2003)[26], the optimal degree of acidity for fish life is between 7.0-8.5. pH is an important factor for the aquatic environment that can support the survival of fish. Too low pH conditions is dangerous to living organisms and increases the solubility of heavy metals in water [30].

BOD in Lusi Island area obtained averages of 6.5-15.9 mg/L. BOD values can be caused by the activities carried out near these waters, especially at station 3 which was the activity center of Lusi Island. This is related to the statement of Lee Wang & Kuo., (1978)[11], a liquid with a BOD content of more than 10 mg/L has been contaminated by organic matter. In addition, Lee, Wang and Kuo [11] also stated that uncontaminated waters had a BOD value ≤ 2.9. Tarigan and Edward [31] added that the maximum levels of BOD for aquatic organisms life range from 3 mg / L to 6 mg / L.

After obtaining the results of the fish diversity index and the physical-chemical water quality above, then the relationship analized between the two to determine the classification of the water pollution level in Lusi Island area, Sidoarjo.
Based Lee, Wang and Kuo [11] the classification level of water pollution index based on diversity by Shannon-Wiener (H') and physical-chemical factors, Lusi Island waters classified to uncontaminated waters. It could be evidenced by the Fish Diversity Index value of >2, whereas the DO value is 15.3 mg/L according to Lee, Wang and Kuo [11] the waters quality was classified to the unpollutant category.

*Liza Parmata* was a species that had a high amount of diversity that was a total of 15 *Liza Parmata* at all stations. The high number of *Liza Parmata* showed the ability of the fish to adapt well to any environmental conditions, so that the spread of this species was quite wide. Then, according to Sulistiono et al [32] *Liza Parmata* can tolerate extreme environmental conditions such as temperature and salinity, and can adapt to various foods in various habitats.

4. Conclusion

The waters of Lusi Island, Sidoarjo, obtained the following conclusions: (1) There were 9 families of fish that was found in Lusi Island Sidoarjo, such as Polynemidae, Engraulidae, Mugilidae, Gerreidae, Chanidae, Clupidae, Bagridae, Leiognathidae, Cynoglossidae. (2) There was a positive relationship between water quality and fish diversity index in the waters of Lusi Island, Sidoarjo Regency, which means that the greater the water quality value, the greater the fish diversity value. (3) The species of fish that had the highest relative abundance according to formula by Odum [6] was *Mystus nigriceps* with a percentage of 50% at station 1, while species that had the lowest relative abundance was *Ethmalosa fimbriata* with a percentage of of 3% on stations 5. (4) The relationship of water quality by physical-chemical water factors, namely temperature, depth, water clarity, flow velocity, turbidity, salinity, DO, CO2, pH, and BOD with diversity index of fish species in Lusi Island waters classified to uncontaminated waters, because the value of H’ overall was 2.31 where H’>2 according to Lee, Wang and Kuo (1978) are classified to uncontaminated category, other than that the DO value on each stations of more than> 6.5 were indicated uncontaminated criteria.

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