Mapping the potential pollution of fisheries industry wastewater in the Southern Coast of Jember Regency: Preliminary study on wastewater management planning

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Abstract. Fisheries industries produce wastewater as by-product. Based on preliminary surveys, there is no integrated wastewater management in the Southern Coast of Jember Regency where the centre fisheries industry was taken place. This study aims to find areas that are potentially polluted by fisheries industries wastewater and offer the information for planning integrated wastewater management in the coastal area of Jember Regency. We collected primary and secondary data about fish processing production and the impact of wastewater for environment. The results were analysed descriptively and potentially polluted areas were mapped with Arc-Gis software. The study area involves two sub-districts, Puger and Ambulu sub-district. Surveys conducted to 16 fisheries industries showed that 81.25% of them discharged the untreated wastewater into the stream directly. Wastewater disposal into the stream not only cause pollution in water bodies but also cause pollution in the Indian Ocean.

1. Introduction

Conserve and sustainably use the oceans, seas and marine resources for sustainable development is the 14th goal of Sustainable Development Goals (SDGs). One of the targets is to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution [17]. In case of marine pollution from land-based activities, more than 80% of wastewater in Latin America, East and Southern Asia, and West and Central Africa release into the stream without treatment [2]. One of pollutant type that contributes to marine pollution comes from fisheries industry wastewater.

Southern Coast of Jember Regency is the center of fisheries industry in Jember. Fishing and processing industry are the main economic activities in this area. **Table 1** shows the number of fisheries product in Jember. The table gives information that fisheries industry in Puger and Ambulu sub-districts ranks the most compared to other sub-districts on the coast of Jember Regency. Based on the table, preserved fish is the most fisheries processing product.

The fisheries industry is the primary economic sector in coastal communities [14, 17]. On the other hand, this production activities produce wastewater as by-product. In fish processing, such as in the process of preserved fish, it requires much water to steam the fish. Generally, traditional industries do not have wastewater treatment before disposing of wastewater [1, 11]. Based on interviews with local communities, it is known that some industries dispose the untreated wastewater into the stream directly. This habit has potential to pollute aquatic ecosystems [7, 17].

Table 1. The Production of Fish Product by Sub district Producer and Type of Product in Jember

Sub District	Product (ton)					
	Dried Fish	Preserved Fish	Fogged	Terasi	Chips	Fish Powder
1. Puger	1.269,58	2.959.75	63,75	11,35	341,05	3,50
2. Ambulu	96,38	1.320,45	28,75	6,25	22,85	1,80
3. Kencong	22,54	61,55	39,25	0,10	2,15	-
4. Gumukmas	5,75	38,50	6,59	-	-	-

(Source: BPS, 2018)

Fisheries industry wastewater contains high organic matter concentration. Generally, the amount of wastewater originates from the processing and washing process. Every fish processing step will produce wastewater from cutting, washing, and processing the product. The wastewater have blood and small pieces of fish and skin, the contents of the stomach condensate from the cooking process, and cooling water from the condenser [6, 11].

High dissolved and suspended organic matter in waters will decrease the Dissolved Oxygen (DO), increase the Biochemical Oxygen Demand (BOD), Total Suspend Solid (TSS), and Total Dissolved Solids (TDS). These parameters are the main parameters of water pollution. High BOD level indicates high organic concentration in the waters [1, 14]. The foul odour comes from decomposition of proteins rich in sulfuric amino acids (cysteine), producing sulfide acids, thiol groups, and ammonia [1, 6, 14]. Wastewater pollution in waters disturb aquatic organism and reduce waters productivity [7, 8].

Based on the description above, the fisheries industry in Jember Regency plays a vital role in supporting the economy of coastal communities. However, untreated wastewater harm waters productivity. Until now, there has never been an integrated waste management in the coastal area. Besides, there has so far been limited research related to water pollution from fisheries industry wastewater in Jember Regency.

