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THE CHANGES OF ENVIRONMENT AND AQUATIC ORGANISM BIODIVERSITY IN EAST COAST OF SIDOARJO DUE TO LAPINDO HOT MUD

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ABSTRACT: Lapindo hot mud to overflow and flood the east coast of Sidoarjo for 9 years has caused changes in environmental factors, particularly aquatic ecosystems environment. This has an impact on biodiversity of aquatic ecosystems in the eastern coastal Sidoarjo. This study aims to determine the quality of aquatic ecosystems on the east coast of Sidoarjo contaminated by Lapindo hot mud and the impact on biodiversity of aquatic organism. Data taken from 5 station consists of wetlands ecosystems, river, brackish water ponds, estuaries, and coastal covering area districts of Porong, Jabon, Tanggulangin, and Sidoarjo, East Java, Indonesia. Determination of stations and substations did purposively based on distribution maps Lapindo hot mud. Data obtained in the form of physical and chemical parameters of waters, biodiversity of aquatic organism analyzed descriptively and quantitatively, and compared as well as the quality standard. The results showed contamination of aquatic ecosystems by Lapindo hot mud has led to changes environment factors and declining biodiversity of the aquatic organism in the eastern coastal of Sidoarjo.

Keywords: Lapindo hot mud, Environmental change, Biodiversity aquatic organism, East coast of Sidoarjo.

1. INTRODUCTION

Hot mud that gushed in Porong, Sidoarjo, East Java, Indonesia since 2006 th is still ongoing. Mud material which high salinity and contain heavy metals has been distributed widely covers the Porong subdistrict, Tanggulangin, and Jabon to the east coast of Sidoarjo, East Java. Although this condition has happened more than nine years ago, and it predicted would not stop. People have not been found effective prevention methods and environmentally friendly to resolve it. In addition to the main bursts with mud volume 156.000 m^3day^{-1} [1], have sprung up over 100 points stray outside the dike bursts [2]. This time to prevent the spread of overflow, sludge collected in the reservoirs that have reached the extent of 800 hectares with a height of 10-12 meters embankment [3]. Although flowed to the sea through Porong river, some of the water from the sludge ponds and wild bursts of flow into the surrounding waters, contaminating aquatic ecosystems including rice fields and farms in the eastern coastal region of Sidoarjo [4].

Lapindo hot mud containing 12 kinds of heavy metals [1]. From 12 different types of heavy metals in the sludge, water level are above the quality standard. The heavy metals are Cd, Pb, Mn and Fe. Lapindo hot mud sediment sludge from 14 different types of heavy metal. The heavy metals which level above the quality standard are10 types, namely Cu, Cd, Pb, Hg, Se, Cr, Zn, Mn, Ag, and Sb [5]. Ten kinds of heavy metal given high potential toxicity to the environment and living things [6]; [7], the highest effect is lead (Pb) based on that in this study determined lead (Pb).

Contamination of aquatic ecosystems by heavy metals will affect the survival of aquatic organism (*biosecurity*) and biosafety fishery products in the Sidoarjo and Madura strait [2]. As a logical consequence, the fishery products from the region will be contaminated by heavy metals.

The lapindo hot mud contains heavy metals, such as lead (Pb), mercury (Hg), cadmium (Cd), and selenium (Se). These metals potentially pollute aquatic ecosystems. The average content of lead (Pb) in water is 0.217 - 0.323 ppm [3] exceeding the threshold quality standard (0.005 ppm). Thus, aquatic ecosystems contaminated by lapindo hot mud automatically contain lead (Pb). This is very dangerous, as it will be absorbed by planktons, plants, and animals.

The mobility of heavy metals in soil and plants tend to be slow [8]. Heavy metals in the Lapindo hot mud will cause the phenomenon of biomagnification in the food chain of aquatic ecosystems [9]; [10]. So if it is contained in the phytoplankton, it will contaminate other aquatic organisms, including plants, fish and shrimp. This is very worrying because the waters of the eastern coastal region of Sidoarjo is the main producer of milkfish (*Chanos-chanos*) and shrimp in East Java [3].

