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Impact Analysis of Oil Palm Plantation Expansion on Fish Biodiversity and Environmental Quality (Water and Soil) in Sungai Bahar, Muaro Jambi Regency, Jambi Province

Hajar Setyaji[1*], Metha Monica[2], Mukhsin[3]
University of Jambi
Corresponding Author: Hajar Setyaji Setyaji2016@gmail.com

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A B S T R A C T

Oil palm plantations in Muaro Jambi, Jambi Province are generally established near water bodies or rivers, often less than 60–100 meters from the river The research employed both survey and experimental methods in the laboratory. Observations included fish biodiversity and the following parameters:Water quality: nitrate, phosphate, BOD, COD, pH, and TDS. Soil quality: nitrate, phosphate, organic carbon (C-organic), and pH.The fish species identified in the study area were: Channa striata (snakehead), Channa micropeltes (giant snakehead), Cryptopterus sp. (silurid catfish), Rasbora sp. (small cyprinids such as red-tail rasbora and slender rasbora), Anabas testudineus (climbing perch), Rasbora reticulata (reticulated rasbora), Helostoma temminckii (kissing gourami), Clarias teijsmanni (catfish), Osphronemus goramy (giant gourami), Puntius hexazona (six-banded barb), Hemibagrus nemurus (baung catfish), and Wallago attu (tapah catfish). The measured water quality parameters were as follows: nitrate 0.2291%, phosphate 81.8642 ppm, BOD 25.280 mg/L, COD 1601.300 mg/L, pH 7.04, and TDS 12.8 ppm. The soil quality parameters obtained were nitrate 0.18070%, phosphate 0.07440 ppm, organic carbon 0.38865%, and pH 5.9–6.2

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INTRODUCTION

Palm Oil Agribusiness (Elaeis guineensis Jacq.), whether oriented toward local or global markets, faces increasing demands for product quality and environmental sustainability. The large number of oil palm plantations in Jambi Province also affects environmental sustainability. Oil palm cultivation requires a high amount of fertilizer because the plant has fibrous roots that block oxygen from entering the soil, leading to reduced soil fertility. As a result, heavy fertilization is needed for the palms to produce good yields. In addition, pesticides are required to prevent diseases in oil palm plants. Most oil palm plantations in Jambi Province are located near water bodies or rivers, often less than 60–100 meters from the riverbanks. Consequently, the soil and river water surrounding the plantations are negatively affected. However, there has been no research specifically examining the impact of oil palm plantations in Muaro Jambi Regency, Jambi Province.

One of the freshwater species that is easily affected by various human activities on surrounding land areas is fish. These activities include forest conversion into settlements for transmigrants, plantations, and industrial waste such as from palm oil production. The decline in freshwater fish diversity is further accelerated by habitat degradation or loss. Various types of information are needed in efforts to conserve biodiversity, including its benefits to humans, species distribution, conservation status, threat trends, and ecological relationships.

Based on the above description, the author intends to conduct a study entitled " Impact Analysis Of Oil Palm Plantation Expansion On Fish Biodiversity And Environmental Quality (Water And Soil) In Sungai Bahar, Muaro Jambi Regency, Jambi Province ".

LITERATURE REVIEW

1. Oil Palm

In Indonesia, about 60% of oil palm plantations are established on podsolic (ultisol) soils. These soils have low fertility status due to their low cation exchange capacity (CEC), organic carbon content below 1%, low mineral reserves, low pH (<5), and high erodibility and leaching rates, making them highly susceptible to degradation (Koedadiri and Adiwiganda, 1994).

Oil palm can grow on various soil types such as Podsolic, Latosol, Gray Hydromorphic, Regosol, Andosol, Organosol, and Alluvial soils. The crop grows best in soils that are loose, fertile, well-drained, moderately permeable, and have a deep solum of about 80 cm without a hardpan layer (Fauzi et al., 2006).

Oil palm is one of the most well-known plantation commodities in Indonesia and is recognized as the highest oil-producing crop per unit area. It can be harvested 3.5 to 4 years after planting (Aritonang, 1986).

The soil pH is closely related to the availability of nutrients absorbed by roots. Oil palm can grow in soils with a pH range of 4.0–6.0, with the optimum pH between 5.0 and 5.6. Low soil pH can be improved through liming. Such acidic soils are commonly found in tidal areas, especially peat soils (Lubis, 1992).

2. Fish Biodiversity

Fish diversity and abundance are also determined by the characteristics of aquatic habitats. The habitat characteristics of a river are strongly influenced by the flow velocity, which in turn is affected by factors such as the river's slope gradient and the presence of forests or vegetation along the riverbanks. These factors are closely associated with the distribution and presence of aquatic fauna (Ross, 1997).

