WASTEWATER TREATMENT STRATEGY FOR FISH PROCESSING INDUSTRY IN KOTA PANTAI MUNCAR OF INDONESIA

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ABSTRACT

This paper reported a preliminary research with an objective to find out wastewater quality of fish processing industries and surface waters where the wastewater was disharged in. Methods consisted of clustering industrial area, sampling points and weekly observation, covering dry and rainy seasons (June – October 2011). Results presented maximum wastewater flowrate and quality as well as rivers and sea waters. Based on the maximum loading, the next works proposed on-site, collection and off-site treatment strategies. In depth research works will be particularly focused on the off-site detoxification system for fish processing industries. International researchers are welcome to join the next research works.

Key words: Fish wastewater quality, surface waters, maximum loading, on-site anaerobic treatment, off-site detoxification system.

1. INTRODUCTION

Kota Pantai Muncar in Banyuwangi regency of East Java was a famous coastal city for producing commercial fish in Indonesia. Fish-based industries developed since 1970. Kota Pantai Muncar covers 10 villages where 130,000 inhabitants live in. Fish proceesing industries distributed in 6 villages along the beach that connected to Bali Strait. According to DKPKB [1] there was 72 big and 96 small scale industries with various products, consuming 511,000 tonne fish yearly. Fish processing industries were the highest economic support to the city of Kota Pantai Muncar, contributing Rp 2.5 Trillion yearly. The fish processing industries provided job for 70% inhabitants of the 6 villages. Therefore, from the economic and social perspective, fish processing industries in Kota Muncar were the main pillar for the city development.

All fish processing industries produced wastewater 14,300 m^3 daily. Fish processing industries were obliged to provide wastewater treatment. During site visit, there was wastewater treatment facility (Figure 1), however, the design and capacity as well as operation and maintenance were not sufficient to produce acceptable effluent quality. Monitoring on wastewater flowrate and quality was not carried out by the industries. It was difficult to identify when the highest loading occured. In fact, the surface waters passing through households were smell and unaesthetic. Indeed, good management of fish processing wastewater has to be applied in order to perform sustainability of fish processing industries without pollution.

Fish processing wastewater composed of solid waste and liquid waste. Solid waste consisted of inorganic materials such as sand particles and organic ones such as fish feeds. Liquid waste contained inorganic substances (mainly N and P) and organic matters. Vincenzo [2] analysed the general characteristics of fish processing watsewater that contained 250g dry weight (DW)/Kg fresh weight, 141g C/Kg DW, 60g Total N/Kg DW, 1g Total P/Kg DW, and other inorganic substances (K, Ca, Mg, Fe and other heavy metals) < 1g/Tonne DW. It revealed that organic matter determined the characteristics of fish processing wastewater.

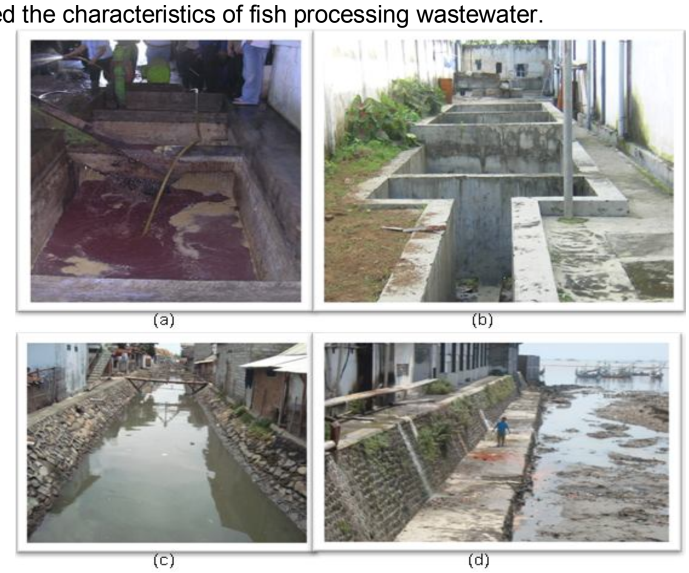

Fig. 1. *Pictures showing wastewater facility at the source (a, b), open ditch carrying wastewater (c) and final disposal into the sea (d)*

An attempt to resolve fish processing wastewater management in Kota Pantai Muncar with limited available data, at the first stage was to carry out preliminary research. The objective of the preliminary research was to gather data on weekly wastewater flowrate and its quality during dry and rainy seasons, and propose treatment strategy. The next stage would be detailed research works on wastewater treatment that is suitable in local conditions.

2. MATERIALS AND METHODS

Figure 2 showed sampling points for wastewater effluents and surface waters. Fish processing industries were divided into three area (A, B, C) based on the clustering industrial area and the location of surface waters where wastewater effluents were discharged. Cold storage and canning were the main industries that located in area A. Oil and filleting were the main industries that located in area B. Fish preservation was the main industry that located in area C. Three largest indutries of each area that produced high quantity of wastewater were chosen as sample of wastewater sources.

