Biodiversity studies of echinoderms in Sedati waters, Sidoarjo District, East Java Province

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Abstract. Sidoarjo waters is a buffer zone of Surabaya City. Sidoarjo has many industries such as the metal, textile and waste treatment industries. Many industrial wastes are discharged into Sidoarjo waters, especially Sedati. Waste entering the waters can affect water quality, which influences the living things. One of them is echinoderms. This research purpose to find out the differences of echinoderms in Sedati waters. The research was done from October to December 2019. The data obtained were analyzed descriptively quantitatively using the diversity index Shannon Winner and ANOVA. The results showed that the diversity of echinoderms species found has significant differences. Species were found like Archaster typicus, Echinothrix calamaris, and Ophiothrix sp. The average diversity of echinoderms was 0.4119 ± 0.1479 (H < 1) so it was classified as low criteria with polluted water quality. The low variation of echinoderms can be caused by several factors such as location, season, physical quality, chemical quality, biotic factors and the fishing gear used. One of the efforts reduce the impact of pollution is to treat waste before it transferred to the release and move the fishing gear used to be more environmentally friendly.

1. Introduction
Indonesia is a maritime country which has a large area of the ocean and has big potential for exploration [1]. The one territory area is Sedati which location in Sidoarjo District. Sidoarjo waters is a buffer zone of Surabaya City which has many industries such as the metal, textile and waste treatment industries. Many industrial wastes are discharged into Sidoarjo waters, especially Sedati. Waste entering the waters can affect the water quality, which influences the living things in Sidoarjo waters [2]. Wastes produce various organic and inorganic matters [3]. The wastes can influence the water quality which affects marine life. One of them is echinoderms.

Echinoderms are invertebrates which have spines in their body surface. According to [4], there are over 6000 echinoderms species in the world. Echinoderms play the main character in the marine ecosystem [5] such in the food web as carnivore, herbivore, omnivore or detritus feeder [6]. Echinoderms more often found in the calm and clear water [7] also in the coral reefs and shallow coastal area. Increasing community activity can affect the environment quality Sedati waters. This case impact to echinoderms diversity which lives in the substrate of the waters. So far there has been
no research examining echinoderms in Sedati waters. Therefore, this research purpose to determine the
diversity of echinoderms, including composition, diversity, evenness and dominance.

2. Materials and methods

2.1 Date and place
This research was conducted from October to December 2019 in Sedati waters, Sidoarjo. Echinoderms
identification was carried out in the Anatomy and Cultivation Laboratory, Faculty of Fisheries and
Marine, Airlangga University, Surabaya. Water quality testing was carried out in the Chemical
Laboratory of the Research and Standardization Center (BARISTAND) Surabaya. The maritime data
were collected in the Meteorology, Climatology and Geophysics Agency (BMKG) Juanda, Sidoarjo
and the Maritime Meteorology and Geophysics Agency (BMKG) Tanjung Perak, Surabaya. Meanwhile, testing of primary substrate samples was carried out in the Laboratory of Soil Mechanics
of Civil Engineering, FTSP ITS Surabaya.

2.2 Tools and materials
The tools used in this research included boats, scratches, Ekman, labelled plastic clips, plastic bottles
measuring 1.5 litres, coolboxes, digital cameras, GPS (Global Positioning System), pH pens, DO
meters and refractometers. The materials used are echinoderms samples, seawater samples, bottom
substrate samples and ice cubes.

2.3 Research methods
This research is an observational using quantitative descriptive method with primary and secondary
data collection [9]. The methods in determining the station using purposive sampling technique while
the determination of the sampling point using stratified random sampling.

2.4 Research procedures
2.4.1 Determining date and place
Sampling was carried out at three stations (station A, B and C). Station A was located in the
northernmost tip of the Sedati area nearing the Surabaya area. Station A is close to the pond. Station B
is located in the middle of Sedati waters. Station B is the estuary of the Juanda River. Station C is
located in the southern end of the Sedati area nearing Porong. Station C is an area close to mangroves
and residential areas. The location of the research sampling can be seen in Figure 1. The sampling
time-frequency is conducted every month from October to December 2019. The research sample was
taken at the time of changing from dry to rainy seasons (transition).

![Figure 1. Sampling research location](image)
2.4.2 Echinoderms Sampling
Echinoderms samples were taken using a dredge net was pulled using a motorboat. The echinoderms samples obtained were then inserted into plastic clips labelled according to the station and point of collection. Then samples were stored in a coolbox that has been given ice cubes. Furthermore, the sample was taken to the Laboratory of Anatomy and Cultivation Faculty of Fisheries and Marine, Airlangga University, Surabaya for observation.

