IMPLEMENTATION OF AN INTEGRATED POLLUTION CONTROL STRATEGY: A CASE STUDY OF MUNCAR FISH PROCESSING AREA

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ABSTRACT

Muncar is one of a few major fish processing complex, which contributes significantly to the local as well as national economic development since most of the products is export oriented. Majority of industry is characterized by the use of a relatively old type of machinery and facility and of improper waste control and management. The fish processing as well as its related economic activity has now caused a serious environmental problem especially nuisance and water/coastal pollution. The important environmental aspects identified include high process water consumption, less efficient use of energy and materials, and minimum implementation of industrial waste control and management. In order to contribute to the government in establishing the framework of environmental management program in the area and in particular to assist the industry in improving its production and environmental performance, an integrated industrial pollution control strategy is proposed. The strategy consists of input as well as output pollution control measures based on a comprehensive and reliable data of existing environmental performance. The ultimate goal is to sustain and balance the environmental functions, namely economical, social and ecological functions. The overall strategy exhibits a multi-year program implementation and involving many relevant government institutions and industries. This paper describes the proposed strategy, which is now adopted by the government as a pollution control program of Muncar for the year 2007-2012. At this present stage, the work focuses on potential implementation of input pollution control measures using cleaner production approach, such as waste prevention, reduction, reuse and recycle and their benefits to industry and environment.

Keywords: cleaner production, fish processing, pollution control program, waste control and management.

INTRODUCTION

Muncar so far gave considerable economic contribution to the region as well as national particularly in absorbing employment (industry, fishermen, transportation services, and other economic activities), generating devisa, and tax. In 2006 it was recorded some 72 large scale and 96 small scale industries in the area, consisting of canning, cold storage, fish meal, fish oil, salted fish, "pindang", and fermented fish sauce (Figure 1). The business value of the region is estimated to be around 600 billion rupiah (value of raw materials) or almost 2000 billion rupiah (value of products) annually.

Despite of the economic benefit, the industrial activity in Muncar also leads to environmental drawbacks. Some problems are identified during this study. Good manufacturing practices have not been implemented by majority of processing industry. Effluent of fish processing activities is leaving the plant without treatment. As a result, the environment is heavily polluted. The situation occurs partly due also to lack of counselling, technical assistance and law enforcement by the government, unavailability of master plan of the egion, and lack of proper infrastructure (management of fishing port, road and drainage, and transportation facility). Due to the poor pollution control the water resources in this area are being depleted and contaminated at alarming rates. Tables 1 and 2 show the water characteristics of the receiving water bodies in Muncar, collected during an industrial survey in 2007 by the State Ministry for Environment (KLH). The tables are intended to describe the general information about the level of pollution in the sampled location. The interrelation among parameters can not here be analysed because of the limited data available. The Storet method for calculating the pollution index (Kepmen LH. No. 115/2003) is not here applicable because the data presented in the tables are based on grab-samples. Some parameters, such as total suspended solid, BOD_5 and COD, are far out of the quality standard of water body according to PP No. 82/2001 about Water Quality Management and Water Pollution Control or KepMen LH No. 51/2004 about Sea Water Quality. The river water and coastal water pollution are most probably as result of the industrial wastewater discharge without proper treatments.

The more important pollutant is industrial wastewater as compared to solid waste and gas emission. Bad odor is resulted from biological decomposition of organics in the drainage systems. The effluent is mainly generated from process water (washing, cleaning, pressed liquid, and residual water) that contains dissolved organics dissolved and suspended solids, nutrient and fat. Activity of small-

scale industries and domestics also contributes to environmental pollution in the region.

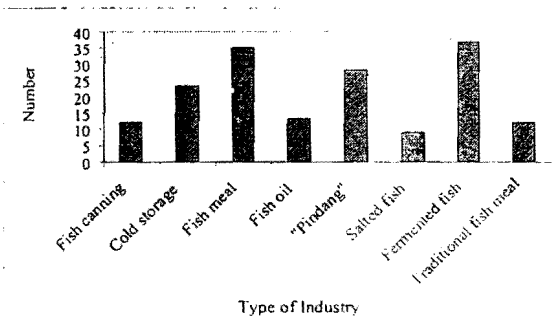

Figure 1. Number and type of industry in Muncar (From: Dinas Perikanan dan Kelautan Kabupaten Banyuwangi, 2006)