Areas contaminated Lapindo hot mud covering wetlands, streams, brackish water ponds, estuaries, and coastal [11]. Besides accommodated in ponds of mud which covers more than 800 hectares, the mud also flowed into the sea through Porong river. Because of land in the area of Porong and surrounding sloping towards the east elevation 5^o, the Lapindo hot mud water flow tends to the eastern coastal of Sidoarjo. With the characteristic of having a relatively high salt content and has lasted for 9 years, then it will have an impact on the environment hue aquatic ecosystems in this region. It needs to be assessed for their impact on the quality of the environment and biodiversity, especially of aquatic organisms in the region. This study aimed to determine changes in the quality of waters ecosystems and biodiversity aquatic organism in the eastern coastal of Sidoarjo.

2. METHODS

This research was conducted using observation the conditions existing *in situ* and laboratory analysis. Data were taken from the five stations were determined by purposive based on distribution maps Lapindo hot mud, which consists of wetland ecosystems around the Lapindo mud ponds, streams, brackish water ponds, estuaries Porong river and Sidoarjo east coast. At each station was determined 5 substations as plot data capture, at each substation of data taken at the three-point plot. The study was conducted during the dry season between the months of June to August 2015. The study measured parameters include the physical and chemical parameters (temperature, salinity, pH and DO), biological parameters (diversity and density of vegetation, plankton and fish). Data of physical-chemical parameters of water, diversity and density of organism was analyzed descriptively qualitative and compared with Standard Quality Standard base on [5], [12], [13].

3. RESULTS AND DISCUSSIONS

3.1 The Quality of Aquatic Ecosystems

In general, the physical-chemistry parameters of water in the eastern coastal region of Sidoarjo, except in wetlands, rivers, and estuaries Porong river relatively fixed [14]. The most significant change is the high salinity of the water, especially in wetlands, rivers, and estuaries [15]. Of the five study sites, most notable changes occurred in wetlands and river ecosystems, which originally fresh water had been turned into salty. Though the location is within 18 km of the sea and free of the influence of the tides.

The Table 1 shows the influx of Lapindo hot mud that high salinity (32-40‰) has caused changes in physical-chemical parameters of waters, especially salinity [16]. Characterize water salinity brackish waters until salt (salinity> 0.5 ‰), but this area is a freshwater ecosystem (stations 1 and 2). Due to the flow of mud that contains a variety of organic materials, the temperature and pH of the water are high, but dissolved oxygen low.

Table 1. Values of physical-chemical parameters in the coastal waters polluted by Lapindo hot mud Sidoarjo

Para meter	Station 1	2	3	4	5	Quality standard*)
a	18.0	21.0	8.0	36.0	32.0	0 – 5
b	30.1	30.3	28.0	29.5	28.3	Dev. 3
c	8.3	8.2	7.6	8.5	8.1	6 – 9
d	2.7	1.0	2.7	1.2	2.0	3

Note: a. salinity (‰), b. temperature (^{o}C), c. pH, d. disolved Oxygen (ppm). 1 *(wetland),* 2 *(river),* 3 *(ponds),* 4 *(estuaries),* 5 *(coastal) *)*[5].

Lapindo hot mud composition of a fluid mixture of salt water (30%) and solids (70%) in the form of coarse sand (sand rather subtle), fine sand, silt (clay) containing hydrocarbons, steam and gas (H_2S). The results of X-ray analysis shows the mineral mud consists of pyrite, albit, caolinite, paragonite, and halite comes from rock that has undergone changes in hydrothermal. Water mud dominated by elements Sodium (Na), Magnesium (Mg) and Calcium (K), (> 8 ppm) and Chloride (Cl) (1.8 ppm) [1], which is brine. High salinity causes changes to freshwater ecosystems become brackish. As a result, most of the plants and aquatic organisms in the mud contaminated sites die [1].

3.2. Community Aquatic Organism

3.2.1 Biodiversity of Plant

Lapindo hot mud flowing into wetlands around the area shelters mud negatively affect organism communities *in situ*, ie changes in community structure organism. On wetlands dominated by plants that are resistant to salt water. This occurs because of changes in hue from freshwater environments become brackishwater.

At all stations, aquatic and wetland plants to grow even lusher and expansive, ie *Typha latifolia* L., *Ipomoea Aquatica*, *Cyperus* sp., *Lemna* sp., *Pistia stratiotes* L. and *Eichhornia crassipes* (Mart.) Solms. Thus this plant has the resistance to the Lapindo hot mud contamination, in particular, the high salinity of the water [17].

