DEVELOPMENT OF EFFLUENT AND WASTE DISPOSAL STANDARDS FOR SOUTH PACIFIC ISLAND COUNTRIES

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INTRODUCTION

Until recently, pollution of the environment was considered a serious problem only in the highly industralised and heavily populated areas of the world. However, with the steady increase in population, urban migration and an increase in industrial development, the need to reduce pollution of the air, water resources (both fresh and estuarine) and in some cases of land in developing countries is becoming quite critical. This is particularly important in the South Pacific in view of the geographical isolation and the ecological fragility of countries of this region.

The growing concern for the quality of the environment has highlighted the need for establishment of measures to ensure that waste materials are disposed of in such a way that (i) life in aquatic systems suffers no damage (ii) marine foodstuffs are safe for human consumption and (iii) coastal waters and beaches are aesthetically acceptable and fit for usage.

The establishment and implementation of a scheme for control of waste disposal are not easy tasks. If the conditions are not sufficiently strict then quality of environment deteriorates rapidly, whereas excessively stringent conditions could put local authorities and industries to much unnecessary expense. The consequences of having improper conditions could be damaging to a nation even if imposed over a very short time. Thus the major problem facing regional countries on this issue is the formulation of suitable guidelines for discharges from various industries into coastal waters and air. Since South Pacific island nations are so widespread and their environments particularly fragile, any recommendations must take into account the following factors : differences in landform, hydrology patterns, climate, scientific/technical expertise and the type of equipment available to measure the effluent quality. Thus, the aim of this project was to review the existing legislation in SPREP member countries relating to waste disposal with a view to developing a set of suitable standards for use in those states which lack such data at present. The study was divided into the following sections :

i) Review of present legislation and planning guidelines in SPREP member states which relate to effluent quality and waste disposal.
ii) Preparation of a list of the types of industries likely to be producing undesirable effluents.
iii) A review of selected standards used in non-regional countries.
iv) Recommended standards for SPREP states.

I. REVIEW OF PRESENT LEGISLATION AND PLANNING GUIDELINES IN SPREP MEMBER STATES WHICH RELATE TO EFFLUENT QUALITY AND WASTE DISPOSAL

The environmental protection legislation in South Pacific countries has been reviewed in detail by Pulea (1983). A compilation of legislation relating to coastal water quality policies has been prepared by Brodie and Morrison (1984). A summary of the acts, ordinances, regulations, policies and administrative provisions relating to environment protection in the SPREP member countries is listed in Appendix I and the details on regional and international conventions relating to protection of the environment are provided in Appendix II.

Examination of these documents shows that at present there is no comprehensive legislation dealing specifically with industrial effluents and waste disposal in most SPREP member countries. There are, however, several acts which include provisions that could be implemented to deal with specific environmental problems. Most notable are the acts outlined below which were presented in the review by Pulea (1983).

The legislation in most countries that covers effluent discharge control is the public health acts, environmental or conservation acts. In countries where mining is a major activity, legislation does exist mainly in the form of Mining Acts which do have sections pertaining to environmental protection.

Cook Islands

The Cook Islands Conservation Act 1975 gives the Director of Conservation power to control pollution from any source including industrial pollution of air, water or land.

Fiji

In Fiji the Public Health Act 1937 contains regulations which could encompass the control of industrial effluents on foreshores, harbours, etc. to ensure minimum environmental hazards.

The Fiji Mining Act 1966 provides for a licencing system to control mining. The Act prohibits mining in certain areas including any reserved forest declared under the Forests Act and makes provisions for the declaration of Government protected areas. The Director of Mines may order the holder of a mining tenement to restore the surface where such surface has been disturbed by prospecting or mining operations.

Federated States of Micronesia

In FSM the laws relating to discharge of industrial effluents into marine environment are covered by the Public Law 3-83, the Environment Protection Act and the Marine and Fresh Water Quality Standards Regulation.

Guam

In Guam the prevention, abatement and adequate control of sources of pollutants into the waters of the territory is controlled by the Federal Clean Water Act (P.L. 92-5000). The Guam Water Pollution Discharge Elimination System (NPDES, establised by the Federal Clean Water Act) deals with pollution discharges to the nation's water by setting guidelines for the levels of contaminants. The US Environmental Protection agency is the ultimate authority for the NPDES permit system.

