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POLLUTION OF FISHERIES IN RIVER

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ABSTRACT

The majority of Indonesia's population lives near water, both on the coast or along rivers and lake shores. For example Citarum River is the largest and the most important river in West Java because of its function as irrigation, source of drinking water and industry, covering the big three reservoirs namely Saguling (5,600 Ha), Cirata (6,600 Ha) and Jatiluhur (8,300 Ha).

The recent study showed that the concentration of heavy metal of Pb (10-33 ppb) in certain location was higher compare to National Water Quality Standard (30 ppb), while Cd was still lower compare to Pb(6-7.3 ppb) and Water Quality Standard (10 ppb). However, concentration of Cd in sediment was higher compare to Sediment Quality Standard (2 ppb). On the other hand, concentration of Pb in sediment was higher (70-230 ppb) compare to Cd (20-60 ppb), but still lower compare to Sediment Quality Standard(530 ppb).

Bioaccumulation of Cd was observed in the fishes living in the Citarum River, which were consumed by the people who live in the village close to the river. For example in concentration Cd in Nile Tilapia is 105 ppb, Tilapia is 109 ppb which higher compare to National Standard. Therefore, this condition is very dangerous especially to the people who consume the fish.

Possible approaches were also discussed in relation to the one of key point of sustainable development goals (SDGs).

Various national and international laws and regulations are existed to protect freshwater. However, law enforcement is difficult and pollution is still continuously occurred. In Indonesia, there is the Act of Republic of Indonesia and the Indonesian Government Regulation and also the Decree of Environment Minister and other ministers who organize and regulate pollution issues in freshwater. Furthermore, there is also standard water quality for all

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designation in freshwater.

Keywords: Pollution, river, Sustainable development goals, law enforcement.

1. INTRODUCTION

Indonesia is considered as one of the world's largest archipelago with more than 17,500 islands and the second longest coastline after Canada. A vast number of population (approximately 225 million) with GNP of about $771 million, makes Indonesia as the largest country in Southeast Asia. Moreover, Indonesia has a diverse range of marine environments and resources. For instance, a diverse coral reef, sea grass and mangrove ecosystems with abundant marine and coastal resources especially the fish resources.

However, as in many other emerging economies, the rapid economic growth is accompanied by a significant increase of population towards the cities. The greater Jakarta area or Jabodetabek (Jakarta-Bogor-Tangerang and Bekasi city), for example, is the main center of the Indonesian economic activity (Nur et al.,2001). Thus, the fast growth in the coastal megacity such Jabodetabek significantly increased the usage of freshwater resources for both domestic and industrial purposes. Additionally, there are 13 rivers that flow through Jakarta and enter the Jakarta Bay. This ecosystem approximately receives wastewaters from more than 10 million inhabitants. Domestic waste, for instance, can be derived from flush lavatories that are collected in septic tanks and disposed separately. Moreover, a huge amount of other wastewaters remains untreated and discharges directly from the households into open channels that are connected with the rivers and river channels. On the other hand, the industrial activities along side the river and river channels also contribute significantly to the pollution discharge into the aquatic environment. There are still, somehow, several irresponsible companies that dump their industrial wastes without any treatment or pass the waste water treatment system. Therefore, the Jakarta river systems receive large amounts of wastewaters and other contaminant loads that will enter the Jakarta Bay (Dsikowitzky et al., 2015; Sindern et al., 2016). This situation actually occurs not only in the megacity such as Jakarta but also in other regions in Indonesia, hence, provokes ecosystem quality degradation. This ecosystem or environmental quality degradation, of course sooner or later, will affect the fish resources in impacted areas.

One of the United Nations (UN) development agendas fully recognizes the importance of managing water and also environment for sustainable development or the sustainable development goals (SDGs). This recognition is considered as a breakthrough, allowing not only the governments and the corporate sector, but also the citizens recognize and take a number of crucial steps. The SDGs agenda also provides a framework that fosters collaboration across sectors, countries and all stakeholders to participate and take the action.