Therefore, it needs integrated wastewater management to realize environmental-based sustainable economic development [4, 7, 16, 17]. The first step to do this goal is to figure out the potential wastewater pollution in the fisheries industry area. This study aims to find areas that are potentially polluted by fisheries industry wastewater on the Southern Coast of Jember Regency and their impact on the environment. This research provides information to the public about the importance of managing wastewater. Beside, these data also serve information as a reference to government for planning integrated fisheries industry wastewater management in the coastal area of Jember Regency.

2. Methodology
2.1. Study area
Figure 1 shows the study area of the research. Southern coast of Jember Regency consist of 6 sub-district. This research was represented by 2 sub-district: Ambulu and Puger, determined by purposive sampling (based on purpose of research). According to **Table 1**, Puger and Ambulu have various and number products of fisheries compared with other sub-district that make both have higher potential area of pollution than the other sub-district.
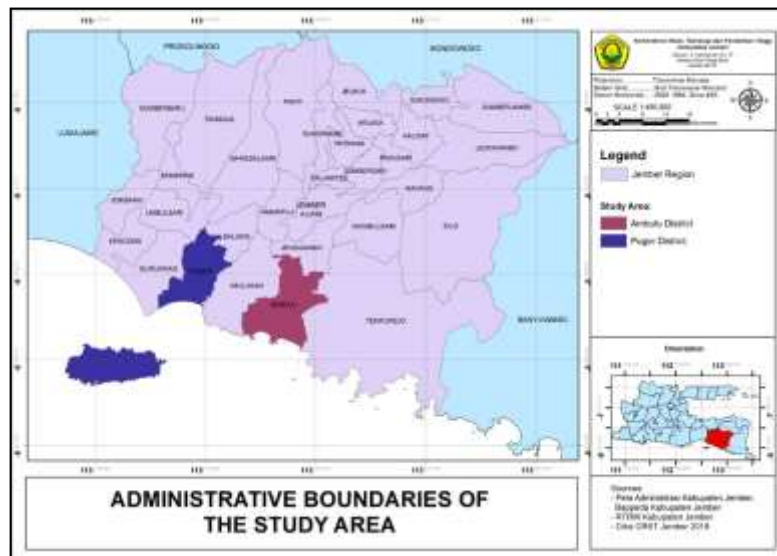
Figure 1. Study area

2.2. Methods
2.2.1. Sampling Points
The sampling points in this study were sites of industry. It was obtained from local government and was positioned using MAPInr application [13].

2.2.2. Determination of potential pollution
The research was descriptive study. The potential pollution areas of fisheries industry wastewater was determined by interview with the owner of the fisheries industry. These interviews were done to get information about the volume of wastewater each day, presence of wastewater treatment plant, and the impact of industry for society that lived around.

2.2.3. Mapping potential polluted area
Secondary survey was conducted for gathering administrative map of Jember Regency, RTRW Jember Regency and Citra CRST Jember Regency. Potential areas were polluted by fisheries industry wastewater were mapped with Arc-Gis software [15].

3. Result
3.1. Number and Distribution of Fisheries Industries
The surveys show that the number of fisheries industry in Puger are eight home industries and one industry with a legal entity (CV). Whereas in Ambulu, there are seven home industries (**Figure 2** and **Figure 3**). Types of fish processed include tuna, salmon, laying, lemuru, and cakalan. Industries in Puger obtain raw materials from Puger coastal waters, and one industry also imports raw materials from Besuki and Situbondo coastal water while industries in Ambulu obtain raw materials from Puger and Watu Ulo coastal waters.

