For Fisheries Management
BAY OF BENGAL PROGRAMME

IMO

FISHERY HARBOUR MANUAL ON THE PREVENTION OF POLLUTION

J A SCIORTINO
R RAVIKUMAR

BOBP/MAG/22

BAY OF BENGAL PROGRAMME **BOBP/MAG/22**

FISHERY HARBOUR MANUAL ON THE PREVENTION OF POLLUTION

J A Sciortino
R Ravikumar

BAY OF BENGAL PROGRAMME
Madras, India
1999

FOREWORD

Fishing harbours in the Bay of Bengal region are patronized by small-scale fisherfolk as well as by owners and operators of large vessels. Thousands of tons of fish are handled every day at these harbours. Although the bulk of fish landed in these countries is destined for local markets, every country wishes to improve the quality of its landed catch to increase exports of seafood products to more lucrative overseas markets.

What constitutes pollution? What is contamination? This manual describes potential pollutants generated by harbour activities and potential contaminants that may find their way into the harbour from outside sources. It discusses the standards needed for water quality, and procedures to monitor standards. It discusses waste management and effluent treatment, and concepts, such as HACCP, designed to ensure fish quality.

Because of recent developments on food safety assurance – such as the concept of Hazard Analysis Critical Control Point (HACCP) and the directives of the European Union – seafood exporting countries will, in future, need to comply with stringent new food safety requirements. This manual's information on sources of pollution and ways to control it is therefore timely.

The BOBP thanks the IMO for supporting the research, preparation and production of this manual. It is the last in a series of collaborative activities on cleaner fishery harbours in the Bay of Bengal region between BOBP and the IMO. Earlier projects included reception facilities for garbage and oily wastes at the Visakhapatnam fishing harbour; the 1991 regional workshop on cleaner fishery harbours, held in Penang, Malaysia as well as a series of pilot projects held in Phuket (Thailand), Negombo (Sri Lanka) and Male (Maldives).

We hope that these collaborative activities, together with the manual, have gone some way toward highlighting and mitigating fishing harbour pollution in the Bay of Bengal region.

Kee-Chai CHONG
Programme Coordinator, BOBP

CONTENTS

LIST OF TABLES

LIST OF FIGURES

BACKGROUND

During early 1987, the International Maritime Organization (IMO) and the Food and Agriculture Organization of the United Nations (FAO) agreed that the two organizations should co-operate through the Bay of Bengal Programme (BOBP) to address marine pollution in the Bay of Bengal region. The BOBP would implement IMO-supported pilot projects to reduce pollution in fishery harbours and thereby improve the fishery harbour environment. Even a decade ago, it was realized that fishery harbours constitute a significant social capital and that there was a serious need to improve management of fishery harbours with particular reference to harbour pollution.

After an IMO appraisal mission in 1989, a pilot project to upgrade the reception facilities for garbage and oily wastes in Visakhapatnam Fishery Harbour, India, was formulated by IMO and later implemented by BOBP with the assistance of the Visakhapatnam Port Trust. This was followed by a BOBP-IMO initiative to assess the status of important fishery harbours in the region. A Regional Workshop on Cleaner Fishery Harbours was held in Penang in 1991. The general consensus was that pollution abatement in fishery harbours is essential if member countries wish to ensure quality products and maximise export potential.

What followed was a series of pilot projects – Phuket in Thailand; Negombo in Sri Lanka and Male in the Maldives. These projects were by no means elaborate; remedial action was not intended as part of project outputs. Again in keeping with the theme of the BOBP's second and third phases, the focus of the IMO-supported project was on working with stakeholders, on creating awareness about harbour pollution and its potential impact and the need to mitigate it. Awareness campaign materials – including a rudimentary booklet on Guidelines for Cleaner Fishery Harbours – were produced.

These pilot projects generated a wealth of experience about different types of harbours and stakeholder perception of the harbours, as well as about the limited options that harbour managers have because they lack information on pollutants, their impacts and their abatement.

We believe that a handbook on Fishery Harbour Management with particular reference to managing harbour pollution, containing information gained not only by BOBP's pilot projects but also from already published material, will give the harbour manager a better insight to the problem of insanitary fishery harbours and help him to initiate appropriate remedial measures.

"Fishery harbour manual on the prevention of pollution" is a step in this direction.

INTRODUCTION

A fishery harbour is a complex of facilities that acts as an interface between the capture of fish and its consumption.

Where small, beachable boats landing small quantities of fish are used, only modest facilities for cleaning, sorting, selling and storage may be required, in which case 'landing place' may be a more appropriate expression than 'harbour'*(see Fig. 1 and Fig. 2).*

However, as the fishing vessels become larger and landed quantities increase, the need for quicker unloading, more selective product handling and improved distribution facilities arises together with a demand for more sophisticated maintenance and repair facilities, both for vessels and equipment (*see Fig. 3 and Fig. 4).*

A comprehensive fishery harbour would include fish processing facilities, cold storage, ice plant and administrative offices, and several other facilities within the harbour complex (*see Fig 5)* including roads, parking areas for private and commercial vehicles, space around the halls for loading and unloading, net repair halls and areas for future expansion. Managing this multiplicity of functions is akin to managing a mini-municipality.

No matter what the category, the fact remains that activities within the fishery harbour complex generate wastes of varying degrees and types. These wastes, if not properly handled, will lead to contamination of the product and degradation of the harbour environment due to pollution. The cost of correcting the problem`after the fact' can be very high. Washing of fish using polluted harbour water and unsanitary handling are factors that contribute to rapid spoilage of fish and pose serious health hazards due to contamination of water and fish.

The fishery industry, especially the small-scale sector, can ill afford economic losses from lower prices received for poor quality fish. Likewise, the national economy cannot afford the loss of entire overseas markets. More significantly, consumer demand for quality is growing rapidly. Importing nations insist on clean and hygenic landing places as pre-requisites to meet the high quality standards for seafood set by them.

Under such circumstances, the burden of responsibility lies heavily with the harbour manager to ensure a clean harbour environment. Ways and means must be found to elicit co-operarion from all harbour users; to ensure that municipal services extend to the fishery harbour complex too; to find appropriate means of collection and disposal of wastes; and, lastly to create an awareness among all stakeholders that the fishery harbour complex constitutes a significant community and social capital that needs to be protected.

A major asset for a fishery harbour manager is a good understanding of his environment and a set of procedures to assess the severity of pollution and implement corrective measures. He needs to be alert to the first signs of environmental degradation to ensure action in time. This handbook provides him with basic technical imformation on typical pollutants encountered in a fishery harbour. It also contains information about sanitation, collection and disposal of wastes, quality standards that he must ensure for water and fish, and guidelines for pollution abatement including suggestions for obtaining compliance from the community through awareness building.

This document puts together a selection of useful published materials on harbour pollution, along with experiences from implementing pilot projects to promote cleaner fishery harbours in the Bay of Bengal region.

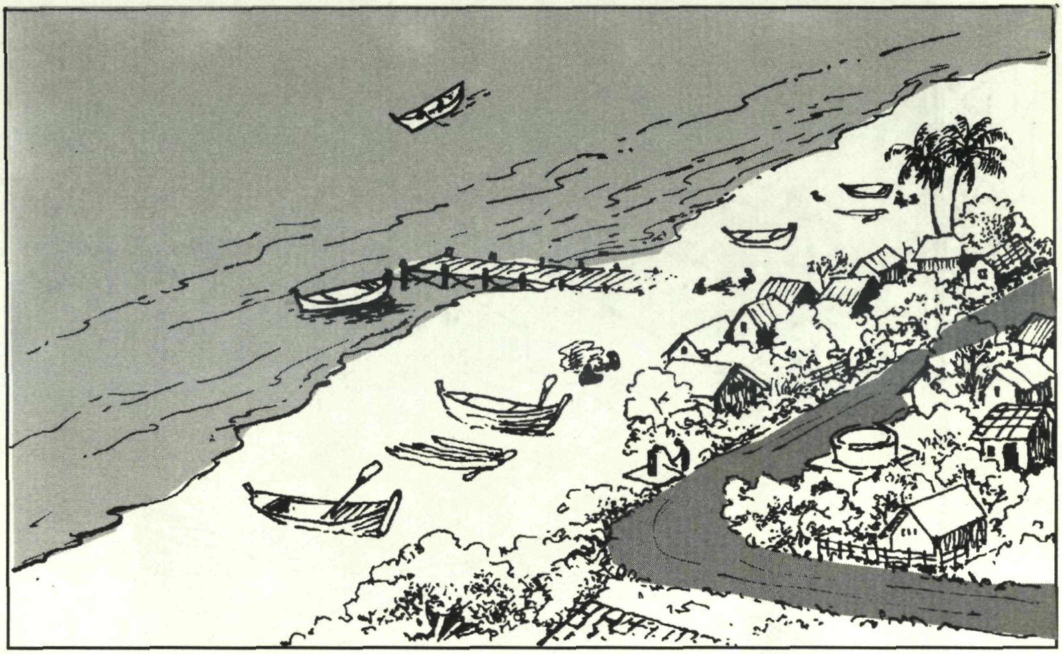


Figure 1

TYPICAL VILLAGE LANDING CENTRE

(Open Beach or Estuarine)

Location of fishing grounds	:	Inshore
Typical fishing trip	:	From 12 to 24 hours
Types of vessels	:	Non motorised fishing canoes,small motorised canoes, gillnets, pole and line, hand-line etc.
Types of landed products	:	Fresh fish, low volume high value
Typical shore processing	:	Gutting, icing, boxing for retail, drying and smoking

CHARACTERISTICS:

- Shallow bay or estuarine landing
- Primitive road access
- Fresh water supply from borewells
- No toilet facilities
- No bunkering facilities
- Ice supplied by traders, no ice storage.

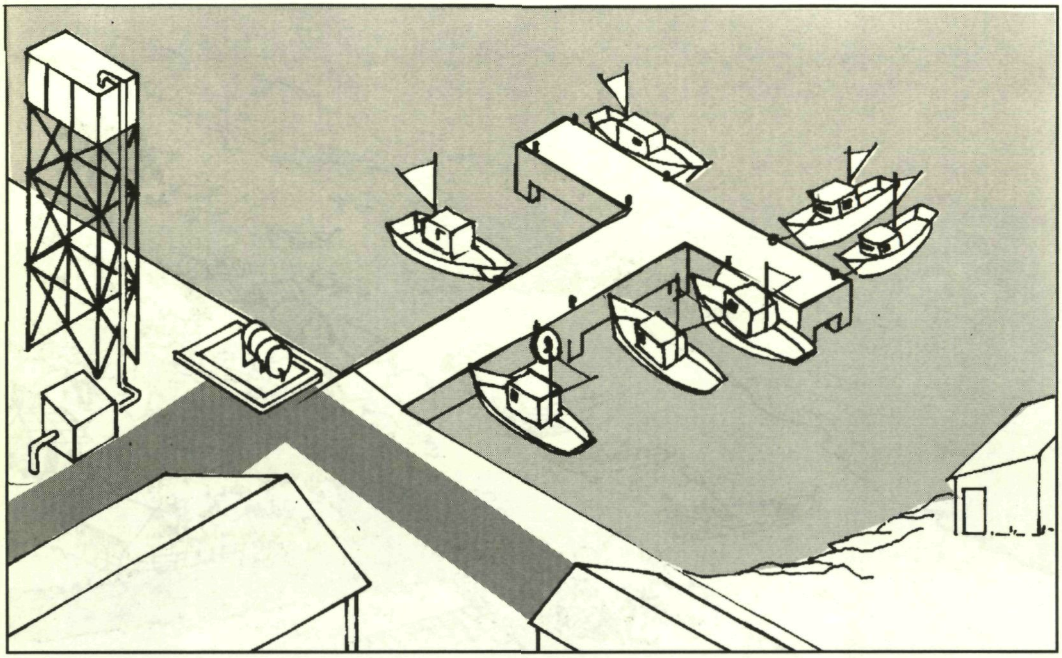


Figure 2

MINOR FISHING PORT

Location of fishing ground	:	Inshore
Typical fishing trip	:	12 to 24 hours
Types of fishing vessels	:	Small motorised vessels, trawlers, gillnetters...
Types of landed products	:	Fresh fish, low volume Trash fish, high volume.
Types of shore processing	:	Gutting, icing, boxing for retail

CHARACTERISTICS:

- Protected bay, beach landing of small vessels possible
- Fresh water available from overhead tank storage
- Fuel supply from drums
- Protected area for fish auction
- Ice supply by traders, no ice plant
- Minor vessel repairs on beach.

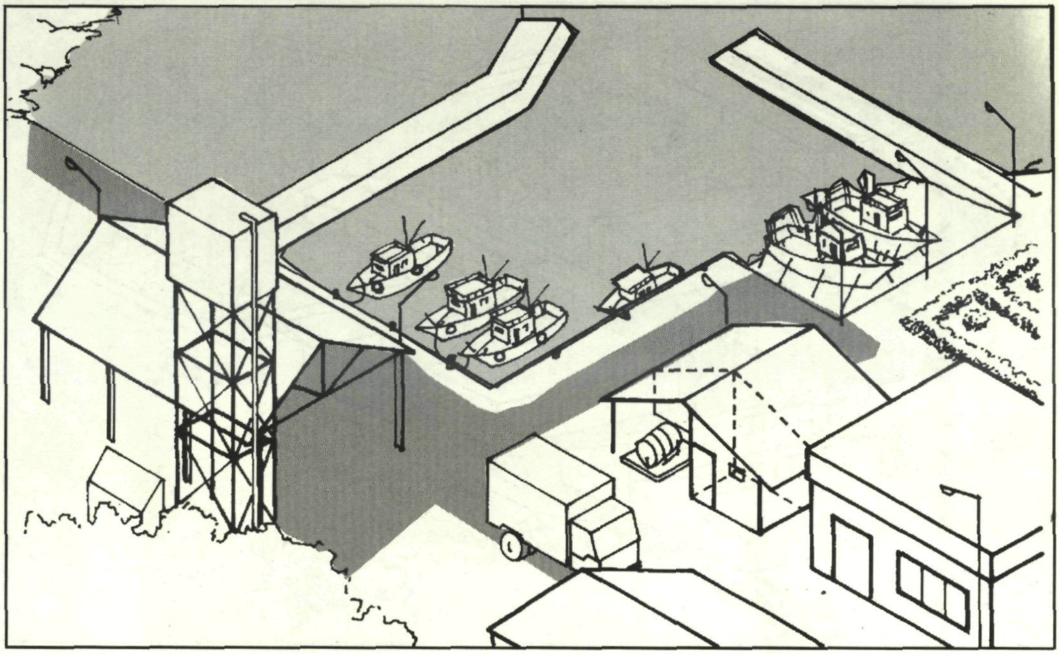


Figure 3

MEDIUM INSHORE FISHERY HARBOUR

Location of fishing grounds	:	Inshore
Typical fishing trip	:	1 to 3 days
Types of fishingvessels	:	Small trawlers , gillnetters, line fishing
Types of landed products	:	High value shrimp, low volume Low value trashfish, high volume
Types of shore processing	:	Gutting, icing, packing for refrigerated trucks

CHARACTERISTICS:

- Break water protection
- Good road access
- Fresh water supply from borewells and municipality
- Mini ice plant
- Slipway for vessel repairs
- Draft to allow vessels upto 15 tons.

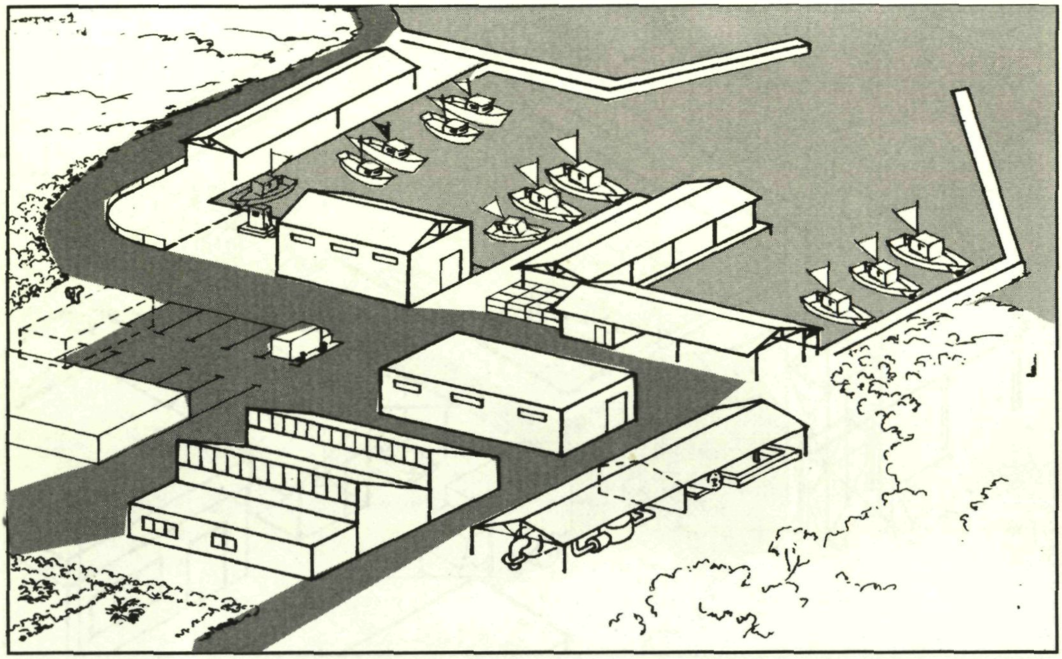


Figure 4

INSHORE/OFFSHORE FISHERY HARBOUR

Location of fishing grounds	:	Inshore/Offshore upto 1 week steaming
Typical fishing trip	:	1 to 15 days
Types of fishing vessels	:	Typically trawlers, purse seiners and off shore gillnetters
Types of landed products	:	High value shrimp, meduim volume High value pelagics, meduim volume Low value trash fish, large volume
Types of landed products	:	Gutting, icing, peeling, drying, freezing, fish meal

CHARACTERISTICS:

- Break water protection
- Draft to allow vessels upto 100T
- Ice and full storage and supply
- Freezing plant
- Municipal fresh water
- Protected auction shed
- Slipway for repair

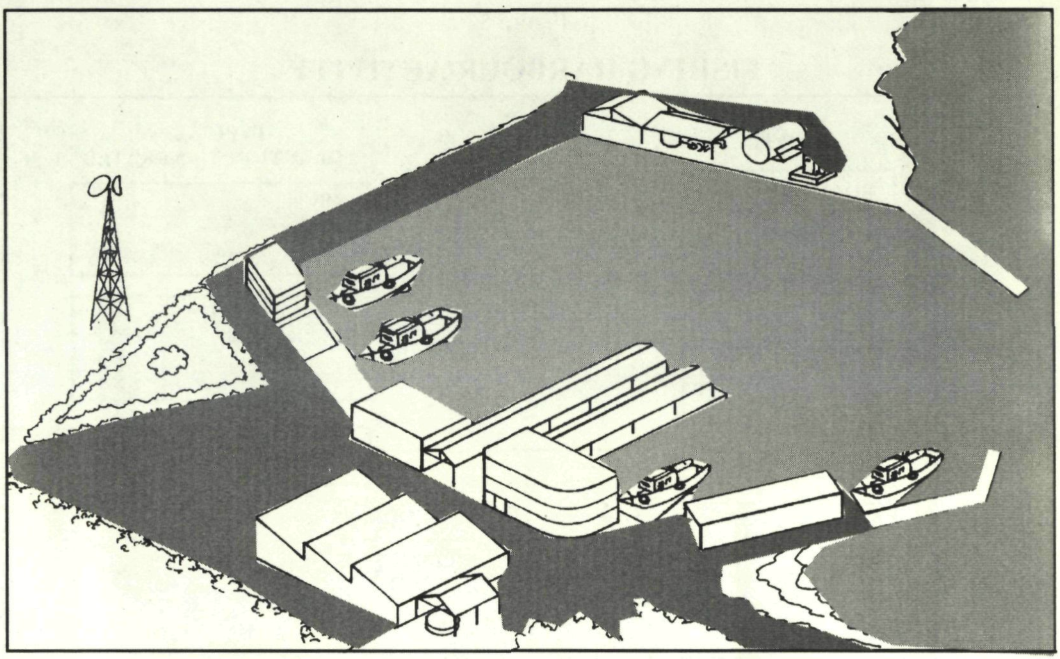


Figure 5

DEEP SEA FISHERY HARBOUR

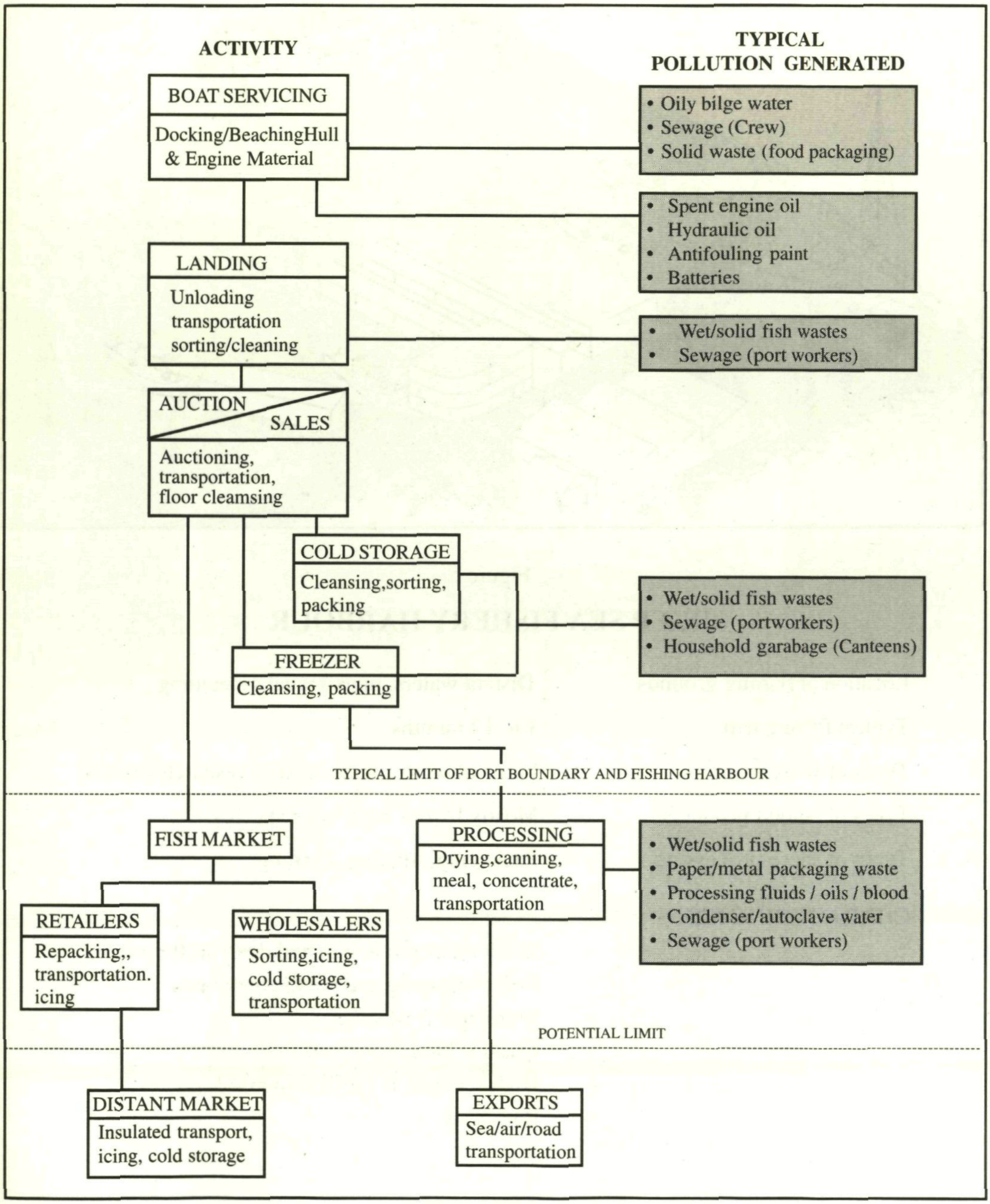
Location of fishing grounds	:	Distant waters, upto 3 weeks steaming
Typical fishing trip	:	1 to 12 months
Types of vessels	:	Large trawlers, purse seiners, research vessels
Types of landed products	:	Mostly frozen high value species
Types of shore processing	:	Packaging, filleting, canning

CHARACTERISTICS:

- Breakwater protection and deep draft upto 6m
- Fish processing and packaging plants
- Municipal freshwater
- Quaside bunkering facilities
- High security, oil spill response serveces
- Rail head

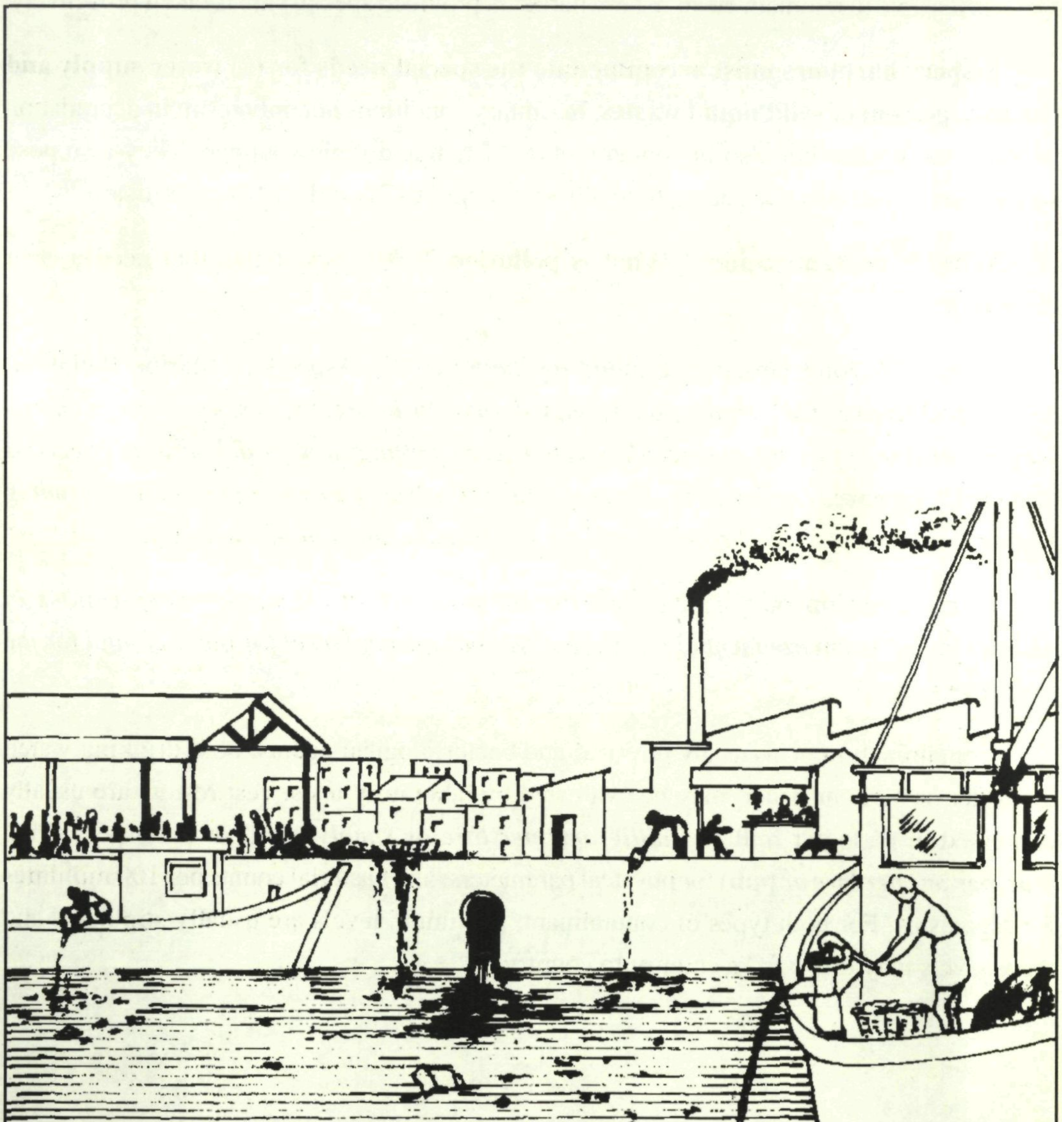
Figure 6

FISHING HARBOUR ACTIVITY



Chapter 1

POTENTIAL POLLUTANTS, THEIR SOURCES AND THEIR IMPACTS



1.1 CONTAMINATION OR POLLUTION ?

It is amazing how many people seem to live alongside serious pollution and not notice it. Fishery harbours and landing places around the world have traditionally been regarded as 'appropriate for insanitary conditions'. Only in the recent past has it been recognized that it is feasible to maintain clean fishery harbours provided special care is taken proactively.

Fishery harbours must accommodate the special needs for (a) water supply and (b) management of solid/liquid wastes. Insanitary conditions not only result in degradation of the environment, but also in contamination of fish and rapid spoilage. They also pose serious health hazards such as typhoid, cholera, hepatitis-B, and gastro-enteritis.

What is contamination ? What is pollution ? These are terms that need a clear definition.

GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution) defines **pollution** as *the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities.*

Contamination on the other hand is *the presence of elevated concentrations of substances in the environment above the natural background level for the area and for the organism.*

Contamination of water by physical and bacteriological agents, be it drinking water, ice water or harbour water, may be evaluated by laboratory tests. Test results are usually expressed in parts per million (*milligrams per litre or simply* **ppm**) or parts per billion (*micrograms per litre or* **ppb**) for physical parameters; and bacterial counts per 100 millilitres for organisms. For both types of contaminant, maximum levels are usually stipulated and these levels may differ from country to country.

1.2 CONTAMINATION OF WATER IN FISHERY HARBOURS

Contaminants in modest quantities are present even in clean aquatic environments. A few metals such as copper, selenium, iron and zinc are essential nutrients for fish and shellfish. Contamination occurs when there is a significant increase in their levels. Problems related to chemical contamination of the aquatic environment are nearly all man-made. Industrial effluents, sludge from sewage treatment plants, agriculture run-offs and raw untreated sewage from urban populations and industry--all these contribute to chemical contamination of the environment.

The main concern of harbour managers however, is that clean water chemically equivalent to drinking water is needed for fish washing, ice making and fish processing. Many chemicals present above a certain level in water can be a public health hazard. Some interfere with water treatment processes, some stain fixtures and plumbing, a few may cause undesirable scaling and may be aesthetically objectionable.

Due to the acute shortage of potable water in many countries, raw sea water is often utilized during fish handling at sea or in port. This means that in addition to tap water, harbour basin or estuarine waters could be a potential source of contamination.

Pollution of harbour waters due to dumping of untreated sewage in contiguous waters and the harbour basin, is often the most common cause for seafood-related diseases and epidemics.

But it is a matter for concern that **harbour water quality is heavily influenced by human activity not only within the harbour complex but in the surrounding environment as well**. Effluents from aquaculture ponds, agriculture runoff, sewage discharge, toxic effluents from industry into the contiguous water body, all affect the marine environment through biological, chemical and physical interactions over different temporal and spatial scales. In addition there may be impacts that arise as a consequence of accidents or failure of normal operations such as oil spills in coastal waters.

The fishing harbour is the focal point of the fishing effort (and sometimes village life revolves around the activities of the harbour). It is here that fish is likely to be contaminated. By charting the flow of fish through the fishing harbour (from the time it is discharged on the quay to the time it leaves the port boundary), points can be identified where contamination or growth of micro-organisms occurs. Control features can then be implemented, based on the identified health hazard. This technique is known as a **H**azard **A**nalysis **C**ritical **C**ontrol **P**oint programme or **HACCP** in short. To the fishing port manager, the three major areas of concern are :

1. Water quality standards of all the water used in the port (potable and sea water);
2. Personal hygiene of the shore-based workers;
3. Standard of cleanliness of the port in general.

Under HACCP, these three areas of concern translate into drastic changes in the long-term. In particular, these involve :

- Minimising and eventually eliminating harbour and coastal pollution from point and non-point sources;
- Improving sanitation and hygiene throughout the fishing harbour;
- Maintaining port and harbour infrastructure in good working order

In order to comply with these directives, a fishing port manager needs to have a good understanding of both the natural environment existing around the fishing harbour as well as the environment generated within the harbour's infrastructure. Since water is the underlying link which connects the various fishing activities together, (such as netting, storing and icing onboard, handling inside a harbour and eventual sale to consumers) and since most water supplies originate outside the harbour area, the fishery harbour manager must ensure that water entering the harbour is chemically and biologically fit for human consumption. Unfortunately, this task is rendered more difficult in countries with a strong indigenous cottage industry, which, through the indiscriminate use of highly toxic chemicals (chemical dyes, pesticides, paints and solvents), generally leads to problems associated with groundwater pollution.

The major contaminants of concern in potable water supplies are :

a) **Suspended solids;**
b) **Biodegradable organics (proteins, carbohydrates and fats);**
c) **Pathogens;**

d) **Nutrients (Nitrogen, phosphorus and carbon);**

e) **Priority pollutants (highly toxic chemicals);**

f) **Refractory organics (pesticides, phenols, surfactants);**

g) **Heavy metals;**

h) **Dissolved inorganics (nuisance chemicals).**

1.3 SUSPENDED SOLIDS

The presence of suspended solids in water gives rise to turbidity. Suspended solids may consist of clay, silt, airborne particulates, colloidal organic particles, plankton and other microscopic organisms. The presence of particulate matter in water, whether organic, inorganic or due to higher micro-organisms, can protect bacteria and viruses from the action of disenfectants. The adsorptive capacity of some suspended particulates can lead to entrapment of undesirable inorganic and organic compounds present in the water and in this way, turbidity can bear an indirect relationship to the health aspects of water quality.

Airborne particulate matter is of particular concern to facilities located near mineral stockpiles (*coal, iron ore, bauxite, etc.*) or down wind from large power stations (*fly ash*), timber saw mills (*saw dust*) or cement factories (*cement dust*). Rain water collection systems are particularly sensitive to such airborne particulates because they usually augment local potable water systems and act as conduits for pollutants to enter potable water systems. Large quantities of aromatic hydrocarbons are also generated by the combustion of fossil fuel in oil-fired power stations and industrial kilns.

1.4 BIODEGRADABLE ORGANICS

Composed principally of proteins, carbohydrates, and fats, biodegradable organics are measured most commonly in terms of BOD (Biological Oxygen Demand). BOD is the quantity of oxygen required for the oxidation of organic matter by bacterial action in the presence of oxygen. The higher the demand for oxygen (the more organic the pollution) the less is the oxygen left to support life. Urban sewage commonly has a BOD of 500 mg/litre. Harbour basin water should have a BOD in the range of 50 to 150 mg/litre.

1.5 PATHOGENS

The most common and widespread danger associated with drinking water is contamination, either directly or indirectly, by sewage, by other wastes, or by human or animal excrement. If such contamination is recent, and if among the contributors there are carriers of communicable enteric diseases, some of the living causal agents may be present. The drinking of water so contaminated or its use in the preparation of certain foods may result in further cases of infection. Natural and treated waters vary in microbiological quality. Ideally, drinking water should not contain any microorganisms known to be pathogenic to man. In practice, this means that it should not be possible to demonstrate the presence of any coliform organism in any sample of 100 ml.

Pathogenic organisms found in contaminated water may be discharged by human beings who are infected with disease or who are carriers of a particular disease. The principal categories of pathogenic organisms are, as shown in Table 1.1, bacteria, viruses, protozoa and helminths.

1.5.1 Bacteria

Faecal pollution of drinking water may introduce a variety of intestinal pathogens – bacterial, viral, and parasitic – their presence being related to microbial diseases and carriers present at that moment in the community. Intestinal bacterial pathogens are widely distributed throughout the world. Those known to have occurred in contaminated drinking water include strains of *Salmonella, Shigella,* enterotoxigenic *Escherichia coli, Vibrio cholerae, Yersinia enterocolitica,* and *Campylobacter fetus.* These organisms may cause diseases that vary in severity from mild gastro-enteritis to severe and sometimes fatal dysentery, cholera, or typhoid.

The modes of transmission of bacterial pathogens include ingestion of contaminated water and food. The significance of the water route in the spread of intestinal bacterial infections varies considerably, both with the disease and with local circumstances. Among the various waterborne pathogens, there exists a wide range of minimum infectious dose levels necessary to cause a human infection. With *Salmonella typhi*, ingestion of relatively few organisms can cause disease; with *Shigella flexneri*, several hundred cells may be needed, whereas many millions of cells of Salmonella serotypes are usually required to cause

Table 1-1
LIST OF INFECTIOUS AGENTS POTENTIALLY PRESENT IN DRINKING WATER CONTAMINATED BY SEWAGE

ORGANISM	DISEASE	REMARKS
Bacteria		
Escherichia coli (enteropathogenic)	Gastroenteritis	Diarrhoea
Legionella pneumophila	Legionellosis	Acute respiratory illness
Leptospira (150 spp.)	Leptospirosis	Jaundice, fever
Salmonella typhi	Typhoid fever	High fever, diarrhoea
Salmonella (~1700 spp.)	Salmonellosis	Food poisoning
Shigella (4 spp.)	Shigellosis	Bacillary dysentery
Vibrio cholerae	Cholera	Extremely heavy diarrhoea, dehydration
Yersinia enterocolitica	Yersinosis	Diarrhoea
Viruses		
Adenovirus (31 types)	Respiratory disease	
Enteroviruses (67 types, e.g., polio, echo, and Coxsackie viruses)	Gastroenteritis, heart anomalies, meningitis	
Hepatitis A	Infectious hepatitis	Jaundice, fever
Norwalk agent	Gastroenteritis	Vomiting
Reovirus	Gastroenteritis	
Rotavirus	Gastroenteritis	
Protozoa		
Balantidium coli	Balantidiasis	Diarrhoea, dysentery
Cryptosporidium	Cryptosporidiosis	Diarrhoea
Entamoeba histolytica	Amoebic dysentery	Prolonged diarrhoea with bleeding
Giardia lamblia	Giardiasis	Mild to severe diarrhoea, nausea
Helminths		
Fasciola hepatica	Fasciolasis	Sheep liver fluke
Dracunculus medinensis	Dracunculosis	Guinea worm
Ascaris lumbricoides	Ascariasis	Roundworm
Enterobius vericularis	Enterobiasis	Pinworm
Hymenolepis nana	Hymenolepiasis	Dwarf tapeworm
Taenia saginata	Taeniasis	Beef tapeworm
Taenia solium	Taeniasis	Pork tapeworm
Trichuris Trichiura	Trichuriasis	Whipworm

gastroenteritis. Similarly. with toxigenic organisms such as enteropathogenic *E. coli* and *V. cholerae* as many as 10^8 organisms may be necessary to cause illness. The size of the infective dose also varies in different persons with age, nutritional status, and general health at the time of exposure.

The significance of routes of transmission other than drinking water should not be underestimated as the provision of a safe potable supply by itself will not necessarily prevent infection without accompanying improvements in sanitation and personal habits. Education in simple applied and personal hygiene is essential.

Surveillance of the bacterial quality of water is also important, not only in the assessment of the degree of pollution, but also in the choice of the best source and the treatment needed. Bacteriological examination offers the most sensitive test for the detection of recent and therefore potentially dangerous faecal pollution, thereby providing a hygienic assessment of water quality with a sensitivity and specificity that is absent from routine chemical analysis. It is essential that water is examined regularly and frequently as contamination may be intermittent and may not be detected by the examination of a single sample. For this reason, it is important that drinking water is examined frequently by a simple test rather than infrequently by a more complicated test or series of tests.

Priority must always be given to ensuring that routine bacterial examination is maintained whenever manpower and facilities are limited.

1.5.2 Viruses

Viruses of major concern in relation to waterborne transmission of infectious disease are essentially those that multiply in the intestine and are excreted in large numbers in the faeces of infected individuals. Concentrations as high as 10^8 viral units per gram of faeces have been reported. Even though replication does not occur outside living hosts, enteric viruses have considerable ability to survive in the aquatic environment and may remain viable for days or months. Viruses enter the water environment primarily by way of sewage discharges. With the methods at present available, wide fluctuations in the number of viruses in sewage have been found . On any given day, many of the 100 or so known enteric viruses can be isolated from sewage, the specific types being those prevalent in the community at that time. Procedures for the isolation of every virus type that may be present in sewage are not yet available. As sewage comes into contact with drinking water, viruses are carried on and remain viable for varying periods of time depending upon temperature and a number of other less well-defined factors. It is generally believed that the primary route of exposure to enteric viruses is by direct contact with infected persons or by contact with faecally contaminated objects. However, because of the ability of viruses to survive and because of the low infective dose, exposure and consequent infections may occur by less obvious means, including ingestion of contaminated water. Explosive outbreaks of viral hepatitis and gastroenteritis resulting from sewage contamination of water supplies have been well documented epidemiologically. In contrast, the transmission of low levels of virus through drinking water of potable quality, although suspected of contributing to the maintenance of endemic enteric viral disease within communities, has not yet been demonstrated.