2.4.3 Sediment sampling
The primary substrate samples were taken using Ekman grab. Ekman’s grabs were placed on the bottom-on the water with a weight dropped from the boat. Then the Ekman grab slowly lifted, and sediment sample was inserted into a plastic clip labelled. Substrate samples were stored in the coolbox. Observation of the type substrate was carried out in the Laboratory of Soil Mechanics of Civil Engineering, FTSP, Sepuluh November Institute of Teknologi, Surabaya.

2.4.4 Water sampling
Seawater sampling was carried out in a depth of 30 cm below the water surface as much as ± 1500 ml, then stored in a coolbox filled with ice cubes. Water sample testing was carried out in the Laboratory of the Research and Standardization Agency (BARISTAND) Surabaya to determine the TSS, BOD and ammonia content.

2.4.5 Environment parameter measurement
Environment parameters measurement recorded from each point include temperature, dissolved oxygen (DO), salinity and degree of acidity (pH). Temperature and dissolved oxygen measurement using a DO meter. Salinity is measured using a refractometer. pH measurement using pH meter. Meanwhile, measurement of other parameters like TSS, BOD and ammonia data was carried out in the Chemical Laboratory of the Industrial Research and Standardization Center (BARISTAND) Surabaya.

2.4.6 Observation and calculation composition
The echinoderms species composition was observed based on species and number of individuals. Echinoderms were identified using an identification key according to [10] Monograph of Shallow Water Indo-West Pacific Echinoderms and a macrozoobenthos marine species identification website.

2.4.7 Diversity index calculation (H’)
The diversity index value ranges from 0 – 3. The criteria for the diversity index value can be seen in Table 1. The diversity index is calculated using the equation formula [11]:

\[ H' = - \sum_{i=1}^{S} \frac{n_i}{N} \ln \left( \frac{n_i}{N} \right) \]

Information:
- \( H' \) = Diversity Index Shannon-Wiener
- \( S \) = number of species
- \( n_i \) = Individual number of i-species
- \( N \) = Total number individual all species

| Number | Diversity Value (H’) | Criteria          | Waters Quality |
|--------|----------------------|-------------------|----------------|
| 1      | \( H' < 1 \)         | Low diversity     | High polluted  |
| 2      | \( 1 < H' \leq 3 \)  | Middle diversity  | Middle polluted|
| 3      | \( H' > 3 \)         | High diversity    | Not polluted   |
2.4.8 Evenness Index Calculation (E)
The evenness index value ranges from 0 – 1. Criteria for a community based on the evenness index value can be seen in Table 2. The formula for the evenness index according to [12]:

\[
E = \frac{H'}{\ln S}
\]

Information:
E = Evenness Index
H' = Diversity Index
\ln = Natural logarithm natural
S = Number of species

| Number | Evenness Index (E)       | Criteria           | Keterangan          |
|--------|--------------------------|--------------------|---------------------|
| 1      | 0 < E ≤ 0.5              | Low evenness       | Suppressed community|
| 2      | 0.5 < E ≤ 0.75           | Middle evenness    | Labile community    |
| 3      | 0.75 < E ≤ 1             | High evenness      | Stabile community   |

2.4.9 Dominance index calculation (C)
Dominance index values range from 0 – 1. The criteria for the dominance index value can be seen in Table 3. The formula for the dominance index [12]:

\[
C = \sum \left( \frac{n_i}{N} \right)^2
\]

Information:
C = Dominance Index
ni = Individual number of a species
N = Individual number all species

| Number | Dominance Index (C)       | Criteria          |
|--------|---------------------------|-------------------|
| 1      | 0 < C ≤ 0.5               | Low dominance     |
| 2      | 0.5 < C ≤ 0.75            | Middle dominance  |
| 3      | 0.75 < C ≤ 1              | High dominance    |

2.5 Data analysis
Differences in the diversity level of echinoderms were analyzed using analysis of variance (ANOVA) with the help of SPSS (Statistical Package for the Social Sciences) version 23.0. This study used the one way ANOVA test to determine differences in echinoderms diversity.

3. Result and discussion
The composition of echinoderms was found shows various values. Based on the research, there are three echinoderms species found, like Archaster typicus 96%, Echinothrix calamaris 6% and Ophiothrix sp. 1%. The composition of echinoderms species found in Sedati waters can be seen in Figure 2.
Figure 2. Echinoderms species composition in Sedati waters

Three species were found on October and November in station A are *Archaster typicus*, *Echinothrix calamaris* and *Ophiothrix* sp. Two species were found on December in station A are *Archaster typicus* and *Echinothrix calamaris*. The only species found on October, November and December in stations B and C is *Archaster typicus*. The fluctuation composition of echinoderms graphic can be seen in Figure 3.