Lapindo hot mud with high salinity has resulted in the death of the majority of plants in east coastal of Sidoarjo and the surrounding

region, except for some species ie *Eichhornia crassipes* (Mart.) Solms), *Pistia stratiotes* L., *Ipomoea aquatic* and *Typha latifolia* L. which still survive [3]. Some species have become more fertile, namely spinach (*Ipomoea aquatica*) and cattail (*Typha latifolia* L.). The latter as well as being even more fertile grows more expansively so it dominates the wetland area contaminated by Lapindo hot mud in eastern coastal of Sidoarjo. With the ability to adapt to the environment polluted by Lapindo hot mud, these plants become resistant to the stress of heavy metals and high salinity.

Table 2. Type and density of the plants of wetlands in polluted areas Lapindo hot mud

Species	Station and density (ind./m^2)				
	1	2	3	4	5
Cyperus sp.	+	++	++	+++	+++
E. crassipes (Mart.)Solms	+	++	+	+++	++
I. aquatica	+	+	++	+	++
Lemna sp.	+	++	+	+	+
*P.stratiotes*L.	+	+	+	+	+
T. latifolia L.	+++	+++	+++	+++	+++

Note: Station 1 *(Mindi village),* Station 2 *(Pejarakan village),* Station 3 *(Reno Kenongo village),* Station 4 *(Kedung Bendo village),* Station 5 *(Ketapang Keres village).*
- = no, + = little, ++ = many, +++= abundant.

The plants (in Table 2) has the resistance to the Lapindo hot mud because able to bind heavy metals in the tissue. The mechanism in accumulating heavy metals that are not harmful to their growth: (1) save a lot of water to dilute the heavy metals and reduce toxicity. (2) to form a compound that that will phytochelatin bind heavy metals and heavy metals by atomic chelated S peptyde derived from cysteine. (3) heavy metals that are bonded to phytochelatin will enter into the root cells by active transport, will be transported by the network phloem and xylem to go to the other body. (4) heavy metals which have entered into the body will drop by excreted older leaves, thereby reducing their concentration [17].

Heavy metals in the water, usually bound by another compound that will form the molecule. It could be a bond of salt (organic or inorganic salts). Salt is absorbed by the roots in the form of ions and can move through the cortex in apoplas, simplas or both. If the past is apoplas, the ions will diffuse through the walls of cortical cells without entering the protoplasm. While moving on simplas is breaking the continuity of endodermis occurs because of the suberin bands of a watertight, so water and dissolved substances can not pass from one side of the endodermis to the other side except the diffusion through the endodermis and protoplas cells through plasmodesmata by the movement of the plasma. Cells that are considered bad in the Stele have a low capacity to hold ions, which tend to leak into the xylem (wood vessels) [18]. Important components as the storage of metal ions are the vacuole, where the metal ions are bound by phytochelatin. Unlike the salt is absorbed by the roots, the salt is not absorbed by the roots to eventually find their way into and onto the surface of the leaf, which when accumulated in high concentrations of the salt can be stored as a precipitate when water evaporates dilution [17].

3.2.2 Biodiversity of Plankton

In the Lapindo hot mud, polluted waters can be identified 16 genera of plankton, consisting of 13 genera of phytoplankton and 3 genera of zooplankton. Porong estuary river an aquatic ecosystem that has the highest diversity of plankton (16 genera), followed by brackishwater ponds (8 genera), and irrigation canals to the rice fields and ponds (7 genera). While the waters around reservoir diversity lower sludge (6 genera). Plankton are the most widely spreading is *Gleocystis* and *Ankyra*, because it was found at all stations, followed *Golenkinia, Spirotaenia*, and *Peronia*, found in 5 stations. While *Bracteacoccus, Eutetramorus, Terpsione, Gyrosigma, Amphilpleura* and *Pompholyx* only found at one station and in very small amounts (1-4 individuals L^{-1}).