It is estimated that some 1300 m^3 of highly contaminated effluent is discharged daily into streams without treatment from large industries alone. Figure 2 shows the wastewater characteristics of various fish processing plants. The concentration of total suspended solid (TSS) varies between 26 and 1700 mg/L, while BOD_5 and COD were up to 1800 mg/L and app. 4000 mg/L, respectively. Carawan (1991), APINI and UNEP (2008), and Miller *et al.* (2008) reported similar data about the highly organic-polluted wastewater of fish processing industries. The characteristics vary considerably depending on the capacity, the type of processing technology, the level of actual production rate relative to the installed capacity, the level of automation and the ease with which equipment can be cleaned, as well as operator practices.

The level of environmental awareness and the understanding on environmental management system among the manufacturer is relatively low. The fact that many waste collectors are recycling and reusing the discharged effluent just outside the factory due to its high fat content, is often used by the industry to justify the practice of not treating the effluent. This recycling process is done by the roadside in a very simple way, without considering aesthetics, cleanliness, health and product quality.

Table 1. Water characteristics of the receiving water bodies in Muncar (KLH, unpublished 2007)

No.	Parameter	Unit	Stan-dard*	Kali Mati	Kali Tratas		Kali Moro	
					Upper Course	Lower Course	Upper Course	Lower Course
1	TSS	mg/L	50	683	91	113.5	150	145.5
2	pH	-	6 - 9	6.65	6.89	6.8	6.92	6.83
3	Sulphides (H_2S)	mg/L	0.002	7.04	0.78	0.55	0.1	0.09
4	Free Chlor (Cl_2)	mg/L	0.03	N.A	0.01	0.01	0.01	N.A
5	Free Ammonia (NH_3-N)	mg/L	-	0.00	0.00	0.00	0.00	0.00
6	Nitrate (NO_3-N)	mg/L	10	2.7	2.46	2.38	1.38	3.62
7	BOD_5	mg/L	3	624	8	601	12	13
8	COD	mg/L	25	1300	20	1300	28	30
9	Oil and Fat	mg/L	1	8.32	0.01	0.006	0.009	0.98
10	Detergent	mg/L	0.2	0.16	0.01	0.11	0.001	N.A
11	Phosphate (PO_4)	mg/L	0.2	2.01	0.38	0.5	1.09	0.08

*)According to PP No. 82/2001 about Water Quality Management and Water Pollution Control

Table 2. Sea water quality of Muncar Coastal (KLH, unpublished, 2007)

No.	Parameter	Unit	Standard*	Value (Distance From Coast)		
				25 m	300 m	350 m
1	TSS	mg/L	20	324.5	114	66.6
2	pH	-	-	7.21	7.91	8.33
3	Sulphides (H_2S)	mg/L	0.01	7.65	0.45	0.57
4	Free Chlor (Cl_2)	mg/L	-	0.01	0.01	N.A
5	Free Ammonia (NH_3-N)	mg/L	0.3	0.0089	0.0065	0.0362
6	Nitrate (NO_3-N)	mg/L	0.008	1.32	2.09	0.38
7	BOD_5	mg/L	20	360	57	12
8	COD	mg/L	-	850	120	30
9	Oil and fat	mg/L	1	0.08	0.03	0.02
10	Detergent	mg/L	1	0.07	0.12	0.24
11	Phosphate (PO_4)	mg/L	0.015	0.17	0.08	0.05