3.2. Fisheries Industry Wastewater: Volume and Disposal
this study only focuses on wastewater generated from the production process. Based on **Figure 4***, the average volume of wastewater varies in each industry, the lowest is 25 litter/day, and the highest is 2.500 litter/day. Fish production process needs water in washing raw materials, cleaning the entrails of fish, and cleaning industrial sites. Production process depends on the availability of raw material from local seawater (Puger and Watu Ulo). When the raw material from local seawater are absent, the production process also temporarily stop.
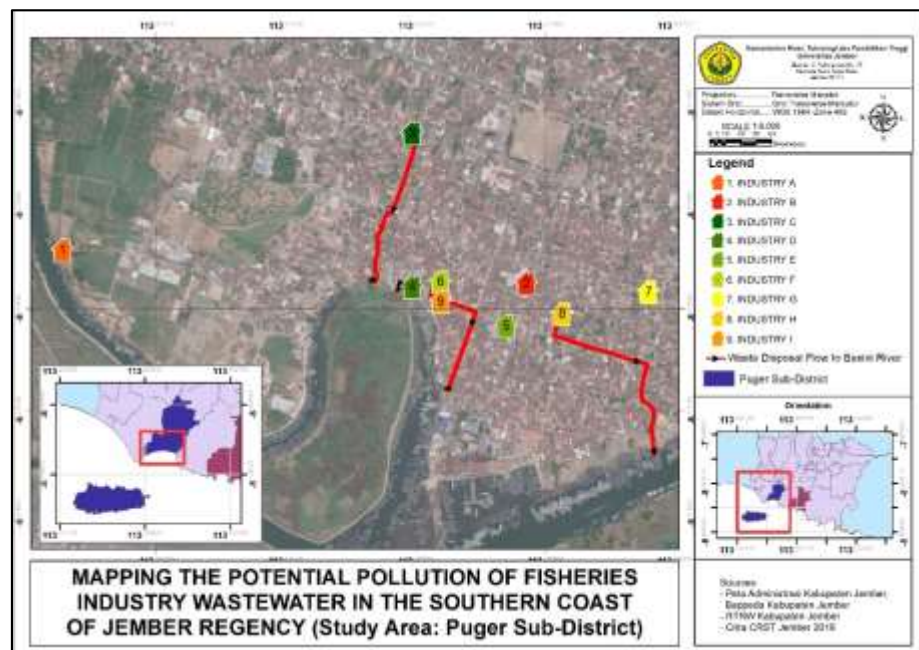
Figure 2. Distribution of fisheries industry and flow of wastewater in Puger Sub District
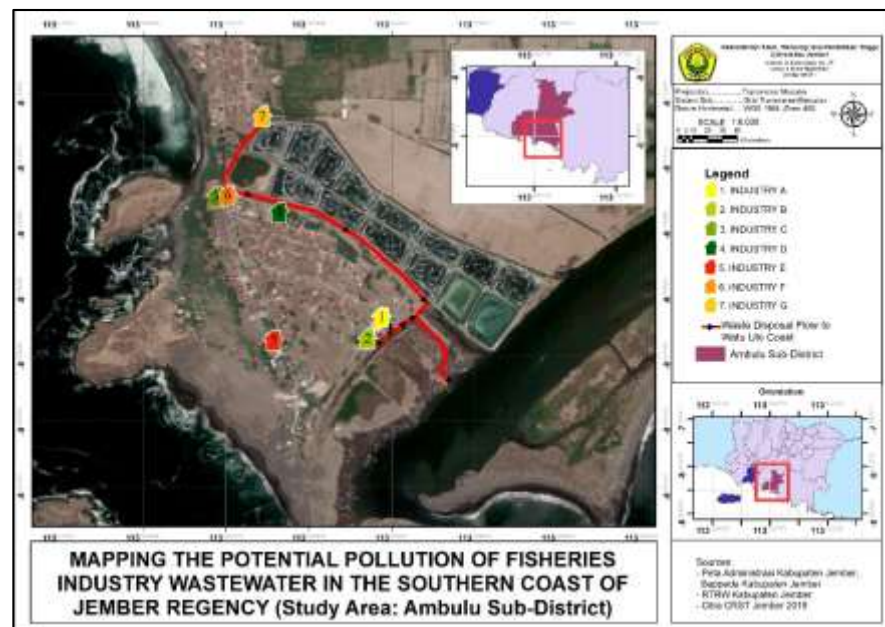