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The present study aims to give an overview on the ecosystem service values of the aquatic ecosystem of Indonesia with specific causes and consequences of ecosystem service degradation, and the state of the art of possible management of aquatic resources in relation to SDGs, preserving the water and environmental quality.

2. MAJOR ECOLOGICAL PROBLEMS IN AQUATIC ECOSYSTEM AND THEIR EFFECT

Indonesia faced many problems in aquatic ecosystems. These problems are diverse, as consequence of various anthropogenic pressures on the ecosystem. Several problems and their subsequent effects are briefly explained hereafter.

2.1 Pollution problems in river ecosystem: from the industrial to the aquaculture activities

In this review, the authors would like to give more attention to one of the crucial river in the West Java Province, Citarum River, as the case study. Citarum River is the largest and the most important river in West Java because of its function as irrigation, source of drinking water and industry, covering the big three reservoirs namely Saguling (5,600 Ha), Cirata (6,600 Ha) and Jatiluhur (8,300 Ha). The main function of these reservoirs is as hydroelectric power to supply energy for Java and Bali, with approximately more than 2,000 Megawatt of production. Additionally, the other function are for fishery, tourism and drinking water material for the Capital City of Jakarta inhabitants, as well as for irrigation of 240,000 ha paddy field in northern part of West Java.

Despite of its crucial role, Citarum River has deteriorated by several pressures, for instance, high sedimentation, heavy pollution from both industrial and domestic waste. The most important industrial waste comes from textile industry. There are 60 textile factories existed along upper part of Citarum River, which dump their waste with and without any treatment. In addition, other industries are food and beverages, net manufacturing, electroplating and tanning. Liquid waste that is produced by these industries is approximately more than 65,618 m^3 day^{-1}. In contrast, domestic waste produced daily by anthropogenic actitivities, also considerably important due to its high organic matter content, which causes eutrophication on the lake and reservoir.

Concentration of Cd in the water column at all sampling stations were still low compared to the water quality standard for drinking water material (Class II) and fishery (Class III), based on the Indonesian Government Regulation on Water Quality Management and Water Pollution Control (No. 82/2001). However, concentration of Pb in station 5 (33.3 ppb) was higher than the Water Quality Standard (30.0 ppb). Table 1 showed that Cd concentration (6.0-7.3 ppb) were lower compare to Pb concentration (10.0-33.3 ppb). Pollutant of heavy metal especially Cd and Pb are

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very toxic after mercury (Hg) that is sourced from textil industry. The other source of Pb was battery industry, electro platting, colouring material, etc. This industrial activities were exist in Citarum River Basin, which have been mentioned before that the waste were dumped to the river with or without any treatment. Additionally, research conducted by West Java Board of Pollution Control showed that all rivers in West Java that flowing to Java Sea, including Citarum River, already polluted by Cd, Pb and As, as well as polluted by high concentration of inorganic matter such as Nitrate (NO_3), Orthophosphaphate (PO_4) and Ammonia (NH_3). NO_3 and PO_4 were nutrient that caused eutophication in the lake, while high concentration of NH_3 was toxic for aquatic organism such as fish (Dhahiyat, 2011).

Table 1: Concentration of Heavy Metal Copper (Pb) and Cadmium (Cd) in the water column and sediment in the Upper Citarum River (Dhahiyat *et al.*, 2012)

Heavy metal (ppb)	Location	Concentration (ppb)		Water quality standard (ppb)		Sediment Standard (ppb)
		Water	Sediment	C II	C III	
Cd	1	7.3	60.0			2
	4	6.7	30.0			
	5	6.0	30.0			
	6	7.0	20.0			
Average		6.8	35.0			
Pb	1	10.0	230.0	30.0	30.0	530
	4	26.7	130.0			
	5	33.3	70.0			
	6	23.3	200.0			
Average		23.3	157.5			

*Note: C II and C III is the classification of standard quality for drinking water material and for fishery, respectively.