Figure 3. The fluctuation composition of echinoderms in Sedati waters

The results on the echinoderm composition (Figure 2), showed that the most common echinoderms species found in each station were *Archaster typicus*. This is because *Archaster typicus* has a wider habitat distribution than other species. *Archaster typicus* usually inhabited areas of the seabed with soft sediments including sand, silt and grasslands [13]. In addition, the basic substrate also affects the distribution of echinoderms. Sedati waters have a muddy substrate. *Archaster typicus* can be found in open ocean waters with mud substrates [14].

Differences in the composition can be caused by season. Echinoderms composition data shows that October has the highest number of echinoderm composition than November and December. The dry season occurs in October while the rainy season occurs in December. This is supported by research from [15] which stated that the season greatly influences the distribution pattern of macrozoobenthos. The temporal distribution pattern of macrozoobenthos shows that in the rainy season it has a lower density than the dry season so that less number and variation of macrozoobenthos are found.

The diversity level of echinoderms showed a very significant difference (p<0.05). Diversity index (H') of echinoderms ranged from 0 to 0.5071. This shows that the diversity level of echinoderms species in Sedati waters is very low or H'<1. The diversity index of echinoderms graphic can be seen in Figure 4.
Water quality parameters can influence low diversity. The ammonia content in Sedati waters shows a value that exceeds the quality standard, especially in station C. The quality standard for ammonia concentration for marine biota is 0.3 mg/L [16]. Ammonia conditions that exceed the quality standard can endanger marine life. The high concentration of ammonia in Sedati waters can be caused by the high waste input from land activities. Based on research [2], it states that the waters of Sedati have the potential for environmental change due to the waste disposal of industrial, agricultural and household wastes from rivers. The high and low species diversity index values can be caused by several things, such as the number of individual species found, the dominance of certain species, water quality and basic substrate [17].

The evenness index value (E) of echinoderms showed a very significant difference (p<0.05). Evenness index values ranged from 0 to 0.2045. This shows that the evenness of echinoderms in Sedati waters is very low or 0 < E ≤ 0.5. The evenness index of echinoderms graphic can be seen in Figure 4.

Low evenness indicates a depressed or unstable community. This can be because the number of individual echinoderms that are scattered is not the same, so there is a tendency for dominant species, such as the explosion of *Archaster typicus* species in stations B and C compared to station A. Echinoderms species inequality is caused by the distribution of the number each species is not spread evenly [18]. Based on research by [19] regarding the diversity and evenness of echinoderms in the intertidal Gili Meno area, showed a low evenness index value of 0.25. The low evenness of echinoderms is due to the small variety of echinoderms species in Gili Meno.

The dominance index value (C) of echinoderms showed a very significant difference (p<0.05). The dominance index value ranges from 0.7327 to 1. This indicates that the dominance level of echinoderms in Sedati waters is at moderate criteria or 0.5 < C ≤ 0.75 and high or 0.75 < C ≤ 1. This dominance value indicates that it is the dominance of a particular species. The dominance index of echinoderms graphic can be seen in Figure 4.

The results showed that *Archaster typicus* in the three stations was found in more numbers than the others. The location of each research station also affects the dominance of echinoderm species. Each research station has different environmental conditions. Station A is located in the SegoroTambak Village, which 86.49% of the area is ponds [20] and close to the East Coast of Surabaya, which has very dense mangrove conservation [21]. This causes the water environment at Station A to be more optimal so that the species found are more varied. Station B is an estuary area located in Tambak Cemandi Village. The estuary flows wastewater originating from domestic waste and industrial waste [2]. While station C is a mangrove area and many residential areas. Station C is located in Kalanganyar Village, which closer to the Porong where Lapindo mud occurs. Although part of the coast is mangrove forest, the water conditions are not very good [22]. In addition, the disposal of Lapindo mud into the sea can have an impact on reducing the diversity of biota in these waters [2]. This causes the circulation conditions in stations B and C to become unstable so that the variation of echinoderms species found is small, resulting in dominance.