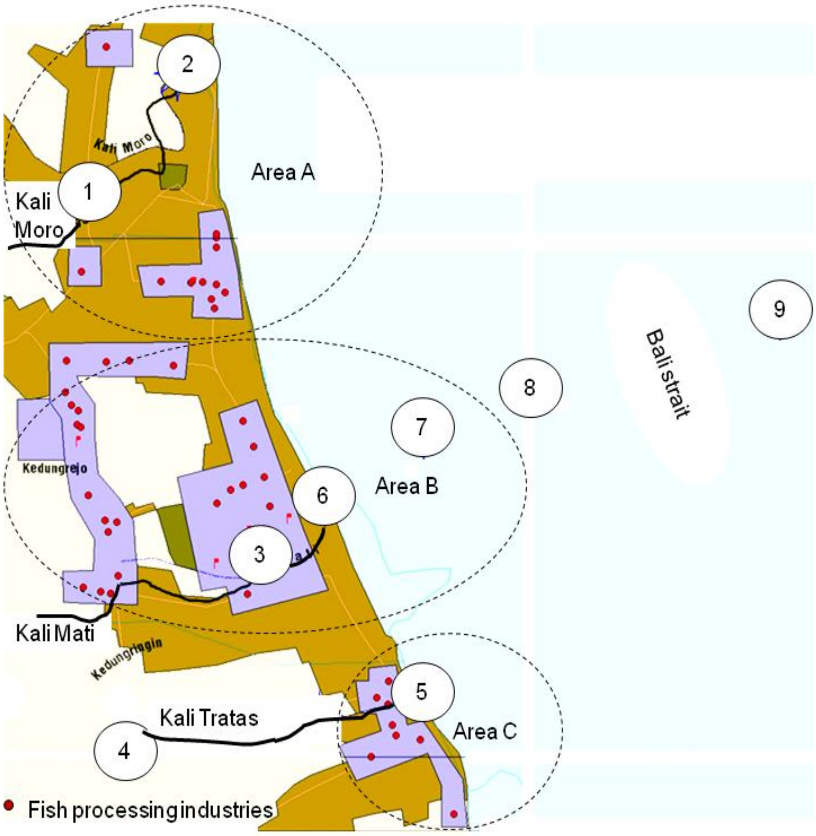

***Fig. 2.** Sampling points in fish processing industries and surface waters*

Surface water samples were collected from upstream and downstream of Kali Moro (point 1 and 2), Kali Mati (point 3 and 6) and Kali Tratas (point 4 and 5). In addition, sea water samples (point 7, 8, 9) were collected with an assumption that they were affected by wastewater of fish processing industries. The distance of points 7, 8 and 9 was 50, 100 and 200m respectively from the beach.

Sample of each point was collected at the same time at noon when industries discharged wastewater at high flowrate. Weekly sample collection was carried out during June to October 2010 that represented dry and rainy season in Kota Muncar. All samples were preserved prior to laboratory analysis. Physico-chemical parameters adopted the local stream standard. Physico-chemicals analysis were carried out using Standard Methods [3].

3. RESULTS AND DISCUSSION

General findings

Composit sample of each sampling point for the maximum level was reported in Table 1-3. In general, all inland surface waters were polluted at least three times higher than the standard quality with an exception of pH. Water pollution was extended to sea water, which was detcted up to 200m from the beach. The quality of all fish processing wastewaters were worse than surface waters. Total river flowrate over the discharged wastewater accounted for dilution factor. At the maximum wastewater flowrate, the dilution factor of Kali Moro, Kali Mati and Kali Tratas was 12, 2 and 10 respectively. The river dilution factors were less than the wastewater dilution for achieving stream standard quality. As a results all rivers downstream were more polluted than the upstream and the lowest dilution factor was Kali Mati.

Table 1. Surface water and wastewater characteristics in Area A

No	Parameter	Unit	Point 1	Wastewater from cold storage and canning industries	Point 2	Local stream standard
1	Temperature	^oC	31	40	31	-
2	Total Suspended Solids	mg/L	580	3,380	360	100
3	pH	-	8	6.7	7.7	6-9
4	Sulfide (H_2S)	mg/L	48	208	24	-
5	Ammonia (NH_3-N)	mg/L	84	374	132.8	10
6	BOD_5	mg/L	250	3,494	1,125	100
7	COD	mg/L	480	6,720	2,160	200
8	Nitrate (NO^{3-}-N)	mg/L	5.22	3.02	2.6	-
9	Detergent	mg/L	3.3	1.52	3.2	-
10	Phosphate (PO_4^{3-})	mg/L	6.1	60.61	36.49	-
11	Oil and grease	mg/L	670	21,012	4,142	15
Kali Moro flowrate was 0.910 m^3/sec at the maximum wastewater flowrate of 0,075 m^3/sec.						