New Caledonia

The relevant legislation is contained in Decree 77-133/cg of 1977 regarding air pollution caused by metal processing, Circulars regarding construction of smoke stacks in the case of combustion works and in the case of industrial plants producing fine dust, Circular (25/D8/71) regarding cement works and Circular (24/07/72) concerning iron ore processing. These together with provisions to maintain water quality are relevant in controlling industrial pollution.

Decree 54-1110, 1954, of New Caledonia deals with the control of mining activities. Under this Act, a Mining Pollution Control Commission was set up to determine pollution control measures to be implemented for each mine in operation.

Papua New Guinea

Provisions of the Environmental Contaminants Act and the Environmental Planning Act in Papua New Guinea can be used to control the activities and locations of industries to ensure minimum environmental hazards. The Environmental Planning Act, which contains a provision that no authority shall grant any licence, permit or lease or provide any loan, grant, guarantee or subsidy in respect of any matter where a requisition has been served under the Act on a party to submit an environmental plan, encourages cooperation amongst other developmental agencies and the environmental authorities in preventing pollution.

The Public Health Act also contains regulations that cover the deposition of solid waste and the emissions of smoke from factories. The location of factories is also subject to zoning restrictions in the Town Planning Act which classifies industries into light, heavy and isolated categories.

The Environmental Contaminants Act through its licencing process is a further safeguard against possible industrial pollution.

In Papua New Guinea environmental considerations in mining activities are taken care of through the Environmental Planning Act and the Environmental Contaminants Acts. The Mining Act (amalgamated) 1977 allows for Government control and management of all mining activities in PNG. The Act includes provisions for the rehabilitation of land after prospecting and mining operations. Section 102 of the Act also provides for compensation to be paid for "damage to the crops and economic trees".

Solomon Islands

The Solomon Islands Mining Act 1969 provides the Minister responsible with the power to subject prospecting for specific minerals to such terms and conditions as he sees fit to impose. The Act also allows Government protection areas to be declared and mining in these areas is only allowed with the consent of the Government. The Director of Mines can order the prospector to restore the surface of the land where it has been disturbed by prospecting or mining operations.

Tonga

In Tonga the Parks and Reserves Act 1976 can be used to control pollution of the marine environment from any source including industrial effluent discharge. The Fisheries Division of the Government is responsible for all prosecutions for offences against this Act.

Although comprehensive environmental protection packages exist in some of the SPREP member countries, the legislation does not have any recommended guidelines for the control of industrial effluent discharge and waste disposal into coastal waters, air and land. Because guidelines are virtually non-existent the authorities responsible for the protection of the environment cannot force industries to monitor the effluents discharged into water, land or air. Also, in many developing countries such controls to protect the environment do not receive sympathetic treatment since governments often see these requirements as an obstacle to economic development, since the full economic consequences of environmental damage have not been assessed.

II. PREPARATION OF A LIST OF THE TYPES OF INDUSTRIES LIKELY TO BE PRODUCING UNDESIRABLE EFFLUENTS

It has already been mentioned that the South Pacific region is not heavily industrialised. Nonetheless, the number of industries such as those producing milk, meat, sugar, and beer in urban areas is increasing as are the problems of consequent disposal of effluents in the surroundings. This has caused considerable concern to environmental scientists, Government officials and the public.

The industries likely to produce undesirable effluents in SPREP member countries are classed under separate categories below and each is discussed separately.

1. BREWING AND DISTILLATION

Brewing and distillation industries exist in Fiji (2), New Caledonia, Tonga, Papua New Guinea (2) and Western Samoa. The brewing process involves production of a fermented beverage of low alcohol content from various types of grain. By distillation of this alcohol a product of high alcohol content is usually obtained.

Outline of the Process

Barley is commonly used in the brewing process because it contains about 60% starch. Prior to the fermentation process the starch present in barley is converted into sugar by a process called malting. This process involves the moistening of barley grains with water under appropriate conditions to initiate germination. During the germination process an enzyme called diastase is formed which converts starch to maltose. Germination and subsequent growth is then stopped by heating the sprouted grain in a kiln. Following washing the ground barley is extracted with hot water to give a liquid called wort. This extraction process is called malting. Beer manufacture continues by boiling wort with hops in a brew kettle to give beer the desired flavour.