*)According to KepMen LH No. 51/2004 about Sea Water Quality

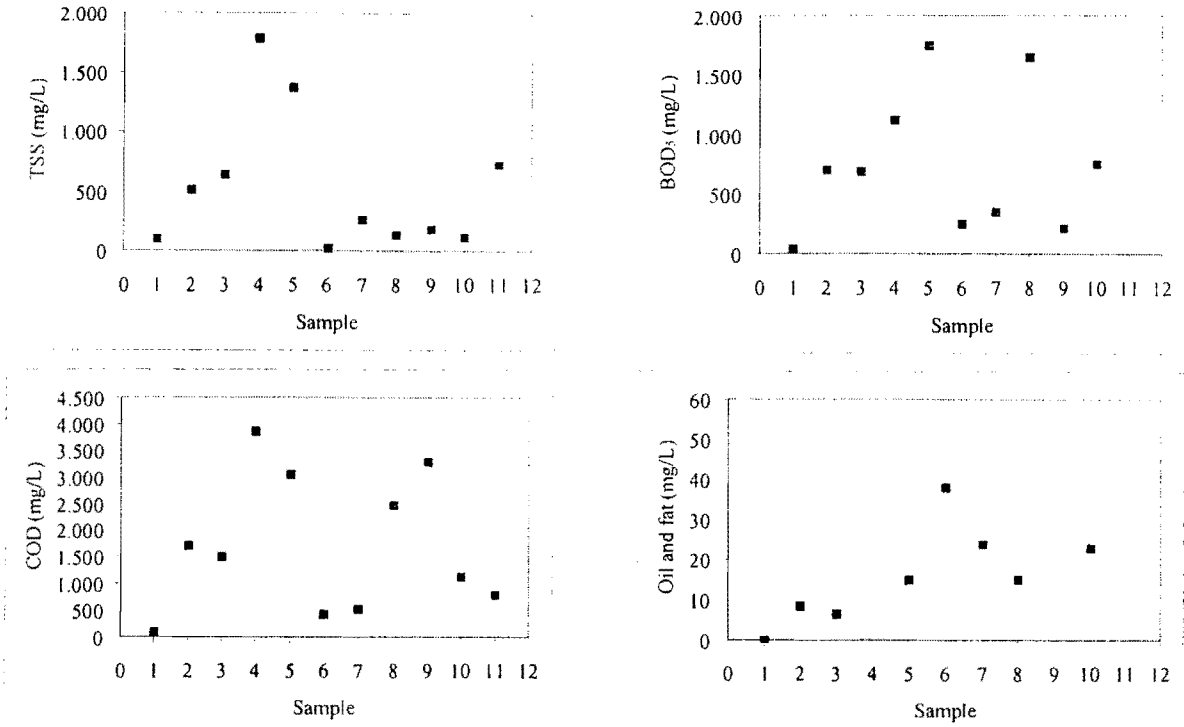

Figure 2. Wastewater characteristics of fish processin

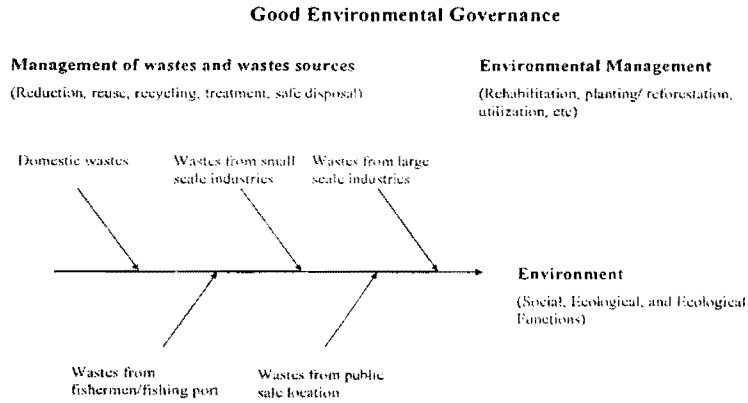

Figure 3. Cause and effect diagram of environmental pollution in Muncar and the proposed strategy

This mode of business practice has imbalanced the functions of environment socially, ecologically as well as economically. In the view of their current contribution the business practices focus much more on the economic aspects rather than on the social and ecological aspects. A systematic program is therefore needed to improve the environmental quality of the region so as to attain the balanced environmental functions in the near future. The proposed strategy consists of two main targets, namely management of waste/waste sources and management of environment as a whole (Figure 3). Because the environment has economical, social and ecological functions, these aspects should be included into the implemented environmental management, both in resource sharing and in active participating in the interrelated problem solving in the area. This paper describes the program of the first strategy and illustrates its preliminary results.

PROGRAM FRAMEWORK AND STAKEHOLDERS INVOLVED

Large-scale industrial activity is the main source of wastes generation in Muncar, along with those resulted from small-scale business, fishing port, and domestic or household activities. The pollution control program related to industrial activity is basically designed to follow the hierarchy of environmental management approach, namely input pollution control followed by output pollution

control. The input pollution control provides a win-win solution because the environmental control measures taken usually lead to economic benefit for the industry. These include waste prevention, waste reduction, recycle and reuse, which mean less utilization of materials and increased productivity. These measures, however, cannot eliminate waste completely and therefore should be combined with end-of-pipe measures. This approach along with its supporting activities is illustrated in Figure 4. The cleaner production approach was used for the formulation of the strategies.