Industrial wastes not only give an effect on the water column, but also on the sediment. Previous study conducted by Dhahiyat et al. (2012) revealed that Cadmium concentration in the sediment at four sampling station ranged from 20 to 60 ppb, and 35 ppb in average. Based on the sediment standard of Netherland of IADC/CEDA (1997), this range of concentrations has already exceeded the standard (2 ppb). In contrast, concentration of Pb in the sediment ranged from 70-230 ppb with the average concentration of 157.5 ppb. This concentration was comparatively lower than those standard of sediment (530 ppb) above. However, Cd and Pb were very toxic substances and it may affect the organisms that lived in the sediment such as benthos. Given the fact that benthos is one of the food sources for fishes, they are able to accumulate heavy metals on the environment that later can be transferred to higher trophic levels through the food chain.

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The source of Citarum River is from spring water in the area of Wayang Mountain in South of Bandung (Bandung is Capital City of West Java Province), flowing from the upstream until downstream in the estuary of Java Sea, along 269 Km. Moreover, Citarum River Basin consists of several lands use such as agriculture, tea plantation, settlement, industrial area and aquaculture activities in both freshwater and in brackish water ponds.

Nowadays, aquaculture practice with floating net cage aquaculture method (hereafter named FNCA) in three reservoirs in Citarum River is economically important, because of fish produced such as nile tilapia (*Oreochromis niloticus*), catfish (*Clarias batrachus*) and common carp (*Cyprinus carpio*) are supplied not only to Jakarta and Bandung but also to the other big cities in Java and Sumatra. Nevertheless, the environmental concern rose due to a lot of fish feed is not entirely consumed by the fish. Thus, about 30% of uneaten fish feed enter the aquatic environment, causing eutrophication and hypoxia in the bottom of the lake, which contribute to the fish mass mortality when turnover occurs.

The described environmental problem in Citarum river basin and river was significantly affect the ecosystem, particularly the living organisms that live in impacted area. Investigation on fish diversity was conducted by Dhahiyat *et al.* (2001) showed that there were 24 species from 15 families of fish in Upper Citarum River categorized as endemic fish (*Channa gachua, Mystus microcanthus*), cultured fish (*Cyprinus carpio, Oreochromis niloticus*) and ornamental fish (*Aequideus pulcher*). However, some years later, research conducted by Hasan (2012) showed that there were only 13 species from 9 families of fish. Thus, 11 species of fishes disappeared due to water pollution on the river.

2.2 Pollution in marine ecosystems

Dumping is defined as activities of throwing, placing and/or importing deliberate waste and/or materials in an amount, concentration, time and specific location with specific requirements to specific environment (Law No. 32/2009, on Protection and Management of the Environment). However, some activities on mining and exploration and production of oil activities at Indonesian marine ecosystem are still being conducted with permission from the Ministry of Environment. Permit can be obtained not only from the Ministry of Environment but also from the governor, or bupati (head of distric)/mayor, when the mining companies agree with their responsibility.

In Indonesia, there are three main activities in dumping waste to the sea, namely submarine tailing dumping (discharge), port pond dredging, dumping of drilling cutting and drilling mud of oil exploration as well as production activities at the sea. Dumping of drilling cutting and drilling mud activities have been conducted in Indonesian sea in several areas, under the specific

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requirement of Ministry Environment's regulation.

As mentioned in abstracts, there are several potential impacts of dumping of tailing and oil activities on the sea as well as on marine ecosystem. Therefore, dumping must avoid sensitive area such as turtle nesting, fish sanctuary, fish migration (especially migration of tune and marine mammal) and marine transportation lane. The potential effects associated with submarine dumping are physical disturbance on the seabed and water collumn, geochemical and chemical effects, organisms level effect, ecological/ecosystem level response and human resource use (Rankin *et al.*, 1977). Whereas the effect of oil exploration and production on sea environment especially from offshore drilling have been considered, for instance: acute or sub-lethal on sensitive organisms or ecosystem, bioaccumulation of heavy metal in marine organisms, burial on benthic organims, increasing of turbidity of water column and effects on marine biological community or seafoods consumers (Swan *et al*., 1994).