The wort is then passed to a fermenter where yeast is added to induce fermentation. Enzymes in the yeast convert sugar in the wort into alcohol and carbon dioxide. Filtration, carbonation, etc., can also be carried out to make beer of the desired type. The type of liquor produced from distillation will depend on the alcoholic liquid used as a base, e.g., the base for brandy is wine, whisky is distilled from a fermented wort derived from barley, rum is distilled from a product obtained by the fermentation of molasses.

Sources of Pollution

The process of malting produces both liquid and solid wastes. The liquid waste is basically a product of the barley steeping while solids consist of the sprouts and rootlets screened out during the malt preparation. Wastes from fermentation and subsequent operations include spent grain, hops and yeast, liquors from spent grain, yeast washing and pressing of yeast wastes and wash waters from the washing of equipment, casks, barrels etc. The liquid wastes have a high suspended solid (SS) content, a high biological oxygen demand (BOD) and a high chemical oxygen demand (COD). Typical effluent compositions are shown below in Table 1.

TABLE 1 : Characteristics of Typical Brewery Waste

Parameter	Typical Concentration
BOD_5 (mg/L)	1200 - 3000
SS (mg/L)	100 - 800
COD (mg/L)	3500 - 4000
pH	4.3 - 11.0

ref : Award, H. (1986)

2. CANE SUGAR MANUFACTURE

Large sugar processing mills exist in Fiji and in Papua New Guinea.

Outline of the Process

At the mill whole cane stalks are crushed between rollers to extract juice which is screened and then treated with lime to prevent sucrose inversion. The extract is then heated, insoluble compounds removed and the liquor concentrated until a mixture of sugar crystals (raw sugar) and syrup (molasses) is formed. Sugar is separated from molasses by centrifugation. In Fiji and Papua New Guinea raw sugar is not refined.

Sources of Pollution

Cane crushing water contains a substantial amount of soil and impurities, especially in Fiji where harvesting is done manually. The cane wash water also contains sugar and may appear coloured. Other waste waters that cause pollution problems include those from floor washing and the washing of equipment. Effluents from sugar-cane processing plants are characterised by high BOD and high SS (see Table 2). The solid trash remaining contains a lot of nutrients including lime, nitrate and phosphate and its disposal near the seashore or estuaries may lead to eutrophication problems. The return of mill mud and mill ash to the canefields is strongly recommended.

TABLE 2 : Characteristics of Typical Sugar Mill Waste

Parameter	Typical Concentration
BOD_5 (mg/L)	500 - 3000
SS (mg/L)	100 - 2000
COD (mg/L)	2000 - 5000
pH	6 - 9

ref : Meade, G.P. and Chen, J.C.P. (1977)

3. METAL FINISHING

A wide range of specialized metal finishing processes are used for protecting metals particularly against corrosion, improving their properties or enhancing their appearance. Metal finishing/processing is a fairly new technology for SPREP member countries, but in the recent years metal finishing industries have been established in Papua New Guinea, Fiji, New Caledonia, French Polynesia, Solomon Islands and Guam.

Outline of Process

Prior to coating, pretreatments are usually necessary to remove natural oxide coatings, corrosion products, and even protective oils and greases. The oxide films and corrosion products can be removed by either mechanical methods (such as brushing, descaling, polishing, shot blasting) or by chemical processes (such as acid pickling, sodium hydroxide descaling). Oil and grease may be removed by using suitable organic solvents. The methods used for metal finishing may be grouped as :

- electroplating
- stripping
- chemical conversion (anodizing, phosphating)
- chromating
- metal coating (galvanizing, rust proofing, sherardizing, peen plating, calorizing, metal spraying, hot dip aluminizing, vacuum metallizing)
- machining (chemical, electrochemical, etching)
- final polishing
- case hardening
- other processes (electroforming, electroless plating)

Sources of Pollution

Because metal finishing involves many processes, the types of effluents produced will vary with the processes involved. Thus pretreatment by means of acid pickling prior to galvanizing will produce used acid pickling liquors containing high concentrations of iron salts which if neutralized will produce insoluble hydroxides, while liquors from pickling of copper and its alloys will contain salts of copper with smaller amounts of zinc. The electroplating acid wastes will generally contain dissolved copper, nickel, zinc, chromium, cyanide and sometimes cadmium or lead. Anodizing gives rise to a range of wastes, including both alkaline and acidic solutions, nitric acid and nitrates, phosphoric acid, chromium-bearing acidic solutions, bright anodizing solutions (nitric/phosphoric/acetic acids) and nickel-bearing sealing solutions. Typical effluent composition is shown in Table 3.