In some developing areas, water sources may be heavily polluted and the water-treatment processes may be less sophisticated and reliable.

Because of these factors, as well as the large number of persons at risk, drinking water must be regarded as having a very significant potential as a vehicle for the environmental transmission of enteric viruses. As with other microbial infections, enteric viruses may also be transmitted by contaminated food. Enteric viruses are capable of producing a wide variety of syndromes, including rashes, fever, gastroenteritis, myocarditis, meningitis, respiratory disease, and hepatitis. In general, asymptomatic infections are common and the more serious manifestations are rare. However, when drinking water is contaminated with sewage, two diseases may occur in epidemic proportions – gastro-enteritis and infectious hepatitis. Apart from these infections, there is little, if any, epidemiological evidence to show that adequately treated drinking-water is concerned in the transmission of virus infections. Gastroenteritis of viral origin may be associated with a variety of agents. Many of these have been identified only recently occurring as small particles with a diameter of 270-350 microns in stools of infected individuals with diarrhea.

Viral gastroenteritis, usually of 24 - 72 hours' duration with nausea, vomiting and diarrhea, occurs in susceptible individuals of all ages. It is most serious in the very young or very old where dehydration and electrolyte imbalance can occur rapidly and threaten life if not corrected without delay. Hepatitis, if mild, may require only rest and restricted activities for a week or two, but when severe it may cause death from liver failure, or may result in chronic disease of the liver. Severe hepatitis is tolerated less well with increasing age and the fatality rate increases sharply beyond middle age. The mortality rate is higher among those with pre-existing malignancy and cirrhosis.

1.5.3 Protozoa

Protozoa are single-celled eucaryotic micro-organisms without cell walls. The majority of protozoa are aerobic. Protozoa feed on bacteria and other microscopic microorganisms. Of the intestinal protozoa pathogenic for man, three may be transmitted by drinking water: *Entamoeba histolytica, Giardia* spp., and *Balantidium coli*. These organisms are the etiological agents of amoebic dysentery, giardiasis and balantidiasis, respectively, and have all been associated with drinking water outbreaks. All three have worldwide distribution. As a group, the intestinal pathogenic protozoa occur in large numbers in the faeces of infected individuals in man and a wide variety of domestic and wild animals. Coliform organisms do not appear to be a good indicator of *Giardia or E. histolytica* in treated water because of the increased resistance of these protozoans to inactivation by disinfection.

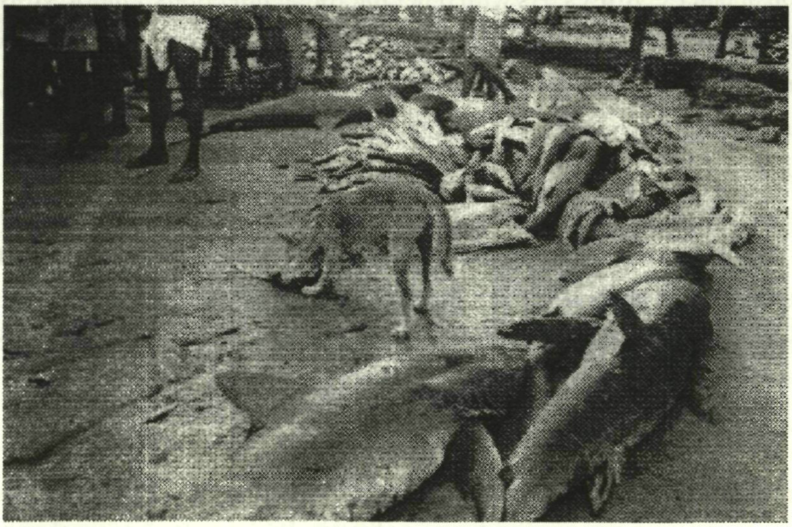


Figure 7 - Inadequate fencing around many fishery harbours allows domestic animals (dogs, cats, cattle and goats) free access to handling and processing areas where infected faeces may be deposited, causing a health hazard

1.5.4 Helminths

A great variety of helminth eggs and larvae have been detected in drinking water and it is clear that all those infective to man should be absent if the water supply is to be safe.

However, the majority of helminths are not waterborne and it is neither feasible nor necessary to monitor water for them on a routine basis. Two groups of helminths are more directly related to water supplies: those transmitted wholly by the ingestion of infected copepod intermediate hosts and those whose cercariae are directly infective to man. A third category groups the remainder of the species.

The first group (*Dracunculus, Spirometra*) comprises Helminths that develop in aquatic copepods and are acquired by man ingesting water containing the intermediate host crustacea. The most important member in this group is the guinea-worm *(Dracunculus medinensis)*, a filarial parasite of man.

Tapeworms of the genus Spirometra, though much rarer in man, also have a stage in aquatic copepods. Adult worms are found in the small intestine of cats. Eggs pass out in the faeces and hatch in water where they may be ingested by copepods.

The second group (*Schistosoma, Ancylostoma, Necator*) comprises a miscellaneous group of flukes and roundworms whose infective larvae are able to penetrate the human skin and mucous membranes.

The human hookworms *Ancylostoma duodenale* and *Necator americanus*, both with a wide tropical and sub-tropical distribution, have eggs that hatch and develop in the soil to the third stage larvae, which then reinfect man by penetrating the skin. Hookworms of domestic animals may also invade man.

The third group of Helminths has resistant eggs or cysts infective to man. If these gain access to drinking water and are ingested, man becomes infected. The most widespread intestinal Helminths are *Ascaris lumbricoides* (roundworm) and *Trichuris trichuria* (whipworm). The human tapeworms of the genera *Hymenolepis*, with a direct life cycle, and *Echinococcus*, where man is infected by ingesting eggs usually acquired from dogs, have the potential for spread in drinking water.

1.5.5 Special note on Malaria and Dengue

Both Malaria and Dengue are not transmitted directly by drinking water but by vectors or carriers that breed in water, in this case mosquitoes. In order to prevent the spread of these diseases, it is of the utmost importance that in all endemic areas, drinking water reservoirs within the port area be adequately covered to prevent mosquitoes from gaining access to the free water surface, where they can breed unhindered.

These reservoirs comprise :

- Elevated water distribution tanks (access manholes);
- Reinforced concrete reservoirs (access manholes);
- Header tanks, whatever size;
- Water cisterns in all toilets.

All manholes should be covered with purpose-made manhole covers and all vents should be equipped with filters or mosquitoe nets.

1.6 NUTRIENTS

Nitrates and nitrites are considered together because conversion from one form to another occurs in the environment. The health effects of nitrate are generally a consequence of its ready conversion to nitrite in the body.

1.6.1 Nitrates and Nitrites

Nitrates are widely present in substantial quantities in soil, in most waters, and in plants, including vegetables. Nitrites also occur fairly widely , but generally at very much lower levels than nitrates. Nitrates are products of oxidation of organic nitrogen by the bacteria present in soils and in water where sufficient oxygen is present. Nitrites are formed by incomplete bacterial oxidation of organic nitrogen. One of the principal uses of nitrate is as fertilizer. Nitrates are also used in explosives, as oxidizing agents in the chemical industry and as food preservatives. Its occurrence in water is brought about by indiscriminate fertilizer use, decaying vegetable and animal matter, sewage effluents, industrial discharges and last but not least, leachates from refuse dumps. Nitrates in the water are limited to 10 ppm.

1.7 PRIORITY POLLUTANTS

These are organic or inorganic compounds selected on the basis of their known or suspected carcinogenicity, mutagenicity, teratogenicity or high acute toxicity.

1.7.1 Arsenic

Arsenic is notorious as a toxic element. Its toxicity, however, depends on the chemical (valency) and physical form of the compound, the route by which it enters the body, the dose and duration of exposure and several other biological parameters. It is recommended that, when water is found to contain arsenic at levels of 0.05 ppm, an attempt should be made to ascertain the valency and chemical forms of the element. Arsenic is commonly associated as an alloying additive with lead solder, lead shot, battery grids, cable sheaths and boiler piping. Nowadays, most arsenic originates from paints or pharmaceuticals and is commonly found in sewage. The concentration of arsenic in sea water is around 0.002 ppm. The primary concerns are carcinogenicity and mutagenicity.

1.7.2 Asbestos

Asbestos is a general term for fibrous silicate minerals of the amphibole and serpentine mineral groups. Six minerals have been characterized as asbestos: chrysotile, crocidolite, anthophyllite, tremolite, actinolite and amosite. Asbestos is commonly found in domestic water supplies. The use of asbestos cement (170 g of asbestos per kg – 80% chrysotile and 20% crocidolite) for pipes in distribution systems could contribute to the asbestos content of drinking water. Background levels are reported to be in the range of less than 1 million to 10 million fibres per litre. The primary concern is carcinogenicity.

1.7.3 Barium

Barium is present in the earth's crust in a concentration of 0.50 g/Kg and the mineral barytes, barium sulphate, is the commonest source. Traces of barium are present in most soils.

Barium is also present in traces in many foodstuffs, such as brazil nuts. Barium is also used in various industrial processes, such as in vacuum tubes, spark-plug alloys, Getter alloys, Fray's metal and as a lubricant for anode rotors in X-ray machines. Drinking water should not contain more 0.050 ppm.

1.7.4 Beryllium

Beryllium is commonly found as part of feldspar mineral deposits and may exist as the mineral beryl in small localised deposits. The primary source of beryllium in the environment is the burning of fossil fuels, although contamination is normally light. Beryllium can enter the water system through weathering of rocks in ground acquifers, atmospheric fallout on rain water collection systems and industrial and municipal discharges. Beryllium is used in metal alloys and certain electrical components. Not all countries have set standards for limits of beryllium in drinking water. Those that have, limit its presence to 0.20 ppb.

1.7.5 Selenium

As a result of geochemical differences, levels of selenium in soil and vegetation vary within broad limits. The chemical form of selenium, and thus its solubility, is another decisive factor as regards its presence in drinking water. Selenium has been identified as an essential nutrient in several animal species, including man. Dietary selenium levels of 5 mg/kg of food or more may cause chronic intoxication, and in seleniferous areas this value has been considered as the dividing line between toxic and non-toxic feeds. Drinking water in general does not represent the only or main source of selenium exposure for the resident population in seleniferous areas. There is a range of selenium intake by humans that is consistent with health, and outside this range deficiency or toxicity can occur. Selenium in drinking water is limited to 0.01 ppm. Selenium is widely used in the electronics industry, TV cameras, solar batteries, computer cores, rectifiers, xerographic plates and ceramics as a colourant for glass. It is also used as a trace element for animal feeds.

1.7.6 Silver

Silver occurs naturally in elemental form and as various ores. It is also associated with lead, copper and zinc ores. Because some metals such as lead and zinc are used in distribution systems and also because in some countries silver oxide is used to disinfect water supplies, silver levels in tap water may sometimes be elevated. The levels of silver in drinking water should not exceed 1 ppb.

In industry, silver is used in the manufacture of silver nitrate, silver bromide and other photographic chemicals, water distillation equipment, mirrors, silver plating equipment, special batteries, table cutlery, jewelry, dental medical and scientific equipment including amalgams.

1.8 REFRACTORY ORGANICS

This group of contaminants is wide ranging and consists of chlorinated alkanes (*carbon tetrachloride*), chlorinated ethenes (*polyvinyl chloride or PVC*), polynuclear aromatic hydrocarbons (*naphtalene, coal tar*), pesticides, herbicides and fumigants (*DDT, Endrin, Aldrin, Lindane, Methoxychlor, Toxaphene and Silvex*), Mono- Dichlorobenzenes (*solvents*), Benzenes (*Benzene, Toluene*), Phenols and Chlorophenols and Trihalomethanes (*Chloroform, Bromoform*).

1.8.1 Chlorinated Alkanes

One of the major uses of chlorinated alkanes in the chemical industry is as an intermediate in the production of other organochlorine compounds. They are therefore produced in large quantities and consequently many are found in raw and finished drinking water. Carbon Tetrachloride is a haloalkane with a wide range of industrial and chemical applications. It has been found to be an occasional contaminant of chlorine used in the disinfection of drinking water but is not produced in drinking water as a result of the chlorination process itself. Carbon Tetrachloride was extensively used as a propellant for aerosols. This chemical has been found to be a carcinogen to laboratory animals The guideline limits this chemical to 3 ppb.

1.8.2 Chlorinated Ethanes

This group of compounds is used widely in a variety of industrial processes as solvents, softeners, paint thinners, dry-cleaning fluids, intermediates, etc. Because of their wide use, they are often found in raw and treated drinking water. Because of their high volatility, they are usually lost to the atmosphere from surface water and therefore generally occur at lower concentrations. Vinyl chloride is mainly used for the production of PVC resins which, in turn, form the most widely used plastics in the world. Low concentrations of PVC have been detected in effluents discharged by chemical and latex manufacturing plants and in drinking water as a result of leaching from substandard (improperly cured) PVC pipes used in water distribution systems. Vinyl chloride is associated with cancer and is mutagenic in a number of biological systems, including *Salmonella* and *E. Coli*. Other chlorinated ethenes include **1,1-dichloroethane** (used in the packaging industry), **trichloroethane** (used as a dry-cleaning solvent) and **tetrachloroethane** (used in dry-cleaning and as a degreasing agent in metal industries). The guideline limit for PVC is 20 ppb.

1.8.3 Polynuclear Aromatic Hydrocarbons

PAH are a large group of organic compounds present in the environment from both natural and industrial sources. PAH are rarely encountered singly in the environment and many interactions can occur with mixtures of PAH whereby the potency of known carcinogenic PAH may be enhanced. These systems are not well understood, however, and their significance as regards environmental exposure to PAH is not yet clear. Contact with coal-tar based linings during distribution is known in some instances to lead to an increase in PAH concentration in water. Because of the close association of PAH with suspended solids, the application of treatment to achieve an acceptable level of turbidity will ensure that minimum PAH levels are achieved. Aromatic hydrocarbons may enter the aquatic environment of the harbour basin from discharges from vessels as ballast water, bilge pumping, engine exhaust, effluents from coastal refineries, crude oil power stations, terrestrial run-off (particularly from urban storm water containing road asphalt particles) and leaching (creosoted components from jetties and wharves). A guideline of 0.01 ppb is recommended.

1.8.4 Pesticides

Pesticides that may be of importance to water quality include chlorinated hydrocarbons and their derivatives, persistent herbicides, soil insecticides, pesticides that are easily leached out from the soil, and pesticides systematically added to water supplies to control disease vectors, such as mosquito larvae (*Malaria and Dengue fever*). Of these compounds, only the chlorinated hydrocarbon insecticides occur frequently and these are very persistent in the environment where they have become ubiquitous. Typical pesticides include :

DDT (Dichloro Diphenyl Trichloroethane), a persistent insecticide, stable under most environmental conditions and resistant to complete breakdown by enzymes present in the soil microorganisms.

Aldrin and **Dieldrin**, two related and very persistent pesticides which accumulate in the food chain. Currently may be used for termite control around the roots of fruit trees.

Chlordane, a broad-spectrum insecticide also used for termite control and for homes and gardens.

HCB or hexachlorobenzene, produced commercially for use as a fungicide.

Heptachlor, another broad-spectrum insecticide used to control agricultural soil insects. Heptachlor is very persistent.

Lindane, a wide-spectrum insecticide of the group called organochlorine insecticides and used in a wide range of applications, including treatment of animals, buildings, water (for mosquitoes), plants, seeds and soil.

Methoxychlor, an insecticide used for the treatment of agricultural crops and livestock.

Guidelines for refractory organics limit total "*drins*" to 0.03 ppb and total "*ddt*" to 1.0 ppb.

1.8.5 Mono-Dichlorobenzenes

Monochlorobenzene is widely used as a solvent and in the manufacture of several chemicals, such as insecticides and phenols. Dichlorobenzenes are important intermediates for dyes, moth repellants, deodorants, dielectric fluids, heat transfer fluids and insecticides.

1.8.6 Benzenes

Benzene and Toluene are produced mainly from petroleum or as a by-product in the manufacture of gas. Both chemicals are widely used in the chemical industry both as intermediates and for the production of styrene, phenol, acetone and cyclohexene (used in manufacturing nylon).

Significant quantities of Toluene are used in the manufacture of plastics, paints, detergents and as petrol additives. The guideline for benzene in water is 10 ppb.

1.8.7 Phenols and Chlorophenols

Chlorphenols are used as biocides and are found in water **as a result of chlorinating water supplies containing phenol**. Chlorphenols are well known for their low taste and odour thresholds. For aesthetic reasons, therefore, individual phenols should not, as a general rule, be present in drinking water above 0.1 ppb. The best approach to controlling pollution by chlorphenols is to prevent the contamination of the source water by phenol (from petrochemical industries) and chlorinated phenolic pesticides (agriculture).

1.8.8 Trihalomethanes

Trihalomethanes (chloroform and bromoform) in drinking water occur principally as products of reaction of chemicals used in oxidative treatment reacting with naturally occurring materials present in the water. Their formation is particularly associated with the use of chlorine for disinfecting water supplies. Notwithstanding this, it is important to recognise the fact that chlorine is an effective water disinfectant and the hazards of disease arising from microbiological contaminants resulting from incomplete disinfection are substantial. Trihalomethanes have several adverse effects on health and the guideline value limits chloroform in drinking water to 30 ppb.

1.9 HEAVY METALS

Trace quantities of many metals are important constituents of most waters. Many of these metals are also classified as pollutants. The presence of any of these metals in excessive quantities will interfere with many beneficial uses of the water because of their toxicity.

1.9.1 Cadmium

Cadmium is widely distributed in the Earth's crust, but is particularly associated with zinc and copper and is produced commercially only as a by-product of zinc smelting. Cadmium shows no signs of being an essential trace element in biological processes; on the contrary, it is highly toxic to the human organism. Like mercury, cadmium and its compounds enter the environment only from geological or human activities (metal mining, smelting and fossil fuel combustion). Cadmium and its compounds are black-listed materials, which by international agreement may not be discharged or dumped into the environment. Cadmium is a cumulative poison and a maximum level of 0.005 ppm is permitted for drinking water.

1.9.2 Chromium

Most rocks and soils contain small amounts of chromium. Chromium in its naturally occurring state is in a highly insoluble form; however, most of the more common soluble forms found in soils are mainly the result of contamination by industrial emissions. The major uses of chromium are for chrome alloys, chrome plating, oxidising agents, corrosion inhibitors, pigments for the textile glass and ceramic industries as well as in photography. Hexavalent chromium compounds (soluble) are carcinogenic and the guideline value is 0.05 ppm.

1.9.3 Lead

Lead is not only the most abundant of heavy metals occurring in nature, it was also one of the first metals used on a large scale by man. Although it is not a nutritionally essential element, its monitoring is important because of its toxicity to human health. Lead is a cumulative poison. Most of the lead produced in metallic form, in batteries, cable sheathing, sheets and pipes, etc., is recovered and recycled, but most lead used in compound form, like paints and petrol additives is lost to the environment, eventually ending up in the aquatic environment. Lead compounds, similar to the ones used in petrol additives are reportedly being used in the production of mercurial fungicides. The presence of lead in drinking water is limited to 0.01 ppm.

1.9.4 Mercury

Although a comparatively rare element, mercury is ubiquitous in the environment, the result of natural geological activity and man-made pollution. Mercury from natural sources can enter the aquatic environment via weathering, dissolution and biological processes. Although extremely useful to man, mercury is also highly toxic to the human organism, especially in the form of methyl mercury, because it cannot be excreted and therefore acts as a cumulative poison.

The potential for long-term human health hazards from ingesting mercury-contaminated fish has led several nations to establish regulations and guidelines for allowable sea-food mercury levels. Nearly all levels above 1 ppb in water are due to industrial effluents connected with chlorine and caustic soda production, pharmaceuticals, mirror coatings, mercury lamps and certain fungicides.

1.9.5 Nickel

Nickel is ubiquitous in the environment. Nickel is almost certainly essential for animal nutrition, and consequently it is probably essential to man. Nickel is a relatively non-toxic element; however, certain nickel compounds have been shown to be carcinogenic in animal experiments.

1.9.6 Tin

Tin and its compounds are significant and controversial chemicals in the environment. As is the case with other elements, not all chemical forms of tin are equally biologically active. In contrast to the low toxicity of inorganic tin (derived from eating canned foods), some organic tin compounds, also known as organotins, are toxic. Tributyltin and Triphenyltin, constituents of anti-fouling paints, are highly toxic and their presence in harbour waters is limited generally to 0.002 and 0.008 ppb respectively. In many countries, organotin anti-fouling paints are not allowed on vessels less than 25 metres long. and the start of a fishing season generally sees an increase of this compound in the water as freshly painted vessels are launched back into the water..

1.10 DISSOLVED INORGANICS

Dissolved inorganic compounds are generally associated with the aesthetic and organoleptic (taste and odour) characteristics of drinking water. For health-related contaminants, what is unsafe for one is unsafe for all, while aesthetic and organoleptic characteristics are subject to social, economic and cultural considerations. Since the majority of consumer complaints regarding water quality relate to its colour, taste or odour, the quality of drinking water, as perceived by the senses, largely determines the acceptability of a particular water.

1.10.1 Aluminium

Aluminium does not appear to be an essential nutrient to man. Compared with the aluminium intake from food, that from water is small. The incidence of discoloration in drinking water in distribution systems increases if the aluminium level exceeds 0.1 ppm.

1.10.2 Chlorides

Chlorides are widely distributed in nature and are present in mineral deposits, in sea water and some industrial processes. The taste threshold for chloride in drinking water is dependent upon the associated cation, but is usually within the range 200-300 ppm of chloride. Based on organoleptic considerations, the guideline value for chloride is 250 ppm.

1.10.3 Colour

Colour in drinking water may be due to the presence of: coloured organic substances, such as humics (decay of vegetation in the water); metals such as iron and manganese; or highly coloured industrial wastes, of which pulp, paper and textile wastes are the most common. Chlorine from the chlorination process is likely to give rise to high levels of trihalomethanes due to the reaction of chlorine with dissolved humic substances.

1.10.4 Copper

The presence of Copper in the water supply, although not constituting a hazard to health, may interfere with the intended domestic uses of water. Copper enhances corrosion of aluminium and zinc fittings, stains clothes and plumbing fixtures. Copper is used in alloys, as a catalyst, in anti-fouling paints and as a wood preservative. Urban sewage contains substantial amounts of copper. The human taste threshold for copper is low, 5.0 - 7.0 ppm, and the taste is repulsive. The limit for drinking water is 1.0 ppm.

1.10.5 Hardness

Water hardness is the traditional measure of the capacity of water to react with soap, hard water requiring a considerable amount of soap to produce a lather. The degree of hardness of drinking water has been classified in terms of its equivalent $CaCO_3$ concentration as follows :

soft	0	to	60 ppm
medium hard	60	to	120 ppm
hard	120	to	180 ppm
very hard	180	to	and above

Soft water has a greater tendency to cause corrosion of pipes and consequently, certain heavy metals such as copper, zinc, lead and Cadmium may be present in the water.

Very hard water, on the other hand, can cause considerable incrustations in pipes and fittings, especially in fish processing plants.

1.10.6 Hydrogen Sulphide

Hydrogen sulphide occurs as a by-product in septic tanks when proteins in sewage are attacked by certain bacteria. Traces in water in excess of 0.05 ppm cause taste and odour problems.

1.10.7 Iron

The presence of Iron in drinking water is objectionable for a number of reasons unrelated to health. Under the pH conditions existing in drinking water supplies, ferrous salts are unstable and precipitate as insoluble ferric hydroxide, which settles out as rusty silt. Such water tastes unpalatable, promotes the growth of "iron bacteria" and the silt gradually reduces the flow of water in the piping. The recommended guideline level of iron in water is 0.3 ppm.

1.10.8 Manganese

Anaerobic groundwater often contains elevated levels of dissolved manganese. The presence of Manganese in drinking water is objectionable for a number of reasons unrelated to health. At concentrations exceeding 0.15 ppm Manganese imparts an undesirable taste to beverages and stains plumbing fixtures. The recommended value is 0.1 ppm.

1.10.9 pH

The value of the pH, expressed as a value ranging between 1 and 10, is a good indicator of the state of the water. Values of 9.5 and above are alkaline in taste. Values of 3 and below are acidic in taste. Values lower than 6 cause problems with corrosion. Values below 4 support little life in a marine environment. Drinking water should have a pH in the range 6.5 to 8.5. Harbour water should have a pH of between 6 and 9.

1.10.10 Sodium

The sodium ion is ubiquitous in water owing to the high solubility of its salts and the abundance of mineral deposits. Near coastal areas, windborne sea spray can make an important contribution, either by fallout on to land surfaces where it drains to the water source or from washout by rain. Domestic, commercial and industrial discharges are another source of sodium in water. In general, sodium salts are not acutely toxic substances because of the efficiency with which mature kidneys excrete sodium. The effects on infants, in contrast to adults, are different because of the immaturity of infant kidneys. A maximum of 200 ppm is allowed in drinking water.

1.10.11 Sulphates

Sulphates are widely distributed in nature and excessive amounts of dissolved sulphates in drinking water lead to problems with hardness. Taste threshold concentrations for the most prevalent sulphate salts are : 200 to 500 ppm for sodium sulphate; 250 to 900 ppm for calcium sulphate; and 400 to 600 ppm for magnesium sulphate. In drinking water, dissolved sulphates are limited to 400 ppm

1.10.12 Zinc

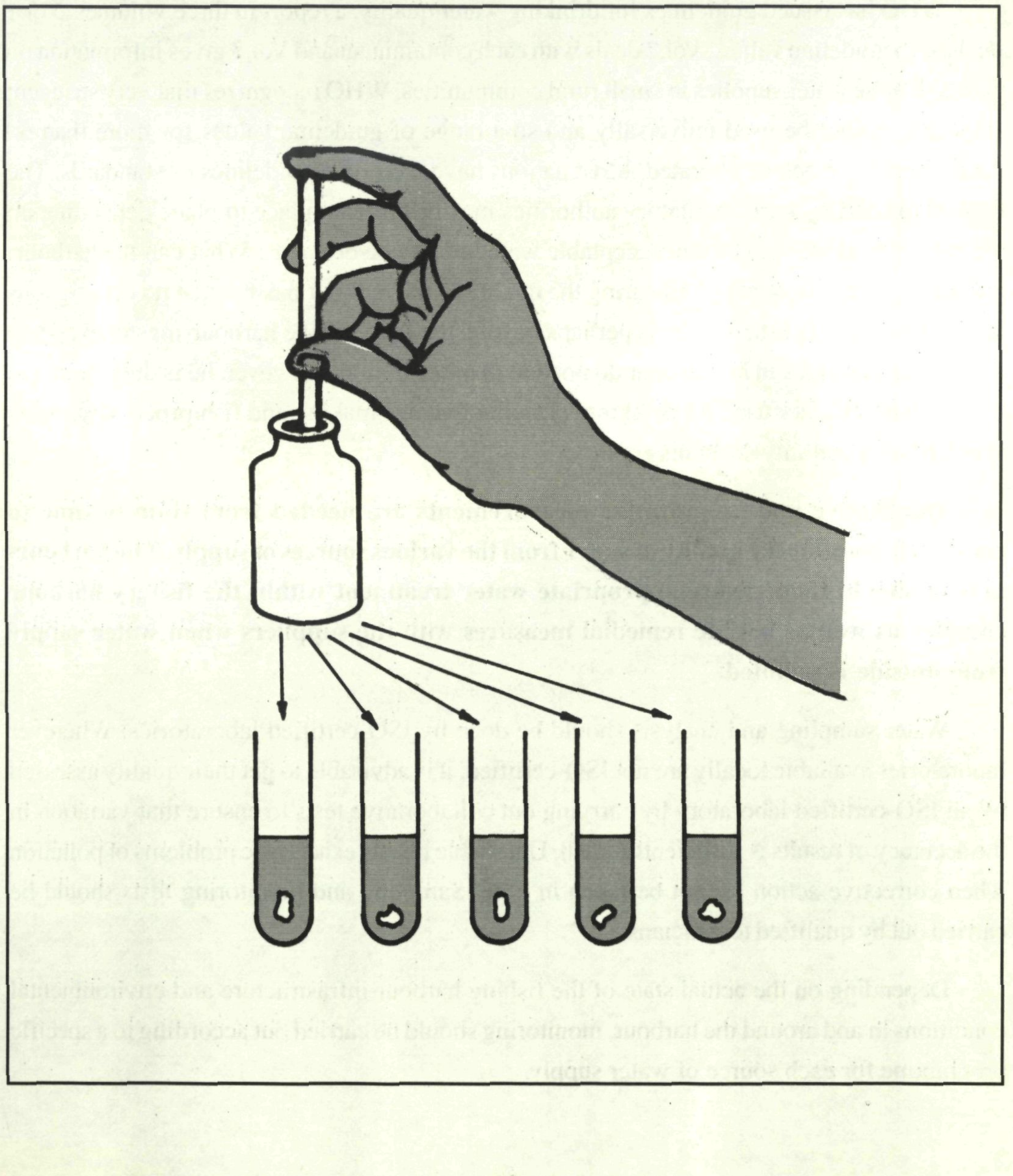
The concentration of zinc in tap water can be considerably higher than that in surface water owing to the leaching action of zinc from galvanised pipes, brass and other zinc alloys. Zinc imparts to water an undesirable astringent taste and in concentrations in excess of 5 ppm. The water may appear opalescent and develop a greasy film on boiling. Levels of zinc should be kept well below this value.

1.10.13 Petroleum Hydrocarbons

Humans have a very low taste threshold for petroleum hydrocarbons, whose taste is particularly repulsive. All components of crude oil are degradable by bacteria, though at varying rates, and a variety of yeasts and fungi can also metabolize petroleum hydrocarbons. Water-soluble components of crude oils and refined products include a variety of compounds that are toxic. High-molecular-weight tars are less damaging in the water than medium-molecular-weight compounds such as diesel. Low-molecular-weight compounds are generally unimportant because they are very volatile and rapidly evaporate. Therefore, diesel spillage at sea is more damaging than crude oil (very tarry) or petrol spillage. For harbour basin water, the limit for dissolved hydrocarbons should not exceed 0.30 ppm. Polluted harbour water can impart an unpleasant flavor to fish if used for washing. Commercial fishermen may also risk tainting a whole catch if their nets have been fouled by diesel or oil.

Chapter 2

WATER QUALITY MONITORING, STANDARDS AND TREATMENT



2.1 WATER SAMPLING

Water used for processing fish, washing fish or making ice is supposed to meet drinking water standards if it is to be considered safe. Reason: contaminated water is the main cause for pathogen-loading of fish, posing a serious health hazard to its consumer.

WHO has issued guidelines for drinking water quality, a report in three volumes. Vol.1 deals with guideline values, Vol.2 deals with each contaminant and Vol.3 gives information on how to handle water supplies in small rural communities. WHO recognizes that very stringent standards cannot be used universally and so a range of guideline values for more than 60 parameters have been elaborated. Most nations have their own guidelines or standards. The control exerted by local regulatory authorities may differ from place to place depending on the local situation. So how can acceptable water quality be defined ? What can the harbour-master do to ensure quality ? Ensuring the quality of the harbour basin when it is contiguous with estuarine or coastal waters is perhaps beyond the scope of the harbour-master except to ensure that activities in his harbour do not add to the pollution. However, he is duty-bound to ensure that the water used for drinking, cleaning fish, ice making and fish processing meets standards of potability set in his country.

Qualitative and quantitative measurements are needed from time to time to constantly monitor the quality of water from the various sources of supply. The harbour-master should then ensure appropriate water treatment within the fishery harbour complex as well as initiate remedial measures with the suppliers when water supply from outside is polluted.

Water sampling and analysis should be done by ISO-certified laboratories. Wherever laboratories available locally are not ISO-certified, it is advisable to get their quality assessed by an ISO-certified laboratory by carrying out collaborative tests to ensure that variation in the accuracy of results is sufficiently small. Unreliable results exacerbate problems of pollution when corrective action cannot be taken in time. Sampling and monitoring tests should be carried out by qualified technicians.

Depending on the actual state of the fishing harbour infrastructure and environmental conditions in and around the harbour, monitoring should be carried out according to a specific programme for each source of water supply.

2.1.1 Borewells

Contamination may arise from pollutants entering the water table some distance from the port or from sewage entering the borehole itself in the port area through cracked or corroded casings. In cases where overdrawing is evident (water is brackish), tests should be conducted at least monthly.

2.1.2 Municipal mains

Supply could be contaminated at source or through corroded pipelines leading to the fishery harbour. Mixing with sewage lines due to defective piping has been known to occur often. Complete tests should be carried out every half year, and the authorities should be informed when results indicate contamination.

2.1.3 Water Tanks and Reservoirs

Both types of structure are prone to bacterial growth if the residual chlorine levels in them are low or non-existent. Testing may not be necessary if periodic scrubbing is carried out. Bacteriological tests should be done at least half-yearly.

2.1.4 Harbour Basin Water

Typically, harbour basins are tested yearly. However, in areas where monsoons are very active, it may be advisable to test at the peak of the dry season when effluent point discharges tend to remain concentrated in the water body and again during the wet season when agriculture run-off may be considerable. Another critical period for harbours is the peak of the fishing season when the harbour is at its busiest and vessel-generated pollution is likely to be at its peak.

2.2 TESTING PROCEDURES

While the details of sampling, testing and analysis are beyond the scope of this handbook, what follows is a general description of the significance of water quality tests usually made.

Testing procedures and parameters may be grouped into physical, chemical, bacteriological and microscopic categories.

- *Physical tests* indicate properties detectable by the senses.
- *Chemical tests* determine the amounts of mineral and organic substances that affect water quality.
- *Bacteriological tests* show the presence of bacteria, characteristic of faecal pollution.

2.2.1 Physical Tests

Colour, turbidity, total solids, dissolved solids, suspended solids, odour and taste are recorded.

Colour in water may be caused by the presence of minerals such as iron and manganese or by substances of vegetable origin such as algae and weeds. Colour tests indicate the efficacy of the water treatment system.

Turbidity in water is because of suspended solids and colloidal matter. It may be due to eroded soil caused by dredging or due to the growth of micro-organisms. High turbidity makes filtration expensive. If sewage solids are present, pathogens may be encased in the particles and escape the action of chlorine during disinfection.

Odour and taste are associated with the presence of living microscopic organisms; or decaying organic matter including weeds, algae; or industrial wastes containing ammonia, phenols, halogens, hydrocarbons. This taste is imparted to fish, rendering them unpalatable. While chlorination dilutes odour and taste caused by some contaminants, it generates a foul odour itself when added to waters polluted with detergents, algae and some other wastes.

2.2.2 Chemical Tests

pH, hardness, presence of a selected group of chemical parameters, biocides, highly toxic chemicals, and B.O.D are estimated.

pH is a measure of hydrogen ion concentration. It is an indicator of relative acidity or alkalinity of water. Values of 9.5 and above indicate high alkalinity while values of 3 and below indicate acididity. Low pH values help in effective chlorination but cause problems with corrosion. Values below 4 generally do not support living orgaisms in the marine environment. Drinking water should have a pH between 6.5 and 8.5. Harbour basin water can vary between 6 and 9.

B.O.D.: It denotes the amount of oxygen needed by micro-organisms for stabilization of decomposable organic matter under aerobic conditions. High B.O.D. means that there is less of oxygen to support life and indicates organic pollution.

2.2.3 Bacteriological Tests

For technical and economic reasons, analytical procedures for the detection of harmful organisms are impractical for routine water quality surveillance. It must be appreciated that all that bacteriological analysis can prove is that, at the time of examination, contamination or bacteria indicative of faecal pollution, could or could not be demonstrated in a given sample of water using specified culture methods. In addition, the results of routine bacteriological examination must always be interpreted in the light of a thorough knowledge of the water supplies, including their source, treatment, and distribution.

Whenever changes in conditions lead to deterioration in the quality of the water supplied, or even if they should suggest an increased possibility of contamination, the frequency of bacteriological examination should be increased, so that a series of samples from well chosen locations may identify the hazard and allow remedial action to be taken. Whenever a sanitary survey, including visual inspection, indicates that a water supply is obviously subject to pollution, remedial action must be taken, irrespective of the results of bacteriological examination. For unpiped rural supplies, sanitary surveys may often be the only form of examination that can be undertaken regularly.

The recognition that microbial infections can be waterborne has led to the development of methods for routine examination to ensure that water intended for human consumption is free from excremental pollution. Although it is now possible to detect the presence of many pathogens in water, the methods of isolation and enumeration are often complex and time-consuming. It is therefore impractical to monitor drinking water for every possible microbial pathogen that might occur with contamination. A more logical approach is the detection of organisms normally present in the faeces of man and other warm- blooded animals as indicators of excremental pollution, as well as of the efficacy of water treatment and disinfection. The presence of such organisms indicates the presence of faecal material and thus of intestinal pathogens. *(The intestinal tract of man contains countless rod-shaped bacteria known as coliform organisms and each person discharges from 100 to 400 billion coliform organisms per day in addition to other kinds of bacteria).* Conversely, the absence of faecal commensal organisms indicates that pathogens are probably also absent. Search for such indicators of faecal pollution thus provides a means of quality control. The use of normal intestinal organisms as indicators of faecal pollution rather than the pathogens themselves is a universally accepted principle for monitoring and assessing the microbial safety of water supplies. Ideally, the finding of such indicator bacteria should denote the possible presence of all relevant pathogens.

Indicator organisms should be abundant in excrement but absent, or present only in small numbers, in other sources; they should be easily isolated, identified and enumerated and should be unable to grow in water. They should also survive longer than pathogens in water and be more resistant to disinfectants, such as chlorine. In practice, these criteria cannot all be met by any one organism, although many of them are fulfilled by coliform organisms, especially *Escherichia coli* as the essential indicator of pollution by faecal material of human or animal origin.

2.3 INVESTIGATIVE ANALYSIS

A harbour master's knowledge of the state of the environment in and around the fishing harbour goes a long way toward preventing outbreaks of contamination or disease with subsequent loss of resources and income. This is particularly so for the many small-to-medium fishing ports scattered around coastlines in developing countries, where, more often than not, environmental help and support from central bodies is meagre and very time-consuming.

The following is a true-life example of an investigative analysis carried out in an ASEAN country in a harbour that was experiencing problems with hygiene (coliform contaminated fish).

2.3.1 Test Case

The port in question is situated in the mouth of an estuary. The town's water supply cannot provide the port with potable water and the port draws groundwater from a series of boreholes in and around the port area. The port's storage infrastructure consists of only one elevated concrete tank which cannot be taken out of service for cleaning. Ice is supplied by outside contractors.

Current laboratory test results were examined and found to be too consistent to reflect natural changes in the environment, pointing a finger of suspicion at the laboratory's Quality Assurance. **A new laboratory with I.S.O. certification was selected to carry out the new tests.**

Water samples were taken by external technicians from the port's borehole, the auction hall's water taps, each and every one of the external ice suppliers and the harbour basin.

A sample report from the laboratory is shown in Table 2-1, on page 42.

In this table, the first column indicates the test parameter and the last column indicates the method used to determine the test result (sometimes, more than one method may be used to determine residuals).

The second column indicates how the parameters are measured (see page 14), the third column gives the actual test result which may then be compared to the values in the fourth column. The values in the fourth column are national standards or limits set by Governments and may differ from country to country. The values in the third column should not exceed those in the fourth column.

Table 2-2 shows the recommended WHO standard limits for potable water.