According to Harteman (2003), biodiversity can be classified into three levels: ecosystem diversity, species diversity, and genetic diversity. Meanwhile, Sinaga (1995) stated that fish species diversity in aquatic environments, including rivers, reflects the level of ecological complexity in those habitats. It is assumed that a higher level of species diversity in a community indicates a more complex ecosystem, due to the greater degree of interaction and energy transfer among organisms, including food web dynamics, predation, competition, and niche differentiation.

3. Water Quality

Oil palm plantations are considered less environmentally friendly and can damage ecological sustainability due to their high water absorption capacity (Adhynugraha, 2012). The use of large amounts of pesticides and herbicides in oil palm plantations has led to a decline in water quality around plantation areas. Moreover, the practice of discharging waste directly from CPO (Crude Palm Oil) factories into nearby rivers still occurs (Desa Sejahtera, 2009).

The physical factors of water that often act as limiting factors for aquatic organisms include temperature, light, conductivity, and current velocity, and therefore, these parameters are commonly measured in aquatic ecology studies (Suin, 2002). Other physical factors used to determine water quality include turbidity, color, transparency, flow rate, and flow volume (Soemarwoto, 2004).

4. Soil Quality

The conversion of forest land into cultivated land has led to a decline in land quality, as indicated by the deterioration of soil physical properties, reduced water infiltration, and increased surface runoff (Arsyad, 2000). The degree of damage resulting from forest land conversion varies depending on land use type. The extent of degradation is primarily determined by the level of change in land cover and soil management practices. This can be observed from the differences in soil management among various land uses, such as oil palm plantations, dryland farms, and mixed gardens.

According to Partoyo (2005), soil quality indicators should reflect the following functions: maintaining biological activity,regulating and distributing water, and filtering and buffering.Soil quality indicators refer to the physical, chemical, and biological properties and characteristics of the soil that describe its condition. The soil quality index is determined using parameters such as rooting depth, bulk density, porosity, silt and clay content, organic carbon, pH, available phosphorus (P), exchangeable potassium (K), available nitrogen (N), and total nitrogen (N-total).

METHODOLOGY

The research was conducted in Bahar River, Muaro Jambi Regency, Jambi Province. The study involved a field survey at the Bahar River research site and laboratory experiments to analyze water and soil quality.

The observations included fish biodiversity and measurements of water quality parameters such as nitrate, phosphate, BOD, COD, pH, and TDS, as well as soil parameters including nitrate, phosphorus, organic carbon, and pH.

RESULTS

A. Fish biodiversity

Figure 1. Bahar River location

The fish species obtained included snakehead (Channa striata), giant snakehead (Channa micropeltes), lais catfish (Cryptopterus sp.), slender rasbora (Rasbora sp.), red-tail rasbora, climbing perch (Anabas testudineus), aropadi (Rasbora reticulata), kissing gourami (Helostoma temminckii), catfish (Clarias teijsmanni), gourami (Osphronemus goramy), tiger barb (Puntius hexazona), baung catfish (Hemibagrus nemurus), and tapah catfish (Wallago attu).
The fishing gear used included longlines (tajur), fish traps, and seruwo nets.Water depth: During low tide, the depth ranged from 2–5 meters, while during high tide it reached 20–30 meters.Water transparency: Ranged between 20–30 cm.Water and air temperature: Water temperature ranged from 15–20°C, and air temperature ranged from 28–32°C.

a. Bubu b. Fish Traps c. Seruwo

Figure 2. Fishing Gear in the Bahar River

B. Water Quality

Table 1. Water Quality in the Bahar River, Muaro Jambi Regency

No	Parameters	Result
1.	Nitrate (%)	0,2991
2.	Phosphorus (ppm)	81.86420
3.	BOD (mgr/l)	25.280
4.	COD (mgr/l)	1601,300
5.	pH	7.04
6.	TDS (ppm)	12,8

C. Soil Quality

Table 2. Soil Quality in the Bahar, Muaro Jambi Regency

No	Parameters	Result
1.	Nitrate (%)	0,18070
2.	Phosphorus (ppm)	0.07440
3.	Organic carbon (%)	0.38865
4.	pH	5,9 – 6,2.

DISCUSSION

A. Fish Biodiversity

Indonesia, which ranks second after Brazil as a megabiodiversity country, has approximately 1,300 species of freshwater fish, with a density of 0.72 species per 1,000 km² (The World Bank, 1998). Habitats rich in freshwater fish include mountain and lowland rivers, swamps, peatlands, and lakes. Kottelat et al. (1993) recorded 272 species of freshwater fish in Sumatra, 30 of which are endemic species.