Figure 3. Distribution of fisheries industry and flow of wastewater in Ambulu Sub District
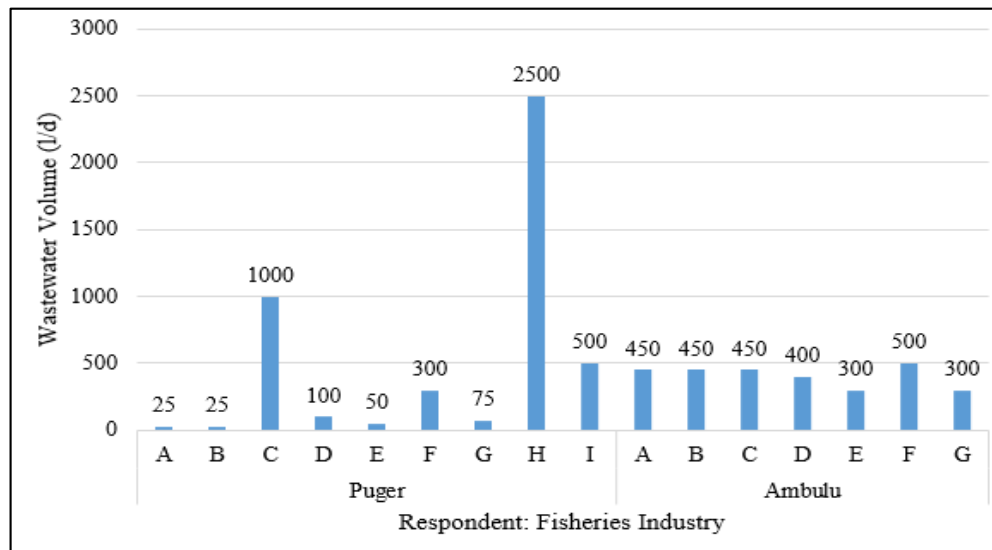
Figure 4. Average of fisheries wastewater (litter/day)

4. Discussion

4.1. Fisheries Industry Wastewater: Volume, Disposal, and Presence of Wastewater Treatment Plant (WWTP)

The surveys show that 87.5% of industries did not treat the wastewater produced from the production process and 85.71% of industries dispose the wastewater into the stream directly. The southern boundary of Jember Regency is Indian Ocean (**Figure 1**). Based on **Figure 2**, in Puger sub-district, the flow of wastewater disposal from industries to the stream through estuary of Puger Coast will end at Indian Ocean. As well as Puger, **Figure 3** shows that in Ambulu sub-district, the flow of wastewater disposal from industries to the stream through estuary of Watu Ulo Coast will end at Indian Ocean.

There are some alternative for the disposal wastewater: 1). Disposal of untreated wastes into stream directly; 2). Discharge of wastes into municipal for combined treatment; 3). Sorting out the industrial waste for treatment before discharged [14]. Both of Puger and Ambulu sub-district still do not have integrated wastewater plant to manage wastewater that produced from fisheries activities. As seen in **Figure 2** and **Figure 3**, wastewater disposal points found scattered and uncontrolled. It difficult to assess environmental quality in coastal area. Because of all streams of water are interconnected and will end into the ocean, wastewater disposal into the stream directly not only cause pollution in water bodies but also cause pollution in the ocean (**Figure 2** and **Figure 3**) [17].

Therefore, wastewater treatment is an important aspect to protect public health and the environment [7, 12, 14]. The absence of wastewater treatment plant affect the quality of the population in developing countries [4]. In this research, 62.5% of respondents do not have wastewater treatment plant (WWTP). Only 37.5% of the respondents recycling the wastewater, as raw material for making fish pellets. Overall respondents do not know the regulation related the limits on wastewater levels in the environment. However, willingness to participate in wastewater treatment is quite high, about 93.75%.

The result shows that the owners of industry have low responsibility to dispose of untreated wastewater. It is because they do not understand the wastewater management regulations, how its impact on the environment and less knowledge about how to treat wastewater. The other possible reason is that they are home-industry scale and personal property, so there is no obligation to have a wastewater treatment plant.