Table 2-1
SAMPLE WATER ANALYSIS REPORT - PORT TAP WATER

Parameter	Unit	Test Remarks	Requirement	Methods
Physical & Chemical*):				
•Colour	Pt.Co scale	3	15	Colorometric
•Odour	,,	negative	odourless	Organoleptic
•pH	,,	6.50	6.5 - 8.5	Electrometric
•Taste	,,	normal	tasteless	Organoleptic
•Turbity	FTU	1	5	Turbidity
•Alumunium	mg/l	below 0.20	0.2	AAS
•Copper	mg/l	below 0.03	1.0	AAS
•Iron Total	mg/l	below 0.04	0.3	AAS
•Manganese	mg/l	0.06	0.1	AAS
•Sodium	mg/l	96.93	200	AAS
•Zinc	mg/l	0.047	5	AAS
•Chloride	mg/l	140.41	250	Argentometric
•Flouride	mg/l	0.09	1.5	Colorimetric
•Nitrate	mg/l	below 0.11	10	Colorimetric
•Nitrite	mg/l	0.96	1	Colorimetric
•Sulphate	mg/l	below 0.94	400	Turbidimetric
•Arsenic	mg/l	below 0.001	0.05	AAS
•Barium	mg/l	below 0.10	1	AAS
•Cadmium	mg/l	below 0.005	0.005	AAS
•Cyanide	mg/l	below 0.01	0.1	Colorimetric
•Chrom Hexavalent	mg/l	below 0.006	0.05	Colorimetric
•Lead	mg/l	below 0.01	0.05	AAS
•Mercury	mg/l	below 0.001	0.001	AAS
•Selenium	mg/l	below 0.007	0.01	AAS
•Organic Matter by $KMnO_4$	mg/l	3.06	10	Permanganantometric
•Dissolved Solid	mg/l	431	1000	Gravimetric
•Hydrogen Sulphide as H_2S	mg/l	below 0.01	0.05	Colorimetric
•Total Hardness	mg $CaCO_3$	95.49	500	AAS
Bacteriological:				
•Total Bacteria	per ml	6.9×10^2	1.0×10^2	Pour Plate
•Coliform	per 100 ml	nil	nil	Filtration
•E.Coli	per 100 ml	nil	nil	Filtration
•Salmonella sp	per 100 ml	negative	nrgative	Filtration

*) Standard Methods

A. Examination of the port's deep borehole test report revealed that whereas the iron and manganese levels were over the limit, indicating vegetable matter in the acquifer, the sodium and chloride levels were low, indicating that the pump was not overdrawing. Both the nitrate and nitrite levels were low indicating that sewage intrusion into the borehole casing was not a problem. The total bacterial count, however, was very high, indicating that the water has to be chlorinated to lower the count.

B. Examination of the auction hall's tap water test report (comparing them to the borehole water) indicates that the bacterial count is slightly lower but not enough to be considered sanitary and fit for drinking. The turbidity also dropped dramatically between borehole and tap, indicating deposition of solids inside the port's only storage tank. The nitrate level also drops as the nitrates are further converted to nitrites indicating bacteriological activity inside the overhead tank as well. As it turned out, chlorinating equipment was not installed.

C. Examination of the ice test reports reveals that both sodium and chlorides are over the limit indicating either leaking cans at the ice plants (dirty brine water enters the ice water during the chilling operation) or overdrawing at the plant's borehole. Closer examination also revealed that the nitrite levels are very high (indicating decomposed sewage) and that coliforms were present in the ice. This pointed a finger at the borehole of one particular plant, which in fact was found to be overdrawing water to meet an increase in demand. The presence of the coliforms also indicated that the ice plant's own chlorinating equipment was not functioning properly.

D. A close look at the river basin water indicated heavy contamination by sewage of the water course.

The conclusions to be drawn from the above exercise are that :

a) The most likely source of contamination was the ice supplied to the fishermen, which in turn contaminated the fish in the holds;

b) The port's own water supply and storage system was in need of an overhaul;

c) The port's river water was not to be used in any of the fish handling processes.

Table 2-3 gives the EU recommendations for harbour waters in general.

Harbour water is never suitable for use in fish handling processes destined for human consumption.

Table 2-2
W.H.O. DRINKING WATER STANDARDS

PARAMETER	UNIT	LIMIT
Aluminium	mg Al/l	0.2
Arsenic	mg As/l	0.05
Barium	mg Ba/l	0.05
Berylium	ug Be/l	0.2
Cadmium	ug Cd/l	5.0
Calcium	mg Ca/l	200.0
Chromium	mg Cr/l	0.05
Copper	mg Cu/l	1.0
Iron Total	mg Fe/l	0.3
Lead	mg Pb/l	0.01
Magnesium	mg Mg/l	150.0
Manganese	mg Mn/l	0.1
Mercury	ug Hg/l	1.0
Selenium	mg Se/l	0.01
Sodium	mg Na/l	200.0
Zinc	mg Zn/l	5.0
Chlorides	mg Cl/l	250.0
Cyanide	mg Cn/l	0.1
Fluorides	mg F/l	1.5
Nitrates	mg NO_3/l	10.0
Nitrites	mg NO_2/l	-
Sulphates	mg SO_4/l	400.0
Suphides	mg H_2S/l	0
TOTAL "drins"	ug/l	0.03
TOTAL "ddt"	ug/l	1.0
Hydrocarbons	mg/l	0.1
Anionic Detergents	mg/l	0
pH		9.2
Total dissolved solids	mg/l	1500
Total hardness	mg/l	500
Alkalinity	mg/l	500
MICROBIOLOGICAL PARAMETERS		
Total Bacteria	Count/ml	100
Coliform	Count/100ml	0
E. Coli	Count/100ml	0
Salmonella	Count/100ml	0

ug = microgram or ppb   mg = milligram or ppm

Table 2-3
EU ESTUARY AND HARBOUR BASIN WATER STANDARDS

PARAMETER	UNIT	LIMIT
Mercury	ug Hg/l	0.50 (D)
Cadmium	ug Cd/l	5.00 (D)
Arsenic	mg As/l	0.50 (G)
Chromium	mg Cr/l	0.50 (G)
Copper	mg Cu/l	0.50 (G)
Iron	mg Fe/l	3.00 (G)
Lead	mg Pb/l	0.50 (G)
Nickel	mg Ni/l	0.50 (G)
Zinc	mg Zn/l	50.00 (G)
Tributyltin	ug /l	0.002
Triphenyltin	ug /l	0.008
Aldrin	ug /l	0.01
Dieldrin	ug /l	0.01
Endrin	ug /l	0.005
Isodrin	ug /l	0.005
TOTAL "drins"	ug /l	0.03
TOTAL "ddt" all 4 isomers	ug /l	0.025
para-ddt	ug /l	0.01
Hexachloro-cyclohexane	ug /l	0.02
Carbon tetrachloride	ug /l	12.0
Pentachlorophenol	ug /l	2.0
Hexachlorobenzene	ug /l	0.03
Hexachlorobutadiene	ug /l	0.10
Chloroform	ug /l	12.0
Ethylene Dichloride	ug /l	10.0
Perchloroethylene	ug /l	10.0
Trichlorobenzene	ug /l	0.40
Trichloroethylene	ug /l	10.0
Hydrocarbons	ug /l	300.0 (G)
Phenols	ug /l	50.0
Surfactants	ug /l	300.0 (G)
Dissolved Oxygen	% Saturation	80-120 (G)
pH		6 - 9
Sulphide	mg /l	0.04 (S)
MICROBIOLOGICAL PARAMETERS		
Faecal coliforms	per 100ml	2000
Total coliforms	per 100ml	10000
Salmonella		0
Entero viruses		0

ug = microgram   mg = milligram   D - Dissolved
G-Guideline   S-Suggested

2.4 WATER TREATMENT METHODS

Treatment of raw water to produce water of potable quality can be expensive. It is advisable to determine the quantity of water needing treatment, as **not all water used in a fishery harbour or processing plant needs to be of potable quality**. Sizing of the equipment is crucial to produce acceptable water at reasonable cost. The main point to remember is that separate systems and pipelines are required for potable and non-potable water to avoid cross contamination. Each system must be clearly identified by contrasting coloured pipelines.

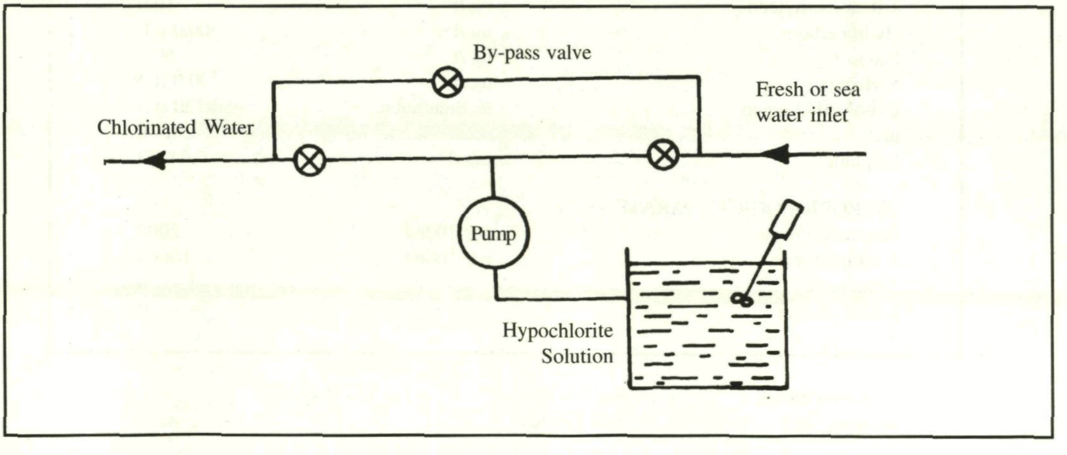
Water used for drinking, cleaning fish and ice-making must be free from pathogenic bacteria and may require secondary treatment or even complete treatment depending on chemical elements that need to be removed. Water for other needs like general cleaning may perhaps need only primary treatment.

2.4.1 Primary Treatment

There are four methods of primary treatment : chlorination; ozone treatment; ultraviolet treatment; and membrane filtration.

Chlorination: Fresh or sea water can be chlorinated using either chlorine gas or hypochlorites. Chlorinated water minimizes slime development on working surfaces and helps control odour.

Figure 8 : CHLORINATION TREATMENT



The main advantages of using chlorine gas are:

- It is the most efficient method of making free chlorine available to raw water.
- It lowers the pH of the water slightly.
- Control is simple; testing simple; and it is not an expensive method.

The main disadvantages are:

- Chlorine gas is toxic and can combine with other chemicals to form combustible and explosive materials.
- Automatic control systems are expensive.
- Chlorine cylinders may not be readily available at small centres.
- Chlorine expands rapidly on heating and hence the cylinders must have fusible plugs set at 70°C. It also reacts with water, releasing heat. Water should not therefore be sprayed on a leaking cylinder.

Figure 9 : PERCENTAGE OF AVAILABLE CHLORINE BY WEIGHT

COMPOUND	CHEMICAL COMPOSITION	% CHLORINE BY WEIGHT
Chlorine gas	Cl_2	100.0
Monochloramine	$NH_2 Cl$	138.0
Diochloramine	NH_4Cl_2	165.0
Hypochlorous Acid	HOCl	135.4
Calcium hypochlorite	$Ca(OCl_2)$	99.2

Hypochlorites are generally available in two forms - sodium hypochlorite solution normally available at 10% concentration and calcium hypochlorite available as a powder.

The main disadvantages of using hypochlorites are:

- Calcium hypochlorite is not stable and must be stored in air-tight drums.
- Sodium hypochlorite is quite corrosive and cannot be stored in metal containers
- Sodium hypochlorite must be stored in light proof containers.
- It is difficult to control the rate of addition of hypochlorites in proportion to water flow.
- Hypochlorites raise the pH in water.
- They are more expensive than chlorine gas.

It is important to understand the manner in which chlorine or chlorine-releasing substances behave when added to water, depending on other substances present.

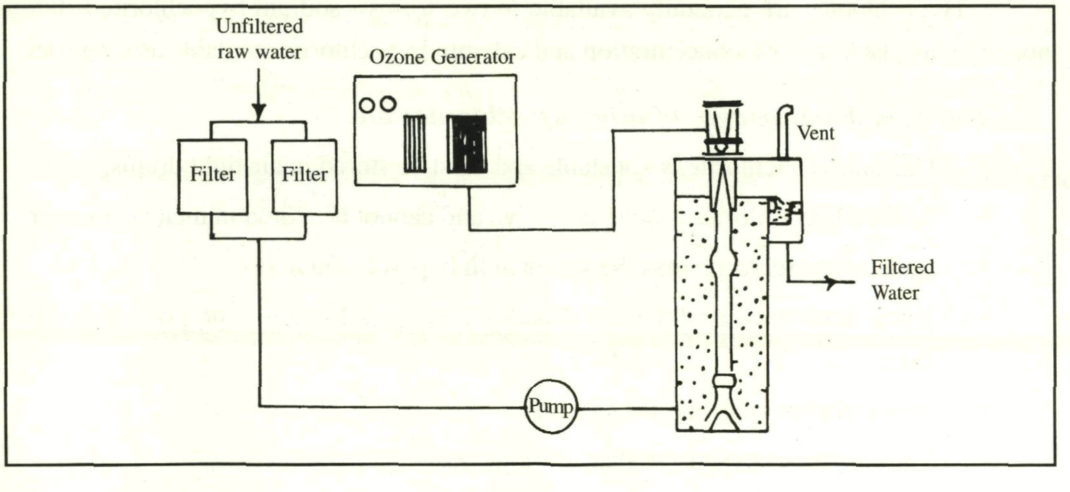
- When water contains reducing substances like ferrous salts or hydrogen sulphide, these will reduce part of the added chlorine to chloride ions.
- When water contains ammonia, organic matter, bacteria and other substances capable of reacting with chlorine, the level of free chlorine will be reduced.
- If the quantity of chlorine added is sufficiently large to ensure that it is not all reduced or combined, a portion of it will remain free in the water. This is termed as *residual free chlorine or free chlorine.*

When chlorine reacts chemically as in the first two cases, it loses its oxidising power and consequently its disinfecting properties. Some ammoniacal chlorides however still retain some disinfecting properties. Chlorine present in this form is termed *residual combined chlorine or combined chlorine.*

From the standpoint of disinfection, the most important form is free chlorine. Routine analysis always aims at determining at least the free chlorine level.

Ozone treatment: Though the principle is relatively simple, this method needs special equipment, supply of pure oxygen and trained operators. Ozone is generated by passing pure

Figure 10 : OZONE TREATMENT



oxygen through an ozone generator. It is then bubbled through a gas diffuser at the bottom of an absorption column, in a direction opposite to the flow of raw water. Retention or contact time is critical and the size of the absorption column depends on the water flow.

The main advantages of ozone treatment are:

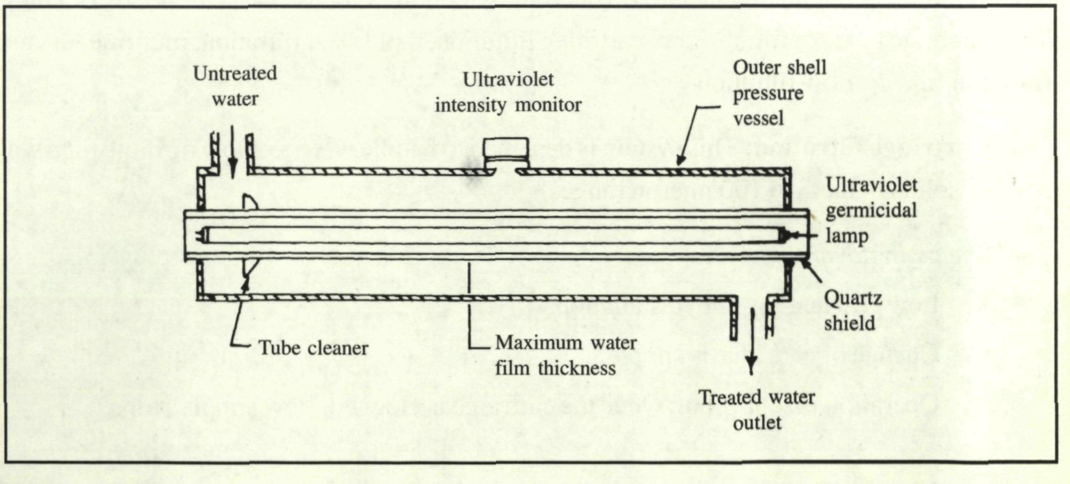
- Ozone is a much more powerful germicide than chlorine especially for faecal bacteria.
- It reduces turbidity of water by breaking down organic constituents.
- The process is easily controlled.

The disadvantages are:

- Pure oxygen may not be readily available locally.
- Ozonized water is corrosive to metal piping.
- Ozone decomposes rapidly into oxygen.
- Water has to be aerated prior to use to remove the ozone.

Ultraviolet irradiation treatment: This method is often used to treat drinking water. Successful commercial installations have been made to purify sea water in large fish processing plants.

Figure 11 : ULTRAVIOLET IRRADIATION TREATMENT



The main advantages of U-V treatment are:

- U-V rays in the range of 2500-2600 Angstrom units are lethal to all types of bacteria.
- There is no organoleptic, chemical or physical change to the water quality.
- Overexposure does not have any ill effects.

The main disadvantages are:

- Electricity supply should be reliable.
- Turbidity reduces efficiency.
- Water may require prior treatment like filtration.
- The unit requires regular inspection and maintenance.
- Thickness of the water film should not exceed 7.5 cm.

Membrane filtration: Osmotic membrane treatment methods are generally expensive for commercial scale installations. Combinations of membrane treatment with U-V treatment units are available for domestic use.

2.4.2 Secondary treatment

Secondary treatment of water consists of sedimentation and filtration followed by chlorination. Sedimentation can be carried out by holding the raw water in ponds or tanks. The four basic types of filtration are cartridge filtration, rapid sand filtration, multimedia sand filtration, and up-flow filtration.

Cartridge filtration: This system is designed to handle waters of low turbidity and will remove solids in the 5 to 100 micron range.

The main advantages are:

- Low cost and 'in-line' installation.
- Change of cartridge is simple.
- Operation is fool-proof. Once the cartridge is clogged, flow simply stops.

The main disadvantages are:

- Sudden increase in turbidity overloads the system.
- Cartridges may not be readily available and large stocks may be required.

Rapid sand filtration: This system consists of a layer of gravel with layers of sand of decreasing coarseness above the gravel. As solids build up on top, flow decreases until it stops. This is corrected by back- flushing the system to remove the solid build up on top, Figure 12.

The main advantages are:

- Cost of filtration media is negligible.
- Operation is simple.

The main disadvantages are:

- A holding tank for filtered water is required to provide clear water back flushing.
- Pumping loads increase as sediments build up.

Figure 12
RAPID SAND FILTRATION

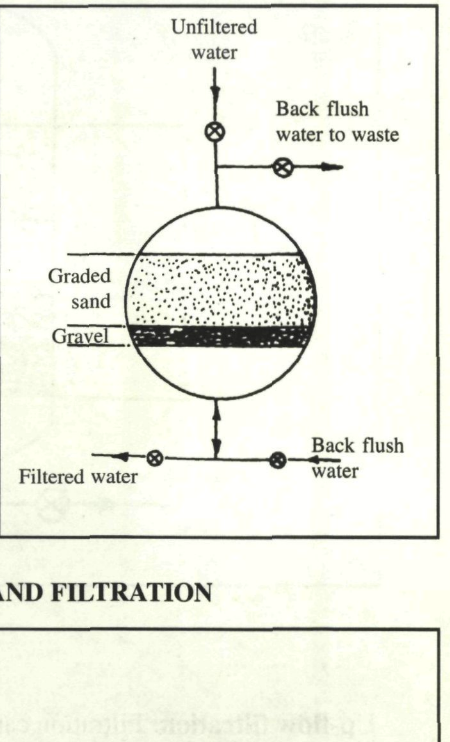
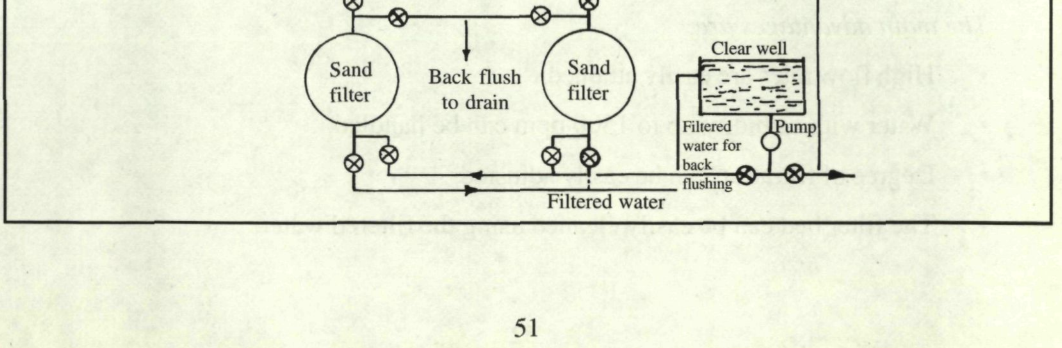
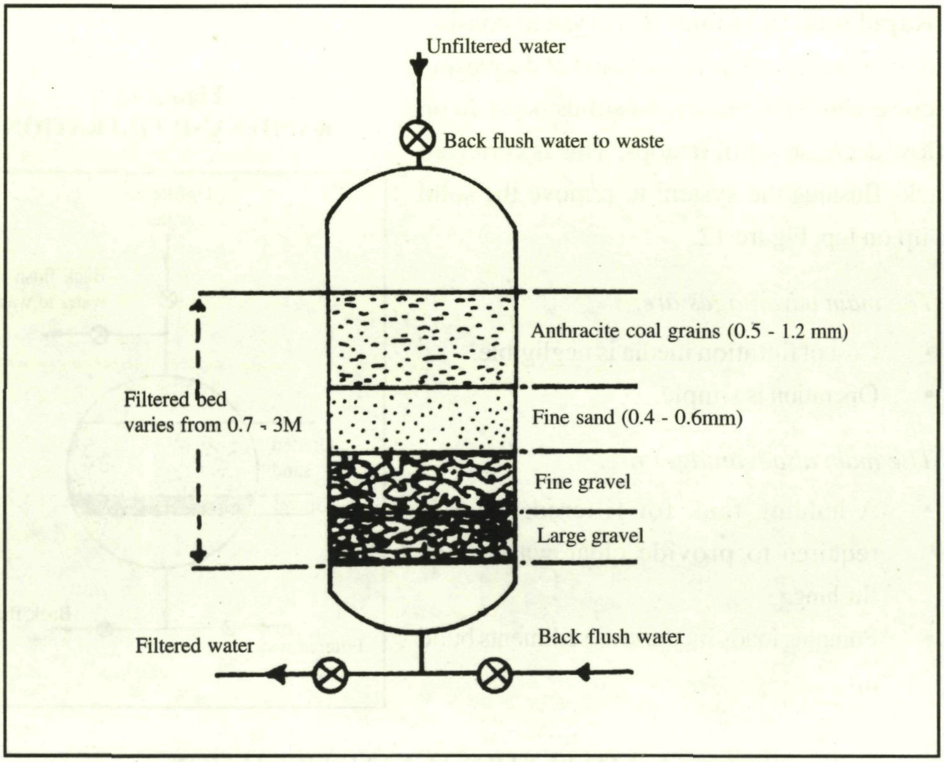


Figure 13 : CONVENTIONAL SAND FILTRATION



Multimedia sand filtration: This system is similar to the rapid sand filtration method,

Figure 14 : MULTI-MEDIA SAND FILTRATION



Up-flow filtration: Filtration can be at atmospheric pressure or by using a pressurised system, Figures 15a and 15b.

The main advantages are:

- High flow rates are easily attained.
- Water with turbidity up to 1500 ppm can be handled.
- Degree of filtration can be easily adjusted.
- The filter bed can be easily cleaned using the filtered water.

Figure 15a : ATMOSPHERIC PRESSURE UP-FLOW FILTER

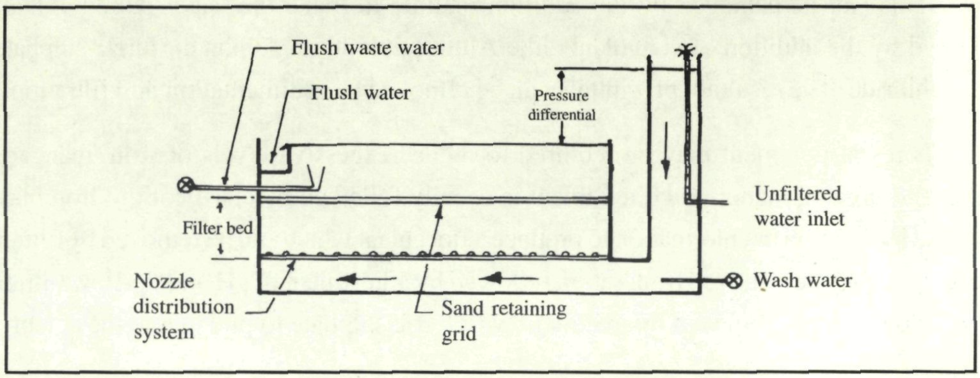
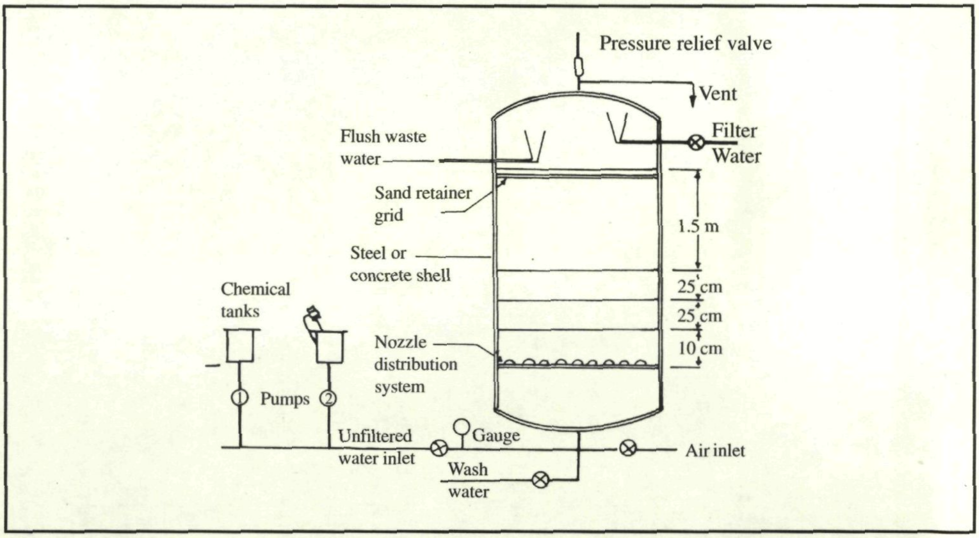


Figure 15b : PRESSURE TYPE UP-FLOW FILTER



The main disadvantage is:

- Close supervision is necessary to ensure that the filter bed does not rupture.

2.4.3 Complete treatment

Complete treatment consists of flocculation, coagulation, sedimentation and filtration followed by disinfection. Flocculation and coagulation will assist in removing contaminants in the water, causing turbidity, colour odour and taste which cannot be removed by sedimentation alone. This can be achieved by the addition of lime to make the water slightly alkaline, followed by the addition of coagulants like Alum (aluminium sulphate), ferric sulphate or ferric chloride. The resultant precipitate can be removed by sedimentation and filtration.

Chemical treatment may be required to reduce excessive levels of iron, manganese, chalk, and organic matter. Such treatment is usually followed by clarification. Iron may be removed by aeration or chlorination to produce a flocculant which can be removed by filtration. Manganese may be removed by aeration followed by adjustment of pH and up-flow filtration. Most colours can be removed by treatment with ferric sulphate to precipitate the colours.

Chapter 3

WATER AND ICE: SUPPLY AND STORAGE

3.1 WATER

An adequate supply of good quality water is a fundamental requirement for fishery harbours, whether the water is used for drinking, cleaning the fish, ice making or fish processing. Where municipal supply of potable water is limited, other sources need to be investigated – including the use of harbour basin water or sea water for certain uses.

To plan the water supply system for a fishery harbour, it is necessary to estimate the peak demand for water which is a direct function of the peak landings; the number of fishing vessels using the harbour; the number of port staff and crew, and harbour facilities like canteens, ice plants and processing plants. The following table may serve as a guide for estimating water requirements.

Table 3-1
GUIDELINES FOR ESTIMATING WATER REQUIREMENTS

Activity	Quantity Required
a. Fish rinsing	1 l/kg of fish landed
b. Auction hall cleaning	10 l/m^2 of floor area
c. Fish boxes cleaning	10 l/box
d. Personal hygiene	100 l/person
e. Canteens	15% of item (d)
f. Vessel supply	30 l/person/day
g. Ice	1 kg for 1kg of fish landed

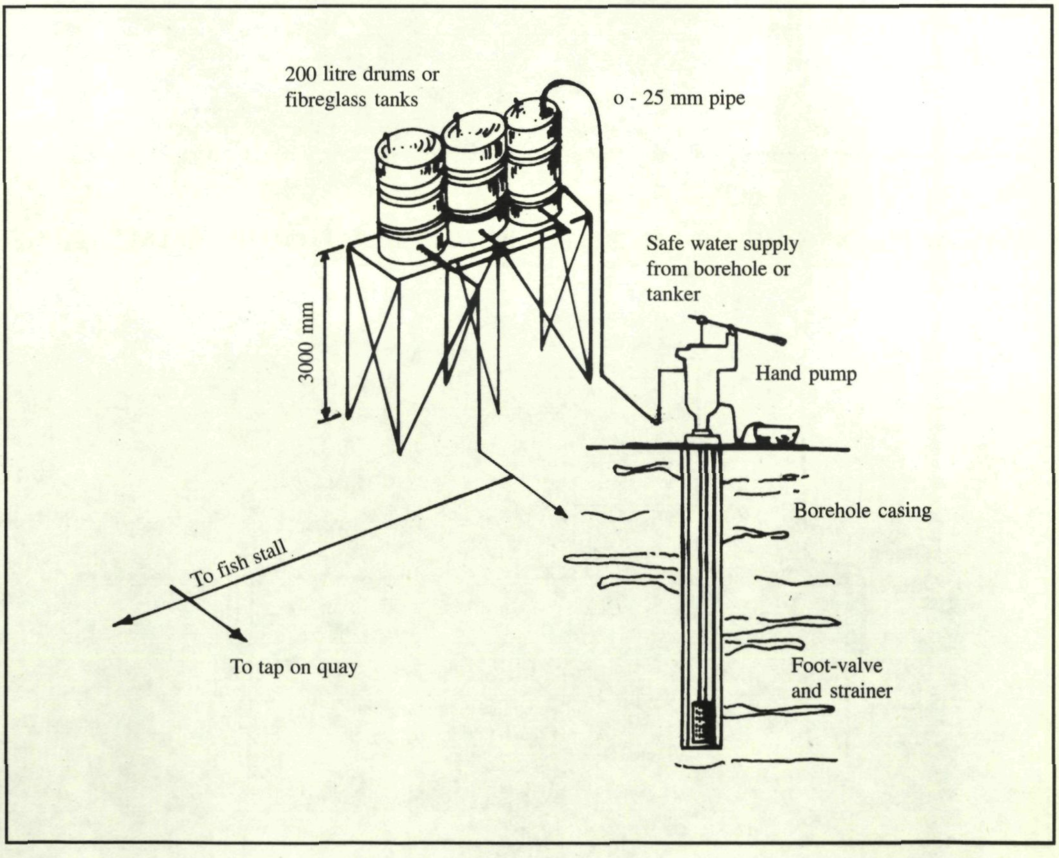
The gross daily volume for item (a) should be increased by 25% to cover seasonal peaks and volume for items (b) and (c) may be reduced by 50% if high pressure cleaning systems are used.

Some common sources of water in fishery harbours are from borewells, rain water collection tanks and pumped sea water. Recent advances in desalination equipment to convert sea water to potable water constitute an option worth investigating.

3.1.1 Borewells

The geological investigation of the sub-strata is generally carried out by a specialist sub-contractor. More than one borehole may be required for complete assessment and the depth need not depend on the local water table. There are instances where shallow borewells may produce contaminated or brackish water, and a deeper well taps into a submerged freshwater aquifer. The major geo-technical requirement is to verify the porosity of the sub-stratum as this will determine the maximum rate of extraction of water. In coastal areas, over-extraction of fresh water from the underground water table has often caused the water to become saline through intrusion of sea water.

Figure 16 : WATER SUPPLY SCHEME FOR AN ARTISANAL LANDING



3.1.2 Sea water

When sea water is used for cleaning purposes, care should be taken to avoid sea water runoff entering the sewage treatment system. The pumps should be suitable for sea water. Sand excluding filter is required for sea water suction from sandy beaches.

Figure 17
REPLACEMENT OF POTABLE WATER WITH SEA WATER FOR SOME SERVICES

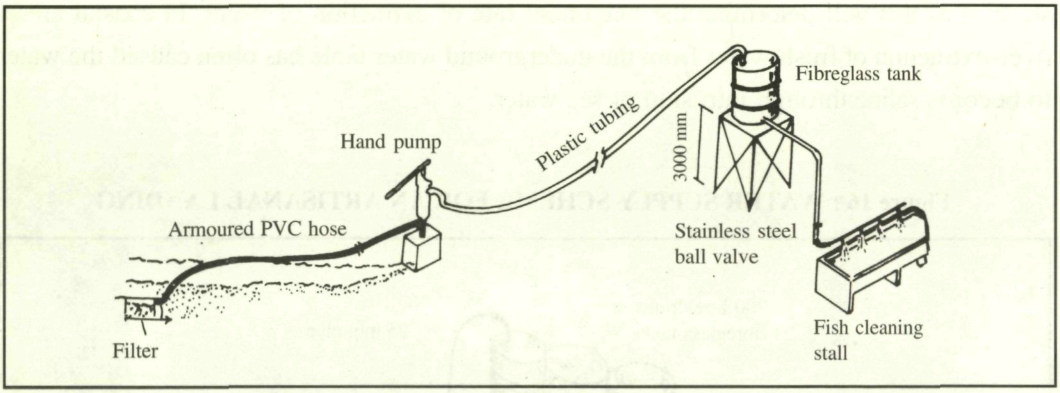
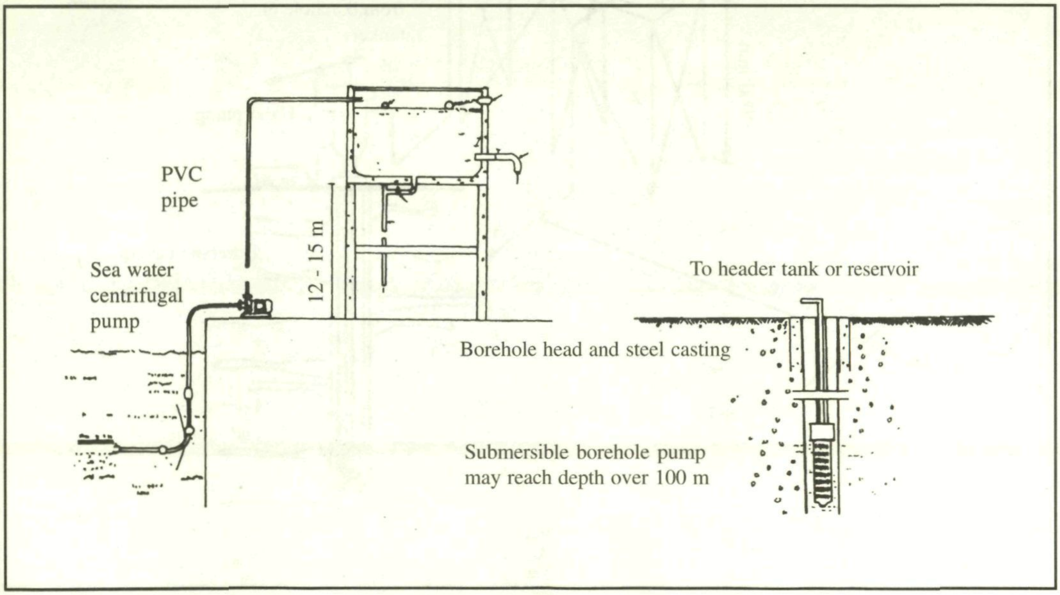


Figure 18
TYPICAL PUMPING ARRANGEMENTS FOR EITHER SEA WATER OR POTABLE WATER



Desalination: Desalination may be carried out in two ways: flash distillation of sea water or reverse osmosis. Flash distillation is relatively inexpensive if heat from a generator can be extracted via the circulating cooling system of the diesel engine. Typically, the system consists of a spherical steel container connected to a vacuum pump with heating coils circulating hot water from the engine's cooling system. The vacuum pump lowers the boiling point of water, thus making the sea water boil. Potable water is distilled off from the top and pumped to a storage tank. The major disadvantage is the frequent descaling required to remove encrustations in the distilling tank.

The preferred method of desalination nowadays is by reverse osmosis. This process consists of pumping sea water at very high pressure against a special osmotic membrane rolled up inside a steel cylinder. The membrane allows only fresh water to pass through. This system is relatively expensive to operate but in arid areas may be the only viable option. Small reverse osmosis plants are now commercially available and the following table illustrates some of their basic characteristics.

Table 3.2
TYPICAL CHARACTERISTICS OF REVERSE OSMOSIS PLANTS

Feedwater	Operating pressure *bar*	Power requirement *kw*	Water production *m^3 per day*
Brackish	45	5.0	12.5
Brackish	45	11.0	100.2
Sea water	56	18.2	45.6
Sea water	56	37.1	91.2

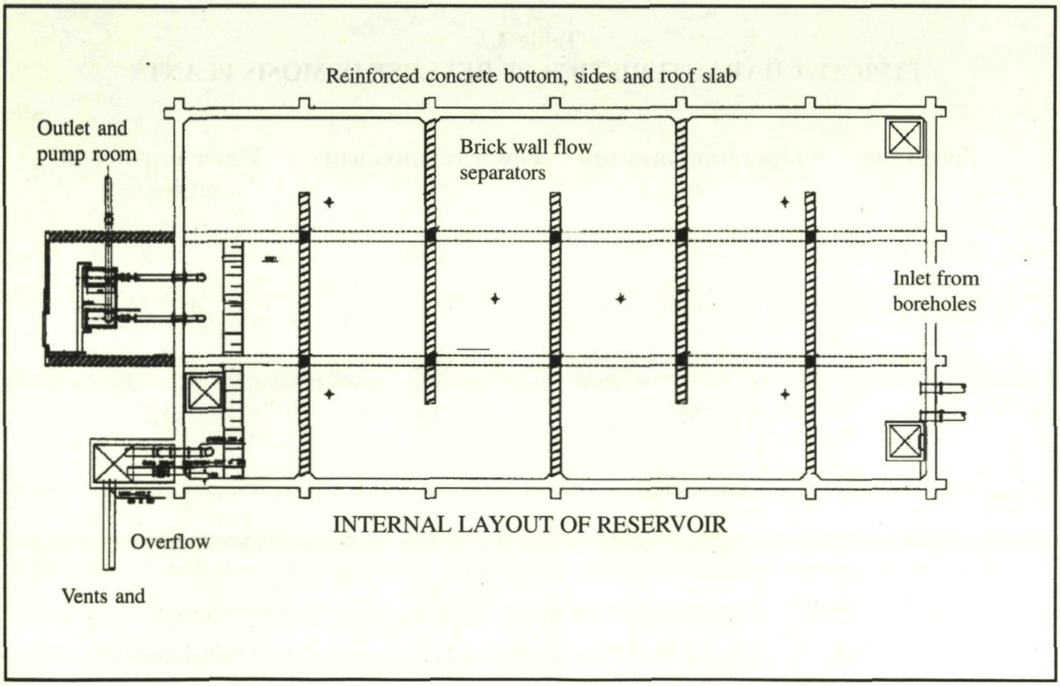
The above figures refer to brackish water with 2000 ppm and sea water with 35000 ppm of sodium chloride. Operating temperature is 25 deg. C. For every deg.C drop below 25 °C, the efficiency drops by 3 %. The membrane is very sensitive to suspended solids.

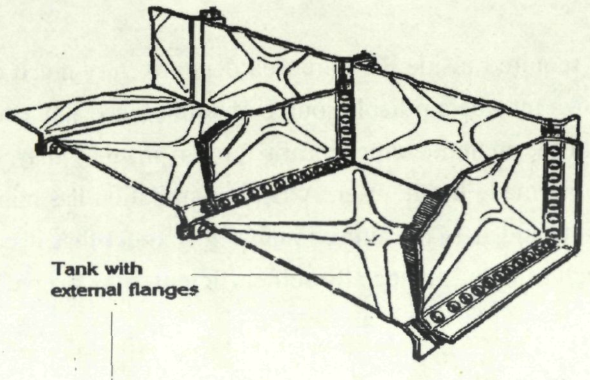
3.2 WATER STORAGE

The type of water storage facility depends on the quantity to be stored as tabled below.