The number of freshwater fish species in public waters is estimated to be around 600 species, including many economically important fish, both consumption fish and ornamental fish, some of which are export commodities (Sukadi, 2003).

Husnah (1999) identified 131 species of fish in the public waters of Jambi, most of which belong to the Cyprinidae family. Recently, several species have become difficult to find locally, such as Lampam (Puntius schwanenfeldii), Baung (Mystus nemurus), Lais (Kryptopterus apogon), Tebakang (Helostoma temminckii), Betutu (Oxyeleotris marmorata), Sihitam (Labeo chrysophekadion), and Putak (Notopterus notopterus) (Makmur, 2002).

B. Water Quality

1. Nitrate Concentration

From the table above, the nitrate concentration is 0.2991%. According to Goldman and Horne (1983), if the nitrate concentration in a water body is less than 0.01 mg/L, the water is categorized as oligotrophic, while a concentration greater than 0.2 mg/L indicates eutrophic conditions.

Nitrate is the main form of nitrogen found in aquatic environments and serves as a primary nutrient for plant and algal growth. Nitrate nitrogen is highly soluble in water and chemically stable (Bahri, 2006). According to Hutagalung and Rozak (1997), an increase in nitrate concentration in water is caused by the inflow of domestic or agricultural waste (fertilizer use), which typically contains high levels of nitrate.

Based on the Regulation of the Minister of Health (Permenkes) No. 46/1990 and the World Health Organization (WHO), the maximum permissible nitrate level for drinking water is 10 mg/L. For daily consumption, nitrate concentration in water should not exceed 10 mg/L. Moreover, water sources used for aquaculture will experience a decline in quality when nitrate concentrations exceed 0.5 mg/L (Adams et al., 1999).

2. Phosphorus Concentration

From the table above, the phosphorus concentration in the water is 81.86420 ppm. Phosphate is a form of phosphorus that can be utilized by plants and is an essential nutrient for higher plants and algae, thereby influencing the productivity level of aquatic ecosystems (Bahri, 2006). According to Hutagalung and Rozak (1997), high phosphate levels are caused by the influx of domestic, agricultural, industrial, and aquaculture wastes that contain phosphate compounds.

3. BOD (Biochemical Oxygen Demand)

From the table above, the BOD concentration is 25.280 mg/L. BOD is an empirical analysis that generally represents the microbiological processes occurring in water. The measurement of BOD is essential to determine the pollution load caused by wastewater and to design biological treatment systems (G. Alerts and S.S. Santika, 1987).

According to Priyambada et al. (2008), land use changes, characterized by increased domestic, agricultural, and industrial activities, significantly affect river water quality conditions, with domestic activities contributing the highest BOD concentrations to river bodies.

The number of microorganisms in aquatic environments depends on water cleanliness. Clean water generally contains fewer microorganisms than polluted water. However, water contaminated with toxic or antiseptic substances—such as phenol, creolin, detergents, cyanide acids, and insecticides—also tends to have a lower microbial population.

A high BOD value indicates that the water is polluted. For example, the maximum allowable BOD_5 concentration for drinking water and for supporting aquatic life is 3.0–6.0 mg/L according to UNESCO/WHO/UNEP (1992). Meanwhile, based on Decree No. Kep-51/MENKLH/10/1995, the BOD_5 standard for industrial wastewater is 50 mg/L for Group I industries and 150 mg/L for Group II industries.

4. COD (Chemical Oxygen Demand)

From the table above, the COD concentration is 1601.300 mg/L. COD represents the amount of oxygen (mg O_2) required to oxidize organic substances present in one liter of a water sample, where potassium dichromate ($K_2Cr_2O_7$) is used as the oxidizing agent (G. Alerts and S.S. Santika, 1987).

In general, unpolluted water has a COD value of less than 20 mg/L, while polluted water can have values greater than 200 mg/L, and industrial wastewater may reach levels of up to 60,000 mg/L (UNESCO/WHO/UNEP, 1992).

5. pH

From the table above, the pH value is 7.04. Normal water suitable for sustaining life generally has a pH between 6.5 and 7.5. Water can be acidic or basic, depending on its pH level. If the pH is below the normal range, the water is acidic, while if it is above the normal range, the water is alkaline. Industrial effluents and wastewater can alter the pH of water, ultimately disrupting aquatic life.

Most aquatic organisms are sensitive to pH changes and prefer a pH range of 7.0 to 8.5. The pH value greatly influences biochemical processes in aquatic environments—for example, the nitrification process tends to cease under low pH conditions. According to the Minister of Environment Decree (KepMENKLH), the acceptable water quality standard for fisheries is a pH between 6 and 9.