Table 2. Surface water and wastewater characteristics in Area B

No	Parameter	Unit	Point 3	Waste-water from oil and filleting industries	Point 6	Point 7	Point 8	Point 9	Local Stream standard
1	Temperature	^oC	33	60	36	34	33	32	-
2	Total Suspended Solids	mg/L	196	57,900	1,125	1,460	250	148	100
3	pH	-	8.3	7.4	7.8	7.8	7.7	7.7	6-9
4	Sulfide (H_2S)	mg/L	8	288	256	7.68	3.52	1.02	-
5	Ammonia (NH_3-N)	mg/L	125.65	16,594	666.5	75.89	78.62	71.51	10
6	BOD_5	mg/L	330	20,380	1,670	626	300	280	100
7	COD	mg/L	640	39,200	3,200	1,840	800	720	200
8	Nitrate (NO^{3-}-N)	mg/L	1.1	64.99	0.92	1.03	0.94	0.82	-
9	Detergent	mg/L	1.55	13.45	1.52	1.39	1.44	1.53	-
10	Phosphate (PO_4^{3-})	mg/L	21.52	1,761	9	9.42	4.28	3.45	-
11	Oil and grease	mg/L	8,906	191,244	3,928	509	690	740	15
Kali Mati flowrate was 0.110 m^3/sec at the maximum wastewater flowrate of 0.050 m^3/sec									

Table 3. Surface water and wastewater characteristics in Area C

No	Parameter	Unit	Point 4	Wastewater from fish salting industries	Point 5	Local stream standard
1	Temperature	^oC	33	41	32	-
2	Total Suspended Solids	mg/L	230	10,325	2,440	100
3	pH	-	8.1	7.2	7.9	6-9
4	Sulfide (H_2S)	mg/L	84	3,120	24	-
5	Ammonia (NH_3-N)	mg/L	92.29	1,008	184.17	10
6	BOD_5	mg/L	210	12,650	500	100
7	COD	mg/L	400	72,000	960	200
8	Nitrate (NO^{3-}-N)	mg/L	1.8	99.95	1.42	-
9	Detergent	mg/L	0.63	13.45	1.5	-
10	Phosphate (PO_4^{3-})	mg/L	6.8	587	9.31	-
11	Oil and grease	mg/L	5,716	15,851	3,744	15
Kali Tratas flowrate was 0.398 m^3/sec at the maximum wastewater flowrate of 0.040 m^3/sec						

On-site wastewater treatment and collection strategies

Kota Pantai Muncar, particularly area of fish processing industries was located in coastal zone where goundwater level is high and suffer from sea water intrusion. The conditions limited the use of on-site sanitation and therefore, off-site sanitation would be feasible. However, the existing treatment facilities (Figure 1a,b) could be improved into anaerobic plant to reduce high level of BOD and COD. Fish processing indutries would be encouraged to provide the on-site treatment method.

Subsequently, it was proposed to collect all fish wastewater processing industries into sewerage system in order to gain efficient treatment instead of individual treatment [4]. Sewerage system would be applied for each area for reasons that there was significant different of wastewater quality (Table 1-3) in addition to prioritize implementation works. Therefore, there would be three sewerage area (in area A, B and C) where area B is prioritized based on the lowest dilution factor of Kali Mati.

Off-site wastewater treatment strategy

Following collection, wastewater treatment plants would be provided in each area. Of course, wastewater treatment plant in area B is given the first priority. The main chemical parameters containing wastewater that was more than 10 fold of standard or needs treatment were total suspended solids, sulfide, ammonia, BOD, COD, phosphate, oil and grease. Based on the main wastewater characteristics, the proposed treatment strategy was as follows:

1. Separation techniques would be feasible to decant settleable inorganic substances and release inorganic gases from wastewater solution. Some separation techniques [2, 5-10] would be reviewed, and decision would be made based on the existing practice.

2. For organic matter, there was three parameters as BOD, COD and BOD/COD ratio that were representative for wastewater treatment [11]. By using the triangle zones, strategies for problem solving can be proposed. The first priority is to transform the toxic wastewater into biodegradable wastewater. Transformation can be carried out by physical and/or chemical treatment that could be solved by on-site anaerobic treatment and the above separation techniques. Following physical treatment, the wastewater is safe to be treated by biological treatment using aquaculture system. By aquaculture means production of aquatic organisms for economic benefit such as fish, shrimp and plants in aquatic ecosystem [12]. The aquaculture can be performed in natural and constructed wetlands.