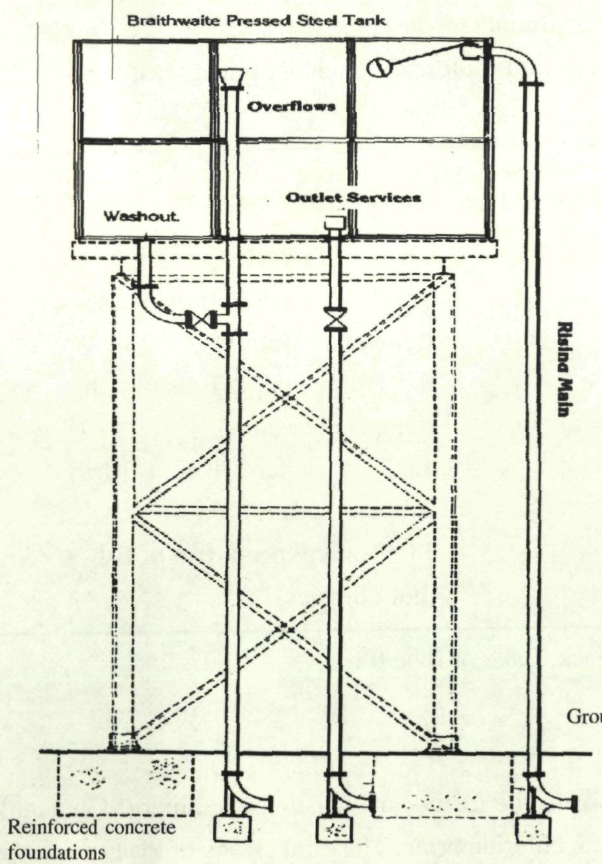
STORED CAPACITY	TYPE OF STRUCTURE
Upto 1 m^3	Plactic or steel drums, single or in parallel connection, usually used as header tanks only and placed above a ground reservoir
Upto 5 m^3	Steel or concrete tank construction, usually serve as small overhead storage tanks, gravity feed
Upto 80/100 m^3	Concrete or steel overhead storage tanks, gravity feed
Above 100 m^3	Above ground or underground reinfrced concrete reservoirs, requiring header tanks

Figure 19a
LARGE CAPACITY ABOVE-GROUND REINFORCED CONCRETE WATER RESERVOIR





Braithwaite proprietory bolted steel tank plates, 4 to 6 mm thick, dimensions 1000 x 1000 mm



Typical Braithwaite overhead tank with gravity feed, including cover, internal partitions and supporting steel work.

Figure 20
A TYPICAL MODERN STEEL OVER-HEAD TANK USING BRAITHWAITE PRESSED-STEEL PANELS

3.3 ICE

Whether an ice plant is actually required inside the port area depends very much on local conditions. Other ice plants in town may be a reliable source of suitable ice and, even with the additional transport costs and the manufacturer's profit thrown in, they may be able to supply ice cheaper than it can be made by the user. A large installation has many economic advantages over a small unit and it is not unreasonable to expect that it can produce cheaper ice. Other factors, such as being financially self sufficient, may over-ride an economic disadvantage.

In addition to water supply and storage, a harbour manager should also be conversant with the manufacture, supply and storage of ice as this product, if contaminated at source (either through contaminated water supplies or through human contact during the manufacturing process), has the potential to contaminate entire fish landings; see also Chapter 2. Contaminated ice has been linked to serious outbreaks of cholera in at least one ASEAN country.

Table 3-3
GUIDELINES FOR ESTIMATING ICE REQUIREMENTS

ACTIVITY	QUANTITY REQUIRED
Onboard, trip greater than 1 week	1.0 T of ice per 2 Tons of fish (temperate waters)
Onboard, trip less than 1 week	0.7 T of ice per 2 Tons of fish (temperate waters)
Onboard, short duration	1.0 T of ice per 1 Ton of fish (tropical waters)
Auction hall, re-packaging	1.0 T of ice per 1 Ton of fish (hot climates)

Ice is usually manufactured in block, flake or tube form.

3.3.1 Block ice

The traditional block ice maker forms the ice in cans which are submerged in a tank containing circulating sodium or calcium chloride brine. The dimensions of the can and the temperature of the brine are usually selected to give a freezing period of between 8 and 24 hours. Too rapid freezing results in brittle ice. The block weight can vary from 12 to 150 kg, depending on requirements; 150 kg is considered the largest size of block one man can conveniently handle. The thicker the block the longer the freezing time. Blocks less than 150 mm thick are easily broken and a thickness of 150 to 170 mm is preferable to prevent the block toppling. The size of the tank required is related to the daily production. A travelling crane lifts a row of cans and transports them to a thawing tank at the end of the freezing tank, where they are submerged in water to release the ice from the moulds.

The cans are tipped to remove the blocks, refilled with fresh water and replaced in the brine tank for a further cycle. This type of plant often requires continuous attention. A shift system is operated by the labour force – 10 to 15 workers for a 100 t/day plant. Block ice plants require a good deal of space and labour for handling the ice.

The latter factor has been the main reason for the development of modern automatic ice-making equipment (flake and tube ice). Compared to other types of ice plants, block ice plants are more prone to producing contaminated ice if high hygiene standards are not scrupulously observed at all times.

Block ice still has a use, and sometimes an advantage, over other forms of ice in tropical countries. Storage, handling and transport can all be simplified if the ice is in the form of large blocks; simplification is often obligatory in small-scale fisheries and in relatively remote situations. With an appropriate ice-crushing machine, block ice can be reduced to any particle size but the uniformity of size will not be as good as that achieved with some other forms of ice. In some situations, block ice may also be reduced in size by a manual crushing method.

3.3.2 Flake ice

This type of machine forms ice 2 to 3 mm thick on the surface of a cooled cylinder and the ice is harvested as dry subcooled flakes usually 100 to 1,000 mm^2 in area. In some models, the cylinder or drum rotates and the scraper on the outer surface remains stationary. In others, the scraper rotates and removes the ice from the surface of a stationary drum, in this case built in the form of a double-walled cylinder. One distinct advantage of the rotating drum method is that the ice-forming surfaces and the ice release mechanism are exposed and the operator can observe whether the plant is operating satisfactorily. The flakes are usually either bagged directly in plastic bags and stored in a chiller or collected and stored in an automated bin or silo. Human contact with the ice is minimal. The range of unit sizes for this type of machine now extends from units with a capacity of 0.5 to 60 Tons/24 h.

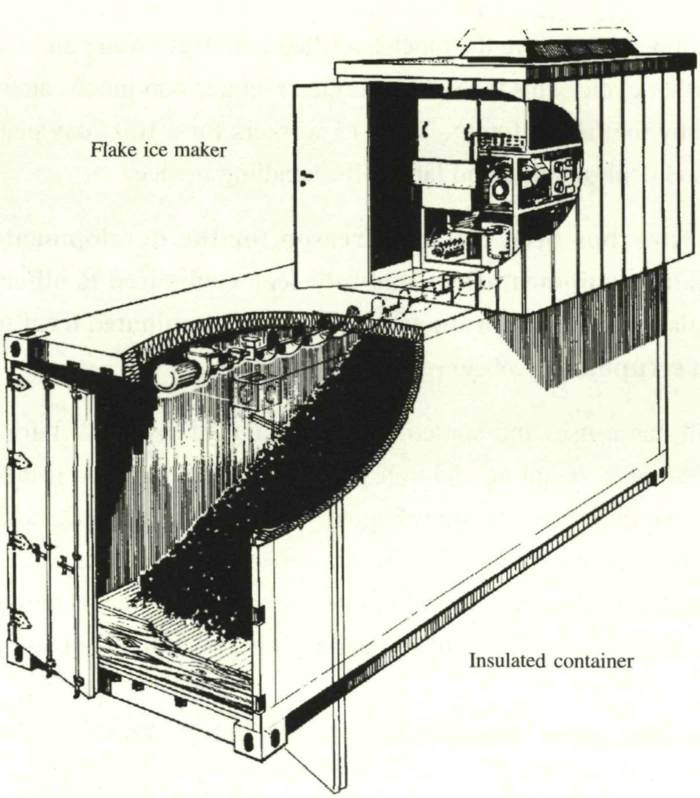


Figure 21 : SELF-CONTAINED FLAKE ICE MAKER WITH BIN STORAGE

3.3.3 Tube ice

Tube ice is formed on the inner surface of vertical tubes and is produced in the form of small hollow cylinders of about 50 x 50 mm with a wall thickness of 10 to 12 mm. The tube ice plant arrangement is similar to a shell and tube condenser with the water on the inside of the tubes and the refrigerant filling the space between the tubes. The machine is operated automatically on a time cycle, and the tubes of ice are released by a hot gas defrost process. As the ice drops from the tubes a cutter chops the ice into suitable lengths, nominally 50 mm, but this is adjustable. Transport of the ice to the storage area is usually automatic. Thus, as in the flake ice plant, the harvesting and storage operations require no manual effort or operator attendance. Tube ice is usually stored in the form it is harvested, but the particle size is rather large and unsuitable for use with fish. Self-contained units, Figure 21, with a rating of up to 10 to 20 tonnes/24 hours can be located within the floor space required for storage, with the icemaker and refrigeration equipment on top.

3.4 ICE STORAGE

Ice manufacture and demand rates are seldom in phase, therefore storage is necessary to ensure that the plant caters for peak demand. Storage allows the ice maker to be operated 24 hours per day. It also acts as a buffer against any interruption to the ice supply due to minor breakdowns and routine maintenance procedures. There is no general rule for estimating ice storage capacity requirements.

Table 3-4
STORAGE REQUIREMENTS FOR VARIOUS TYPES OF ICE

TYPE OF ICE	STORAGE SPACE (m^3 per Ton)
Flake	2.2 - 2.3
Tube	1.6 - 2.0
Crushed block	1.4 - 1.5

3.4.1 Block ice stores

Block ice cannot be stored in silos or bins unless the ice is crushed beforehand. This type of ice is therefore stored in block form in refrigerated rooms.

Refrigerated rooms should be professionally designed and constructed so as not to allow contact of the stored ice with unauthorised persons or domestic animals. The floor should be a seamless-type floor with no cracks or joints. Persons handling the ice in the store should wear rubber boots and gloves.

A conventional block ice plant would also have a considerable amount of extra storage in the ice making unit, since it is usual to maintain the ice cans filled, even when demand has fallen below the plant's rated capacity.

3.4.2 Bin storage

Bin storage may mean anything from a box holding no more than 500 kg to a large installation of 1,000 tons or more. Bin storage can be used for any type of ice and may incorporate a separate cooling system. Whatever the size of system used, ice storage should always be within an insulated structure since the saving made by reducing ice meltage, particularly in warmer climates, is always worth the extra cost of the insulation. An insulation thickness of 50 to 75 mm of polystyrene or its equivalent in one of the many other suitable types of insulation, is suggested. Small bins may be arranged with the icemaker above the storage space, Figure 21; the bin is filled by gravity and a FIFO system is operated by removing the ice at a low level. This simple bin system is suitable for processors making and using their own ice.

Bins of up to about 50 tons capacity can be constructed without a mechanical unloading system. This type of storage would usually be a high structure with a sloping base and access to dislodge compacted ice. Any ice left undisturbed for a few days will compact and fuse together. Ice which is free flowing when used daily may require a mechanical unloading system if used infrequently.

3.4.3 Silo storage

Silo storage is generally used with a free-flowing subcooled ice such as flake ice and, in order to be effective, it must have an independent cooling system to maintain the ice in

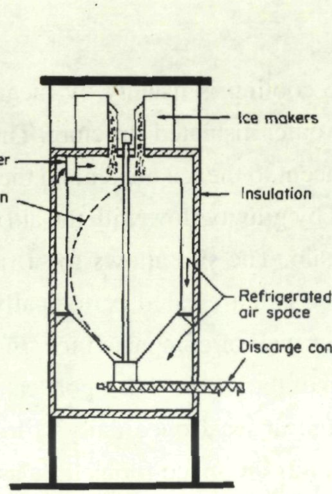


Figure 22a : Silo ice store with a swing chain agitator

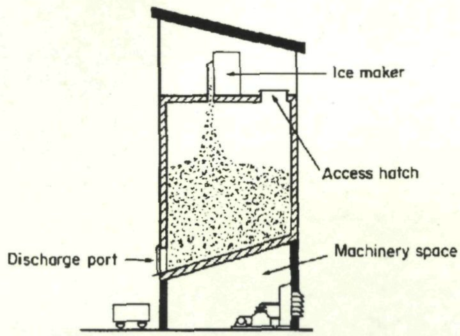


Figure 22b : Bin ice store with ice maker on top

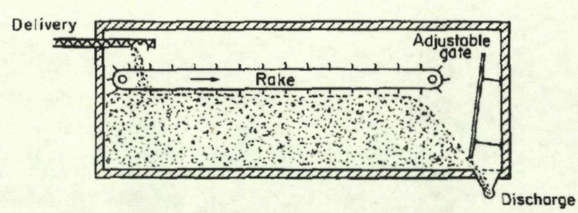


Figure 22c : Ice store with raker

Figure 22 TYPICAL ICE STORES

this subcooled condition. The cooling is usually by means of an air cooler in the jacket space between the silo and the outer insulated structure. The air cooler is normally placed at the top of the jacket space adjacent to the ice maker and the air space is cooled by gravity or fan circulation. Ice is collected by gravity flow with the aid of a chain agitator which scrapes the ice from the walls of the silo. The silo allows for a first-in-first-out (FIF0) system of storage but, if the storage space is not cleared periodically, only the central core of ice is used, leaving a permanent outer wall of compacted ice, Figure 22. An access hatch should therefore be provided at the top of the silo so that a pole can be inserted to collapse the outer wall of ice into the central core at least once daily. Silo storage is expensive for small quantities of ice and although units are made for as little as 10 tons, this method of storage is more suited for storing 40 to 100 tons of ice.

Chapter 4

WASTES AND THEIR MANAGEMENT

4.1 HARBOUR WASTES

The fishery harbour complex is a hub of activities with nearly all of them being potential waste generators. In the absence of adequate facilities for collection, treatment and disposal systems, these wastes will pollute the harbour complex and the harbour waters. Floatable material may escape from the area and end up along the coastline and beaches causing further damage to ecology and aesthetics.

Pollution from harbour-generated wastes can be categorized as those that cause:

- visible pollution of land and water by oil spills and sewage;
- invisible pollution of harbour water by hazardous wastes; and
- degradation of the harbour environment by discarded litter and fish offal.

Typically they may be further categorized as:

- **non-toxic solid waste including flotsam washed into the harbour;**
- **toxic solid waste;**
- **dredging spoils;**
- **oily waste including accidental oil spills;**
- **sewage and grey waste; and**
- **fish offal and blood water.**

In the past the approach to waste management was to look at wastes as an 'end-of-the-pipe problem' and adopt appropriate treatment technologies. While some form of such treatment may be required, it is often far more practical and cost-effective to minimize the amount of waste generated in the first place. Waste minimization is achieved through the practice of the '3 R's'- reduction, reuse and recycling.

Reduction refers to minimizing the amount of waste generated from a given operation or process. It is accomplished by using less polluting materials in place of highly polluting ones; implementing processes that generate less waste; and good operating practices. In fact, source reduction is really not about managing waste, but about managing the raw materials more carefully in the first place.

Reuse refers to using the waste material 'as is' — such as using waste oil for fuel.

Recycling refers to reclaiming materials from the waste product such as scrap metal recycling or transforming waste plastic or paper into new products. There are many benefits from recycling. It reduces the amount of waste for disposal; saves natural resources; and provides jobs for scrap collectors and dealers.

In a fishery harbour complex, the harbour master should perform a 'waste audit'. This is a management tool that enables him to evaluate policy and remedial actions. The audit should help identify the source, quantity and concentration of all waste streams. It should then be possible to evaluate from practical and cost considerations which of the '3 R's' or disposal is most suitable for the fishery harbour complex with a given set of local conditions.

4.2 WASTE AUDIT

The fishery harbour complex has many activities within the complex and each of them may be a point source of waste. The harbour master should group the harbour area into zones according to the activity performed in each zone and analyse them individually for the kind of waste generated; the probable quantities; and the method of disposal. The table below lists typical harbour activities and the wastes associated with them. Estimating the quantities is a matter of judgement based on existing practices.

Table 4-1
TYPICAL WASTE STREAMS

Zone	Source	Waste generated
Harbour basin	Fishing vessels	Bilge water Lube oil Sewage Toilet waste Kitchen waste Deck washing Fish hold cleaning
	Fishing vessels and Current	Floating garbage
Landing jetty/ Marketing	Auction hall	Fish waste Blood water Trash fish Hose down water
	Gutting area	Fish offal Hose down water
	Fuel pump	Oil leaks
Main complex	Toilets	Sewage Waste from wash areas
	Canteen	Kitchen waste Waste from wash area Litter and food scraps
	Boat repair	Oil and grease Paint cans, paint Anti-fouling paint cans Used batteries Torn nets and rope Wood shavings, steel scrap
	Offices	Toilets and Garbage

We shall now look at the above wastes in terms of their classification and suggested disposal.

4.3 NON TOXIC SOLID WASTES

Typical non-toxic wastes in a fishery harbour include paper, plastic bags, plastic containers, metal containers, old tyres, pieces of rope, bits of netting, food wrappers, bottles, fruit peels and flotsam like driftwood, generally termed as litter. This type of waste not only makes the harbour look dirty, it can clog drains, foul boat propellers, choke water intakes and so on. Some of the waste may be biodegradable and the rest non-biodegradable.

Figure 23 : DISCARDED NON-TOXIC WASTE

4.3.1 Reduction

Probably the key to minimizing this waste is to encourage the use of products that need less packaging or buying in bulk. For instance, if the fishery harbour supplies engine oil to boats, it may be better to buy one 50-litre can instead of 50 one-litre cans.

4.3.2 Recycling

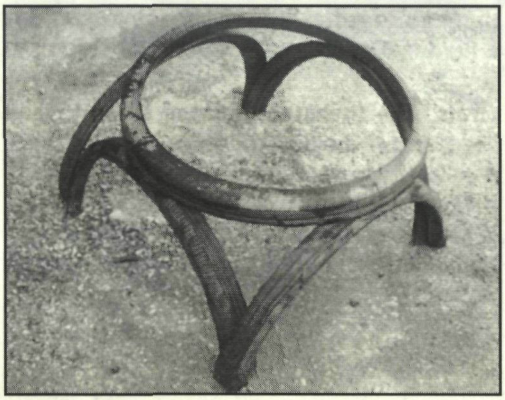
Many of the waste items can be recycled. This involves collecting and sorting the discarded materials suitable for recycling. Paper, plastic, glass and aluminium cans can be recycled. Wet organic matter can be converted into compost. In Thailand, old tyres are converted into garbage bins.

4.3.3 Collection

The harbour master must ensure that adequate containers are strategically placed within the harbour complex for collecting the litter. It is advisable to have separate containers to facilitate the segregation of waste into *recyclable dry waste, wet organic waste* that can be composted and *hazardous waste* which needs special care in disposal. Floating garbage is best collected by small boats using a scoop net or as the figure below shows, two vessels working together using a floating net boom.

Figure 24 : Two vessels towing a floating boom and net across the river to collect floating debris

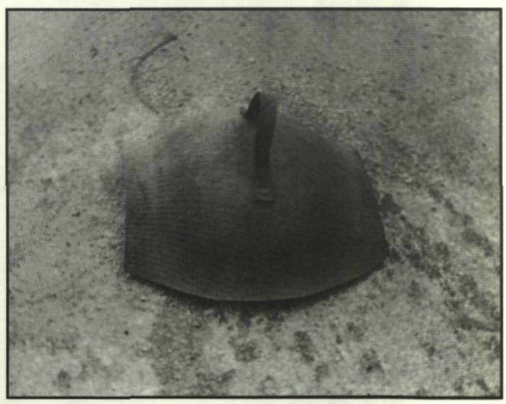
The type of garbage skips and receptacles depends on the method of solid waste handling by the municipality in the area. Garbage receptacles may be custom-made if a compacter truck is used for collection of heavy duty plastic or galvanized steel. The size should take into consideration whether the receptacles are manually emptied into the collection truck. It is often the case that large concrete bins overflow with garbage as the accumulated garbage makes it unpleasant for those emptying them. Plastic receptacles, if used, should be u-v stabilized or protected from direct sunlight. Steel containers should be galvanized.



The stand of a local tyre garbage bin made from used truck tyres

The garbage bin

The garbage bin on its stand



The lid of the garbage bin

Figure 25 : GARBAGE RECEPTACLE MADE LOCALLY FROM OLD TYRES

Figure 26a
THE RECEPTACLE FROM THE PREVIOUS FIGURE SHOWN ON ITS STAND

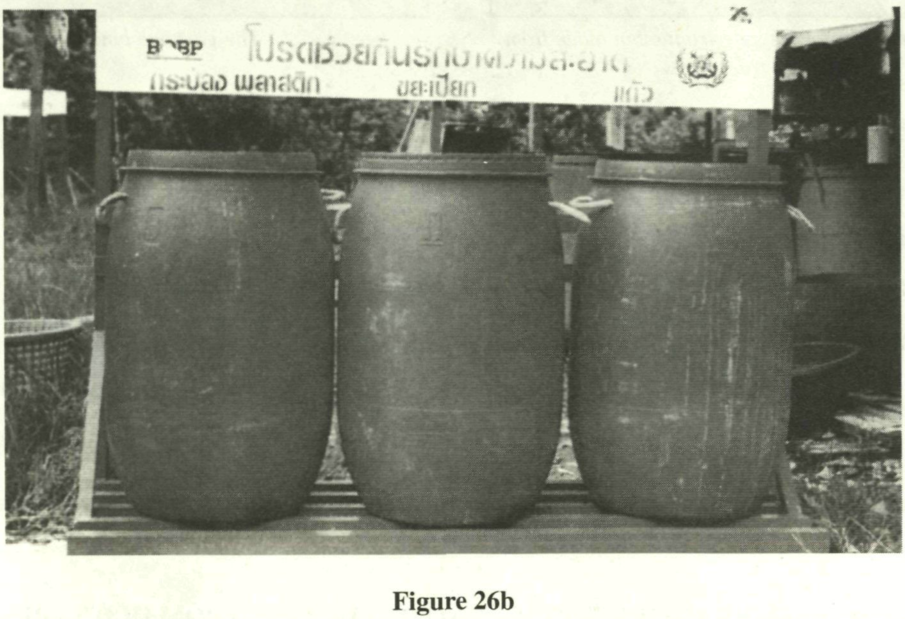


Figure 26b
DISCARDED PLASTIC CHEMICAL BARRELS RE-UTILISED AS RECEPTACLES

Figure 27 : EXAMPLES OF CUSTOM-MADE RECEPTACLES

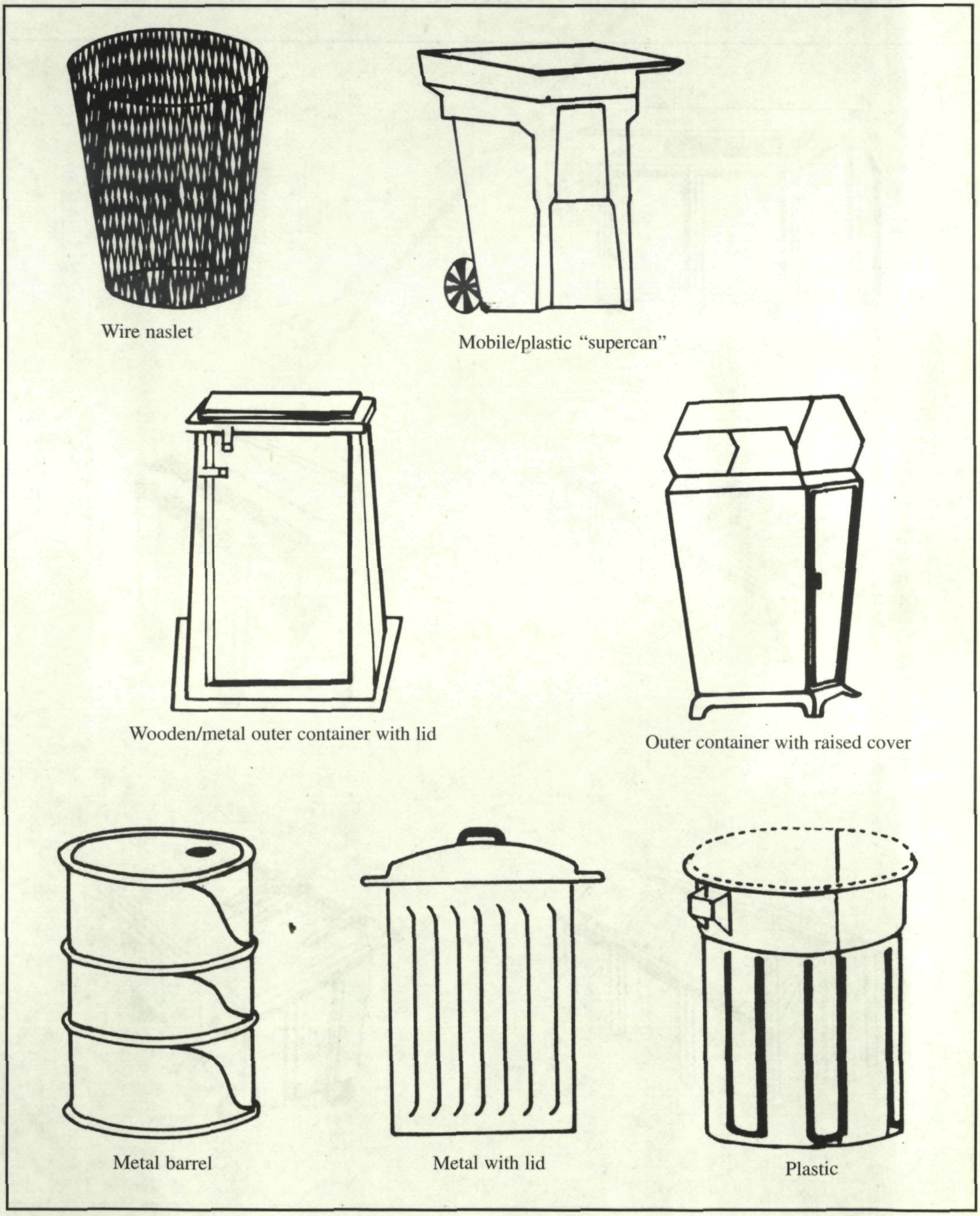
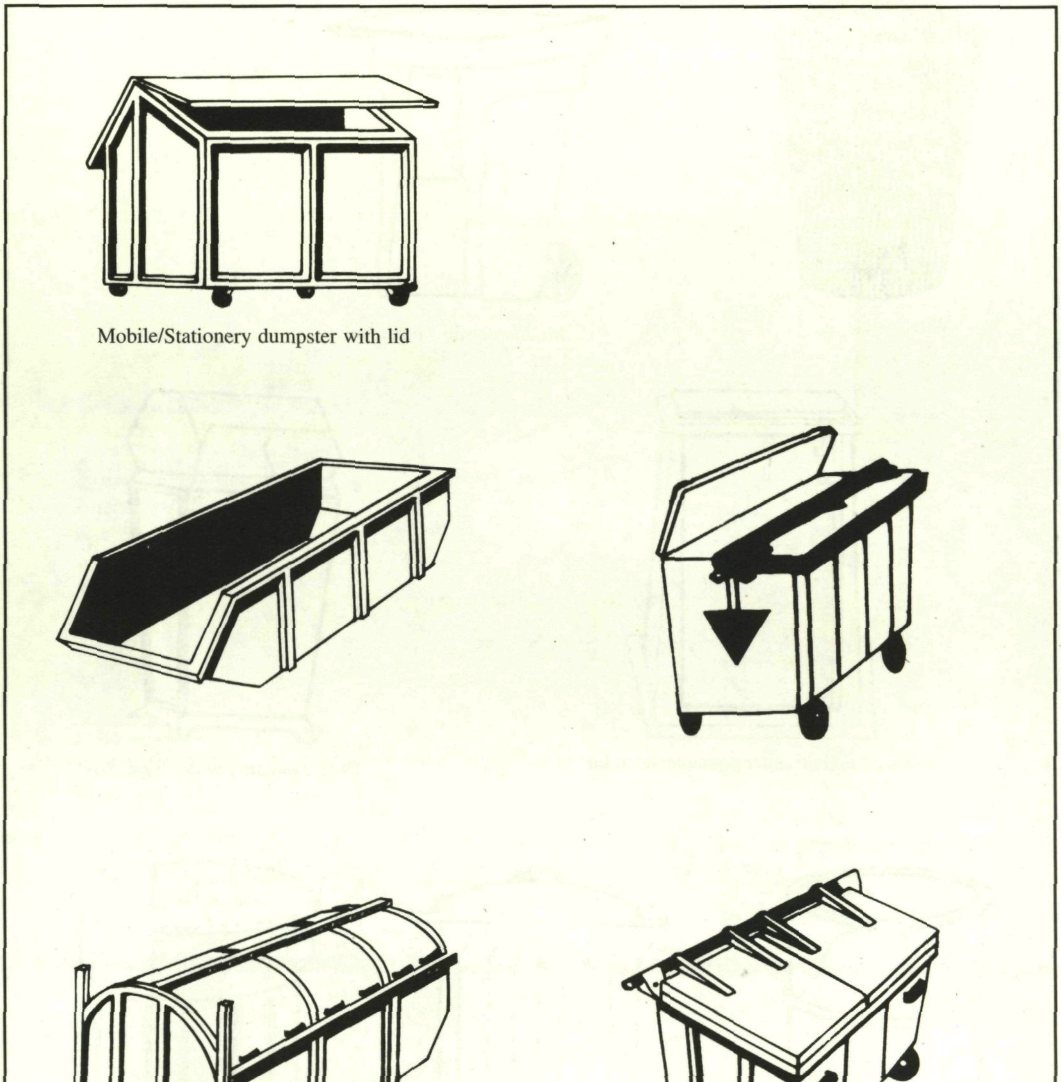


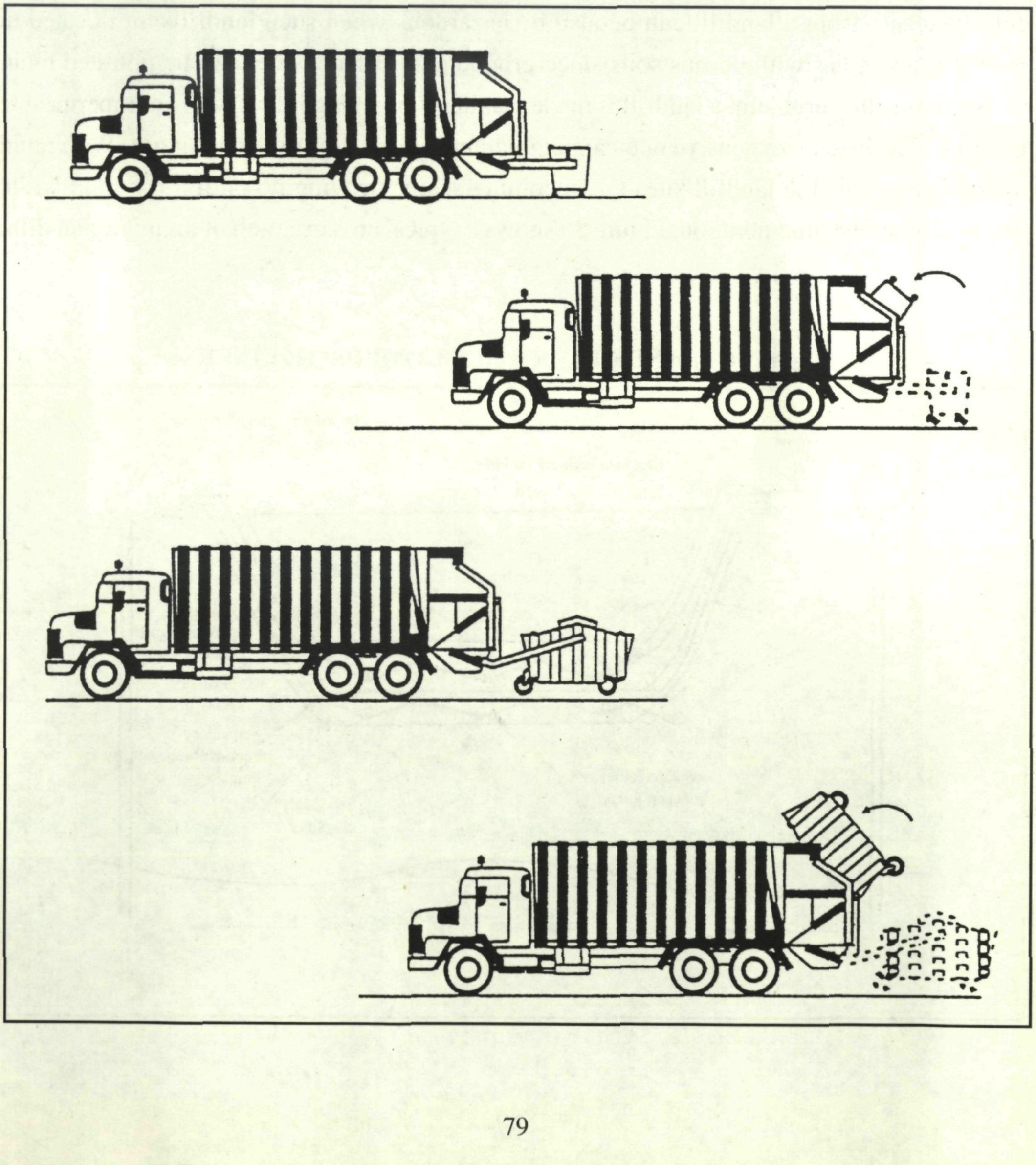
Figure 28
EXAMPLES OF RECEPTACLES TO STORE WASTES IN HARBOUR AREAS



4.3.4 Disposal

Eventual disposal of solid wastes is usually the responsibility of the municipality. The harbour master should take all steps to meet the municipality requirements for collection and schedule. In some harbours, private garbage collectors are contracted to transport the harbour garbage to selected sites serviced by the municipality.

Figure 29 : TRANSPORTATION BY TRUCK TO COLLECT WASTES



In the event that the garbage is to be disposed of by the fishery harbour on its own, the practice of open dumping of solid wastes should be discouraged. Garbage which is neither compacted nor covered smells foul and attracts flies and rodents. Domestic animals feeding at such a dump can catch and spread diseases. Leachate and rain runoff can contaminate land and water sources nearby.

Landfills are considered better alternatives. Here, large earth-moving equipment compact the garbage and cover it with a layer of soil. Each day's garbage becomes a buried cell. Leachate from a landfill can be also be hazardous when such landfills are located in wetlands and areas with porous soils since ground and surface water can be polluted by it. To overcome this problem, a landfill is made 'sanitary' by lining it first with an impermeable material. This can be expensive and cannot guarantee leachate from leaking out. With rapid urbanization, suitable landfill sites are becoming scarce, leaving no option for solid waste disposal other than incineration. Figure 30 shows a typical cross-section of a sanitary landfill.

Figure 30 : LANDFILL DOUBLE COMPOSITE LINER

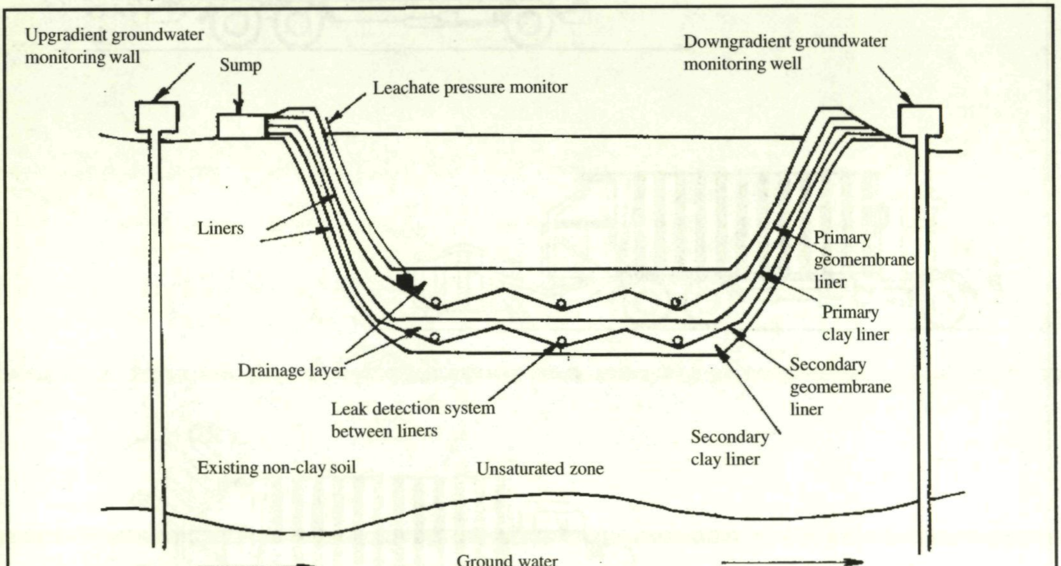
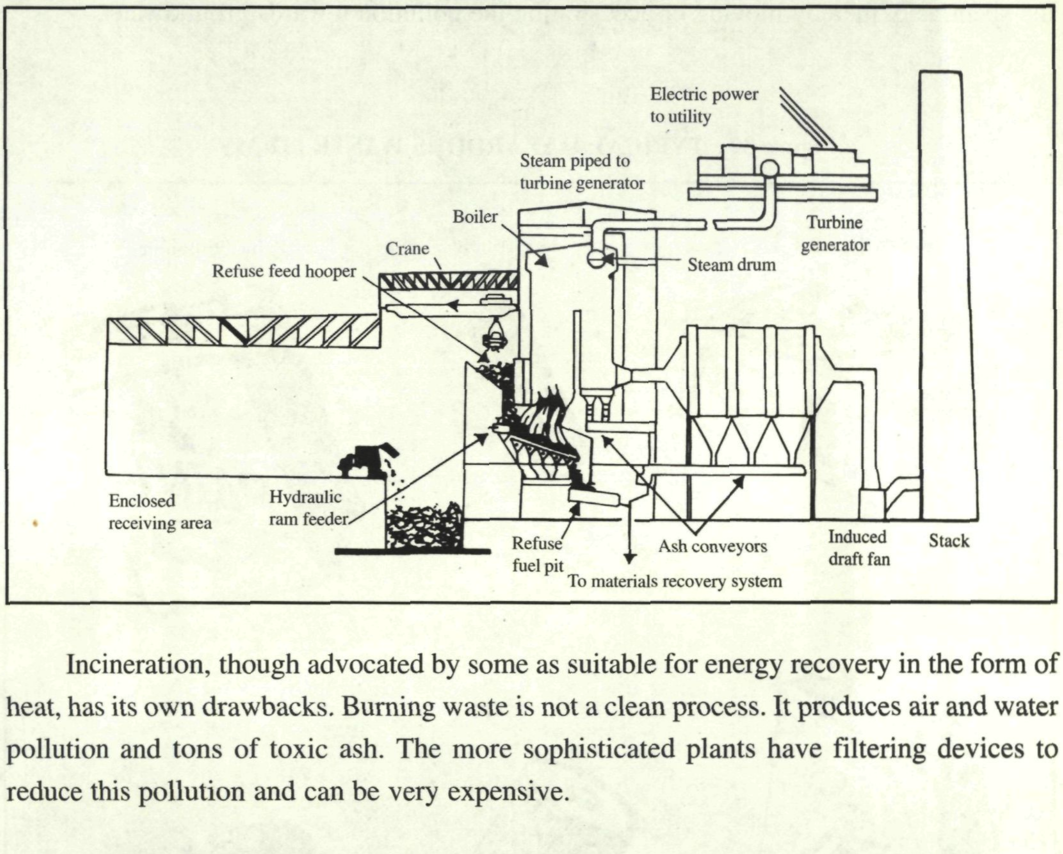


Figure 31 below, shows a typical cross-section of an industrial type incinerator.