The program includes industrial waste survey to provide comprehensive and reliable data as well as the understanding on why and how waste is generated, its quantity and characteristics, and its variation. Results of the survey will lead to identification on the opportunities to implement cleaner production and waste minimization measures. The program will be followed by looking for the proper on-site partial wastewater treatment technology. After all a comprehensive feasibility study will be conducted to assess the need for a collective wastewater treatment.

Observation results indicate a lack of awareness, knowledge and skills of stakeholders in environmental management. A number of supporting programs, such as training, establishing pilot projects (model), monitoring and law enforcement will therefore be carried out. A set of training programs are designed for four categories of participant, namely local government authority, large- and small-scale industry, and fishermen. The training topics for each category of participant are given in Table 3. Technical assistance is provided in the forms of consultative services, facility grants, and joint research as well as demonstration projects in the areas of product quality improvement, cleaner production and waste minimization, design and optimization of wastewater treatment facility, establishing an environmental management system, and monitoring of effluent quality.

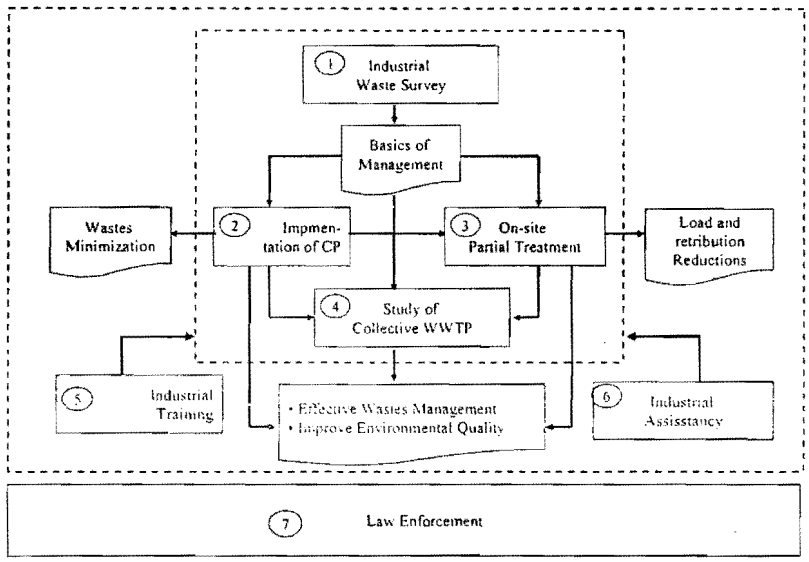

Figure 4. Strategy for industrial environmental control and management

Table 3. Training programs for specific category of participant

No	Training Topics	Category of participant			
		Industry (large scale)	Industry (small scale)	Fishermen	Local Government Authority
1	Environmental awareness	■	■	■	■
2	Good Manufacturing Practices (GMP), product quality improvement	■	■		
3	Cleaner production, and waste minimization	■	■	■	■
4	Implementation of Environmental Management System (EMS)	■	■		■
5	Design and optimization WWTP	■			
6	Improvement of quality and catch to reduce by-catch, reducing fish damage through improved handling procedure and facility			■	■
7	Management of fishing port and other physical facilities				■
8	Effluent Monitoring and Evaluation	■			■

As a summary, the programs and activities of environmental pollution control, government sectors in charge (in line with their main tasks and functions). The important performance indicators for successful environmental management program in Muncar include: 1) improved human resources awareness and capability and local environmental institution, 2) improved environmental awareness and increased participation of society and industry, 3) reduced pollution load, and 4) improved environmental quality (land, streams and drainage, coast).

ROOT OF THE PROBLEMS AND POTENTIAL CONTROL MEASURES

Input pollution control measures

The most important fish processing industries in terms of their waste generation are fish meal, cold storage and canning, and fish oil refinery. They use considerable amount of water, and thus generating a lot of wastewater with high concentration of oil/fat, dissolved organics, and solids. Initial investigation on the way industry is operating suggesting some potential for cleaner production implementation. Following are some cleaner production opportunities potentially implemented in the above industries.