6. TDS (Total Dissolved Solids)

From the table above, the TDS concentration in the water is 12.8 ppm. According to the World Health Organization (WHO), drinking water with TDS below 10 ppm is considered safe for consumption (Anonymous, 2013). Meanwhile, according to University of Alberta (2013), freshwater typically has TDS values ranging from 0.5 to 1.5 ppm, and drinking water ranges from 25 to 500 ppm.

The TDS concentration in a water body is influenced by various factors. A high concentration of dissolved ions does not necessarily indicate that a river is polluted or unhealthy. It is common for rivers to dissolve and carry ions from the minerals in rocks and soils through which they flow. If the geological deposits contain salt (sodium chloride or potassium chloride) or limestone (calcium carbonate), significant concentrations of ions such as Na^+, K^+, Cl^-, Ca^{2+}, and HCO_3^- can occur, contributing to hard water conditions.

C. Soil Quality

1. Nitrate

From the table above, the soil nitrate concentration is 0.18070%. Nitrate is the main form of nitrogen found in aquatic environments and serves as a key nutrient for plant and algal growth (Bahri, 2006).

Nitrate (NO_3^-) and nitrite (NO_2^-) are naturally occurring inorganic ions that are part of the nitrogen cycle. Microbial activity in soil or water decomposes waste containing organic nitrogen, first forming ammonia, which is then oxidized into nitrite and nitrate. Since nitrite is easily oxidized into nitrate, nitrate is the most commonly found compound in both groundwater and surface water. Pollution from nitrogen fertilizers, including anhydrous ammonia as well as organic waste from animals and humans, can increase nitrate concentrations in water. Nitrate-containing compounds in soil are typically highly soluble and can easily migrate through groundwater (Utama, 2007).

2. Phosphorus

From the table above, the soil phosphorus concentration is 0.07440 ppm. Phosphorus is the next essential nutrient that is often found to be deficient in Indonesian soils. The low phosphorus content in soil can be caused by several factors, mainly nutrient removal through crop harvesting, leaching, and erosion of the topsoil layer.

In such soils, phosphate fertilization often does not produce the expected results, because a large portion of the applied fertilizer becomes bound to soil components. The phosphorus element (P) in soil undergoes several transformation processes, including mineralization, immobilization, adsorption and desorption on the surfaces of minerals such as clay, Fe and Al oxides, and carbonates, as well as precipitation and dissolution of secondary minerals like calcium, aluminum, and iron phosphate, or weathering of primary minerals such as apatite (Nash, 2013).

3. Organic Carbon (C-Organic)

From the table above, the soil organic carbon (C-organic) content is 0.38865%. The main source of soil organic matter comes from plant tissues, including litter and plant residues, which are available in large quantities each year. Chemically, soil organic matter consists mainly of carbohydrates, proteins, lignin, and smaller amounts of other compounds.

One of the best sources of organic matter for soil is manure. The chemical composition of manure varies depending on the species, age, and condition of the animal, as well as the type and amount of feed and the handling and storage of the manure before use. The application of manure can increase soil organic carbon, total nitrogen, exchangeable calcium (Ca-dd), and soil pH. Adding manure means adding organic material that serves as a reserve of nutrients, a water-binding agent, and helps in the formation of micro- and macropores, which support the growth of soil microorganisms. The decomposition of organic matter by microorganisms produces simpler compounds that become essential nutrients for plants (Kartasapoetra, 1991).

4. pH

From the table above, the soil pH ranges from 5.9 to 6.2. According to Isrol (2009), good soil generally has a pH close to 7. Soils with low pH values often contain high amounts of phosphorus.

CONCLUSIONS

The fish species found at the research location were snakehead (Channa striata), giant snakehead (Channa micropeltes), lais catfish (Cryptopterus sp.), slender rasbora, red-tail rasbora, climbing perch (Anabas testudineus), aropadi (Rasbora reticulata), kissing gourami (Helostoma temminckii), catfish (Clarias teijsmanni), gourami (Osphronemus goramy), tiger barb (Puntius hexazona), baung catfish (Hemibagrus nemurus), and tapah catfish (Wallago attu).
The soil and water quality at the research site were found to be polluted.

RECOMMENDATIONS

It is recommended that oil palm plantations should not be established near water bodies, maintaining a minimum distance of 60–100 meters from rivers or other aquatic areas.

FURTHER STUDY

This research has limitations so that further research is needed on the topic of Optimization of Intellectual Property Rights to Drive Business Innovation in the Digital Era: A Review to perfect the research and increase insight for readers and writers.

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