Figure 31 : A TYPICAL CROSS-SECTION OF INCINERATION PLANT



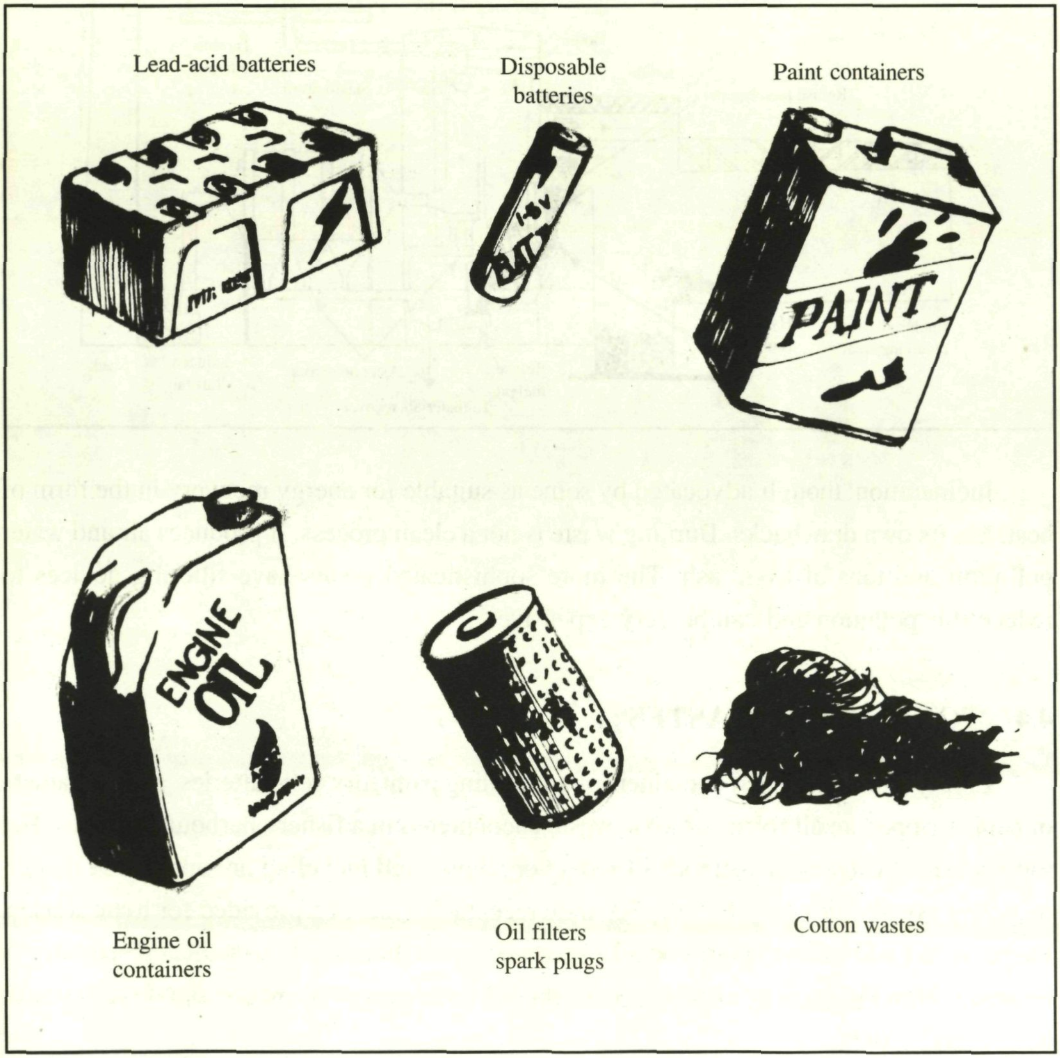
Incineration, though advocated by some as suitable for energy recovery in the form of heat, has its own drawbacks. Burning waste is not a clean process. It produces air and water pollution and tons of toxic ash. The more sophisticated plants have filtering devices to reduce this pollution and can be very expensive.

4.4 TOXIC SOLID WASTES

Empty paint cans, used containers of antifouling paint, dry cell batteries, and containers of paint stripper are all forms of toxic waste encountered in a fishery harbour complex. The same waste management methods of reduction, reuse, and recycling are applicable though recycling possibilities may be few. Separate receptacles must be provided for toxic wastes. Disposal of toxic wastes should be left to competent authorities. If a medical dispensary is located within the harbour complex, care should be taken not to mix hospital wastes with the general wastes.

Spent lead batteries can be reconditioned, or the lead can be recovered even at the village level by local smelters and put to other uses like lead sinkers for fishing nets. However, precautions are needed to ensure safety for the worker and to prevent careless dumping of the spent acid, thereby moving or accelerating the pollution towards groundwater.

Figure 32 : TYPICAL HAZARDOUS WASTE ITEMS



4.5 DREDGING SPOILS

The harbour basin may need dredging from time to time due to siltation. Disposal of dredging spoils at sea, if not carefully planned, can be damaging to the marine environment – affecting fish life and fragile organisms like corals if native to the area. Discolouration of nearshore water could result in adverse effects on beach recreation and tourism. Dredged material can be put to better use when used for land reclamation of low-lying coastal land, if it is not contaminated.

Dredging spoils from the harbour basin may be contaminated by sewage, oils and heavy metals from workshops and other industry around the port area. It is therefore advisable to dump such waste into an established dump site away from known fish breeding and fishing areas. Such a site is usually where seabed currents are low and do not allow dispersal of contaminants in the water column.

4.6 OILY WASTE AND OIL SPILLS

Oil pollution occurs in harbour basins when leaks from shore facilities for the supply of diesel fuel to fishing vessels find their way into the harbour water; when vessels pump out oily bilge water in port; when used engine oil is dumped overboard and when an accident results in leakage of fuel oil. A fishery harbour which is contiguous with the main harbour also faces the risk of major oil spills if the main port is a transfer point for crude oil or refined products from oil tankers.

To mitigate oil pollution, the fishery harbour manager should take necessary action to:

- Provide shore-based reception facilities for oily wastes (bilge water and spent oil) from vessels and
- Minimise leaks while bunkering.

In addition, he should be prepared to assist those responsible for containment and clean-up operations if a major oil spill occurs in the vicinity. Appropriate oil recovery tools like skimmers will prove useful in removing spilt oil from the harbour basin.

Figure 33
A TYPICAL SCENE INSIDE A FISHING HARBOUR – BILGE WATER BEING PUMPED OVERBOARD

4.6.1 Oily wastes

If adequate shore-based facilities are not available for receiving oily wastes, vessels will in all probability dump wastes overboard, as Figure 33 glaringly demonstrates.

Oily wastes discharged to reception facilities are usually mixtures of oil and water and in some cases, solids. The composition ratio of these solids can differ considerably, depending on the type of wastes; **bilge water** consists mainly of water contaminated with oil, whereas **waste oil** and fuel residues consist mainly of oil contaminated with water.

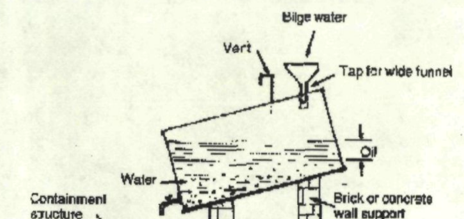


Figure 34a
Artisanal oil/water separator

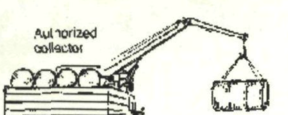


Figure 34b
Separated bilge oil collection

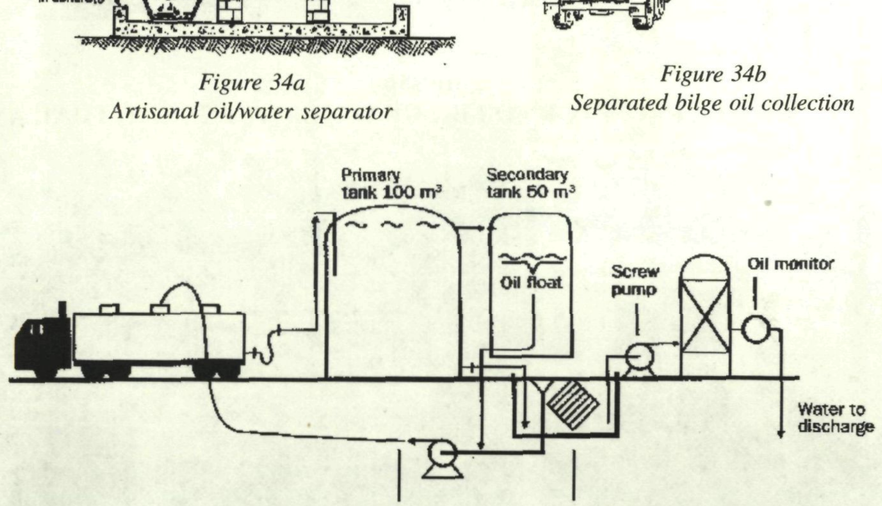


Figure 34c : Cross section of a typical oil-separation and storage facility for fishing ports

Figure 34a illustrates an artisanal oil separator for bilge water. Figure 34c shows a commercial size oil separator which can achieve very low concentrations of residual oil in the discharge water (5 parts oil per million parts water).

Figure 35a
THE 10m^3 MOBILE RECEPTOR FOR BILGE WATER AT VISAKHAPATNAM, INDIA

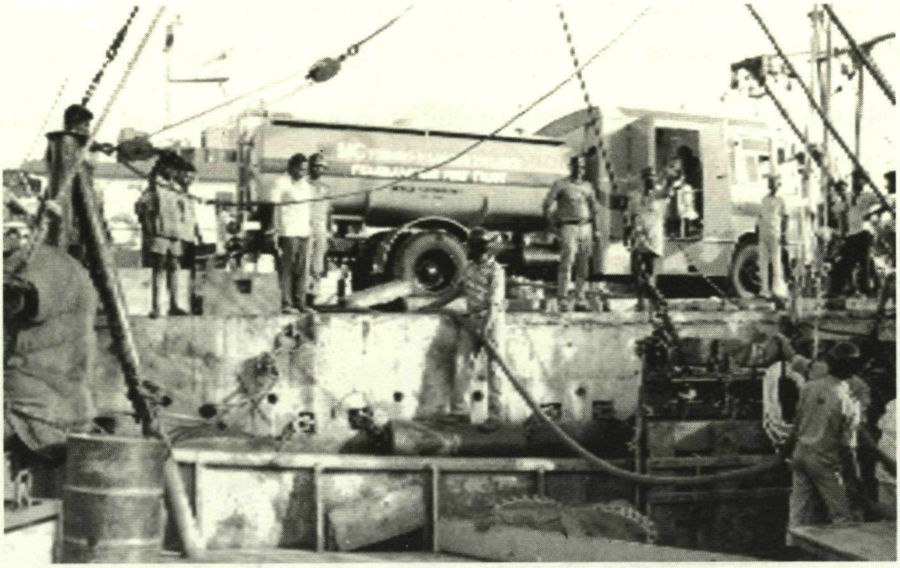


Figure 35b
THE 1 m^3 MOBILE RECEPTOR FOR BILGE WATER AT PHUKET, THAILAND

The oil collected by the separators may then be returned to a recycling plant by authorised collectors. In Visakhapatnam, India, the main port has a fixed installation of 100 m^3 capacity to service cargo ships and an 8 m^3 mobile tanker to collect oily bilge water from some 100 fishing vessels ranging from 15 to 25m in length. The mobile tanker is fitted with a vacum pump and an oil-resistant hose to span four vessels moored abreast. In Phuket, a much smaller mobile tanker (1 m^3) was used for collecting oily bilge water.

Reception facilities for used engine oil inside harbours are intended as a temporary storage only, whereas the reception facilities for bilge water need to separate the oil from the considerably larger volume of water. The oil may then be transferred to the used oil storage facilities for collection at a later date, and the treated water returned to the sea. Waste or spent engine oil can be recycled 100 per cent and it is now very common for refineries to collect used oil from harbours, car repair shops and petrol stations.

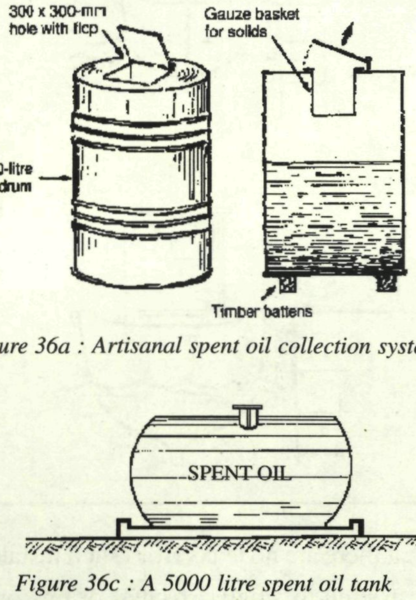


Figure 36a : Artisanal spent oil collection system

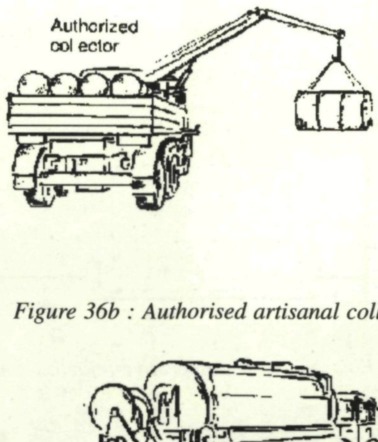


Figure 36b : Authorised artisanal collection

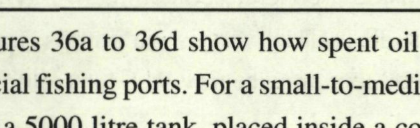


Figure 36c : A 5000 litre spent oil tank for a small fishing port

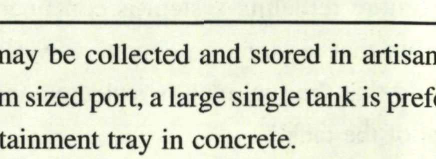


Figure 36d : Collection by road tanker

Figures 36a to 36d show how spent oil may be collected and stored in artisanal and commercial fishing ports. For a small-to-medium sized port, a large single tank is preferable, typically a 5000 litre tank, placed inside a containment tray in concrete.

4.6.2 Minimizing bunkering leaks

Refueling facilities in fishing harbours may vary from small artisanal units to large commercial installations. In an artisanal refueling facility diesel could be supplied from 200 litre steel drums, as shown below in figure 37a. On a larger scale, for instance by a co-operative society, a large steel tank with a capacity of 5000 litres is usually installed away from the jetty. This tank is connected to a quayside fuel pump. In larger harbour installations, proper fuel storage tanks should be constructed as per the specifications laid down by the American Petroleum Institute and known as API Standard 650.

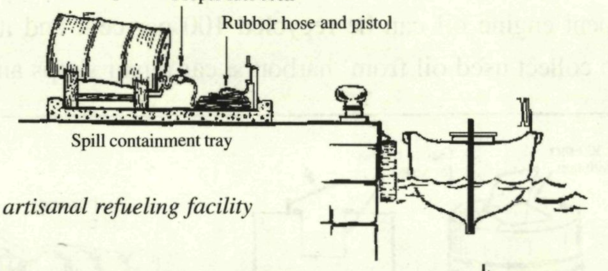


Figure 37a : Individual artisanal refueling facility

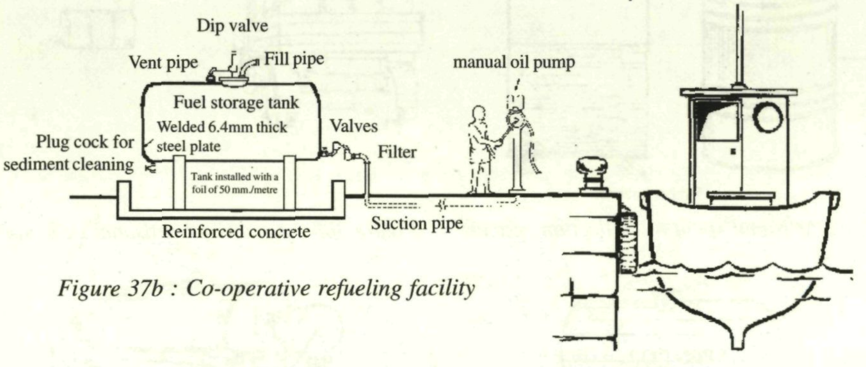


Figure 37b : Co-operative refueling facility

In all cases the harbour master must ensure that there are no leaks from such installations. He must ensure that gravity feed systems are restricted to small artisanal drums only and that the entire refueling system is contained inside a concrete containment tray. He must also ensure that in larger co-operative systems, all fuel delivery is via pumps (not gravity feeds) and that the fuel tank is inside a concrete containment tray that can hold the entire contents of the tank.

4.6.3 Coping with oil spills

Oil contamination is highly visible, whether in the form of oil slicks or tarballs in harbour basins and coastal waters. The potential effect of oil spills on commercial fisheries – particularly the loss of marine habitats – is a matter of serious concern. Oil pollution can even lead to closure of fisheries, through potential impact on human health, tainting of seafood and fouling of fishing gear.

Tanker accidents are the best-known cause of oil pollution. But the most common cause is spills during terminal operations. Because they occur close to the shore and often in a confined area such as ports, their environmental damage to the immediate vicinity can be considerable. These areas are highly productive biologically, and provide shelter for many marine organisms at sensitive young stages. The fact that in many parts of the world, especially south-east Asia, they are also sites of extensive aquaculture, emphasizes the importance of protecting them.

When a major oil spill occurs in the vicinity of the fishery harbour, it is expected that the harbour master will render assistance to the team responsible for combating the spill and for subsequent clean-up operations. He is expected to have a basic understanding of the dynamics of oil spills and be conversant with the tools used for containment and clean-up operations.

On leaking or spilling into the sea, oil is subject to a series of processes that distribute the product in the environment and at the same time cause it to age or gradually convert, thus changing its physical and chemical characteristics.

Spreading: After the spill, oil spreads over the water surface in the form of a thinning film. In the case of most spills, slick size is generally controlled after the first hour or two, by a surface tension-viscosity relationship which is independent of spill volume. Spreading competes with emulsification. Emulsification greatly increases the viscosity of the remaining slick, reducing the tendency to spread.

Evaporation: This is a process by which low-to-medium molecular weight components of relatively low boiling point evaporate into the atmosphere. Components with boiling points lower than 200°C will evaporate within 24 hours. The loss of more volatile components will cause the remaining oil to have a higher viscosity.

Solution: This is a process by which low molecular weight compounds are lost by the oil to the water. These products are then available for uptake by marine organisms and can be toxic.

Emulsification: When small drops of oil are dispersed into water due to turbulence in the water, an oil-in-water emulsion is formed. This has a much higher viscosity than the original oil. After prolonged weathering, the emulsion becomes highly viscous and is commonly referred to as 'chocolate mousse'.

Sedimentation: When mixed with particulate matter like sand or silt, the oil eventually settles to the bottom.

Microbial degradation: Over 90 species of micro-organisms capable of degrading oil by biological oxidation have been identified. Biological degradation increases rapidly when nutrients like nitrates and phosphates are present.

There are four main methods of combating an oil spill:

- mechanical recovery;
- dispersant use;
- in-situ burning; and
- allowing the oil to come ashore for clean-up later.

Mechanical containment and recovery of oil is the most desirable option. Booms are used for containment, and skimmers are used to recover oil from the water surface.

Natural or induced agitation of water causes dispersion of oil into the water column. Dispersants are mixtures of surfactants in one or more solvents, specifically formulated to enhance the rate of this natural process and thereby reduce the amount of oil coming ashore.

In-situ burning has the advantage that it rapidly removes large volumes. But it poses fire hazards, and has limitations when the thickness of the oil slick is less than 2 mm. Emulsions burn poorly, if at all.

The last option of letting the oil come ashore is chosen only when the shoreline can be cleaned relatively easily or has low environmental, social or economic value.

4.6.3.1 Mechanical Containment

Booms

Unless it is highly viscous or dense, oil when spilt will float and spread. Unless control measures are taken early, the slick will cover a wide area in a comparatively short time, making clean-up operations more difficult. To avoid this, booms can be used to prevent the spreading, and facilitate oil recovery.

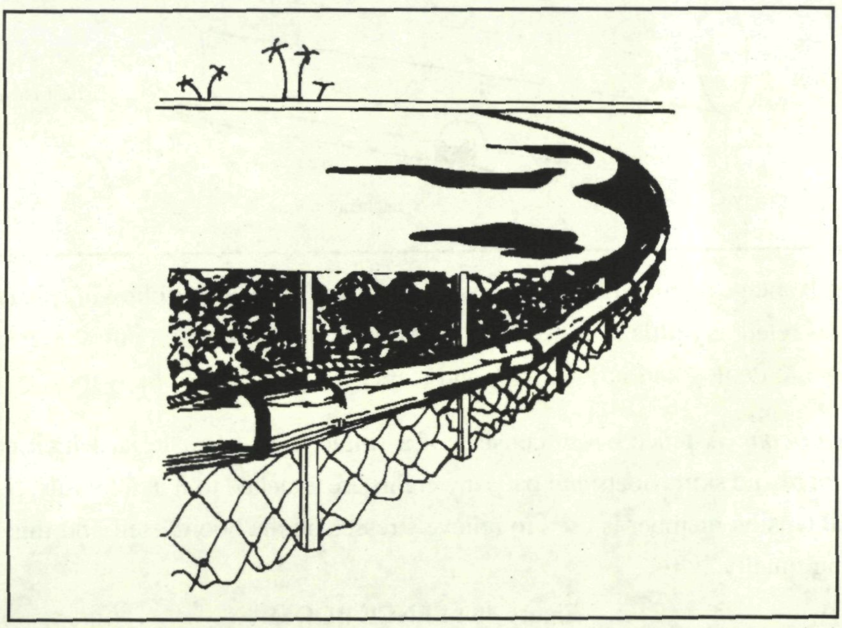


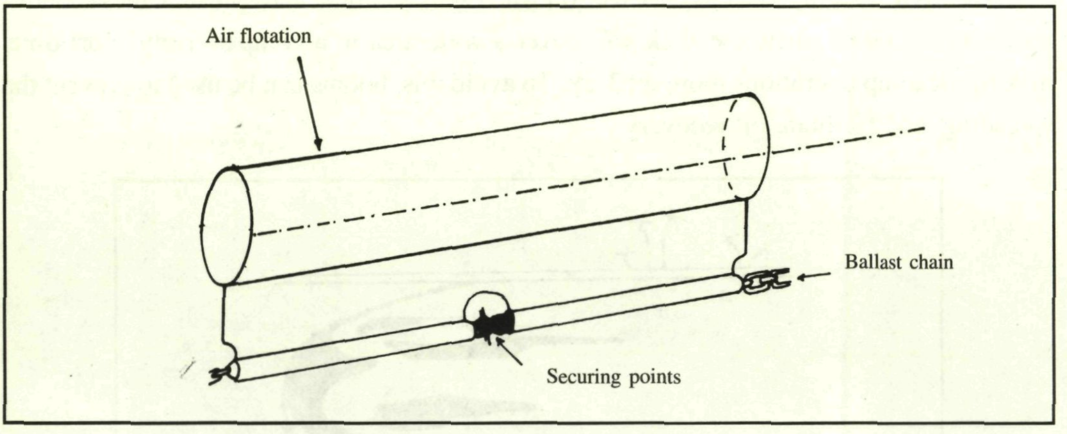
Figure 38 : An artisanal floating oil boom made from bamboo floaters, pieces of timber uprights and fish net filled with rice straw sorbent. The sorbent can be dried and incinerated ashore.

There are many kinds of booms. Their structure may differ, but basically they comprise the following components:

- freeboard to prevent or reduce splashover;
- subsurface skirt to prevent or reduce escape of oil under the boom;
- flotation by air or some buoyant material;
- longitudinal tension member (chain or wire) to withstand the effect of winds, waves and currents.

Inflatable boom: These booms consist of inflatable air chamber or tubes. In most cases air is supplied from a low pressure blower but some are self-inflating. The skirt is made of oil and water-resistant fabric.

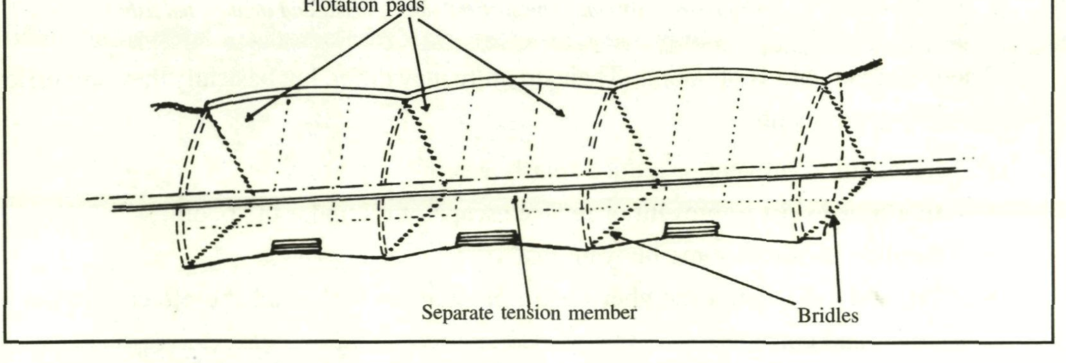
Figure 39 : INFLATABLE BOOM



The advantages of an inflatable boom are that it has good wave-following characteristics and requires relatively little storage space. The disadvantages are that unless self-inflatable, it takes time to deploy and inflate. Rips and tears can cause loss of buoyancy.

Fence boom: A fence boom consists of a single sheet of material which constitutes both freeboard and skirt; floats and ballast weights are attached to it at intervals. Sometimes an external tension member is used to relieve stresses on the boom itself and this improves sea-keeping quality.

Figure 40 : FENCE BOOM

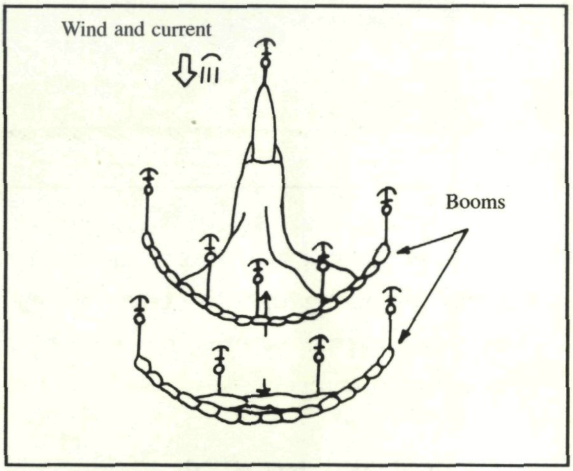


The optimum deployment of a boom will depend on weather conditions, the state of the sea and other factors. The following are typical deployment methods:

1. *Encircling*: This method may be employed in the early stages of spill control when discharge rate is low. The boom is deployed around the spill source, leaving a limited entry for workboats. If the spill is from a shore facility, the shoreline may constitute a part of the encircling barrier.

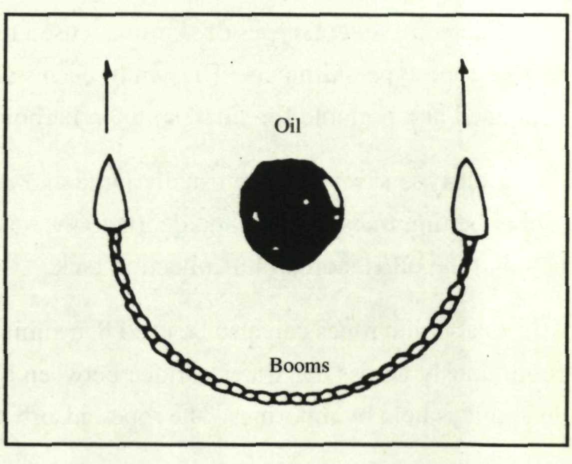
2. *Waylaying*: Such a deployment is used for large oil spills, where sufficient lengths of boom are not available, or where encircling is difficult because of adverse weather and rough sea. Booms are laid at some distance from the spill source to intercept the approaching oil. In tidal waters, another set of booms may be laid on the other side of the source in anticipation of current reversing. (Figure 41).

Figure 41 : WAYLAYING



3. *Towing*: If wind and current velocity are too high for stationary containment or if the oil is already widely scattered, booms can be towed at low speed (less than 0.5 m/s) through the water. (Figure 42).

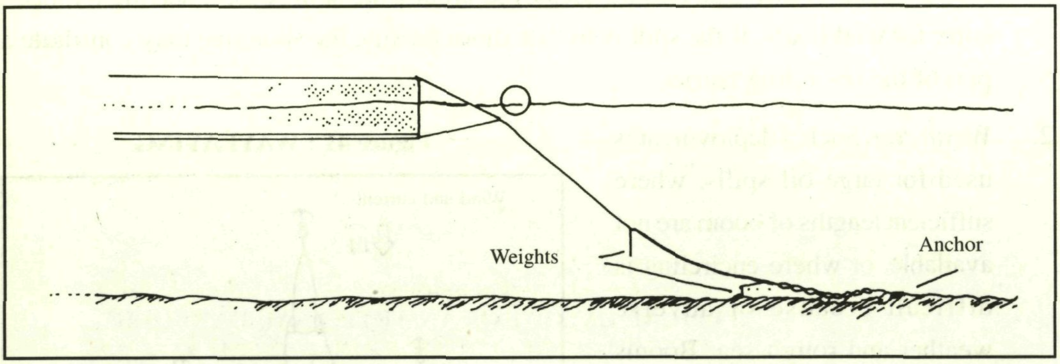
Figure 42 : TOWING



4. *Netting*: This system consists of booms, buoys with anchors and weights laid upstream of the boom, and sheets of net. In cases where tarballs or mats are floating

below the surface, nets are extended to the sea-bed from the skirt of the boom. Normally, this deployment method is used nearshore. (Figure 43).

Figure 43 : A NETTING OPERATION



5. *Mooring*: Booms may also be moored to conventional anchors or concrete blocks. Usually, mooring ropes five times the depth of water are required, and when ropes of buoyant material are used, this must be compensated for by adding extra chain or weights to the ropes.

4.6.3.2 Mechanical recovery of oil

Skimmers

There are several types of skimmers used to recover floating oil – such as drum, disk, belt or rope type skimmers. They may be installed in special collection vessels; be self-contained and portable for small spills in harbour basins; and even mounted on shore.

Belt-type skimmers are usually large and are installed in vessels. An endless loop of rubber belting transports oil and debris to the vessel. Pinch rollers separate the oil from the belt and the oil is stored in a collection tank.

Oleophilic ropes can also be used in a similar fashion (Figure 45). A loop of rope runs continuously across the water surface between a collection device which drives the ropes, and pulleys held by moorings. The ropes adsorb oil and carry it to a collection device where

Figure 44 : EXAMPLES OF DIFFERENT SKIMMER TYPES

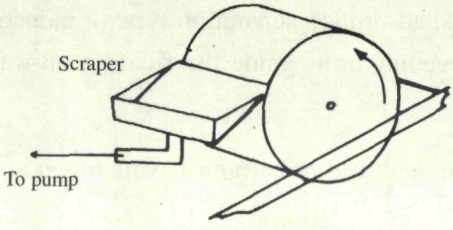


Figure 44a : Drum Skimmer

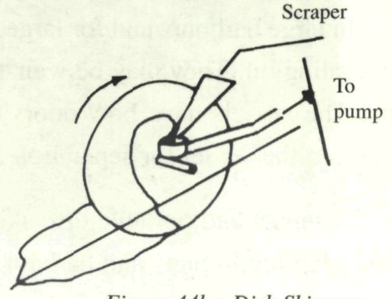


Figure 44b : Disk Skimmer

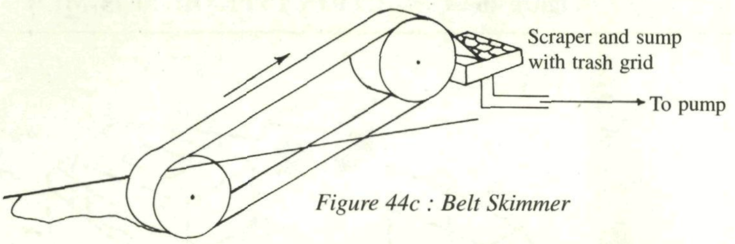
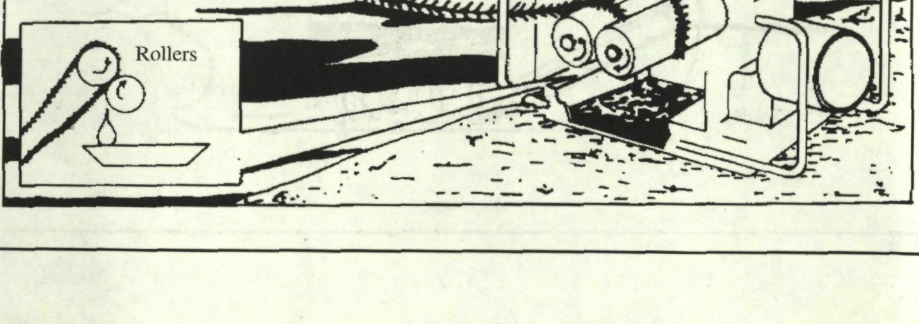


Figure 44c : Belt Skimmer

Figure 45 : OLEOPHILIC ROPE SKIMMERS



rollers squeeze the oil out of the ropes into a reservoir. Rope systems are unaffected by floating debris and can be used in very shallow waters.

In large harbours and for large slicks, specialized oil recovery vessels are used to skim the floating oil. They may be weir-type skimmers, adsorption separation type or induction type. The vessels have bow doors or ramps. Sweeping arms guide the floating oil-water layer into the vessel for separation and recovery.

Compact and portable disc skimmers can be deployed in harbour basins to get at oil films adhering to piers and harbour walls.

Figure 46 : INDUCTION TYPE OIL SKIMMER

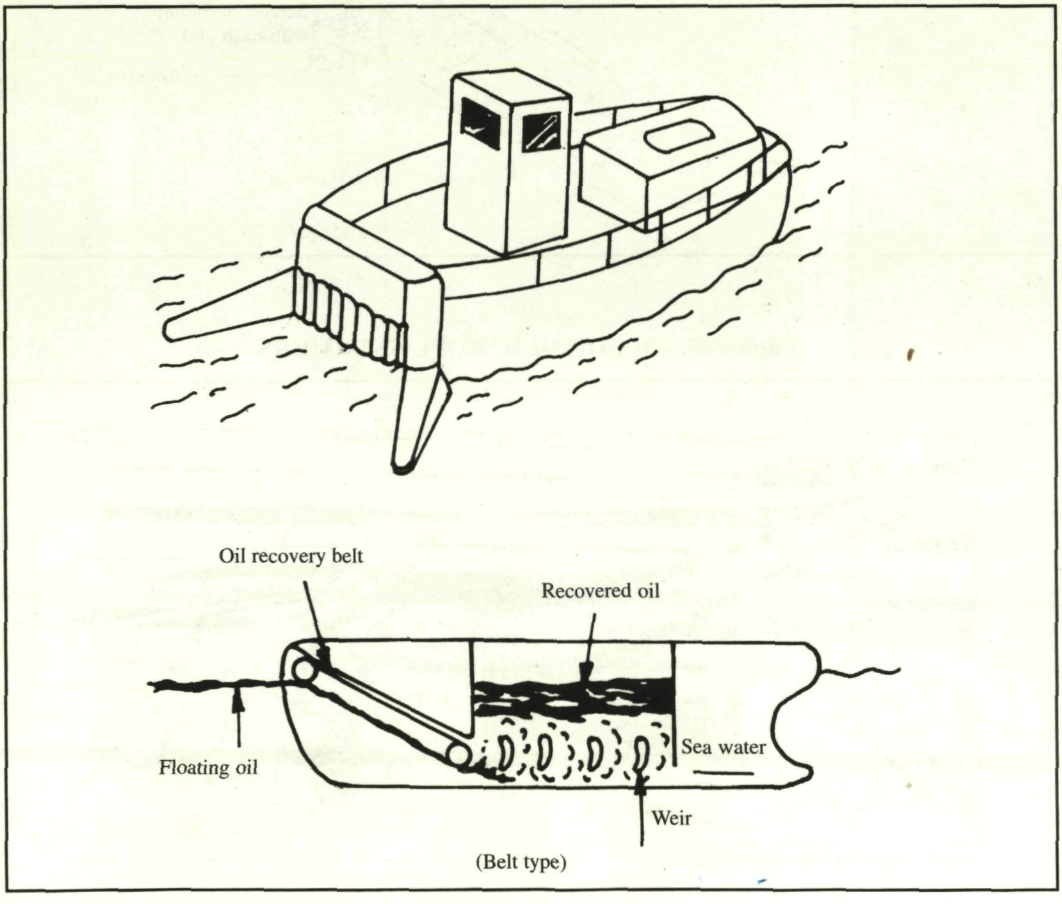
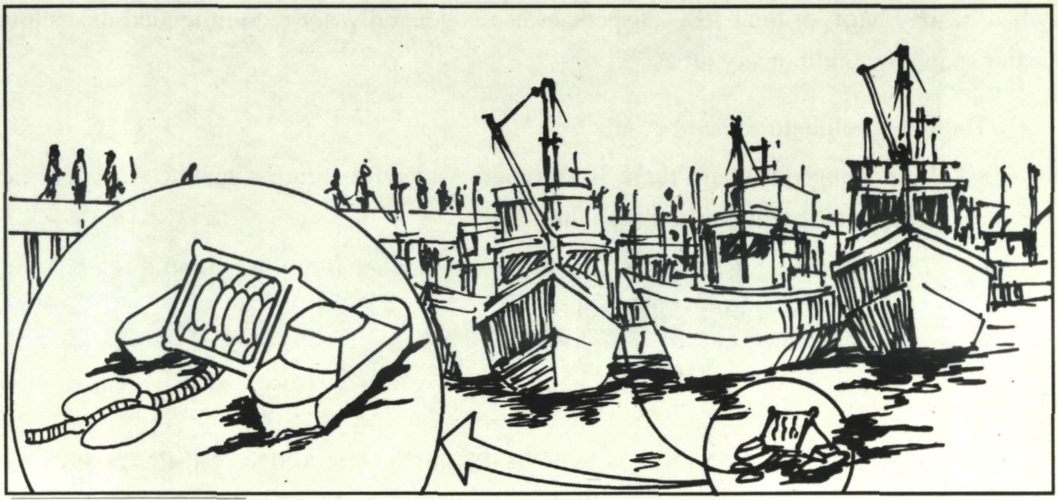


Figure 47 : PORTABLE OIL SKIMMER



4.6.3.3 Dispersant Use

The hydrocarbon type of dispersants used in the past have had adverse effects on the environment due to their toxicity. Modern dispersants used today are significantly less toxic than the oils they disperse. They can be used either pre-diluted with sea water or in a concentrate form.

For concentrate dispersants, treatment ratios of 1:10 to 1:20 (dispersant:oil by volume) are needed. Under rough sea conditions, less dispersant may be needed.

The possible **toxic effects of dispersed oil** in the water column are a primary consideration when assessing the use of dispersants to deal with an oil spill.

Recreational areas for instance, may be of little value from the biological point of view, but they may be important for some local economies. In such cases, dispersants may be used relatively close to the shore.

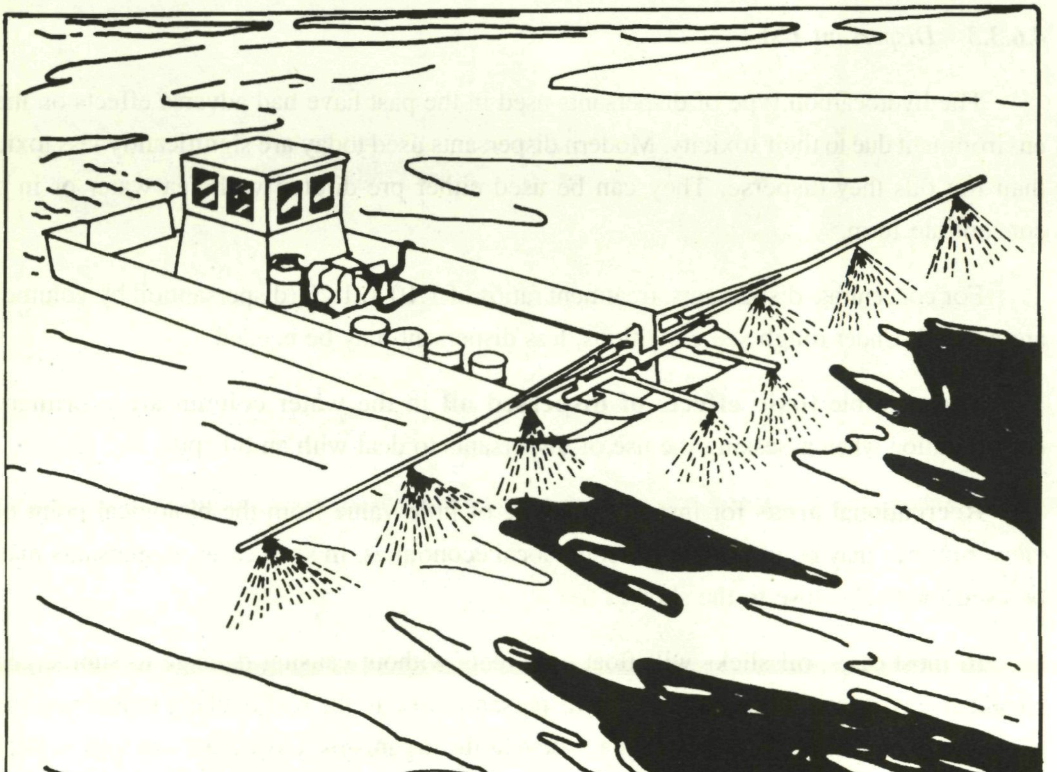
In most cases, oil slicks will float over reefs without causing damage to submerged **corals** and associated organisms. Using dispersants close to the reef is likely to increase the exposure to oil, with possible damage to some of the organisms. Dispersant use over or near coral reefs should be avoided as far as possible.