Fish Meal Processing

Fish meal product has a high nutritional value, and is used as feed for livestock and farmed fish. Figure 5 shows process flowchart of fish meal production. Raw material is cooked and pressed to release water and oil, the pressed cake is then dried and crushed to get fish meal powder. During the process, a by-product in the form of fish oil is resulted. Depending on the type of raw materials and process efficiency, from 1000 kg fish processed, normally about 200–270 kg fish meal and 150-200 kg fish oil are produced (UNDP, 1999). Water, which makes up the rest of the fish matter, is evaporated during the process. The important environmental aspect is the use of low performance of oil trap facility that leads to effluent that contains high concentration of oil/fat, dissolved organics, and suspended solids. Some options for improvement include 1) installation of decanter and centrifugal oil separator so as to maximize protein and fat recovery and thus minimizing suspended solids and oil/fat in the effluent, 2) utilization of wastewater for producing liquid fertilizer or feed, and 3) waste segregation.

Cold Storage and Canning

Figures 6 and 7 show the process flow diagram of cold storage and canning production. The most important environmental aspect for both types of industry is the high consumption of water, which then results in high generation of wastewater. The existing cold storage and canning industries do not yet implement cleaner production principles and treat their wastewater improperly. Some potential opportunities for process improvement are identified which are: 1) modification of washing/cleaning technique, for example counter current mode of cleaning and water recycling, 2) energy reuse during cold water washing, 3) use of conveyor instead of flumes for material transport, 4) utilization of fish scales for manufacturing of chemical coagulant (PPRC, 1993), and restricting the use of detergents and soaps (McDonald et al., 1999).