Besides, waste is often considered to have no economic potential, so it disposed away in the environment. Otherwise, treated wastewater have many benefits to the communities, improve the

income and environment quality. Therefore, design wastewater treatment have to: 1). Reducing the volume and level of water pollution through prevention efforts; 2). Immediately treat the polluted waters; 3). Using proper technology; 4) reuse and recycle wastewater as an effort to conserve water and nutrients; 5) providing a platform for the development of technological innovations in wastewater treatment [5, 10].

4.2. Fisheries Industry Wastewater: Impact for environment and communities

Fisheries processing industry produces wastewater containing blood, viscera, offal product, skins, meat fines, fish heads and shells. The characteristic of wastewater originated from fisheries processing is high concentration of organic materials, with their impact in high level of COD and BOD; oil, fats, suspended solution (SS); and nutrient, such as nitrogen and phosphate [1, 6, 14]. Disposal of untreated wastewater into the stream directly will have an impact on the health of aquatic ecosystems, reducing biodiversity and ecosystem services [2, 6, 7].

The high concentration of organic matter in the waters will increase the growth of microorganisms and affect dissolved oxygen levels [9]. Research on the effects of low dissolved oxygen concentrations in waters shows that macro invertebrates give a negative response in reproductive damage, changes in immune response, and growth of aquatic organisms and affects interactions at the trophic level. Conditions of low dissolved oxygen concentration (hypoxia) are serious environmental problems in the regulation of fisheries management strategies for environmental recovery. Another adverse effect, the wastewater causes turbidity in waters that prevent sunlight penetration into water bodies. It can disrupt photosynthesis process and decrease dissolved oxygen levels. Decreased levels of dissolved oxygen will also disrupt the life of living things in the waters [2, 7, 9].

Not only impact the environment, but fisheries industry wastewater pollution also affect communities that lived around the industry. One of the problems in fisheries processing industry is unpleasant odour which comes from decomposition of organic matter in the wastewater [2, 14]. Generally, communities support the presence of fisheries industry in the study area. It is because most of them involve in the fisheries activities as workers. So, it gives positive impacts, such as increasing job opportunity, public welfare, regional income and development of coastal area. Only 20% of respondent disturb with the unpleasant odour from wastewater. However, about 33.33% of respondents said that there must be treatment to wastewater in order to it does not pollute the environment.

4.3. The importance of integrated wastewater management

The fisheries industry has a positive impact on coastal area development as well as increased income and welfare of coastal communities. However, the absence of infrastructure for processing wastewater from the production process have the potential to pollute the environment. Even more, when untreated wastewater dispose to the stream directly. It can cause waters pollution and decrease ecosystem productivity. Therefore an integrated wastewater management is needed to make certain waters quality, control the pollution and create a sustainable and environmental-based economy [6, 16]. Well-manage wastewater will generate positive feedback to the environment and followed with the improvement of food security, health, economy, and sustaining ecosystem services [17]. The success and sustainability of wastewater management requires involving various parties, including the communities, industry owners, innovations in waste management, and government supervision [4].

5. Conclusion

The number of fisheries industry in Puger and Ambulu sub-district are nine and seven respectively. Most of them did not have wastewater treatment plant and dispose the untreated wastewater to the stream directly. Wastewater disposal points in both study area found scattered and uncontrolled and flow through estuary toward Indian Ocean. It needs an integrated wastewater treatment management to reduce the negative impacts arising from pollution to restore the health of aquatic ecosystems to reach environmental-based economic sustainability. Mapping the points of wastewater disposal and their flow

serve information as a reference for planning integrated fisheries industry wastewater management in the coastal area of Jember Regency.

This preliminary study was a descriptive research. The potential pollution areas were described based on interview. Furthermore, it needs a quantitative methods to determine the level of pollution in waters due to fisheries industry wastewater.

Acknowledgments

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