In shallow water, dispersed oil in the water column is likely to reach concentrations where it may harm or taint **fish**. Dispersant use is generally not recommended in shallow water spawning and nursery areas.

The main points to remember are:

- Dispersing oil where there is sufficient water for dilution has no known toxic effects on marine or benthic biota; and
- Toxic effects of using dispersant are possible when dilution potential is less, as in shallow bays or over coral reefs.

Figure 48 : BOW SPRAY SYSTEM FOR DISPERSING OIL USING DISPERSANTS



4.7 SEWAGE AND EFFLUENT TREATMENT

Untreated municipal sewage is perhaps the most common cause of water pollution when the sewage is discharged into it. Disposal of urban and industrial sewage is one of the most difficult problems in water pollution control. It is often feasible to use a submarine outfall to discharge waste effluents into unconfined coastal waters nearby, where the diluting and absorbing capacities of these waters greatly simplify treatment and disposal problems. But when the discharge is in confined waters, the risk of pollution is very high. Discharge into the harbour basin of raw sewage and grey waste from the harbour complex only exacerbates the problem.

The main problem with sewage pollution is the introduction of pathogenic micro-organisms into the water body, thereby posing a health hazard to those who come into contact directly or indirectly with the contaminated water. The presence of faecal coliform bacteria is generally indicative of sewage pollution.

The serious threat to public health and financial losses on account of poor fish quality make it necessary for the harbour master to accord a high priority to monitoring water quality for signs of faecal pollution and for ensuring that sewage and gray waste from the harbour complex is adequately treated and safely disposed of. It is also necessary for him to interact with the municipality on issues relating to sewage pollution of contiguous waters.

To ensure that there is no pollution from sewage generated in the harbour complex, the harbour master should take steps to provide for proper collection and disposal not only from shore facilities but also from fishing vessels using the harbour. Adequate toilet facilities should be made available for harbour users. Defecation in the open by people and by animals near the waterside should not be tolerated.

Sewage effluent from a fishery harbour consists of:

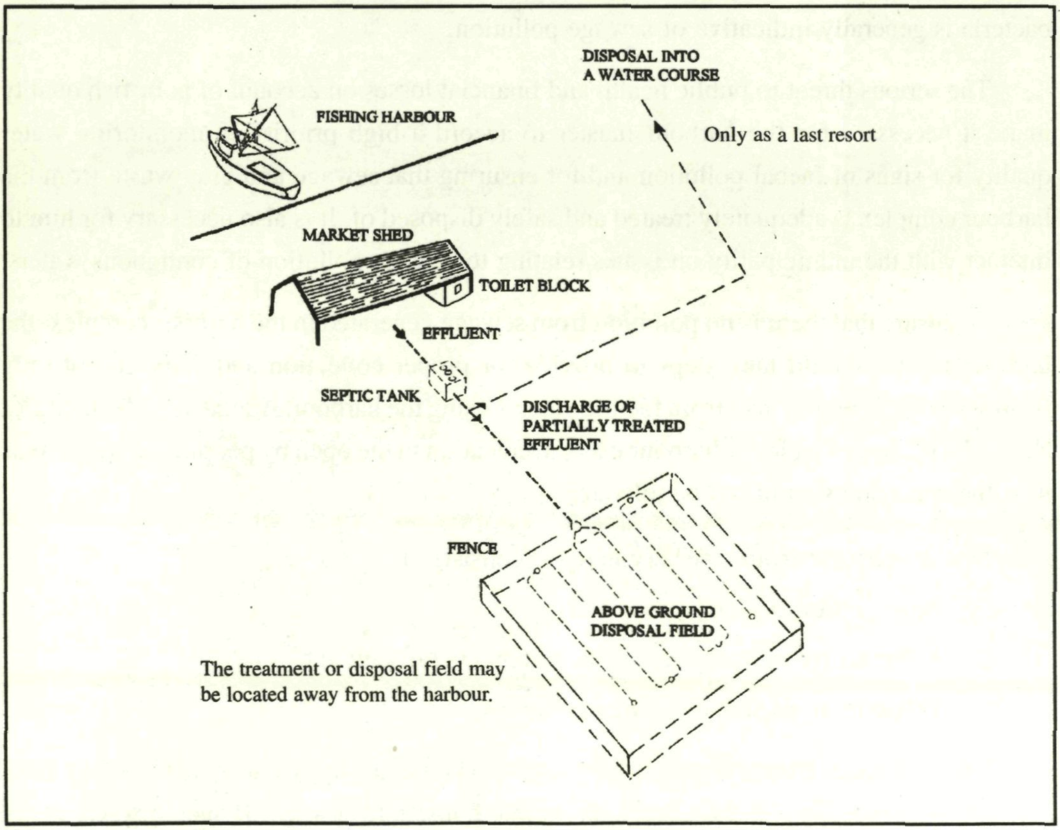
1. Sewage from toilets;
2. Effluents from wash areas with detergents present; and
3. Effluents from fish cleaning operations.

The combined effluent from a fishing harbour should ideally be connected to a municipal sewer to be taken away and treated with normal household sewage. If such a sewer is not available within a reasonably economic distance, the effluent has to be treated before being discharged into a water course. Depending on the size of the fishing harbour, the effluent may be treated either via septic tanks and on-site natural treatment systems (artisanal harbours only) or via a proper sewage treatment plant (coastal, offshore and distant-water harbours). In both cases, adequate space should be provided for the purpose.

4.7.1 Artisanal harbours

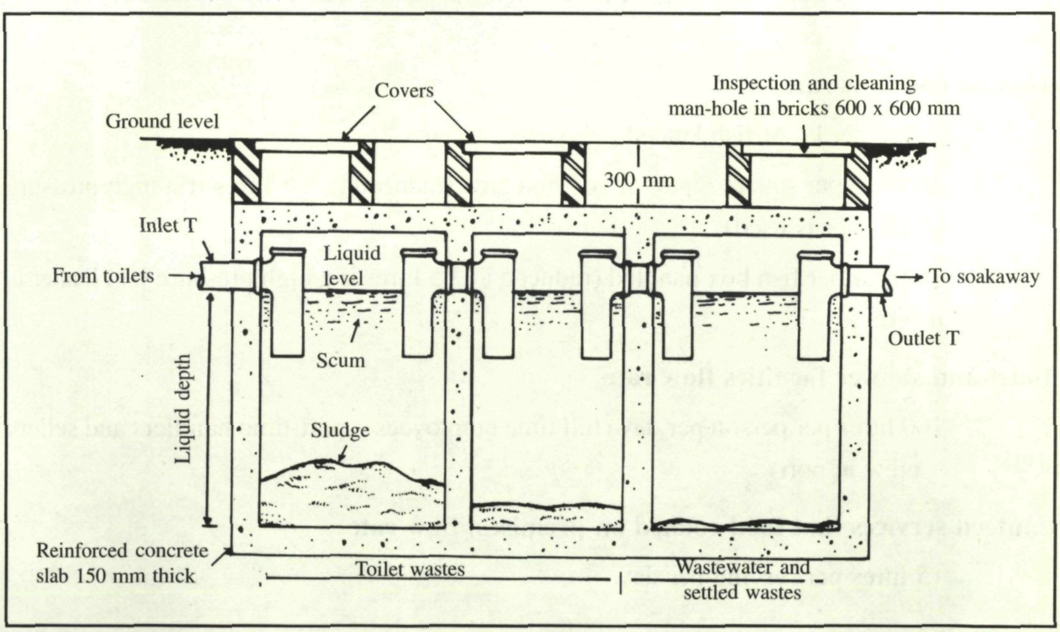
Artisanal harbours are more often than not situated in areas where the basic municipal infrastructure is very primitive or even totally lacking; introduction of sophisticated

Figure 49
TYPICAL LAYOUT OF AN ARTISANAL HARBOUR NATURAL TREATMENT SYSTEM



mechanical wastewater effluent treatment systems may also not be a viable option because of the costs involved. Natural treatment systems, on the other hand, may be designed to take advantage of the physical, chemical and biological processes that occur when water, soil, plants, micro-organisms and the atmosphere interact. The processes involved in natural systems include many of those used in sophisticated mechanical treatment systems, such as sedimentation, filtration, gas transfer, adsorption, ion exchange, chemical precipitation, chemical oxidation, and biological conversion and degradation - plus others unique to natural systems such as photosynthesis, photo-oxidation and plant uptake. In natural systems, the treatment process occurs at natural rates and tends to occur simultaneously in a single ecosystem reactor. In a mechanical system the processes occur sequentially in separate tanks at accelerated rates as a result of energy input.

Figure 50 : TRADITIONAL 3-STAGE SEPTIC TANK



The first stage of a natural treatment system is the septic tank, generally located in or around the harbour and into which all the effluent should be directed. A 3-stage septic tank is a rectangular underground chamber divided internally into three compartments.

After coarse screening through a basket sump, the effluent is retained inside the compartments for a minimum period of three days; during this period, the solids in suspension settle to the bottom of the first compartment where they are attacked and digested by bacteria. As a result, the volume of sludge is greatly reduced and the effluent clarified to some extent. Appropriate manholes should be provided over each compartment to enable sludge to be removed (pumped out) during maintenance.

The dimensions of the chamber should be such that peak total daily effluent flows are retained for a minimum period of three days inside the tank. Obviously, the larger the volume to be treated the larger the tank should be. Various methods are available to reduce the volume of water to be treated, such as high pressure jet cleaners for hosing down operations (largest consumer of water), automatic or spring-loaded taps over wash-hand basins and dual-flush action toilet flushing equipment.

The following guidelines may be used when calculating a harbour's total daily effluent flow rate.

Auction hall flow rate

1 litre per kg of fish landed every day;

10 litres per square metre of covered area (reduced to 2.5 litres if a high pressure jet cleaner is used);

10 litres per fish box handled (reduced to 2.5 litres if a high pressure jet cleaner is used);

Toilet and shower facilities flow rate

100 litres per person per day (full time employees + part-time handlers and sellers + crew in port).

Canteen services (hot food cooked on premises) flow rate

15 litres per serving per day

This total volume should also be adjusted for peak summer conditions when fish handling and visiting crews increase in numbers. The effluent from the septic tank should then be piped for further treatment to one of several types of natural treatment systems. It should be discharged into a waterway or into the sea only as a last resort.

Natural treatment systems may consist of one of the following :

- **Slow rate treatment** (effluent is sprayed or channelled over vegetated land to provide treatment), Figure 51;
- **Constructed wetlands - emergent plants** (effluent is fed into inundated areas that support growth of emergent plants such as cattail, bulrush, reeds or sedges), Figures 52a and 52b;
- **Constructed wetlands - floating aquatic plants** (effluent is fed into inundated areas that support plants of the floating species such as water hyacinth and duckweed), Figure 53.
- **Rapid infiltration** (effluent is applied intermittently to shallow spreading basins and lost into the ground), Figure 54;

4.7.1.1 Slow rate treatment

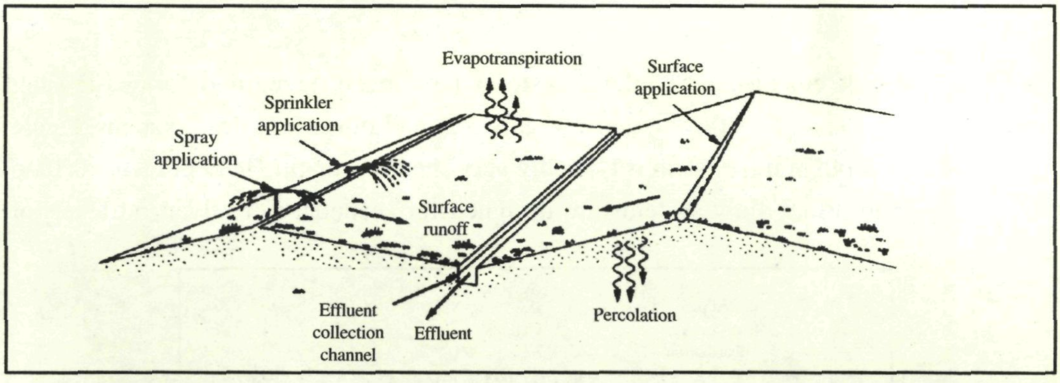


Figure 51 : TYPICAL ABOVE-GROUND SLOW RATE TREATMENT FIELD

Slow rate treatment, the predominant natural treatment process in use today, involves the application of effluent or wastewater to vegetated land to provide treatment and to meet the growth needs of the vegetation. The applied water is either consumed through evapotranspiration or percolates vertically and horizontally through the soil profile. Any runoff is usaually collected and reapplied to the system. This system needs a moderately slow soil permeability and in areas of high precipitation needs effluent storage. The effluent may be applied via sprinklers or furrows. Typical area requirements for this system are 15 to 45 acres per million litres of effluent per day.

4.7.1.2 Constructed wetlands - Emergent plants

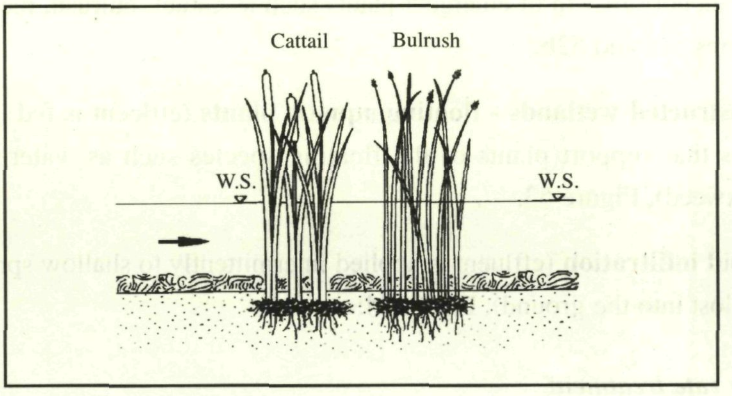


Figure 52a : FREE WATER SURFACE FLOW TREATMENT

Two types of constructed wetland systems have been developed for wastewater treatment: free water surface flow systems, Figure 52a, and subsurface flow systems, Figure 52b. The water depth in this system is typically very shallow, ranging in depth from 0.10 to 0.60 metres. Subsurface flow systems are designed for secondary or advanced levels of

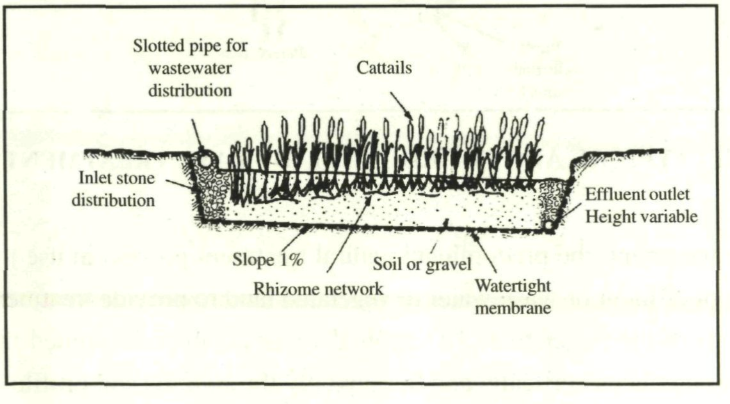


Figure 52b : SUBSURFACE WATER FLOW TREATMENT

treatment. These systems have also been called root zone or rock reed filters and consist of channels or trenches with relatively impermeable bottoms filled with sand or rock media to support emergent vegetation.

This system is generally classified as a constructed wetland where the effluent may be collected after treatment and re-utilised in agriculture. Lack of a free water surface also makes it ideal for areas prone to mosquitoe infestation. Effluent storage is needed in areas of high precipitation. Typically, 4 to 14 acres per million litres of effluent treated daily are required.

4.7.1.3 Constructed wetland - Floating plants

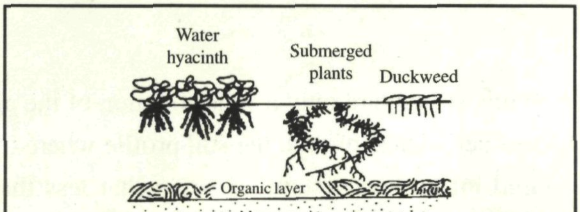


Figure 53 : FLOATING AQUATIC PLANT SYSTEM

Constructed wetlands offer all of the treatment capabilities of natural wetlands, but without the constraints associated with discharge to a natural ecosystem. Floating aquatic plant systems are similar in concept to free water surface systems except that the plants are floating species such a water hyacinth and duckweed. Water depths are typically deeper, ranging from 0.50 to 1.80 metres. Supplementary aeration has been used with floating plant systems to increase treatment capacity and to maintain aerobic conditions necessary for the biological control of mosquitoes. For this reason, the ponds should be stocked with mosquito fish. Area requirements are similar to other wetland systems.

4.7.1.4 Rapid infiltration

In rapid infiltration systems, wastewater effluent is applied on an intermittent schedule usually to shallow infiltration trenches or spreading basins. Vegetation is not usually provided.

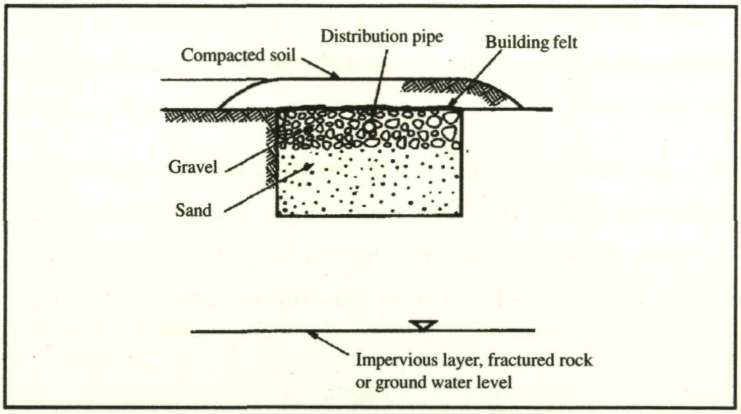


Figure 54a : SHALLOW SAND-FILLED FIELD TRENCH

The evaporative losses in this system are only a small fraction of the applied water. Hence, most of the applied effluent percolates through the soil profile where treatment occurs. The treatment potential of rapid infiltration systems is somewhat less than that for slow rate systems because of the lower retention capacity of the soil and the relatively higher inflow of water. In locations where the groundwater level is high (such as in coastal areas) or the underlying strata not permeable enough, pressure-dosed field trenches have been successfully used (Figure 54a). Pressure distribution, which serves to distribute the effluent evenly over the sand in the trench, is a key factor contributing to the success of this type of disposal.

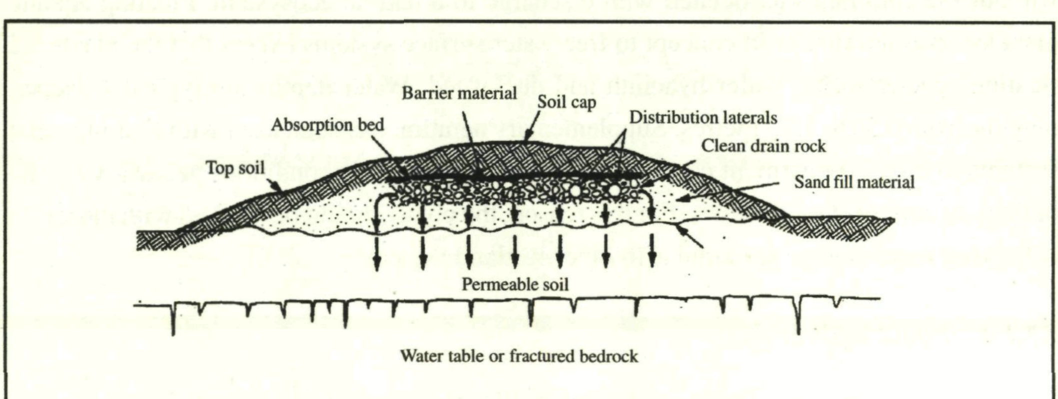


Figure 54b : MOUND SYSTEM

The mound system (Figure 54b above), is essentially an intermittent sand filter that is placed above the natural surface of the ground. The effluent in this system is pumped from the septic tank through a piped pressure distribution system placed at the apex of the gravel layer. Mound systems have been used in areas where the soils are permeable and the water table very high or the soils not permeable at all. The system works well only if the water accumulated under the mound can be pumped away. This system requires mechanical pumping at all stages of the treatment and may not be suitable in areas which lack a steady power supply.

4.7.1.5 Which system is more suitable?

This question cannot be answered until the site has been evaluated by a competent geologist. However, the principal considerations in the design of a natural wastewater treatment system are :

- A preliminary site assessment;
- Detailed site evaluation;
- Assessment of the hydraulic assimilation capacity of the terrain;

The preliminary site assessment should consider the geomorphological features of the area, such as surface slopes, existing marshes or wetlands, flooding potential, groundwater extraction, water table levels and landscaping.

The detailed site evaluation should include identification of the soil characteristics, percolation coefficients and hydrogeological characterization of the area.

From these investigations it should be possible to determine the hydraulic assimilation capacity of the area, that is the suitability of the area to receive septic tank effluent without jeopardising the environment and public health (groundwater).

Fresh water should be utilised in the toilet flushing system when septic tanks are used for treating waste water. The presence of sea water (upto 30%) in the raw effluent decreases the efficiency of the bacterial decomposition of the sludge. Beyond 50% of sea water, bacterial decomposition is seriously compromised.

4.7.2 Other harbours

Other harbour installations, such as commercial fishing ports, situated away from municipal centres, should install proper sewage treatment plants which can handle a larger volume of water and produce an effluent which may be discharged directly into a water course. Depending on the required degree of purity of the effluent, a sewage treatment plant may consist of :

- **Screening** and disintegration (removal of major solids);
- **Sedimentation** (to settle out organic solids into sludge);
- **Biological filtration** (over a pebble bed inside circular tanks);
- **Tertiary treatment** such as microstraining, aeration and upward flow rapid gravity sand filters.

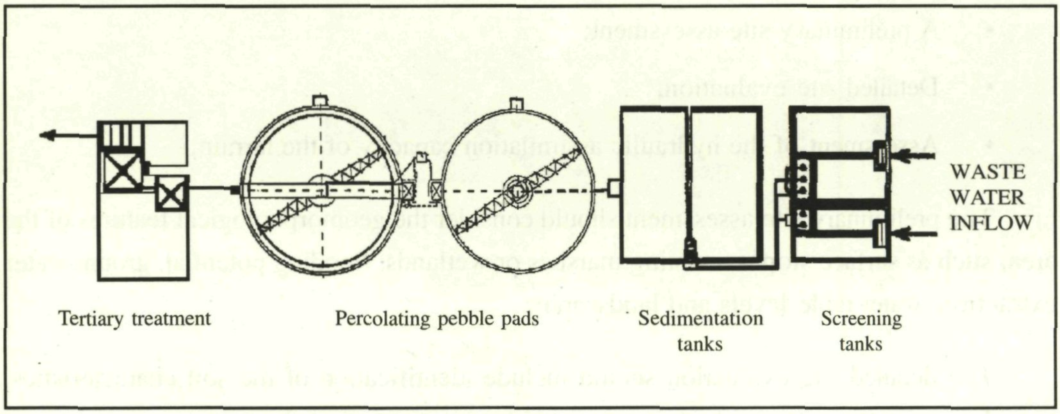


Figure 55 : TYPICAL MODERN SEWAGE TREATMENT PLANT

In small plants, screening for large solid matter which may interfere with pipe flow is generally carried out with manually racked bar screens at 60º to the flow . The rest of the organic solids are then macerated by means of a special pump and the fluid pumped into long sedimentation tanks; there, the drop in velocity allows some of the suspended matter to settle as sludge which is then removed periodically, dried and disposed of (buried, burnt or dumped offshore). The biological treatment is achieved by spraying the liquid from the sedimentation tanks over a pebble bed by slow-moving rotating arms. Here, biological oxidation takes place (aerobic digestion) by micro-organisms in the slime covering the stone pebbles. If further treatment is necessary, the fluid is then pumped into a tertiary treatment section; otherwise, the liquid is pumped to an outfall which should be located some distance away from the harbour.

4.7.3 Wash-hand basin effluent

In small harbours where the sewage is treated through a septic tank, the effluent containing detergents from the wash hand basins and the shower units may be discharged into a soakaway away from the septic tank or directly to a constructed wetland, Figure 56.

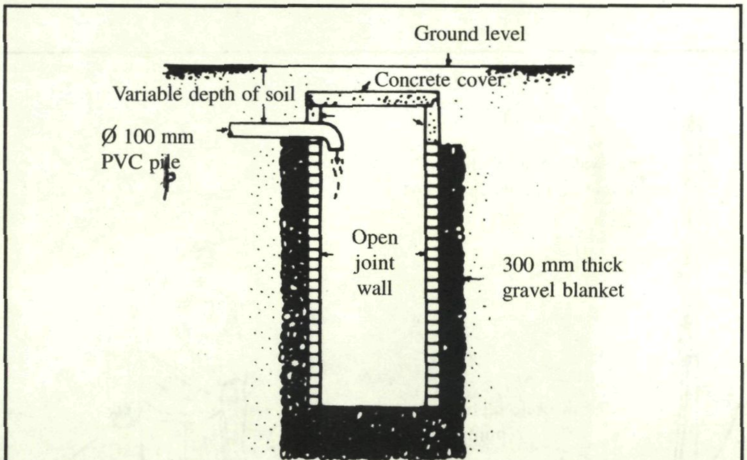


Figure 56 : SIMPLE SOAKAWAY

Soakaways are the simplest type of drain and suitable for sandy terrain only. Soakaways should be placed as far away from water supply boreholes as possible.

4.7.4 Market floor run-off

Market, auction and processing floors are generally hosed down using copious amounts of water; the water may contain both solids (fish scales, discards, entrails, etc.) and liquids (blood and fish oils). This run-off is not a health hazard by itself but rather a nuisance. It may indirectly attract pests to the food handling area, such as flies. Before entering the drainage system, this run-off should be channelled to a basket drain to separate all the solids which may otherwise cause blockages in the drainage system. The basket drain should be in stainless steel or plastic and easily accessible for cleaning. Moreover, due to the large volume of water involved, this run-off should preferably never be mixed with the toilet's effluent as this will appreciably increase the flow rate through the septic tank. This run-off water is best diverted to a soakaway, especially if sea water is used for this purpose.

In larger installations, it may still be uneconomical to channel this large volume of run-off to the treatment plant as this will increase the basic cost of treatment for all effluent. If environmental conditions permit (absence of sharks, outfall placed outside the harbour

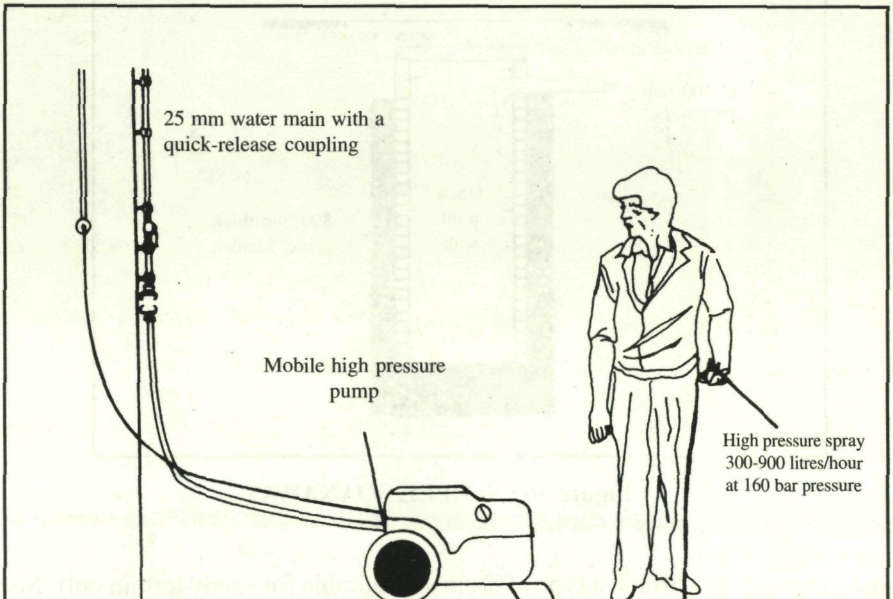


Figure 57a - Shows a mobile high-pressure cleaner suitable for cleaning market hall floors with a low water consumption.

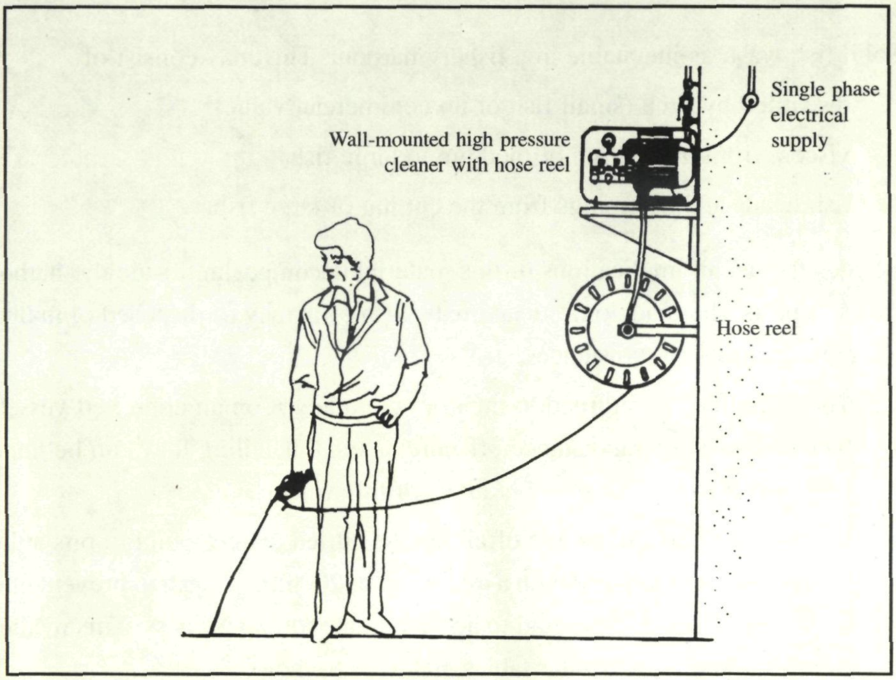


Figure 57b - Shows a fixed high pressure cleaner mounted on the wall. Small units like this are also very suitable for cleaning fish baskets, which generally require copious amounts of running water.

basin, strong currents present nearshore, etc.), this run-off may be channeled directly into the sea via a long underwater outfall.

An alternative solution to this dilemma is to reduce drastically the volume of run-off at source, i.e. at the handling halls, and this may be achieved by the use of high-pressure cleaning equipment.

Small compact high-pressure cleaners manage to clean a surface using about one fifth to one fourth of the volume of water normally used by a common 25mm diameter hose. The potential savings in water consumption may outweigh the cost of the electric power (3 to 5 Kw) required to operate the cleaners.

4.8 FISH OFFAL

Solid fish waste is inevitable in a fishery harbour. This may consist of

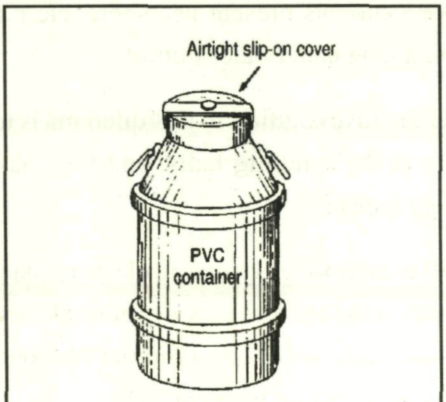
- discarded bycatch (small fish of no commercial value);
- viscera from the gutting of medium to large fish;
- fish heads and trimmings from the cutting of large fish.

Besides the health implications of this material decomposing inside the harbour area, it also attracts pests, flies and domestic animals. Fish offal may be disposed of in three ways depending on the local circumstances.

1. The offal may be returned to the sea by loading it on an approved vessel, which then dumps it a long distance offshore; a small handling levy can be imposed on landed fish to finance the operations of this vessel.
2. In very small quantities, the offal may be buried underground in pits at least two metres deep and covered with a minimum of 200mm of earth to prevent infestation with flies and other pests and to accelerate the rotting process. This method is not suitable when groundwater tables are close to the surface.
3. When the quantity of offal is large, recycling into fish-meal should be encouraged; this usually gives rise to a cottage industry downstream from the landing process.

Irrespective of the size of the harbour, the best receptacle to store wet wastes in until they may be recycled or disposed of, is airtight PVC drums like the one shown in Figure 58.

Figure 58
PVC AIR-TIGHT BARREL



These airtight containers should be placed at vantage points all round the harbour, including fish handling areas and points of sale. They should not be placed in corners and hidden away from sight. They should be placed in cool sheltered spots away from direct sunlight.

4.8.1 Fishmeal

Fishmeal is a valuable source of protein for livestock. It also contains useful quantities of nutrients, vitamins and minerals. It is generally believed that many commercial fishmeal plants have failed because of inadequate raw material supplies. Even at the cottage industry level, a careful assessment should be made of the economic viability of establishing the plant.

Although all kinds of fish and fish offal can be used to make fishmeal, efficient utilization reqires certain elementary precautions :

- The material should be reasonably fresh as spoilt fish may reduce the nutrional value of the fish meal;
- Certain tropical fish (like puffer fish) contain toxins and should be excluded;
- The offal must not be collected off the ground (free of sand and mud) but from airtight plastic barrels placed purposely around the harbour area.

A simple method to obtain fishmeal on a cottage industry level to process around 300 kg/day is described below.

The processing method

i. *Cooking :* The raw materials, after washing, are cooked in a boiling drum (Figures 59 and 60) for 15 to 20 minutes;

ii. *Pressing :* The well-cooked mass is put into a press drum and maximum pressure applied for about 15 minutes to drain all the liquid away;

iii. *Crushing :* The pressed cake is put into a grinder and crushed; crushed fragments drop through a sieve at the bottom of the drum;

Figure 59 : SEQUENCE OF FISH MEAL PROCESSING

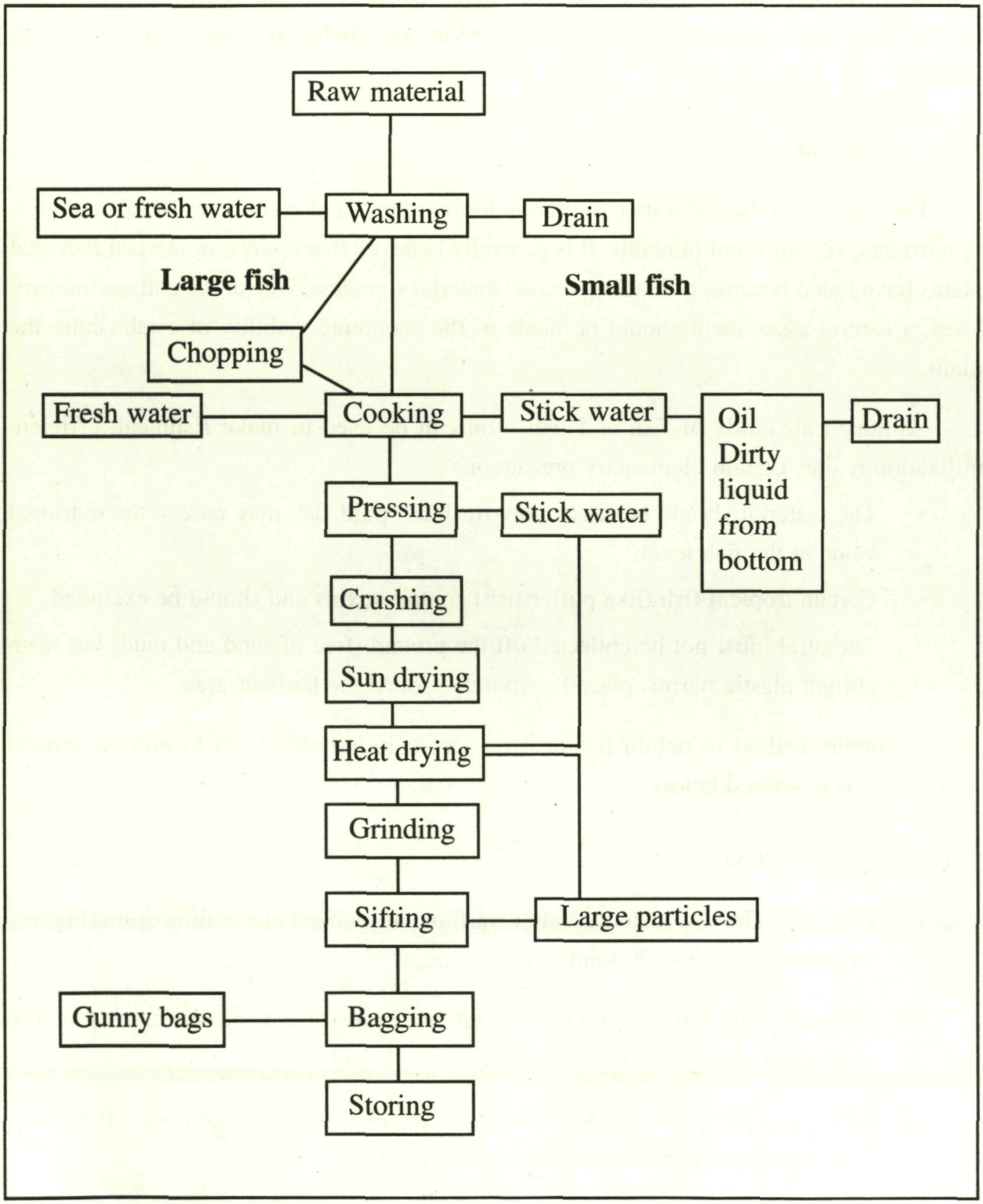


Figure 60 : COMPONENTS OF A MINI FISH MEAL PLANT

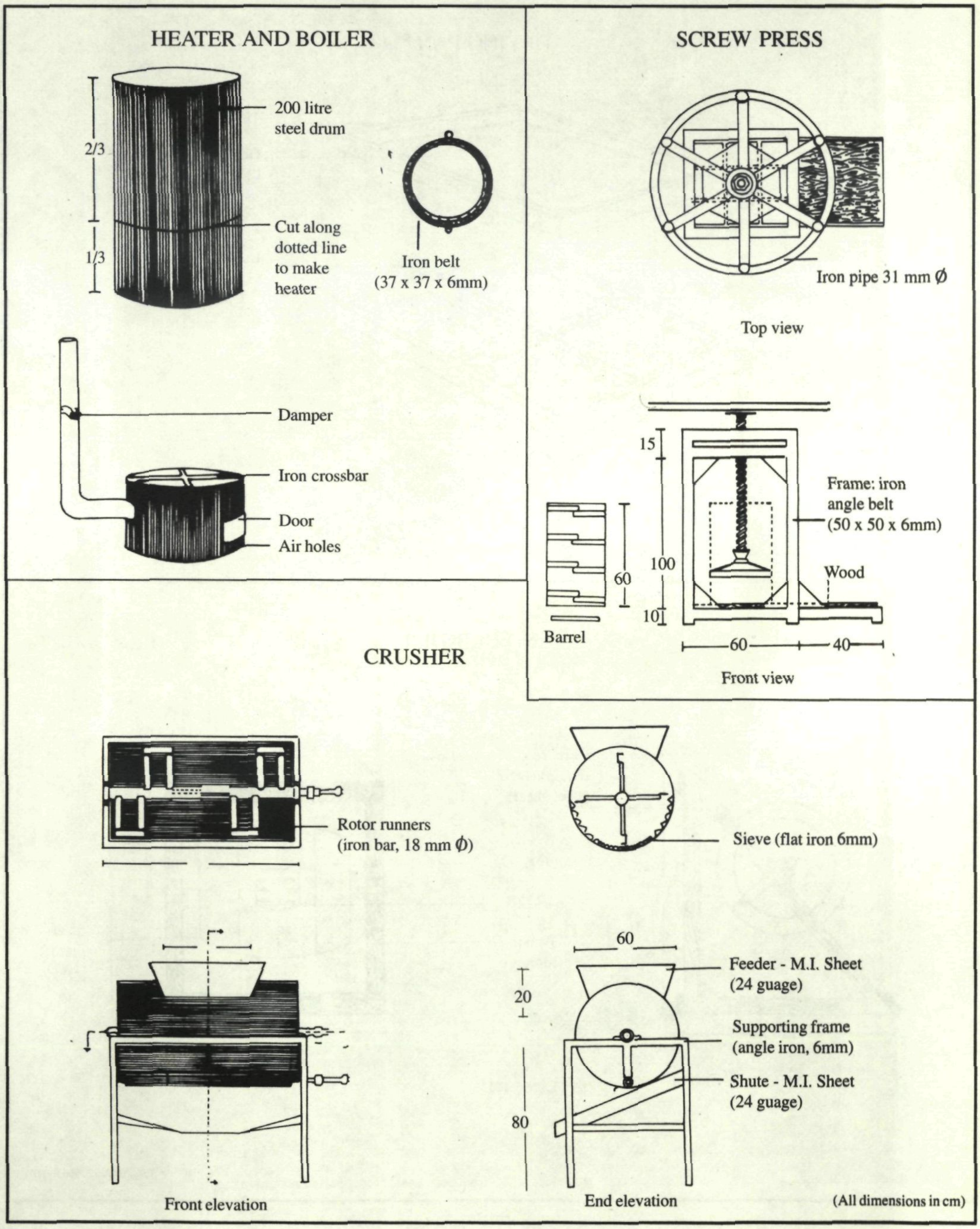
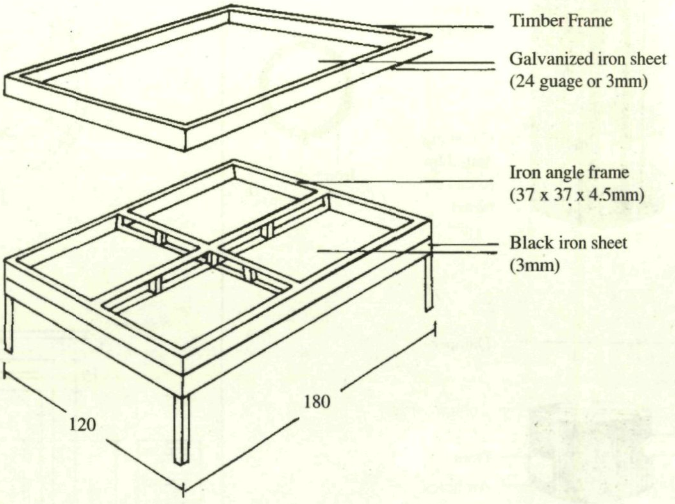
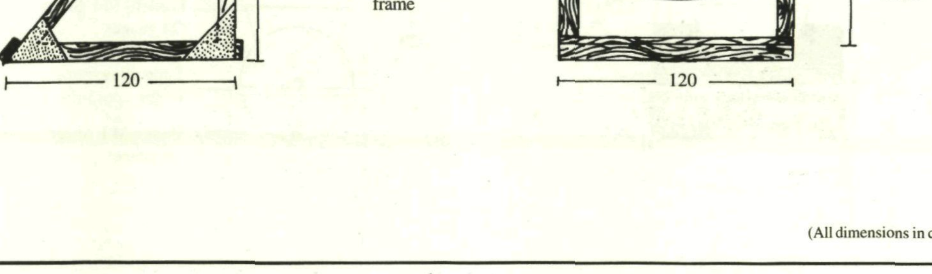


Figure 61 : COMPONENTS OF A MINI FISH MEAL PLANT

DRYING PAN



HAND GRINDER



(All dimensions in cm)

iv. *Drying :* The crushed meal is spread over a mat for sun-drying. During drying, the crushed mass is raked over from time to time. After one full day, the partly dry meal is spread over the drying pan and heated by two heaters. (Figure 61).

v. *Grinding :* The dried material is ground using the grinder for 10 to 15 minutes.

vi. *Sifting :* The ground meal is sifted using a sieve of 3mm mesh. The retained material should be further dried.

vii. *Bagging:* Cooled ground material is packed in jute bags and stored in a dry and cool place. Careful and quick handling at this stage is important to minimize insect infestation problems.

viii. *Utilization of stick water :* Protein can be recovered from the stick water during the boiling and pressing stages. At the end of boiling, skim off the oil layer and mix this with the meal in the drying pan in the ratio of 2:3 and continue the drying process. Stick water collected from the press is dealt with in the same way.