![Figure 4](image-url)

**Figure 4.** The Diversity (H'), Evenness (E) and Dominance (C) index of echinoderms in Sedati waters
The results showed that the diversity index and evenness index values were always lower than the dominance index values. The diversity index value runs straight with the evenness index value but is inversely proportional to the dominance index value. According to [23] that diversity index value of echinoderms in the research was in a low category from 0.23 to 0.31. The evenness index value ranges from 0.22 to 0.29 so that it is included in the unstable or depressed group because it has a value close to 0 (zero). This indicates the dominance of one species over other species. The dominance index values ranged from 1.73 to 1.85, with the criteria of having a very high dominance. In general, the abundance of a species can be influenced by many interrelated factors, especially environmental quality factors, both physical and chemical [24]. Environmental quality plays an important role in regulating the metabolic processes of aquatic biota [25]. Environmental factors are the determining factor of aquatic biota life [26].

The average data of physical parameters obtained were temperature 30.2 ± 0.827 °C, salinity 33 ± 1.879 ppt, stream 0.005 ± 0.0033 m/s and TSS 16.22 ± 21.498 mg/L. During the research, physical parameters fluctuated every month. Based on research data, the temperature value of the research station was between 28.5 to 31.2 °C. This value is still in the optimum range for echinoderms survival [16]. The salinity measurements obtained from each station ranged from 30 to 35 ppt. This range is still quite optimal for echinoderm life [16]. The results showed that Sedati waters had a stream velocity from 0.0006 to 0.0119 m/s. According to [2m7] the stream velocity in sea waters ranges from 2 to 5 m/s. Total Suspended Solid (TSS) data in this research ranged from 2 to 66 mg/L. This value is still at the optimum level [16].

The average data for chemical parameters obtained were DO 5.06 ± 0.511 ppm, pH 8.18 ± 0.18, BOD 19.06 ± 8.616 mg/L and ammonia 0.309 ± 0.146 mg/L. During the research, the chemical parameters fluctuated every month. The results of DO measurements during the research were 4.27 to 5.68 m. The DO value obtained indicates that the waters are at the threshold. According to [16] states that the DO value for marine life is DO> 5 mg/L. Variations in the pH value of the waters greatly affect the biota in the waters. The research data shows that the pH range of Sedati waters is 7.84 to 8.43. This shows that the pH value in Sedati waters is quite optimum [16]. BOD data in this study ranged from 0.63 to 37.53 mg/L. The maximum standard of BOD recommended for deep-sea biota is 20 mg/L [16]. The higher BOD concentration indicates that the decomposition is contaminated. Data showed that the total ammonia concentration in Sedati waters ranged from 0.196 to 0.633 mg/L. The total ammonia standard for marine biota is 0.3 mg/L [16]. As it is known that ammonia is one of the parameters of organic pollution in the waters, if the ammonia concentration in the waters is too high, it can be suspected of contamination [28].

Biotic factors can also cause low water quality. One of the biotic factors that affect water quality is toxic plankton. According to [29] it was noted that toxic plankton was found in Indonesian waters in 2004. This phenomenon can occur due to the appearance of excessive nutrient pollution in the waters [30]. Based on research by [31], the high population of toxic plankton can worsen water conditions. This can increase the toxicity to the water [32]. Apart from that, aquatic biotic factors can also influence the distribution of natural food [33] and marine biota [34]. Natural food distribution is very important for marine life. Provision of natural food must be available at all times for the survival of aquatic biota [35].

Another factor that causes low diversity of echinoderms in Sedati waters is the fishing gear used. The fishing gear used is dredge net. The effect of dredging (scratching) causes disruption of marine life and long-term changes for benthic communities [36]. This disturbance results in reduced abundance, diversity and biomass of benthic as a result of the continuous harming. The low diversity of echinoderms can indicate that the Sedati waters are polluted. One of the efforts that can be made to reduce the impact of pollution is by treating waste originating from the land before being discharged into the water. Waste treatment must be carried out from upstream to downstream because if it is not done, it can cause environmental pollution [37].

Besides, the capture of marine life using a dredge net must be reduced because it can damage the aquatic ecosystem. As for the development of the scratching catching business, it can be developed by
modifying the dredge net of the physical teeth. Physical teeth are one of the factors that cause environmental damage because of their working principle that sticks and hijacks the substrate [38]. The lifestyle of the Sedati community must also be changed, so the environment remains sustainable. The bad pattern of human life can create environmental manipulation, so that cause various environmental pollution appears [39]. If humans can protect the environment properly, the water quality will be optimum. This will have an impact on the survival of increasing marine life.

4. Conclusion
The diversity level of echinoderms in Sedati waters is significantly different. The average diversity of echinoderms found was 0.4119 ± 0.1479, so it was classified as a low criteria. The highest diversity value occurred on November station A is 0.5071 while the lowest diversity value occurred in October, November and December, both in station B and C is 0 (zero).

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