The entry of Lapindo hot mud to wetlands has caused environmental changes in hue, which was originally freshwater into saltwater [19]. The result can alter community structure of aquatic organisms, especially plankton as a manufacturer in the waters. It is characterized by the dominance *Chrisophyta*, which is brackishwater or saltwater plankton. Changes in the salinity of the water due to the composition of the sludge which pollute the water ecosystem are dominated by the elements Na and Cl [20]. Analysis of muddy water is dominated by elements such as sodium (Na), magnesium (Mg) and calcium (K), with an average content of above 8 mg/l and Chloride (Cl) an average of 1.8 mg L^{-1} [1].

Zooplankton is able to live in high-salinity waters are very limited to a few species of which, *Copepods, Brachionus, Pedalia, Diptera* and *Artemia* [21]. According to Soule [22] phytoplankton that lives in the range of salinities above 20‰ largely a plankton group Bacillariophyta. Such circumstances allegedly associated with the condition of waters that support, especially the state of salinity and nutrient availability. Bacillariophyta or Bacillariophyceae more adaptable to its environment and the phytoplankton groups favored by fish and shrimp larvae. Pollutants into

the waters to be mixed with water into a plankton habitat and affect its activity. Heavy metals can accumulate in the body of water organism, the phytoplankton and zooplankton because the average absorbed by aquatic organisms is faster than the process of excretion [22].

On the river is the most abundant plankton *Netrium*. According Dahuri in Suwondo, [23], with the discovery of diatoms in a water then indicates that the polluted waters mild to moderate. The existence of the group is due to Bacillariophyta or Diatom because Diatom groups can live in waters salinity. This is in accordance with Soule [22] that the phytoplankton that can survive in water salinity is largely Bacillariophyta group.

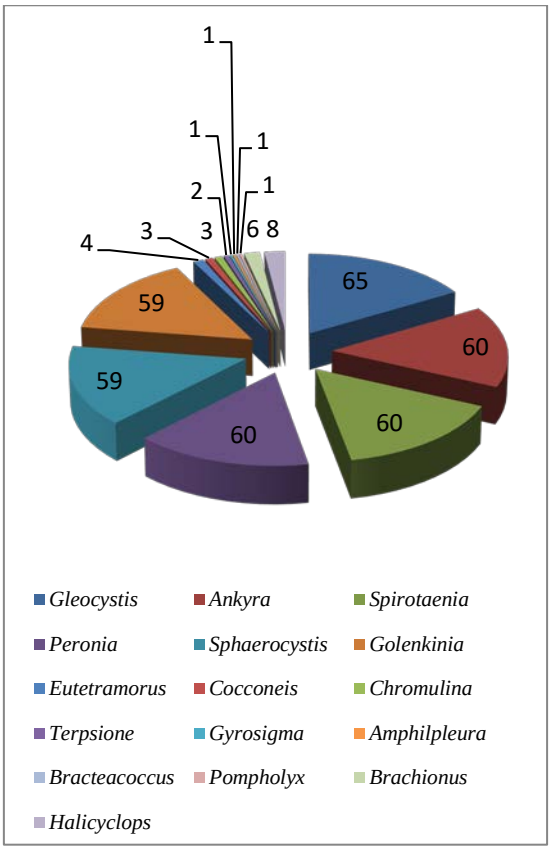

Figure 1. The density of plankton (ind.L^{-1}) in waters polluted by Lapindo hot mud

Plankton is one of the chain's most important and most critical in the foodchain of aquatic life. Change it can stimulate changes in community structure of aquatic ecosystems. Lapindo hot mud influx has caused the loss of carrying capacity of the ecosystem to life plankton. Lapindo mud has led to rising salinity, turbidity, and decreased water transparency [1]. The third parameter water quality is very important for the survival of plankton. With cell structure, fragile freshwater plankton will not survive in saltwater environments that increase reached 2000% of its natural condition. Water turbidity due to the influx of mud is very high, reaching 493.50 NTU at 213.50 NTU around the spillway and in the downstream, whereas the upstream rate of only 16.75 NTU turbidity. This led to high turbidity obstruction light penetration into the water that inhibits the process of photosynthesis, phytoplankton consequently difficult or even not be able to hold his life. This condition is very contradictive with area uncontaminated Lapindo hot mud, which can be identified 6 genera plankton density 2-118 individuals L^{-1}.