Figure 62 : TYPICAL BY-CATCH USED FOR FISHMEAL PRODUCTION

4.8.2 Fish Silage

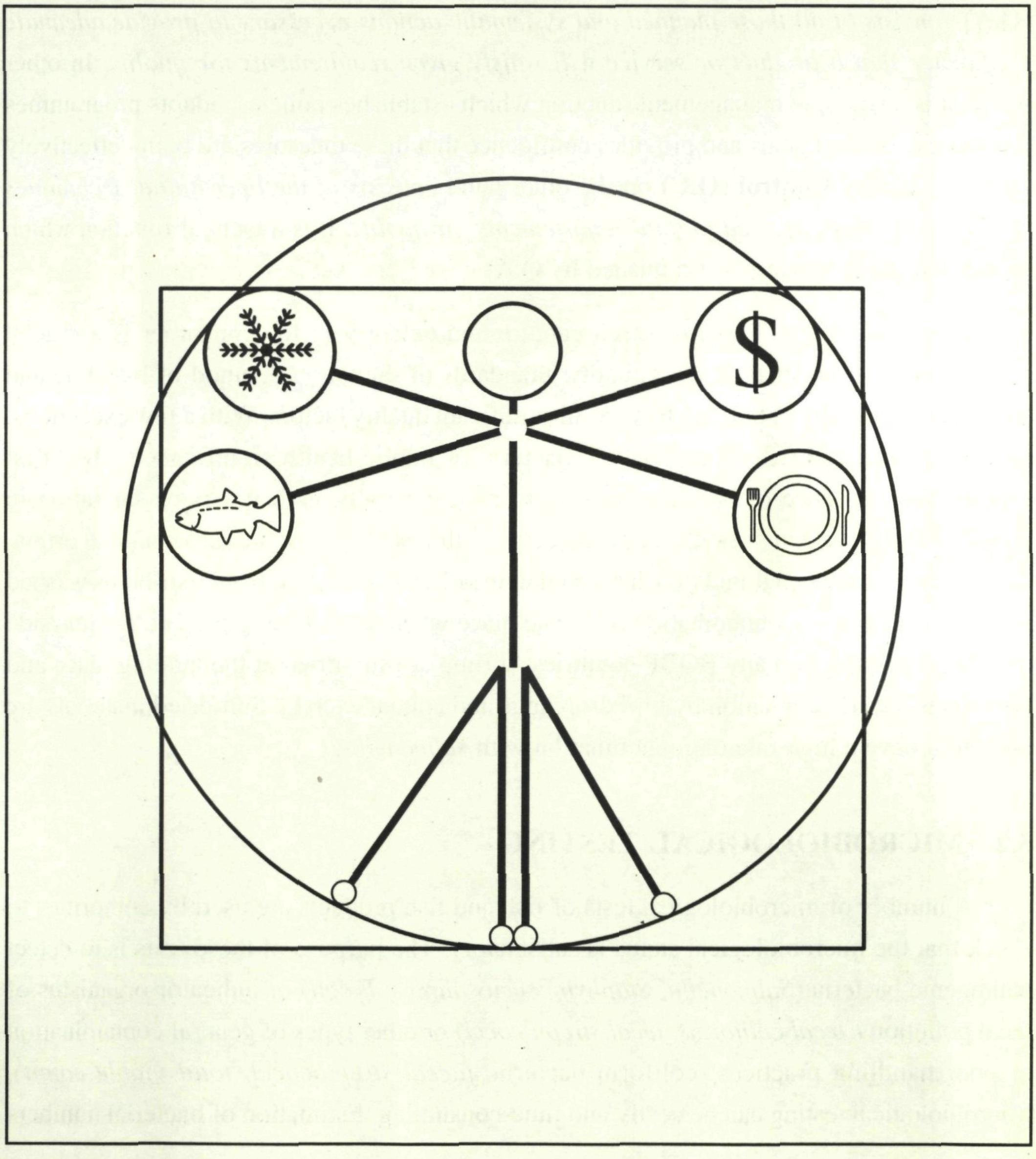
As an an alternative use of fish waste and offal, fish silage for animal feed is another possibility. One of the main advantages of fish silage over fish meal is low energy and capital cost. Energy is required only to grind the fish and mix it in formic acid (2 – 3 %) to reduce the pH level or a fermentable carbohydrate source and a culture of lactic acid producing bacteria. Another advantage over fishmeal is that its manufacture is not accompanied by an unpleasant odour.

The addition of formic acid encourages the breakdown of fish tissue by its own enzymes, while at the same time inhibiting the activity of spoilage bacteria. After one to three days, a stable free running liquid is obtained whose protein content is similar to that of the raw material. This liquid may be directly incorporated in feeding regimes for pigs, or it may be dried with a carbohydrate carrier like rice bran for feeding poultry.

Manufacture of silage is done by comminuting the raw material, mixing in the acid and allowing the product to liquify. On the small scale (batches of say 50 kg) these operations can be carried out manually.

Chapter 5

FISH QUALITY ASSURANCE



5.1 DEFINITION OF Q.A.

From the outset, a distinction needs to be drawn between Quality Assurance and Quality Control as the difference between them has been blurred due to indiscriminate use of these two terms. According to the International Standards Organization (ISO), **Quality Assurance (Q.A)** *consists of all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.* In other words it is a strategic management function which establishes policies, adapts programmes to meet established goals and provides confidence that these measures are being effectively applied. **Quality Control (Q.C)** on the other hand *consists of the operational techniques and activities that are used to fulfil requirements for quality.* It is a tactical function which carries out the programmes established by Q.A.

Proper handling of fish between capture and delivery to the consumer is a crucial element in assuring final product quality. Standards of sanitation, method of handling and the time/temperature of holding fish are all significant quality factors. With a few exceptions, fish are considered free of pathogenic bacteria of public health significance when first caught. The presence of bacteria harmful to man generally indicates poor sanitation in handling and processing and the contamination is almost always of human or animal origin. *Salmonellae* have been found in fish washed with polluted water and from fish-holds washed with polluted water. Contamination may take place when the fish are gutted at the quayside in a dirty harbour. In many BOBP countries, shrimp are sun-dried at the landing place and are targets for contamination by bird droppings and animal excreta. Sun-dried materials are known to have a high rate of contamination with *salmonellae*.

5.2 MICROBIOLOGICAL TESTING

A number of microbiological tests of fish and fish products are used by authorities to check that the microbiological status is satisfactory. The purpose of these tests is to detect pathogenic bacteria (*Salmonella, Staphylococcus aureus, E.coli*) or indicator organisms of fecal pollution (*fecal coliforms, fecal streptococci*) or other types of general contamination or poor handling practices (coliform bacteria, *faecal streptococci, total viable count*). Microbiological testing can be costly and time-consuming. Estimation of bacterial numbers in fish is frequently used to retrospectively assess microbiological quality or to assess the presumptive safety of the product. The number, size and nature of the samples greatly influence the results and even the most elaborate sampling cannot guarantee the safety of the product. However, it is still worthwhile; if substandard consignments are found, the psychological effect on the seller is high, especially if the consignment is deemed for export to countries that have established microbiological criteria.

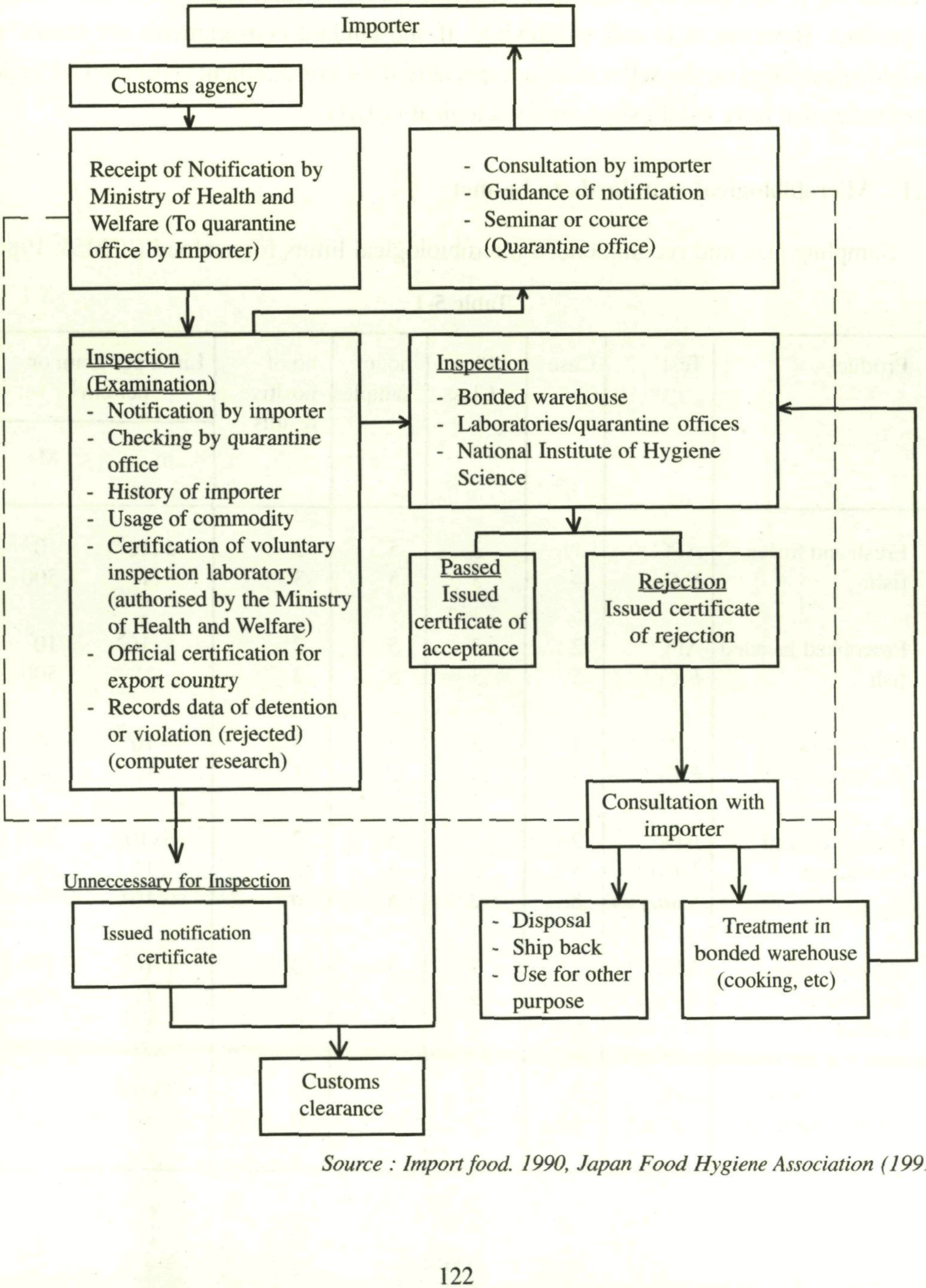
5.2.1 Microbiological standards to be met

Sampling plan and recommended microbiological limits for seafood (ICMSF 1986)

Table 5-1

Product	Test	Case	Plan Class	no. of samples	no.of positive results	Limit per gram or per cm^2	
						m	M
Fresh and frozen fish;	APC *E.Coli*	1 4	3 3	5 5	3 3	$5x10^5$ 11	10^7 500
Precooked breaded fish	APC *E.Coli*	2 5	3 3	5 5	2 2	$5x10^5$ 11	10^7 500
Frozen raw crustaceans	APC *E.Coli*	1 4	3 3	5 5	3 3	10^6 11	10^7 500
Frozen cooked crustaceans	APC *E.Coli* *S.aureus*	2 5 8	3 3 2	5 5 5	2 2 0	$5x10^5$ 11 10^3	10^7 500 -
Cooked, chilled, and frozen crabmeat	APC *E.Coli* *S.aureus*	2 6 9	3 3 2	5 5 5	2 1 0	10^5 11 10^3	10^6 500 -
Fresh and frozen bivalve molluscs	APC *E.Coli*	3 6	2 2	5 5	0 0	$5x10^5$ 16	- -

Table 5-2
INSPECTION PROCEDURE FOR IMPORTED FOOD IN JAPAN



Source : Import food. 1990, Japan Food Hygiene Association (1991.)

Table 5-3
MICROBIOLOGICAL TESTS INCLUDED IN THE MICROBIOLOGICAL STANDARDS AND REGULATIONS OF A TYPICAL EU COUNTRY

	France
Raw fish, fillets, fresh/frozen	1,2,7,10,11*
Semi preserves	
pasteurized	1,2,7,10,11
non-pasteurized	1,2,7,10,11
Smoked salmon	1,2,7,10,11
Crustacean	
raw	1,3,7,11
cooked	1,3,7,11
cooked and peeled	1,3,7,10 11
Molluscs	
live	3,4,7
raw	-
pre-cooked	1,3,7,10,11

* The figures refer to tests for:

1. Aerobic plate count (TVC)
2. Coliforms
3. Fecal coliforms
4. Fecal streptococci
5. Enterococci
6. *E.Coli*
7. *Salmonella*
8. *Shigilla sp.*
9. Total enterobacteriaceae
10. *Staphylococcus aureus*
11. Anaerobic sulfite red.

Table 5.4
STANDARDS AND CRITERIA OF FISH AND FISHERY PRODUCTS UNDER THE FOOD SANITATION LAW, JAPAN.

CLASSIFICATION	STANDARDS AND CRITERIA	REMARKS
Fish paste products (fish sausage and ham)	- Coliform organism : negative/g - Nitrite radical : 0.05 g/kg or less	There are also processing & preservation standars
Salted salmon roe	- Nitrite radical : 0 : 005 g/kg or less	
Boiled octopus	- Viable Bacteria count : 1.0 x 10^5/g or less - Coliform organism : negative/0.01 g	Only frozen octopus. There are also processing & preservation standards*
Raw oyster for uncooked	- Viable Bacteria count : 5.0 x 10^4/g or less - E.coli MPN/100 g : 230 or less	There are also processing & preservation standards

Table 5-5
COMPILATION OF LEGAL LIMITS FOR HAZARDOUS SUBSTANCES IN FISH AND FISHERY PRODUCTION IN JAPAN

ITEMS	STANDARDS
Mercury (Hg)	0.4 ppm (Total Hg) 0.3 ppm (Methyl Hg) * weekly intake is supposed not to be above 170 µg methyl Hg for an averag adult weighing 50 kg. Diets of pregnant women and children should be more strictly controlled.
PCB	Offshore fish (edible portion) : 0.5 ppm Inland sea fish (edible portion) : 3 ppm
Dieldrin (including aldrin), pesticide	0.1 ppm (hard-shelled mussels only)
Paralytic shellfish poison, Diarrhetic shellfish poison, (shellfish poison)	4 MU 0.005 MU * 4 Mouse Unit (MU) _ 80 ug/100 g (saxitoxin)

The following table will serve as a guide for the harbour manager.

Table 5-6 : GUIDELINES FOR PATHOGENS

Total viable count	Not to exceed 100,000 per gram.
Salmonella	Not to be detected in 25g of meat.
E.Coli	Less than 10 per gram
S.aureus	Less than 1000 per gram
Faecal coliforms	None

While cost considerations and the availability of testing facilities locally may preclude the establishment of microbiological testing in the fishery harbour complex, other methods should be used by the harbour master to assure a reasonable degree of protection for both consumer and supplier against risks associated with microbial contamination within the harbour complex.

5.3 WHAT ARE THE OTHER OPTIONS ?

Preventive strategies based on thorough analysis of prevailing conditions are much more likely to provide an assurance of fish quality. **The Hazard Analysis Critical Control Point (HACCP) system** is one such strategy. In recent years a number of other quality systems have been introduced, such as **certification under an Internationally Accepted Standard (ISO 9000 series) and Total Quality Management (TQM)**. The main reasons to implement such quality systems are:

i. To improve the efficiency and profitability of their operations and the quality of the product.

ii. To satisfy a requirement from the customer/importer.

iii. To provide defence in legal actions

iv. To keep up with the competition.

5.4 THE HACCP CONCEPT

The system is based on the recognition that microbiological hazards exist at various points, but measures can be taken to control these hazards. The anticipation of hazards and the identification of control points are therefore key elements of HACCP. The system offers a rational and logical approach to control food hazards and avoid the many weaknesses inherent in the inspectional approach. Once established, the main effort of the quality assurance programme will be directed towards the Critical Control Points (CCPs) and away from endless final product testing. This will assure a higher degree of safety and at less cost.

The main elements of the HACCP system are:

- Identify potential hazards. Assess the risk of occurrence.
- Determine the Critical Control Points (CCPs)
- Establish criteria to be met to ensure that each CCP is under control.
- Establish a monitoring system.
- Establish corrective action when CCP is not under control.
- Establish procedures for verification.
- Establish documentation and record-keeping.

Identification of potential hazards: Hazards have been defined as the unacceptable contamination, growth or survival of bacteria in food that may affect food safety or quality (spoilage) or the unacceptable production or persistence in foods of substances such as toxins, enzymes or products of microbial metabolism. In other words a hazard is a biological, chemical or physical property that may cause food to be unsafe for consumption. For inclusion in the list, hazards must be of such a nature that their elimination or reduction to acceptable levels is essential for the production of safe food.

Hazard analysis requires two essential ingredients. The first is the appreciation of the pathogenic organisms that could harm the consumer or cause spoilage. The second is a detailed understanding of how these hazards could arise. In order to be meaningful, hazard analysis must be quantitative. This requires an assessment of both severity and risk. Severity refers to the serious consequences when a hazard occurs, while risk is an estimate of the likelihood of a hazard occurring. It is only the risk that can be controlled.

Determine the CCPs: A CCP is a location, procedure or processing step at which hazards can be controlled. CCP1 is that which will ensure full control of a hazard and CCP2 is that which will minimize but not assure full control. Within the context of HACCP, the meaning of "control" at a CCP means to minimize or prevent the risk of one or more hazards by taking specific preventive measures. If an identified hazard has no preventive measure at a certain step then no CCP exists at that step.

Establish criteria, target levels and tolerances for each CCP: To be effective, a detailed description of all CCPs is necessary.This includes determination of criteria and specified limits or characteristics of a physical, chemical or biological nature which ensure that a product is safe and of acceptable quality.

Establish a monitoring system for each CCP: The monitoring should be able to detect deviations from specifications or criteria for corrective action to be taken. When it is not possible to monitor a critical limit on a continuous basis, it is necessary to establish a monitoring interval that will be reliable enough to indicate whether the hazard is under control. Periodic verification of sanitation controls and random microbiological tests of fish can be very valuable as means of establishing and verifying the effectiveness of control at CCPs.

Corrective actions: The system must allow for corrective action to be taken immediately when monitoring results indicate that a particular CCP is not under control. Action must be taken before the deviation leads to a safety hazard.

Verification and documentation: Verification is the use of supplementary information to check whether the HACCP system is working. Procedures may include review of CCP records, review of deviations, random sample collection and analysis. Inspections should be conducted routinely or unannounced, when the fish originating from the harbour complex is implicated as a vehicle of food-borne disease, or when requested on a consultative basis.

5.4.1 HACCP System for Fresh and Frozen Fish Products

The hazard analysis for these products is fairly straightforward and uncomplicated. The live animals are caught in the sea, handled and processed without any use of additives or chemical preservatives and finally distributed with icing or freezing as the only means of preservation. Contamination with pathogenic bacteria from the human/animal reservoir can occur when the landing place is unhygienic or when the fish are washed with contaminated water. Most fish and crustaceans are cooked before eating although a few countries have a tradition of eating raw fish. Cooking the product before consumption usually eliminates the risk from contamination with pathogenic bacteria. However, an indirect hazard exists if contaminated products are polluting the working areas and thereby transporting the pathogens to products which are not cooked before eating (cross contamination). Cooking will not, however, eliminate the growth of heat-stable toxins (histamine).

Time and temperature conditions at all steps from capture of fish to distribution constitute a CCP1 in preventing growth of pathogenic bacteria and spoilage bacteria. Below 1°C, no growth of pathogenic bacteria takes place. Therefore a maximum time at temperatures over 5°C must be specified in the criteria for this CCP. Exposure for only a few hours of fatty fish to the sun, air and ambient temperature during fish handling on the vessel or at the harbour is sufficient to introduce severe quality loss and cause early spoilage.

A sensory assessment (appearance, odour) of the fish when landed is a CCP2 for ensuring that until this point the material has been under control, and that spoiled fish or shrimp and potential toxic species can be discarded.

Personal hygiene as well as fishery harbour sanitation are CCPs preventing contamination of products with micro-organisms and filth. The seriousness of the hazard varies, depending on the intended end-use of the product (cooking or no cooking). Occasionally a microbiological check of the cleanliness of working surfaces can be made. This control procedure must be carried out on a weekly basis. When the routines are well established, microbiological control of cleanliness can be carried out monthly.

Water quality is a CCP1 in preventing contamination from this source. Where in-plant chlorination is used, chlorine levels must be measured and recorded. Chlorine levels should be measured daily.

5.4.2 Application of HACCP system in Fishery Harbours

Harbours vary a great deal in size and the quantities of fish they handle. Accordingly the hygienic requirements and the design of fish handling areas may vary considerably. Quite obviously the requirements of a small harbour or landing place where fish is landed, repacked in ice and distributed to the local market are different from the hygienic requirements of a large complex which includes fish processing of a variety of seafood and cold storage. In most fishery harbours where there is no seafood processing other than handling of fresh fish, all that is needed may be temperature and water quality controls besides encouraging a cleanliness ethic.

5.4.3 Checklist for ensuring seafood safety

1. **Landed fish should not be exposed to the sun and should be iced.**

2. **Inspect fish for appearance and odour and reject fish of unacceptable quality.**

3. **Periodically perform bacteriological tests on representative samples.**

4. **Follow a cleaning schedule for all work areas and surfaces, using water containing 5 to 10 ppm of free chlorine.**

5. **Remove all fish slime and blood by hosing down with chlorinated water. At the end of the day, rinse all surfaces with clean water having 5 ppm of chlorine.**

6. **Apply personal hygiene rules strictly to prevent contamination of fish. Smoking and spitting in work areas should not be permitted. Hands must be washed with bactericidal soap prior to handling fish and after a visit to the toilet.**

7. **Check that water supply and treatment systems are in order. Water and ice samples should be analysed as per testing schedule by ISO certified laboratories for levels of chemical and bacteriological contamination and potability certificates obtained.**

8. **The harbour should be free from litter and other wastes.**

9. **Check to ensure that all drainage systems are in good working order.**
10. **The harbour should be free of animals, rodents and pests.**
11. **Ensure that there are no bird nests in the fish handling area.**
12. **Check that wastes are being disposed of sanitarily.**
13. **Check cold storage equipment to ensure that the right temperature is being maintained.**
14. **Ensure that all precaution and warning signs are readable.**

5.4.4 Advantages of the HACCP system

The HACCP system is an ideal tool when resources are scarce. The general principle of the HACCP concept is to direct energy and resources towards areas where they are necessary and most useful.

The main advantages can be summarized as follows:

- Control is proactive in that remedial action can be taken before a problem occurs.
- Control is through features that are easy to monitor such as time, temperature and appearance.
- Control is cheap in comparison with detailed chemical and microbiological analysis.
- The operation is controlled by persons directly involved with the fish product.
- It can be used to predict potential hazards.

5.5 THE ISO-9000 SERIES CERTIFICATION OF THE INTERNATIONAL STANDARDS ORGANIZATION

For seafood processing establishments, the most relevant standards of the ISO 9000 series are the ISO 9001 and 9002. The former is a quality system standard that lays down requirements for product development, production, delivery and after sales functions. The latter concerns only production and delivery. The ISO 9003 deals with quality system requirements for final inspection and testing.

ISO 9000 standards comprise many elements. Of these, management responsibilty and commitment is the first and most important element. The next element is the presence of a documented quality system organized in three levels comprising the Quality Manual, Procedures and Instructions. Process control is another requirement to ensure that all processes influencing the quality of the final product are specified and documented in detail. The schedule of testing and inspection and the test equipment used should demonstrate acceptable compliance with the defined specifications. A corrective action system concerned with revising work operations should be in place to try and eliminate the causes of failure. Quality records including inspection reports, analytical results and corrective action reports should be maintained. Internal quality audits on a regular basis is another requirement. Training of staff, personal hygiene, cleaning and disinfection are a vital part of the ISO 9000 standards with particular reference to the food industry.

The work involved in establishing and implementing a quality system like ISO 9001 or 9002 should not be under-estimated. It is a very demanding project in terms of time and resources. (See Figure 63, page 133). The time required is often 1-2 years even for a medium-sized establishment.

Marketing merits, reduced quality costs and higher efficiency are the main advantages of the quality system that contribute to a higher profitability. The main objective of quality management according to the ISO 9000 series is meeting the agreed requirements of the customer. This underlines that the quality of a company's products is the key factor in a company's performance.

Quality systems such as the ISO 9000 series serve to establish confidence in the customer. Once confidence is established, entry into world markets is simplified.

Table 5.7
PHASES OF A QUALITY SYSTEM APPROACH

Formation of a quality management group

Hazard Analysis

Audit of present system elements

Estimation of resources and total period of time required for the project including certification

Formation of project organisation

Preparation of Quality Manual (levels 2 and 3) to be included in departmental manuals i.e. table of contents

Decision on time schedule for preparation of departmental manuals

Establishment of working groups for the preparation of the individual procedures and instructions

Commenting, reviewing, approving and issuing procedures and instructions

Implementation of procedures and instructions

First approach to certifying body

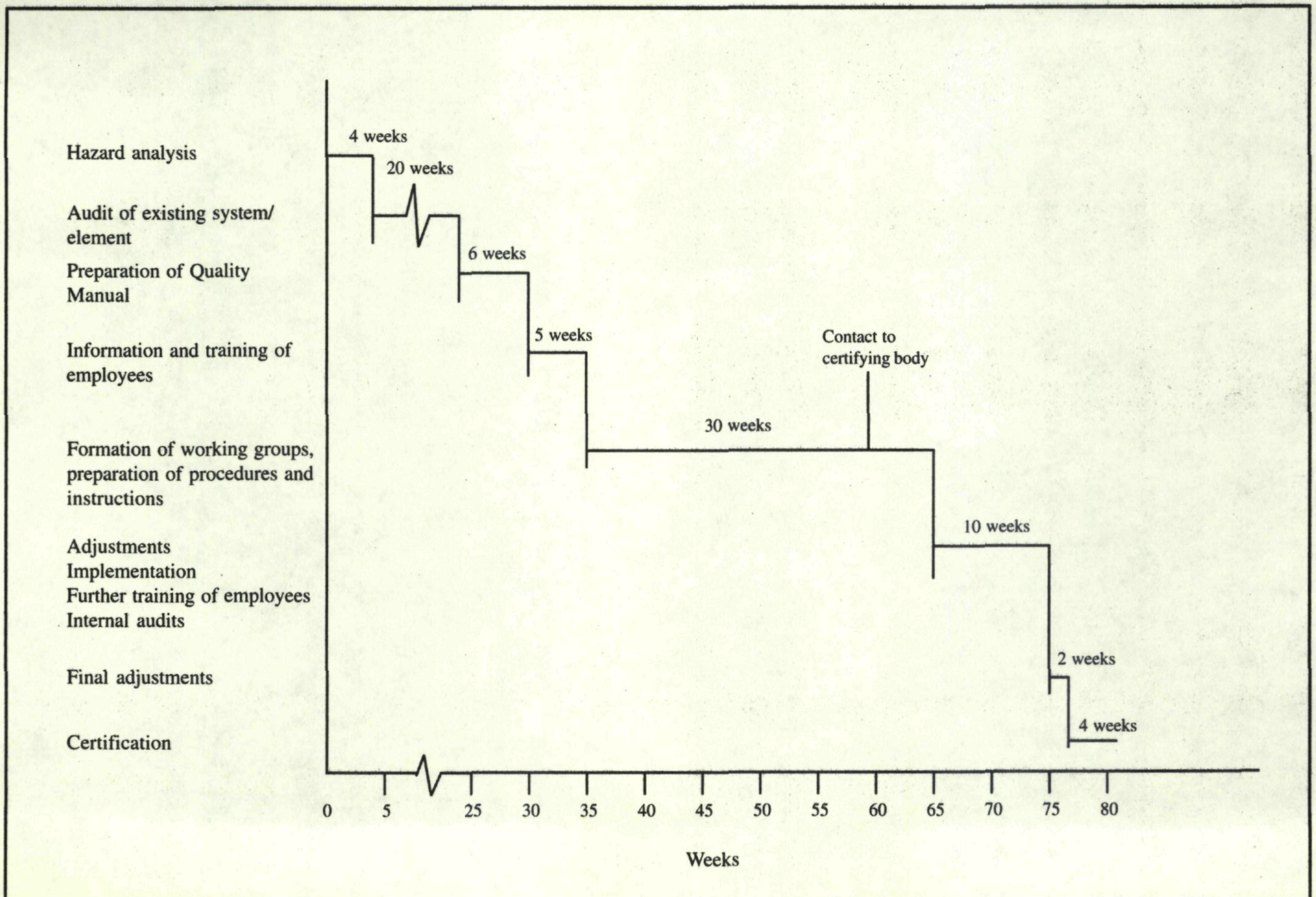
Internal auditing

Corrections, adjustments etc.

Further training of staff

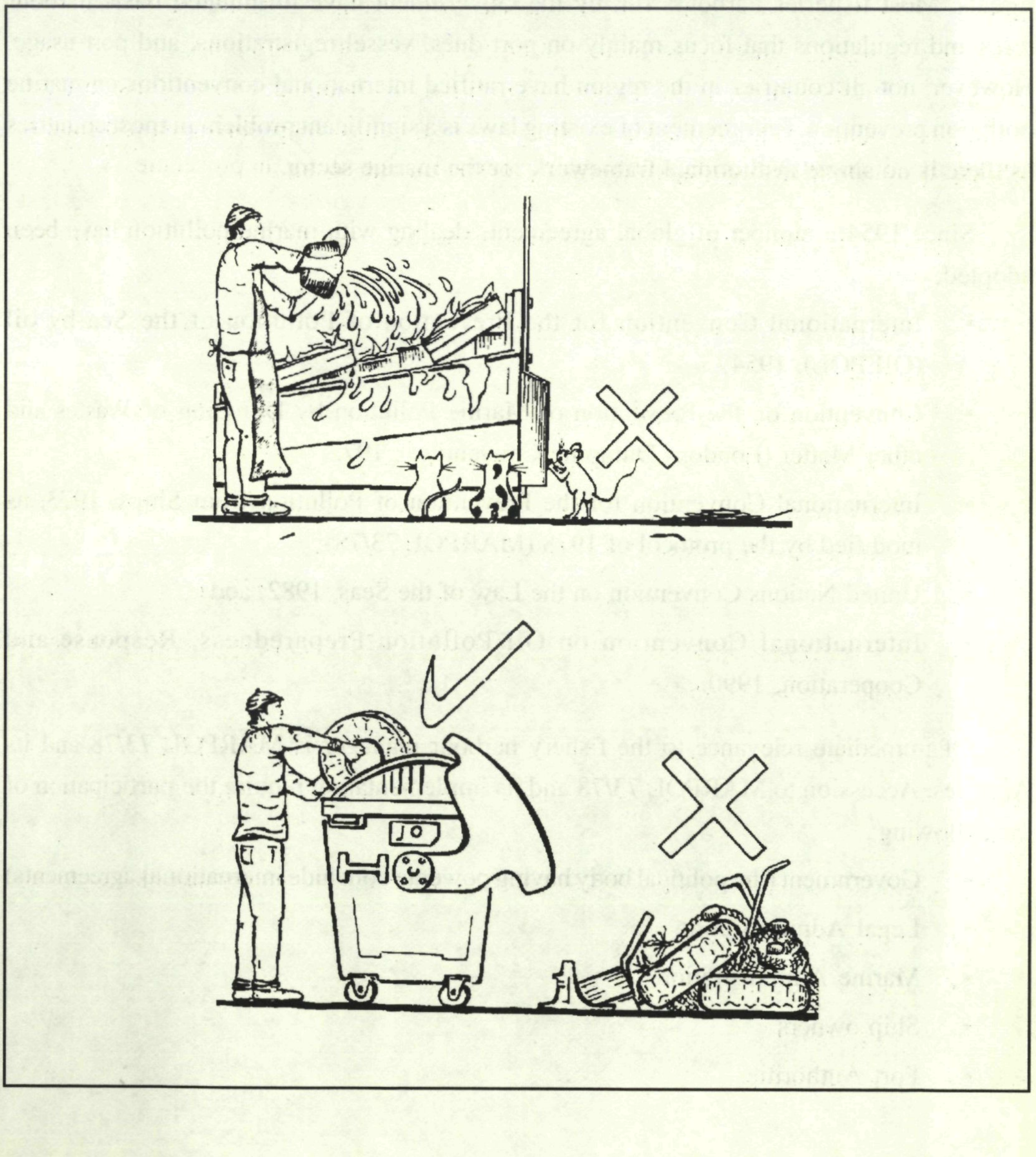
Certification

Figure 63: Time schedule for establishing and implementing a quality system in a small-size food processing plant



Chapter 6

COMPLIANCE



6.1 GLOBAL CONVENTIONS TO MITIGATE MARINE POLLUTION

The fishery harbour and its contiguous waters are part of the coastal zone. Pollution of the harbour has direct effects on the coastal zone and *vice versa*. In the Bay of Bengal region, national and local legislations exist that are meant to regulate potential environmental threats. Most fisheries harbours run by the Government have formulated basic harbour rules and regulations that focus mainly on port dues, vessel registrations, and port usage. However, not all countries in the region have ratified international conventions on marine pollution prevention. Enforcement of existing laws is a significant problem in most countries as there is no single institutional framework for the marine sector.

Since 1954 a number of global agreements dealing with marine pollution have been adopted:

- International Convention for the Prevention of Pollution of the Sea by oil (OILPOL), 1954;
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London- Dumping Convention), 1972;
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 (MARPOL 73/78);
- United Nations Convention on the Law of the Seas, 1982; and
- International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990.

Of immediate relevance to the fishery harbour manager is MARPOL 73/78 and its Annexes. Accession to MARPOL 73/78 and its implementation require the participation of the following:

- Government (the political body having power to conclude international agreements)
- Legal Administration
- Marine Administration
- Ship owners
- Port Authorities

The political desire of a State to accede to or ratify MARPOL 73/78 is fundamental. Governments may wish to become parties to MARPOL 73/78 as a result of :

1. Marine environmental concerns for waters under their jurisdiction;
2. Benefits to shipowners (worldwide acceptance of ships);
3. Benefits to their ports (means of control of pollution); or
4. Concern for worldwide environment.

It should be recognized that whereas parties to MARPOL 73/78 have obligations, they also have privileges. If pollution occurs within their territorial waters they can prosecute. A non-party, on the other hand, does not have the privilege of prosecuting any ship that pollutes its shoreline.

The main concern of port authorities under MARPOL 73/78 is the provision of adequate reception facilities for:

- Oily wastes
- Noxious liquid substances
- Sewage
- Garbage

For fishery harbours, oily wastes, sewage and garbage reception facilities are the main concerns if the State has ratified MARPOL 73/78.

6.2 NATIONAL LEGISLATIVE BODIES (BOBP)

The enacting institutions in BOBP member-countries are many and the subject matter is diverse. The list of acts and decrees of relevance to marine pollution prevention existing in each country is given below:

Table 6.1 : NATIONAL LEGISLATIVE BODIES

Country	Legislation	Subject	Enacting Ministry
Indonesia	Regulation 20/1990	Water pollution control	President's office
	Decree KM 86/1990	Prevention of oil pollution by ships	Ministry of Transportation
	Decree KM 215/A1506	Provision of waste reception facilities in ports	Ministry of Transportation
	Decree 46/1986	Ratification of MARPOL 73/78	President's office
	Decree 18/1978	Ratification of international fund for compensation due to oil pollution damage	President's office
	Regulation 5/PRT/1990	Water quality control	Ministry of Public Works
Malaysia	Merchant Shipping Ordinance 1952 Environmental Quality Act 1974 Exclusive Economic Zone Act 1984	Pollution from ships Pollution from dumping Reception facilities	Ministry of Transportation
	Environmental Quality Order 1987	Construction of fishery harbours Expansion of fishery harbour	Department of Environment
	Environmental Quality Act 1974	Sewage and Industrial effluent discharge	Department of Environment
Thailand	National Environmental Quality Act 1975	Water pollution control	ONEB

Table 6.1 : (Continued)

	Public Health Act 1941,1984	Public Health Disposal of Solid waste	Ministry of Public Health
	Provincial Authority Acts	Water supply and drainage	Local provincial government
Bangladesh	Territorial Water and Maritime Zone Act & Rules 1974, 1977	Marine pollution prevention	Department of Environment
	Environmental Pollution Control Ordinance 1977	Industrial and domestic wastewater discharge	DOE
	Protection of the Marine Environment of Bangladesh Act (Draft)	Oily waste pollution by ships Reception facilities for waste in harbours	DOE
India	Water (Prevention and Control of Pollution) Act 1974 amended 1988	Effluents and waste disposal	State Pollution Control Boards
Sri Lanka	Coast Conservation Act No.57 of 1981	Coast conservation	Central Environmental Authority
	Sri Lanka Ports Authority Act No. 1979	Port Management	Port Authority Marine Pollution Prevention Authority
Maldives	Bill on environmental legislation submitted to Parliament		

6.3 HARBOUR MANAGEMENT

Many different operational systems exist in the Bay of Bengal region for the management of fishery harbours. They may be broadly classified as:

- *Privately owned*: Ownership by a person or company involved in processing.
- *Autonomous Port Trust*: Control by a Governing Board or Port Trust represented by port users, local or State Government bodies and Fisheries Departments.
- *Municipally owned*: Governed by committees of members drawn from the municipal council.
- *State owned*: Administered by a board of directors appointed by the Government.
- *State owned*: Leased to a co-operative society.