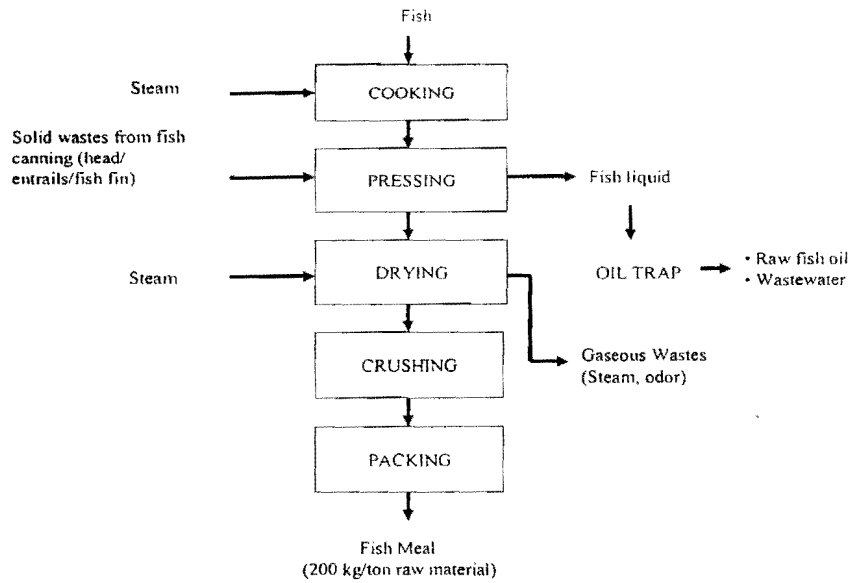

Figure 5. Process flowchart of fish meal production

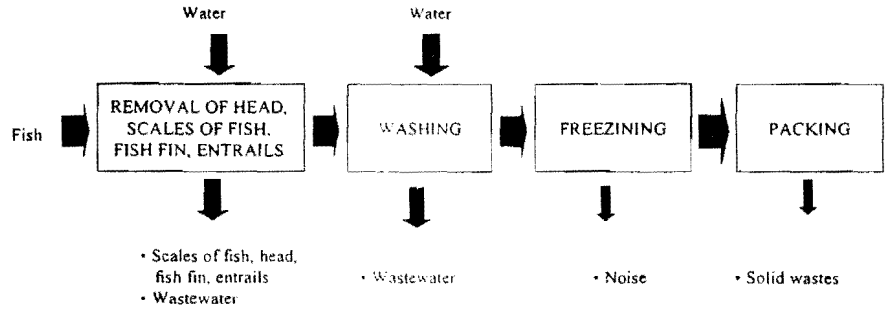

Figure 6. Process flowchart of cold storage

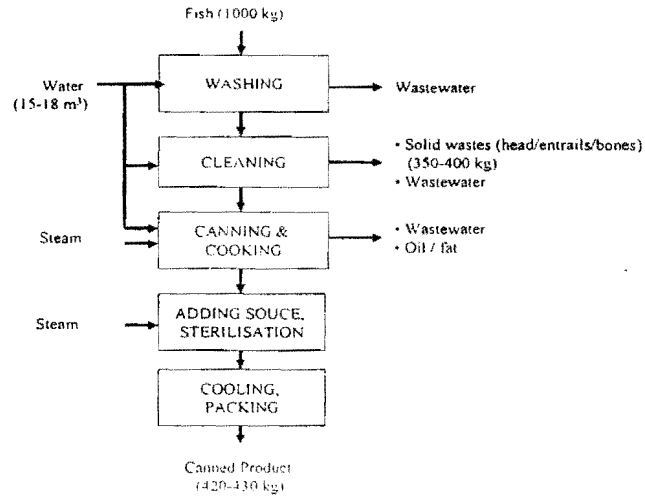

Figure 7. Process flowchart of fish canning production

Fish Oil Refinery

Fish oil product has a high nutritional and economical value and is used in food and industrial applications. Low quality of fish oil is refined in this type of industry. Refining process consists of degumming to remove gummy materials and neutralization to remove free fatty acids. Since soap is formed in the process, neutralization bleaches also the oil. Washing with water is subsequently required to remove the residual soap (Figure 8). The polishing process generates a low-volume, high-strength effluent. An alternative of waste minimization can be done by using the soap stock as a raw material for soap making for general laundry purposes.

Table 4 shows the effluent characteristics taken from one of cold storage and one of canning factory in Muncar. The pollutant level, particularly BOD, COD and suspended solids, is higher compared to that of similar industries implementing cleaner production in Thailand as reported by Nair (1990) or in Germany as reported by Rueffer and Rosenwinkel (1991). Since the high concentration of pollutant often means loss of valued materials, reduction in pollutant will give economical benefit. Nair (1990) reported that water consumption and organic loss (fish component) can be reduced up to 25 and 20 percent, respectively, by applying proper waste minimization measures. Another ways to manage process water in fish processing plants effectively are reported else where in literature (ECIPS, 1994).

The byproducts of fish processing industries are possible to upgrade, more knowledge is however needed on the chemical composition, including seasonal variation, of the fishery stocks. This is necessary in order to find effective and safe preservation and storage procedures and to find biomolecules with possible application in the food, feed, and pharmaceutical industries (Arason, 1993).

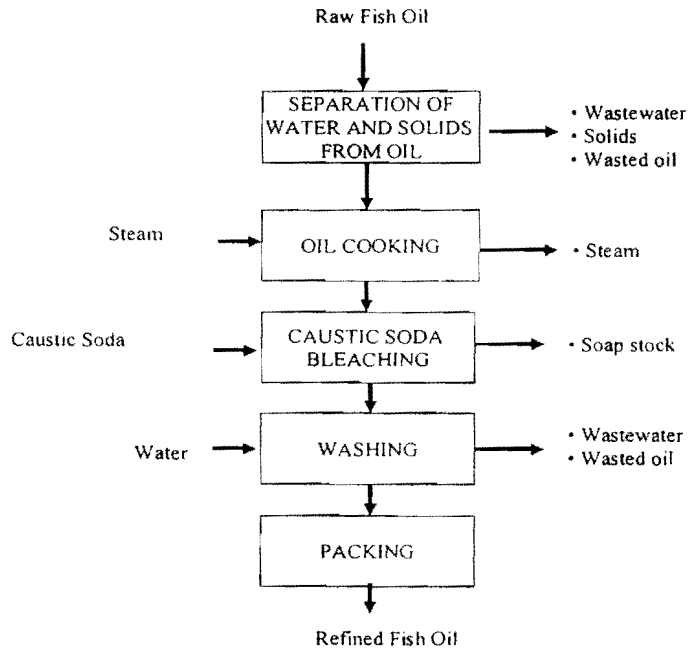

Figure 8. Process flowchart of oil/fat refining

Table 4. Effluent characteristics of a cold storage and a canning factory in Muncar (KLH, unpublished, 2007)