Off-site detoxification system

The overall system was presented in Figure 3. On-site anaerobic treatment of fish processing wastewater would be provided by improving the existing wastewater treatment facility at the source. The collected wastewater would be treated by off-site detoxification system. The final effluents would be discharged into the real aquaculture where fish is cultured for industrial input. Therefore, the system is in loop-management to support sustainability.

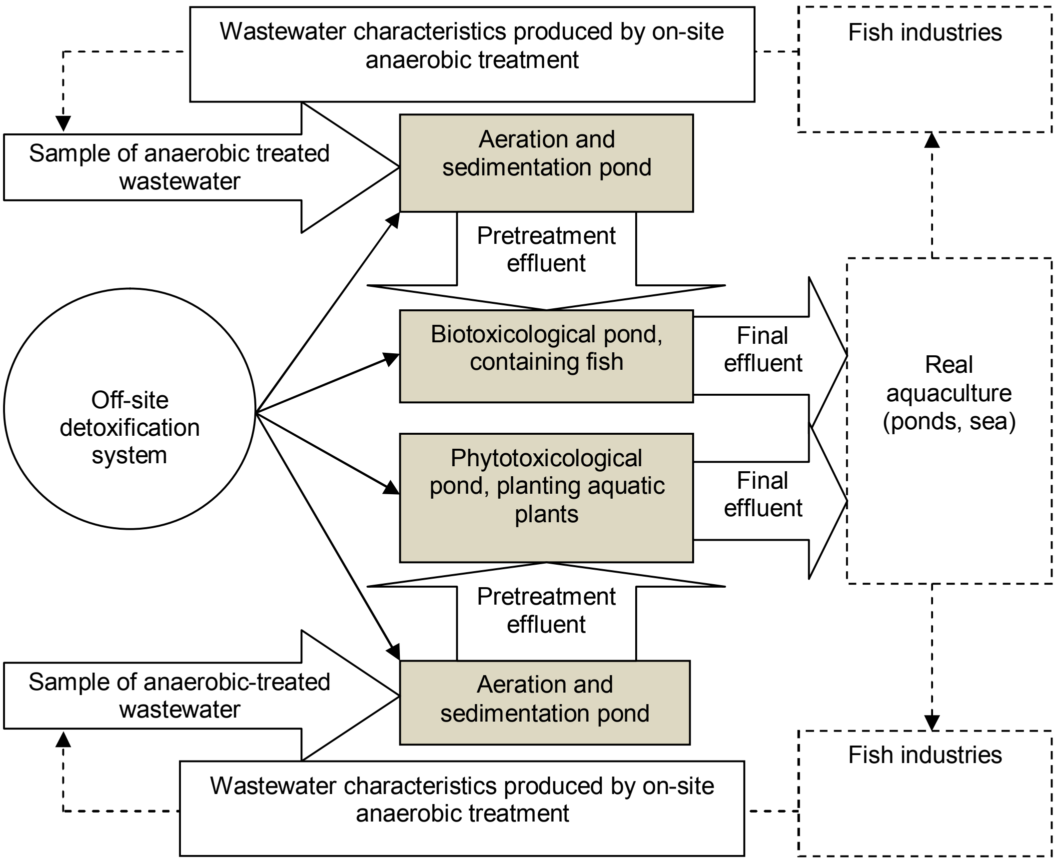

Fig. 3. *Off-site detoxification system for fish processing wastewater treatment in Kota Pantai Muncar, Kabupaten Banyuwangi, Indonesia (dotted boxes were not covered for the current research project)*

Sample of anaerobic treated wastewater would be collected from the existing facility. The off-site detoxification system consisted of pretreatment methods and ecotoxicological ponds. The pretreatment methods, consisting aeration and sedimentation were aimed to separate settleable and floating materials from wastewater in addition to reduce dissolved substances (mainly C and N) to some extent. Subsequently, the pretreated wastewater would be assessed by fish and plants in separate ponds, named biotoxicological pond and phytotoxicological pond respectively. Biotoxicological and phytotoxicological ponds in small scale were provided for representing the real aquaculture. The safest condition between biotoxicological pond and phytotoxicological pond would be taken as the detoxification system for fish processing wastewater treatment in Kota Pantai Muncar, Kabupaten Banyuwangi, Indonesia. The safety of pretreated wastewater in both ecotoxicological ponds would be determined by no observed effect level (NOEL) of wastewater towards the test aquatic organisms for at least one year exposure.

4. CONCLUSION

At the maximum flowrate of fish processing wastewater for Kota Pantai Muncar contained mainly total suspended solid, sulfide, nitrogen, phosphate, organic matter in the form of BOD, COD and oil and grease. On-site strategy would be an improvement of the existing facility into anaerobic plant. The collection strategy would be sewerage system that is applied in each clustering industrial area. Off-site strategy of wastewater treatment consisted of separation techniques and biological treatment in aquaculture in the form of detoxification system.

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