Irrespective of the type of the ownership, the most effective way to manage a fishery harbour is by establishing a Port Management Body whose duties should include:

- Compliance with laws, regulations and rules governing the use of the facility (landing fees, berthing charges, sale of water and fuel etc.);
- Compliance with environmental conservation and monitoring measures adopted by the planning authorities (waste recycling, spent oil recovery, waste disposal, etc.);
- Control over other users when the facility also serves boats other than fishing vessels.

In order that the Port Management Body is able to carry out its functions, it must be:

1. Commensurate with the size of the facility and the responsibilities expected of it (one person may be enough for a small landing place, but a group of persons may be necessary for larger ports).
2. Adequately funded to function as intended (landing fees, berthing charges and other levies should cover maintenance and running costs).
3. Considerate to the needs of other users of the harbour (if the jetty also serves passenger ferries).

A typical port management body should normally include a harbour master, an administrative officer; a maintenance officer, a fisheries statistics officer; fish auction/ marketing officer; and a health officer. In larger ports, these officers need support staff.

6.3.1 Duties of a harbour master

The harbour master is usually in overall charge of a harbour and decides on how the facility is used. Ideally he should have a maritime background and should be fully conversant with maritime regulations and the navigational and operational needs of fishing vessels. In addition, he should be knowledgeable in:

- National legislation;
- Maintenance of the harbour infrastructure (engineering, dredging, navigation equipment, refrigeration, water supply, water treatment etc.)
- Fishing methods and fishing regulations; and
- Public hygiene and pollution prevention.

6.3.2 Duties of the Administrative Officer

His main tasks would normally include maintenance of records; accounts; collection of berthing charges; sale of water and fuel; recruitment of harbour personnel and levying of fines imposed by the harbour master.

6.3.3 Duties of the Maintenance Officer

His main tasks are the upkeep of navigational equipment; updating hydrographic information of the harbour basin, entrance and approach; maintenance and monitoring of the water supply system; and maintenance of water treatment and refrigeration systems.

6.3.4 Duties of the Statistician

He is generally from the Fisheries Department deputed to the fishery harbour. His tasks are to record species and quantities landed daily; wholesale prices of landed fish; number and type of fishing boats and landed quantities for each species. His records are of utmost importance to the Fisheries Department to enable them assess the status of the fishery and take precautionary management interventions.

6.3.5 Duties of a Hygiene Officer/ Health Officer

With the increasing importance of fish as a primary source of food, concern about the possibility of tainted fish entering the food market chain has been rising. His duties should therefore ensure that :

- Fish or fish products are not contaminated during handling;
- Potable standard water is used for washing fish;
- The port area is clean and free from pests and vermin;
- Port workers maintain personal hygiene; and
- Ice and water supplies to fishing vessels are pathogen- free.

6.3.6 Fishery Harbour Rules and Regulations

As mentioned earlier, there are several types of fishery harbours and landing places in the Bay of Bengal region. Privately owned and small coastal landing places have no specific rules. As for the main harbours in the region – whether they are managed by the local government or a quasi government institution – any harbour rules that exist are concerned mainly with the use of port facilities and port dues.

Needless to say, enforcement of pollution-specific rules is meaningless and extremely difficult, if the fishery harbour in question does not have the required infrastructure for waste collection and disposal, and if it does not provide the appropriate reception facilities for oily wastes, garbage and sewage for vessels using the harbour. Most fishery harbours in the region have been established by governments as a service to the fisheries sector. The revenue from port usage is barely sufficient to meet the maintenance needs of the harbour.

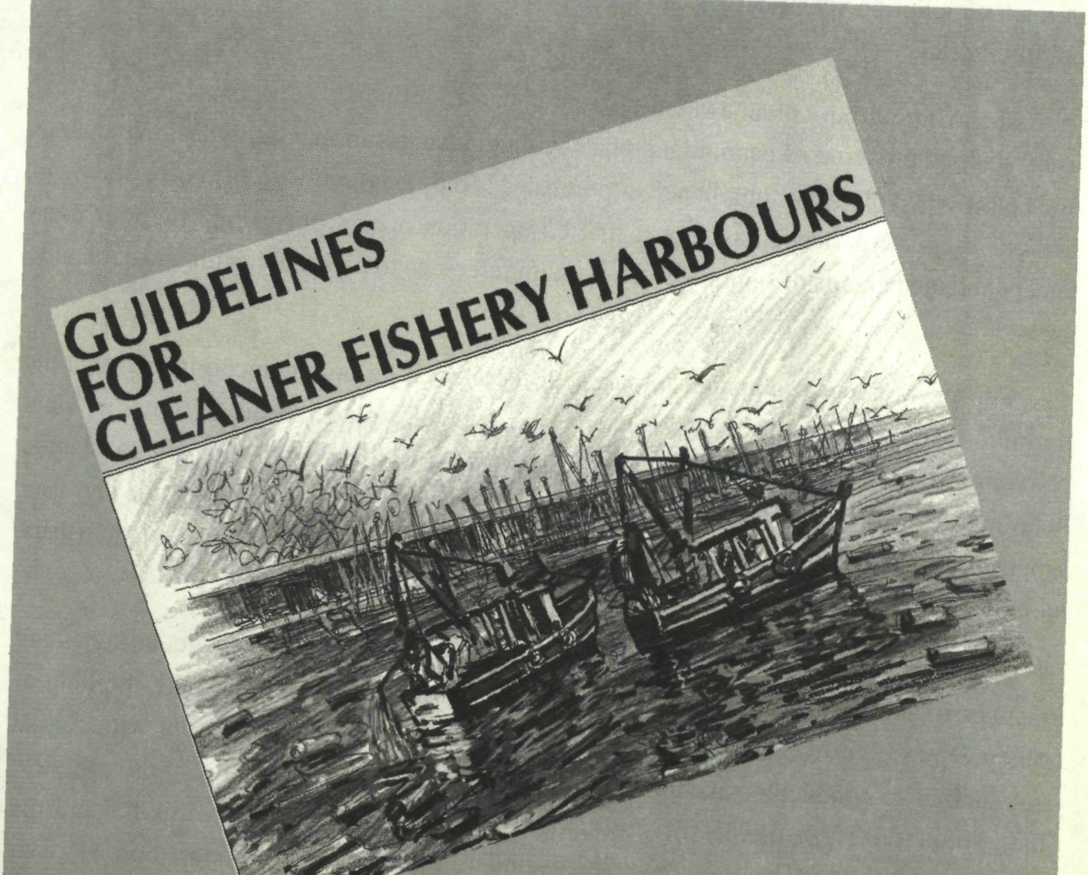
Under such circumstances, to ensure compliance with global, national and local laws to prevent marine pollution, the harbour master should:

- perform a waste audit and estimate the load from different waste streams;
- provide cost estimates to the authorities concerned, with assistance from harbour infrastructure specialists, for the basic upgrading of the facility to meet current hygiene and sanitary standards; and
- take measures to improve port security and deny access to unauthorized visitors and vendors.

When the harbour has been upgraded, the harbour master should prepare an amended set of port rules and regulations to include pollution abatement clauses that also cover third party supply of fuel, ice and canteen services; levy a pollution abatement surcharge on port users; include stiff penalty clauses for transgressing harbour rules; organize training programmes for staff to participate in quality programs; and conduct awareness campaigns for harbour users and the general public concerning the cleanliness ethic.

Chapter 7

AWARENESS BUILDING



7.1 AWARENESS CAMPAIGNS

Awareness-building among stakeholders on the need for, benefits of and mechanisms for cleaner fishery harbours is a key element of fisher harbour management to support operational practices, equipment and facilities to ensure a pollution-free harbour. Pilot projects in the BOBP region have demonstrated that the reception and disposal of garbage can easily be integrated with the municipal system with fairly low inputs. Oily wastes can also be minimized with strict enforcement of quayside regulations to prevent pumping of oily bilge water by vessels in port and by providing adequate reception facilities. However, the lack of pollution-specific rules and regulations makes harbour user support in mitigating pollution vital.

The major purpose of an awareness campaign is to influence the behaviour of harbour users since improvements cannot take place without changes in their attitudes, perceptions and behaviour. Voluntary compliance of port rules is only possible with the co-operation of harbour users. Experience has shown that co-operation occurs only when harbour users understand the benefits of sanitary practices with reference to personal health and economic gains.

For an awareness campaign to succeed, there must be communication between the harbour manager and the harbour user. This can take place through inter-personal communication, persuasive communication using an opinion leader who occupies a position of influence in the area, and mass communication between the communicator and user groups like boat operators, fish traders, suppliers and the general public who use the fishery harbour.

The first step in an awareness campaign is to understand the knowledge, attitudes and practices of the various user groups. The fishery harbour manager can take the help of fishery extension officers, social science faculties or NGOs who are working with coastal communities to conduct a stakeholder study. A careful analysis of such a study will yield clues about the right theme for the campaign; the most appropriate media and the organizational channels that are most appropriate to get the message understood. Harbour personnel responsible for implementing the campaign may need to be specially trained in inter-personal communication while making use of the material, keeping in mind that exposure to media alone may not be enough to achieve behavioural change.

The mass communication media are :

- Newspapers;
- Radio;
- Television where available;
- Exhibitions;
- Outdoor hoardings (billboards); and
- Printed material in the form of booklets, posters and stickers.

Development of communication materials should be handled by specialized agencies – either government information departments or commercial advertising agencies with inputs from the harbour manager.

7.2 A CASE STUDY – NEGOMBO, SRI LANKA

A pilot project on awareness-building to promote Cleaner Fishery Harbours was completed in 1997. The main elements of the project are briefly described below.

7.2.1 Pollution assessment study

A study to assess pollution of harbour waters and the surroundings was carried out by the National Aquatic Resources Agency, Sri Lanka. The main findings were that:

- harbour waters were polluted by raw sewage and defecation by humans and animals;
- boats frequently pumped out their oily bilge water in the harbour basin;
- fish offal was dumped into harbour waters as there were no facilities for collection and disposal;
- polluted harbour water is used to wash fish and the landing jetty because potable fresh water is inadequate.

7.2.2 Stakeholder study

The National Institute of Fisheries Training undertook a stakeholder study to understand the perceptions and behaviour of the many harbour-user groups. Some of the interesting findings are:

- Many considered that natural flushing of the lagoon by sea water was adequate to dilute and disperse the pollutants;
- Fish could not be contaminated by harbour water since they were caught in the deep sea;
- Using harbour water to clean the fish imparted the fish a better taste;
- Maintaining the harbour was not a community problem but the responsibility of the municipality.

The study also recommended that radio broadcasts by the Fisheries Radio Unit, visual aids like posters, stickers and exhibitions and an illustrated booklet in story form were the most suitable media channels to create an awareness of pollution, and its problems and how to deal with them.

7.2.3 Development of communication materials

Radio: The media unit of the Ministry of Fisheries and Aquatic Fisheries Development was briefed about the objectives. It was agreed that the Fisheries Radio Unit would include in their regular broadcasts, informative stories about harbour pollution and how the listener can contribute to pollution abatement. In addition, special broadcasts of interviews with various stakeholders would also be made to air their views and suggestions.

Posters & stickers: Two designs were made for distribution to all stakeholders and for display at main town centres and schools at various fishery harbours.

Exhibition panels: Six exclusive panels were made highlighting different aspects of harbour pollution. Together with panels from the marine pollution unit of NARA showing marine pollution of the coastal zone and panels from the Post-Harvest Unit of NARA showing aspects of fish quality, an exhibition was held to kick-start the awareness campaign with a

EXHIBITION PANELS

Panel	Content	Message
1	Location of landing centre and its contribution to the pollution load	Lagoon's capacity to absorb pollutant is not unlimited
2	Sanitary handing of fish, avoiding the use of harbour water to clean fish to prevent pathogen loading of fish	Improve post-harvest fish handling
3	Dumping of fish offal, attraction to pests and foul odour	Collect fish offal for suitable disposal by burial, converting to fishmeal/silage
4	Oil pollution due to oily bilge water pumping,dumping of used engine oils, and fuel leaks while bunkering	Collect oily waştes for recycling
5	Pollution from grey waste water, kitchen waste, garbage and plastic litter	Keep the premises clean
6	Better fish quality means better prices, and the lagoon is a public asset to be preserved	Cleanliness pays

Cleaner Harbour Day. The exhibition was inaugurated by the Deputy Minister for Fisheries and other dignitaries including Negombo town officials.

Booklet: The perception study pointed out that comic books were very popular with fisherfolk, especially on their fishing trips and that an illustrated booklet in story form would hold their interest much more than plain printed text full of do's and dont's.

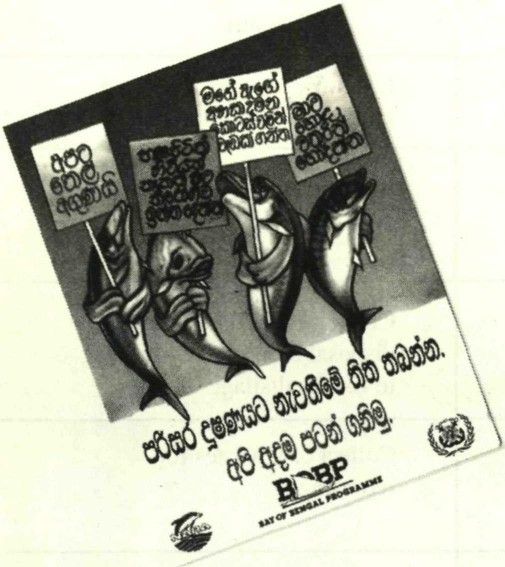
An eight-page booklet was produced with a simple story line as follows:

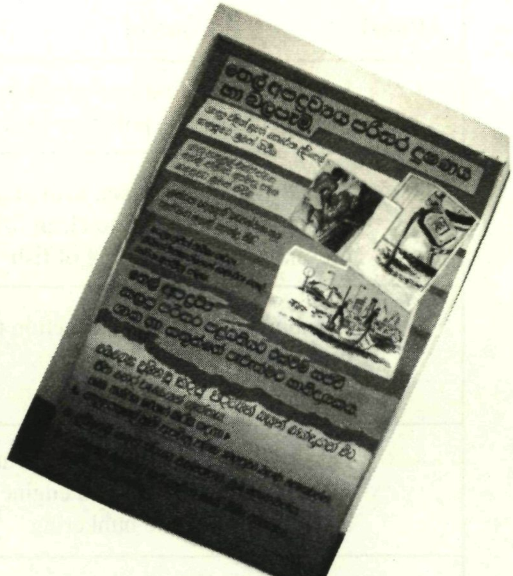
i. Youth from a fisherfolk family returns to Negombo from overseas, on vacation

ii. He is upset by the state of the fish market and the port when he goes to purchase fish;

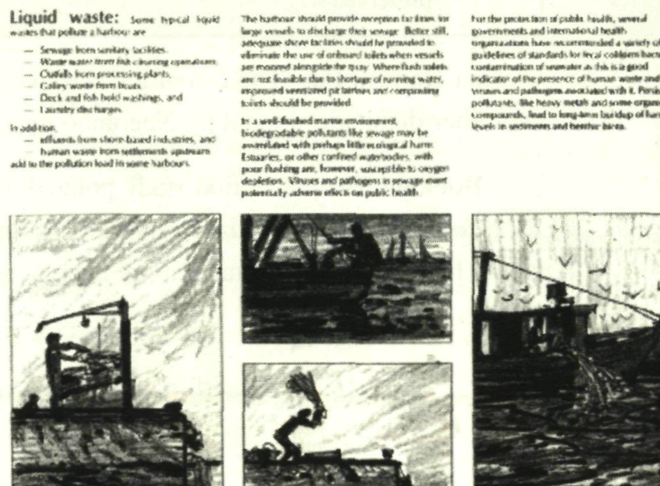
iii. He has a vision of how to implement a pollution abatement program;

AWARENESS-BUILDING MATERIALS





A sampling of BOBP awareness-building materials on cleaner fishery harbours :
Posters in Sri Lanka (above), a comic book in Sinhala (facing, top), and an illustrated booklet, "Guidelines for cleaner fishery harbours" (below)



Liquid waste: Some typical liquid wastes that pollute a harbour are

— Sewage from sanitary facilities.
— Waste water from fish cleaning operations.
— Outfalls from processing plants.
— Galley waste from boats.
— Deck and fish hold washings, and
— Laundry discharges.

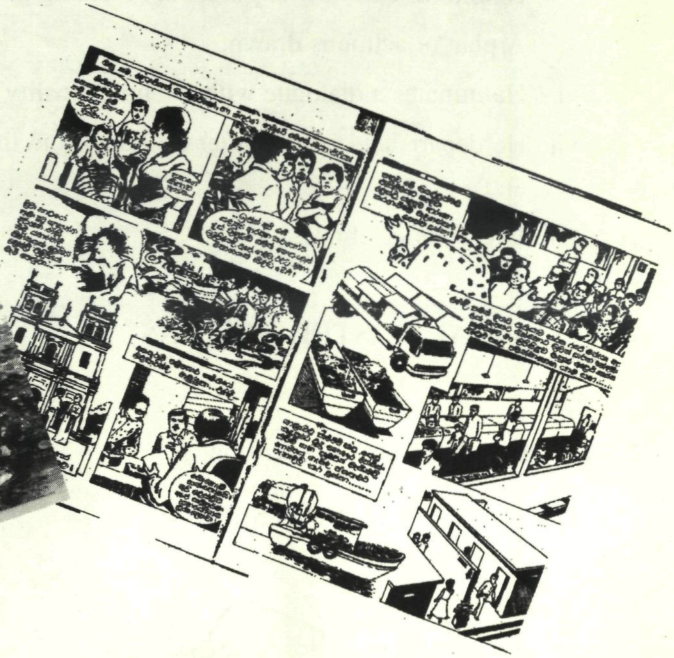
In addition,
— effluents from shore-based industries, and
— human waste from settlements upstream

add to the pollution load in some harbours.

The harbour should provide reception facilities for large vessels to discharge their sewage. Better still, adequate shore facilities should be provided to eliminate the use of onboard toilets when vessels are moored alongside the quay. Where flush toilets are not feasible due to shortage of running water, improved ventilated pit latrines and composting toilets should be provided.

In a well-flushed marine environment, biodegradable pollutants like sewage may be assimilated with perhaps little ecological harm. Estuaries, or other confined waterbodies, with poor flushing are, however, susceptible to oxygen depletion. Viruses and pathogens in sewage exert potentially adverse effects on public health.

For the protection of public health, several governments and international health organisations have recommended a variety of guidelines of standards for fecal coliform bact
contamination of seawater as this is a good indicator of the presence of human waste and viruses and pathogens associated with it. Persi
pollutants, like heavy metals and some organ
compounds, lead to long-term buildup of har
levels in sediments and benthic biota.



llection and disposal: Effluents from
h the fish handling area and sanitary facilities
uld be pretreated in a 'septic tank' prior to
eping into a soakaway, which is the simplest
y to dump effluent into the ground. There is,
wever, a great risk of polluting the groundwater
e soakaways are too close to groundwater
ply. Soakaways cannot be used where clay is
sent.

tic tanks are rectangular chambers with two or
e separate compartments that are usually
ed below ground level and which receive
lated waters from the fish handling areas and
itary facilities (toilets). After coarse screening
ough a basket sump, the effluent is retained

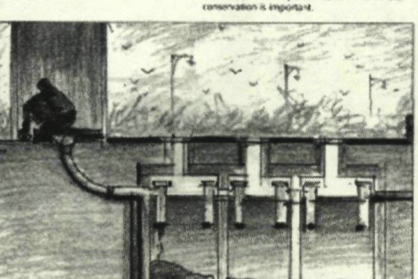
in the compartments for 1-3 days. During this period, the solids in suspension settle to the bottom of the tank where they are attacked and digested by bacteria. To start the biological process in a septic tank, a piece of rotten meat should be dropped in the first chamber.

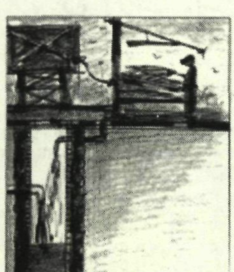
If the fishing shelter is large enough to warrant the construction of a septic tank, the whole drainage system should, preferably, be run on freshwater and not seawater. Unlike seawater, freshwater will keep the septic tank working at maximum efficiency, ensuring that the effluent leaving the septic tank is as unpolluting as possible.

Use of seawater to flush toilets and carry municipal waste may be an important option where water conservation is important.

Discharge of primary treated sewage outside the harbour requires careful consideration in the siting of outfalls to take advantage of areas with greater flushing and which contain less sensitive ecosystems.

Recycling of treated effluent for agricultural and irrigational lands and the rearing of fish in sewage-fed ponds have been successful in India.





iv. A meeting of village elders is arranged where he describes how to improve the conditions and how to go about obtaining government support;

v. A plan of action is drawn;

vi. He initiates a dialogue with the municipality and other government agencies;

vii. He departs and returns after a year to find that improvements have taken place; and

viii. Everyone celebrates.

7.3 TYPICAL POSTER DESIGNS

7.3.1 Oily bilge water prevention

Origin : FAO TRAINING SERIES

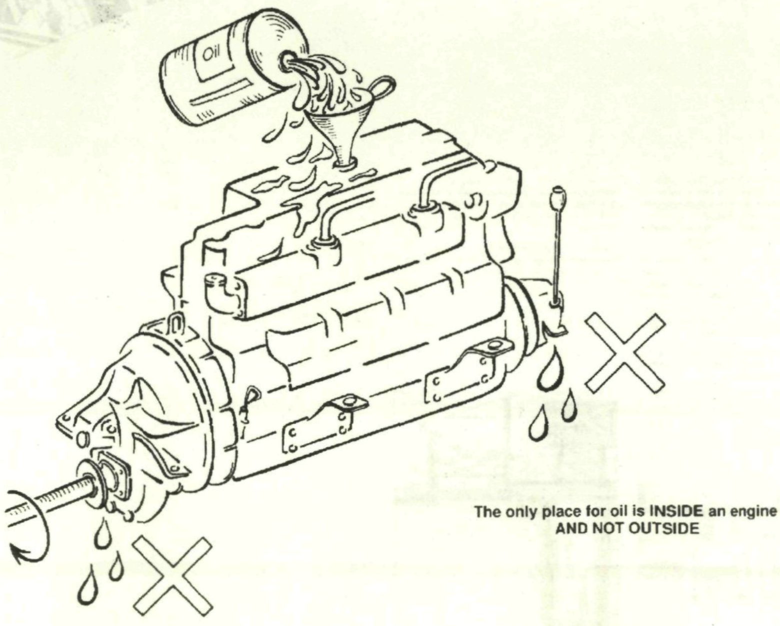


Figure 64: Drawing for a poster to be displayed in fishing harbours to remind fishermen to replace leaking oil seals and to exercise care when replacing engine oil.

Leaking oil seals and oil spillage contribute to create oily bilge water which must then be treated before being returned to the sea. Although it is an offence under MARPOL to dump oily bilge water at sea, very few fishermen seem to understand the process. Invariably, most bilge water ends up in the sea.

7.3.2 Wet wastes and pests

Origin : FAO TRAINING SERIES

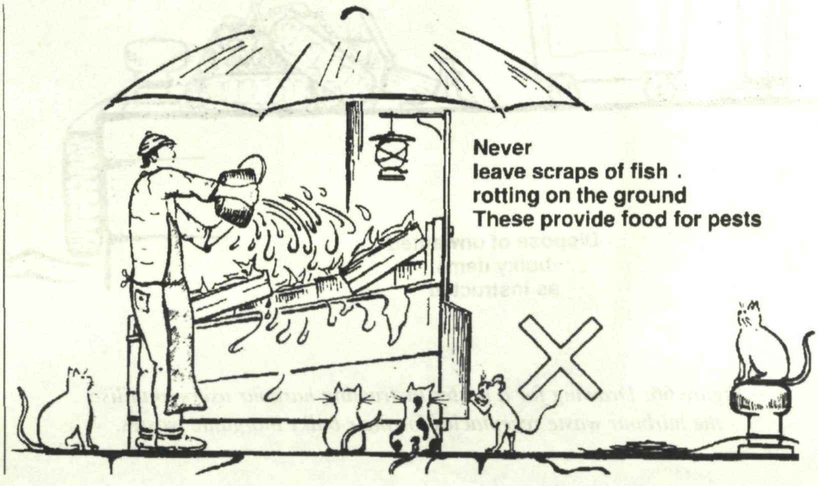


Figure 65: Poster to be affixed inside the port area where fish hawkers congregate to sell fish.

Although fish gutting and cleaning should be forbidden inside the harbour area, sometimes this practice cannot be helped. In order to avoid the spread of diseases which accompanies the presence of houshold pests, hawkers should be instructed on the proper disposal of unwanted wastes. Wet waste bins should be provided in ample quantities and placed in strategic locations.

7.3.3 Solid waste collection

Origin : FAO TRAINING SERIES

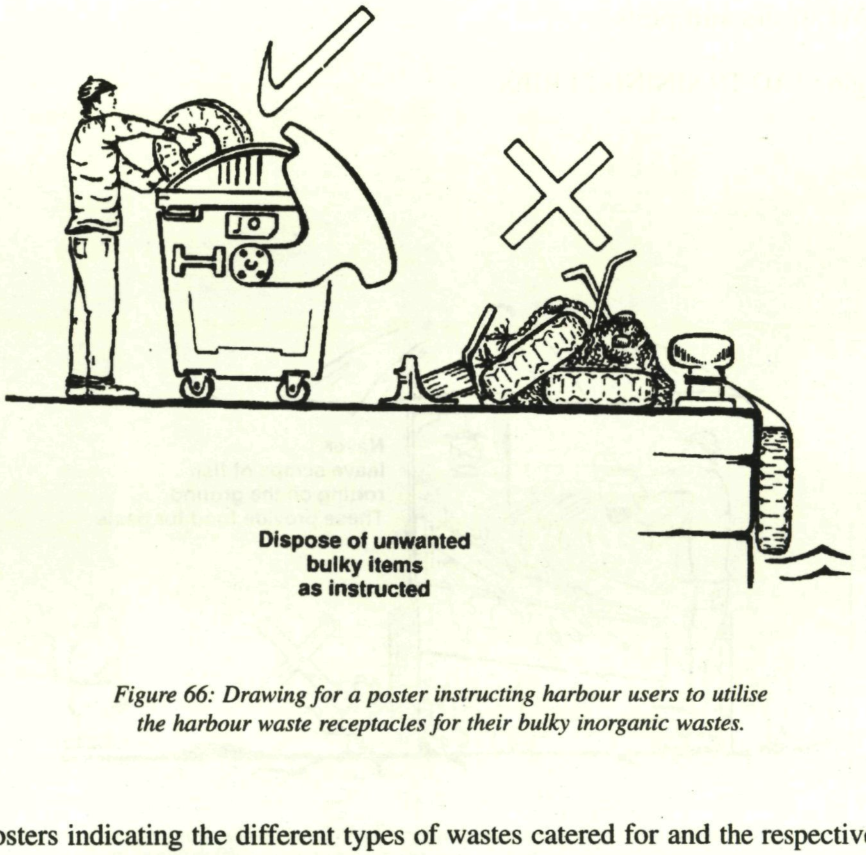


Figure 66: Drawing for a poster instructing harbour users to utilise the harbour waste receptacles for their bulky inorganic wastes.

Posters indicating the different types of wastes catered for and the respective bins to use should be placed at the entrance to the harbour as well as in strategic locations around the port. The bins for the different wastes (non-toxic, toxic and wet wastes) should be colour-coded and suitable for the kind of waste.

Appendix 1

PORT HYGIENE CHECKLIST

Based on E.U. Directives

The standard of personal hygiene of the workers employed inside a fishing harbour depends on both the sanitary infrastructure available and the harbour management in enforcing certain directives.

TOILETS : Toilets should be constructed to the highest standards possible to ensure the maximum lifetime. Poorly built facilities break down very quickly and in hot climates they give rise to "toilets of opportunity" elsewhere. Toilet facilities should always be properly maintained and full-time manning by attendants is desirable. Toilets should never open on to a work area where fish is being handled due to the risk of flooding from blocked drains.

WASH-HAND BASINS : An adequate number of wash-hand basins should be provided within each toilet block. These should be equipped with arm or foot-operated faucets, and soap should be available at all times. Household-type fittings should not be specified, as these do not withstand the rigours of constant use. Water-saving spring loaded faucets should be provided in areas where water in scarce.

SHOWERS : The importance of showers in hot climates should not be underestimated; fishermen returning from long journeys always welcome a shower with proper running water. As with toilets, showers should be built to the highest standard possible and manned by attendants. When the harbour is not offloading fish, showers should be locked up.

SIGNS AND BILL BOARDS : Appropriate signs and bill boards listing food hygiene regulations should form part of the harbour's sanitary awareness infrastructure. These signs should be displayed at all the strategic locations within the port boundary. Examples :

- "*NO SMOKING, NO SPITTING, NO EATING*" signs should be posted wherever fish is being handled;
- "*HAVE YOU WASHED YOUR HANDS?*" signs should be posted at all toilet exits;

Adequate signs should also be posted in prominent locations indicating the direction to the toilets. **Proper and frequent training of port workers in personal hygiene should form part of the harbour master's management brief.** Port sanitation is to the port what personal hygiene is to the workers employed by the port. Port sanitation is best explained by the following simple regulations :

1. All water supplies inside the port should comply with national drinking water standards;

2. All ice, whether manufactured inside the port or brought in from outside suppliers, should also comply with national drinking water standards;

3. All chlorination equipment should be functional and adequate supplies of the chlorination agent should be held in stock;

4. All sampling and testing carried out inside the port should be carried out by ISO certified laboratories only;

5. Appropriate signs should be displayed within the port area covering the prohibition of dumping, spillage, use of sea water from inside harbour basin, spitting, eating areas, access for domestic animals, etc.;

6. Appropriate bill boards should be displayed at strategic locations listing fines for contravention of port hygiene rules;

7. All drainage systems (indoor and outdoor) should be kept in perfect working order;

8. Port perimeter fences should be properly maintained to keep unauthorised people and domestic animals from entering the port area at any time;

9. The entrance and exit to a fishing port area should be manned during business hours to prevent unauthorised people from gaining entry to the fish handling areas;

10. Disinfection of required areas should be carried out on a regular basis;

11. No excessive trash and wet waste should be left to accumulate in work areas;

12. No rodent harbourage should exist in and around the port area (tall weeds, junk piles and municipal rubbish);

13. No birds should be nesting inside open sided auction halls and fish handling sheds;

14. Only employees and officially recognized fish traders should be allowed access to the work area during fish handling operations and auctions;

15. Toilet and shower facilities should be kept scrupulously clean and in perfect working order;

16. Only electrically powered machinery should be allowed inside the auction or handling sheds to prevent oil, petrol and diesel from leaking onto the floors which are sometimes used as auction surfaces for large fish;

17. The entire fish handling area should be hosed down properly at the end of business and locked up to prevent unauthorised entry until the next auction.

Appendix 2

HYGIENE INFRASTRUCTURE DEFICIENCIES
based on actual observations

The sanitary infastructure inside many fishing harbours is always a cause for concern,especially when health or food hygiene inspectors are expected for an official inspection visit. The following infrastructure deficiencies are amongst the most common infractions which the inspectors look for :

a) Toilets are sometimes totally absent from the harbour infrastructure;

b) Toilets do not have an adquate water supply to flush;

c) Toilets drains are often uncovered and full of rubbish like plastic bags, fruit, etc. causing blockages;

d) Toilets open out onto work areas where sewage can flood directly into the processing/handling area;

e) Toilets and wash-hand basin fittings are often out of order, broken or missing;

f) Toilet wash-hand basins are often left without soap or wipe towels/blowers;

g) No "HAVE YOU WASHED YOUR HAND?" signs posted inside toilets;

h) Doors are often unserviceable and removed off the hinges because the timber from which they are manufactured absorbs too much moisture and renders them inoperable;

i) Toilets and shower blocks are often unattended and abandoned;

j) Toilets are often flooded from leaking pipes or roofs;

k) Sewage disposal or treatment is either absent or totally inadequate;

Appendix 3

PERSONAL HYGIENE FACILITIES ONBOARD VESSELS

Based on EU directives

The standard of personal hygiene set out for the shore workers inside the fishing port also applies to the crews onboard fishing vessels. It is very common for wooden trawlers (all sizes) with fishing trips lasting more than three days and crewed by 10 or more people to be lacking even the basic hygiene facilities. Needless to say, this always leads to contaminated fish landings.

The figures below show how basic facilities may be retro-fitted to existing vessels.

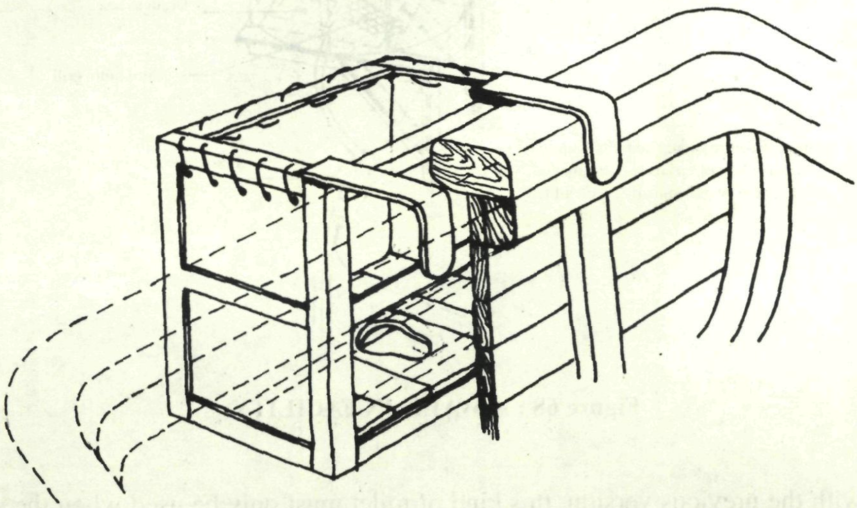


Figure 67 : STEEL FRAMED FACILITY HANGING OVER THE TRANSOM

The structure above consists of a steel framed box structure suspended over the rear of the vessel and is ideal for retro-fitting existing vessels with a high transom. Access is over the coaming. The facility should be used only on the high seas when the vessel is moving. When the vessel is in port, shore facilities should be used.

When the transom of a vessel allows for modifications in the coaming, a walk-in facility may be installed. This type of retro-fit is safer in rough weather due to the fact that access is not gained by jumping over the coaming.

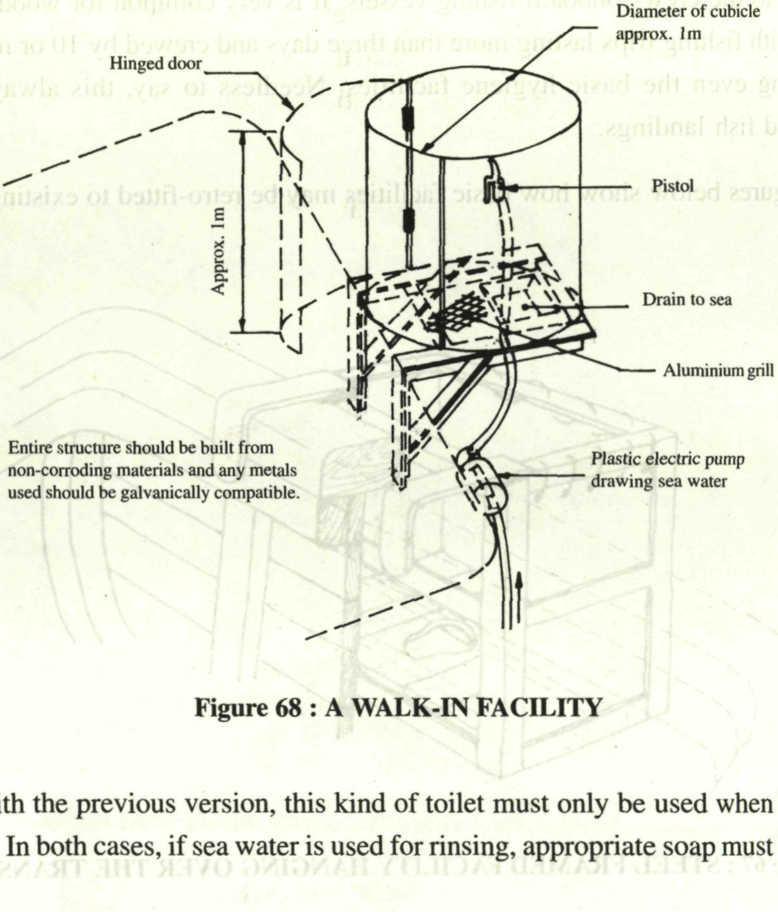


Figure 68 : A WALK-IN FACILITY

As with the previous version, this kind of toilet must only be used when the vessel is out of port. In both cases, if sea water is used for rinsing, appropriate soap must be provided.

REFERENCES

1. GUIDELINES FOR DRINKING WATER QUALITY, Volume 1, Recommendations, *World Health Organization,* Geneva, 1984.

2. GUIDELINES FOR DRINKING WATER QUALITY, Volume 2, Health Criteria and Other Supporting Information, *World Health Organization,* Geneva, 1984.

3. GUIDELINES FOR DRINKING WATER QUALITY, Volume 3, Water Quality Control in Small-Community Supplies, *World Health Organization,* Geneva, 1984.

4. WASTE WATER ENGINEERING, TREATMENT, DISPOSAL AND REUSE, *Metcalf and Eddy, McGraw-Hill 1991.*

5. COMPREHENSIVE MANUAL OF PORT RECEPTION FACILITIES, *International Maritime Organization, London, 1995.*

6. MARPOL-HOW TO DO IT, Manual on the practical implications of ratifying and implementing Marpol 73/78, *International Maritime Organization, London, 1993.*

7. MARINE POLLUTION, *Clark R.B. Oxford Science Publications, Calendon Press, Oxford 1986.*

8. ICE IN FISHERIES, *Graham J, Johnston W.A. and Nicholson F.J., Food and Agriculture Organization, Fisheries Technical Paper No. 331, Rome 1993.*

9. CONSTRUCTION AND MAINTENANCE OF ARTISANAL FISHING HARBOURS AND VILLAGE LANDINGS, *Sciortino J.A., Food and Agriculture Organization, Fisheries Training Series No. 25, Rome 1995.*

10. FISHING HARBOUR PLANNING, CONSTRUCTION AND REHABILITATION, *Sciortino J.A., Food and Agriculture Organization, Distant Learning Course, Rome 1998.*

11. COUNCIL DIRECTIVE (91/493/EEC) ON HEALTH CONDITIONS FOR THE PRODUCTION AND THE PLACING ON THE MARKET OF FISHERY PRODUCTS, *Commission of the European Communities, Brussels 22 July 1991.*

12. COUNCIL DIRECTIVE (92/48/EEC) ON MINIMUM HYGIENE RULES ONBOARD VESSELS, *Commission of the European Communities, Brussels 16 June 1992.*

13. CLEANER FISHERY HARBOURS IN THE BAY OF BENGAL, *Compiled by R. Ravikumar, BOBP/WP/82, 1992.*

14. GUIDELINES FOR CLEANER FISHING HARBOURS, *R. Ravikumar, BOBP/MAG/17, 1993.*

15. DEALING WITH FISHERY HARBOUR POLLUTION – THE PHUKET EXPERIENCE, *R. Ravikumar, BOBP/WP/93, 1994.*