3. SUSTAINABLE MANAGEMENT ACTION PLAN OF AQUATIC ECOSYSTEMS

In order to manage the aquatic ecosystems in Indonesia ecologically sustainable, several action plan should be taken into consideration by government, policy makers and overall by the small-holder farmers and land-use practitioners as well as other stakeholders. In this section, authors provide the action plan for different sectors, for example the agricultural, aquaculture and industrial sectors.

Agricultural activities contribute significantly to the nutrients loading from the used fertilizers and also chemical contaminant from the herbicide and pesticide for pest control. Additionally, these agricultural lands are normally link with aquatic ecosystem, such as rivers. Therefore, the government should set up a clean regulation and monitors strictly the law enforcement for any violation made. On the other hand, biotechnological approach can be made to minimize the contaminant loads into the environment. For instance, by creating the eco-friendly bioherbicide and applying organic farming. Another possible solution to overcome significant nutrient loading into the aquatic ecosystems is by applying the ecotone zone. Loss of nutrients from agricultural land to surface waters can cause environmental harm to fish and other aquatic organisms. Vegetated buffer zones between agricultural land and surface waters have proved to be effective filters for trapping diffuse pollutants. Application of simple ecological biotechnology such as denitrification walls also could be possible solution to suppress the occurrence of eutrophication.

The overdense population of floating cage net aquaculture (FCNA), is the major problem due to massive nutrient input from the uneaten feed and fish excretion to the water column and bottom environment. Therefore, to prevent eutrophication, utilization of fish feed should be more

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efficient to limit organic discharge to the water body. Efficiency in feeding process can be achieved by using technological approach such as e- fishery, which is a electronic and internet based automatic feeding system that enabling monitored feeding frequency to avoid excess amount of feed given. Moreover, the eco technology can also be applied, to increase DO by using aerator in the water body.

The other environmental management of the lake where fish mortality often occurred is to identify the zonation of fisheries and also provide mechanism of adaptation to turnover occurrence by adopting eco-friendly aquaculture method, for instance the use of double net (or secondary net). In this system, the feed waste was trapped by the second net and consumed by other fish species such as tilapia, thus feed waste production can be minimized. The farmer should identify period of overturn, thus volume of fish cultured can be reduced occasionally. The overturn usually occurred in the month of December until March. Utilization of fish killed as feed fish material is the alternative to benefit the fish mass mortality phenomenon, considering high protein content of fish, and the price of fish mill is considerably expensive.

Untreated wastewater and hazardous materials from the industrial activities are the major threat for the environment. In most developing countries, including Indonesia, there are very few enterprises that have conducted responsible wastewater treatment by using wastewater treatment plants. This is mainly due to high costs of treatment and lack of effective environmental pollution control laws or law enforcement. Application of simple wastewater treatment involves the use of engineered systems that are designed and constructed to utilize natural processes. These systems are designed to simulate the natural wetland systems, utilizing wetland plants, soil, and associated shellfish, micro-organisms to remove contaminants from wastewater effluents. Thus, this simple wastewater systems can be an alternative for treating nitrate contaminated aquifers, denitrification of nitrified sewage effluents and irrigation return flow.

4. CONCLUSIONS

Indeed, aquatic ecosystems in Indonesia are facing serious and different anthropogenic pressures, for instance, uncontrolled domestic, agricultural (including fisheries and livestock) and industrial waste (such as textiles and mining). To overcome this problem, aquatic/water resources based management approach can be a possible solution to sustain the health of aquatic ecosystem services provisions, and therefore should be adopted for the sustainable management of aquatic ecosystem and associated resources in the country.

In this review, the immediate action measures for the better aquatic ecosystem should be: control of water pollution, check the degradation of aquatic habitats (rivers, lakes and reservoirs), control sedimentation, protect salinity intrusion, monitor nutrient loading, conserve the

mangrove ecosystem and maintaining river flow from the upstream. A multi-disciplinary policy development and strategies is essentially needed in order to bring policies into action is also essential for the sustainable management of aquatic ecosystem in Indonesia.

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