3.2.3 Biodiversity of Fish

Puddles of water in wetland mud around the Lapindo hot mud embankment pond, a habitat for many species of fish, which is then taken by the public for consumption. The identification results show in wetland habitats found nine species of fish which are all fish species resist against oxygen-poor conditions. It is characterized by the presence of a respirator in every species of the fish [3].

Table 3. Diversity and density of fish are found in polluted waters Lapindo mud

Species	Station and Density		Total (ind.)	Relative Abundance (%)
	1	2		
O. mossambicus	31	44	75	48.70
M. gulio	17	11	28	18.18
P. reticulata	6	7	13	8.45
T. trichopterus	-	9	9	5.84
O. niloticus	3	5	8	5.19
A. testudineus	8	-	8	5.19
Placostomus sp.	6	-	6	3.90
B. schwanefeldi	-	4	4	2.60
C. striata	-	3	3	1.95
Total	71	83	154	100

Of the nine species of fish, the most dominant is Tilapia (*Oreochromis mossambicus*), while the least catfish (*Channa striata*). Unless fish head tin (*Poecilia reticulata*) and fish brooms (*Placostomus* sp.), Seven other species is a species of fish commonly consumed by the public.

Species of fish found in waters around the Lapindo hot mud embankment consists of 8 genera, 8 familia and 4 orders. The fourth order is a member subclassis Actinopterygii, namely the Order Perciformes familia Cichlidae (*Oreochromis mossambicus* and *Oreochromis niloticus*), familia Anabantidae and Belontiidae characterized by having organs additional breath

in the form of a maze that allows living in a poor neighborhood of oxygen (*Anabas testudineus* and *Trichogaster trichopterus*), familia Channidae has labyrinth primitive (*Channa striata*). The Order Siluriformes, 2 familia that had marked Bagridae grouse and jaw length (*Mystus gulio*) and Loricariidae had a mustache with a hard skin (*Placostomus sp.*). Order of the familia Cyprinidae Cypriniformes (*Barbodes schwanefeldi*). Order of the familia Poeciliidae Cyprinodontiformes who are having children (*Poecilia reticulata*) [24].

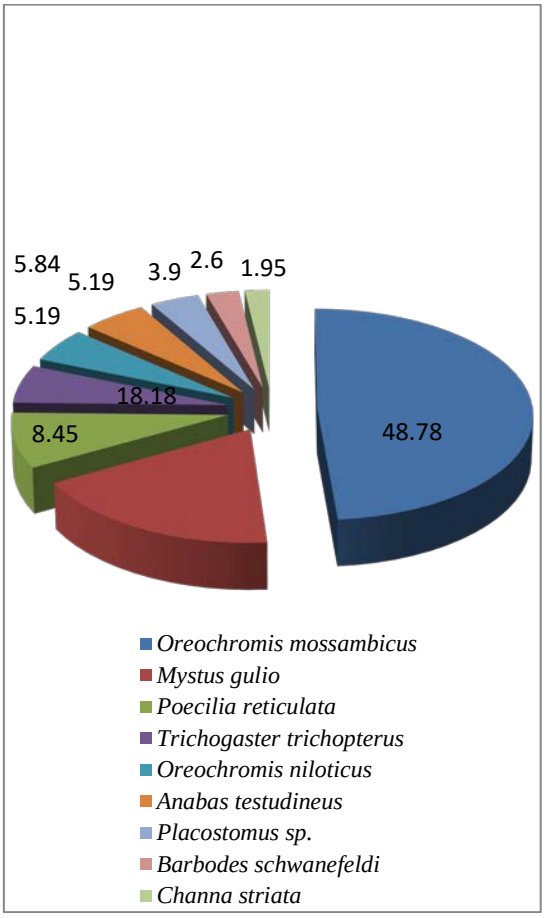

Figure 2. The relative abundance (%) fish in the waters around dike shelter Lapindo mudflow

4. CONCLUSION

Based on these results it can be concluded that the inclusion of the Lapindo hot mud into the aquatic ecosystem in the eastern coastal Sidoarjo has led to changes in environmental factors on aquatic ecosystems, especially salinity of the water, thereby reducing the carrying capacity for the life aquatic organism. This is evident from the low biodiversity of the aquatic organism (aquatic plants, plankton, and fish) on aquatic ecosystems in the eastern coastal Sidoarjo contaminated Lapindo hot mud.

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