No.	Parameter	Unit	Standard*	Cold storage	Fish canning
1	TSS	mg/L	100	98.5	637.5
2	pH	-	6 - 9	7.66	7.2
3	Sulphides (H_2S)	mg/L	-	0.89	0.47
4	Free Chlor (Cl_2)	mg/L	1	0.02	0.08
5	Free Ammonia (NH_3-N)	mg/L	10	0.004	0.006
6	BOD_5	mg/L	100	46	689
7	COD	mg/L	200	100	1500
8	Nitrate (NO_3-N)	mg/L	-	1.03	4.09
9	Detergent	mg/L	-	0.76	0.04
10	Phosphate (PO_4)	mg/L	-	0.75	4.17
11	Oil and fats	mg/L	15	0.02	6.54

*)According to KepMen LH No. 06/2007 about Wastewater quality standard for fish processing industry.

OUTPUT POLLUTION CONTROL MEASURES

Input pollution control usually only reduces the amount and toxicity of waste but cannot completely eliminate it (Nair, 1990; UNEP, 1998; UNDP, 2000). Therefore the approach is usually combined with output pollution control measures particularly waste treatment processes so as to ascertain safe disposal of effluent to the environment (Carawan *et al*, 1979). However, installation of proper wastewater treatment plant may not be technically feasible due to space limitation for most industries. Only partial in-plant treatment is possible. In fact many fish processing plants in Muncar have already installed such a treatment facility (mostly oil trap), despite of the need for further process optimization.

Alternatively, a flotation unit can be used as an additional pre-treatment facility for further removal of oil and organic solids from the fish processing effluent before discharging into environment. Rueffer and Rosenwinkel (1991) reported that the flotation unit can reduce about 82% of organic load, 70 - 90% of fats and 90 – 95% of TSS. In this way, the pre-treated wastewater can then be processed easily by using conventional activated sludge, for example, in a collective wastewater treatment to meet the requirements of direct discharge in the receiving water bodies.

Since it is realized that pretreatment alone will not be sufficient to completely treat the wastewater, the proposed program will also look at the feasibility of establishing a collective wastewater treatment system in the region. The need for collective treatment facility is determined only after waste

minimization programs are conducted and accurate data of effluent quantity and quality as well as its variation is available. A thorough feasibility study covering technical (location, operation, technology), financial (investment, source of funding), socio-economic, and institutional (organization, tariff system, monitoring and evaluation) aspect is an important prerequisite for successful collective treatment program. In this context, it should be noted that individual in-plant treatment is still necessary in order to meet the standard quality of influent determined by the collective facility and also to minimize the retribution costs.

CONCLUSIONS AND RECOMMENDATIONS

Environmental pollution in Muncar can be attributed to industrial activities, wherein wastewater generation being the predominant cause. Bad odor in the area is caused by biological decomposition of organics in the drainage systems. Main source of wastewater is process water from cleaning and washing operation and also residual fish liquid from pressing operation, which contains dissolved organics, fat/oil, nutrient, and suspended solids. Most of industries have not implemented good manufacturing practices and proper waste management measures, and therefore the environment is heavily polluted physically, chemically, and biologically.

A framework of environmental management programs has been formulated and currently adopted by the government to be used partly by the authority (relevant government institutions) and related parties (industry, NGO, society) as a guidance to work in a synergistic way in order to solve the environmental problem in Muncar. The implementation of the program is currently still on going, comprehensive evaluation and detailed discussion of results are therefore not yet to carry out. The program is basically designed to follow the hierarchy of environmental management approach, namely input pollution control followed by output pollution control. The input pollution control provides a win-win solution because any environmental control taken means also economic benefit for the industry. The preliminary study indicates some possibilities to implement waste minimization measures, which will result in improving productivity and efficiency. Despite of the existing industrial limitations, the study has identified some possibilities to implement an in-plant pretreatment such as oil trap and dissolved air flotation in order to reduce the pollution load. Considering that pretreatment may not be sufficient to meet the standard for direct discharge, a comprehensive study is necessary to assess the technical, socio-economical, and institutional feasibilities of establishing a collective wastewater treatment plant in order to ensure safe disposal of effluent to the environment.

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