TABLE 3 : Characteristics of Electroplating Plant Waste

Parameter	Typical Composition
pH	3 - 8.5
Cu (mg/L)	0.1 - 0.3
Zn (mg/L)	0.1 - 8
Cr (mg/L)	0.1 - 5
Ni (mg/L)	0.01 - 60
Cd (mg/L)	0.01 - 0.1
CN (mg/L)	5

ref : Award, H. (1986)

4. TANNING

Tanning is the process whereby animal hides and skins are converted into leather. Recently a tanning factory was established in Suva and the products - mostly leather shoes, handbags, belts and travelling bags - are produced for local markets as well as export to countries like Australia and New Zealand. Tanning is also carried on in Papua New Guinea and New Caledonia.

Outline of the Process

The first stage in the tanning process is the hide preparation because hides and skin contain hair, protein, grease and oil which have to be removed. After the unwanted material has been removed, the hides and skins are treated with appropriate tanning agents to produce leather. The leather then undergoes various finishing operations to achieve the desired surface finish and mechanical properties.

Sources of Pollution

Both the preparation of the hide and the subsequent tanning contribute to pollution and these are discussed separately.

i) Hide Preparation

The hides are prepared for tanning in the beam house process in a number of stages. The first stage is the washing and soaking in large amounts of salt to remove dirt, blood, manure and non-fibrous proteins as well as to preserve the hides for long periods. This stage is followed by liming and unhairing in which the soaked hides are treated with a mixture of lime slurry and a solution of sodium sulphite. During this process the hair is destroyed and the hides swell so that tanning agents can penetrate easily.

Liming and unhairing are followed by fleshing where any remaining muscle and fatty tissues are removed. Finally, the hides are delimed with weak acids (and/or acid salts) and bated with a proteolytic enzyme (pancreatin, trypsin) which peptizes the protein fibres and removes unwanted protein (elastin). The process of washing, soaking, liming and unhairing produce substantial amounts of waste-water heavily contaminated with organic matter resulting in high BOD and SS.

ii) Tanning

Depending upon the type of leather to be produced different tanning chemicals are used. The common ones used are vegetable tanning, chrome tanning or a combination of chrome/vegetable tanning (also known as semi-chrome tanning). The process of tanning produces waste-water heavily contaminated with used tanning solutions. Since tannery operations are basically a series of washings to remove all unwanted materials in the hide, the wash liquors are heavily contaminated with used tanning solutions. Waste water may be alkaline or acidic, highly coloured and have high oil and grease (O/G) levels and high salt content. Such wastes will generally have high BOD, COD, SS and odour. Also of concern would be chromium ions particularly the hexavalent state, Cr(VI), which is the form most toxic to humans and also aquatic invertebrates and fish. Typical effluent composition is shown in Table 4.

TABLE 4 : Characteristics of Tannery Waste

Parameter	Typical Composition
BOD_5 (mg/L)	500 - 1500
COD (mg/L)	3000 - 6000
SS (mg/L)	400 - 1000
O/G (mg/L)	120 - 500
Total Cr (mg/L)	12 - 100
pH	6 - 11

ref : Award, H. (1986)

5) **FOOD MANUFACTURING AND PROCESSING**

The following industries have been grouped under this heading:

i) Abattoirs and meat canning/packing
ii) Manufacture of dairy products
iii) Refining edible oils and fats
iv) Canning and preserving of fruit and vegetables
v) Canning and preserving of marine food (fish, crustacea, shellfish, clams, etc.)

i) **Abattoirs and Meat Canning/Packing**

At abattoirs the slaughtering of animals, dressing and packing of cattle, sheep, lamb and poultry products occur.

Sources of Pollution

The water from the washing of stock trucks and stock before slaughtering will contain substantial amounts of dirt and faecal coliforms. The washwater also contains blood, washings of hides, skins, hair and washings of all edible portions. The effluents will thus be highly contaminated with organic matter which results in high BOD and SS. Typical effluent composition is shown in Table 5.

TABLE 5 : Characteristics of Abattoir Waste

Parameter	Typical Effluent Composition
BOD_5 (mg/L)	1200 - 3800
SS (mg/L)	450 - 2400
COD (mg/L)	5600 - 6900
O/G (mg/L)	20 - 100
pH	7 - 7.2

ref : Award, H. (1986)

ii) <u>Manufacture of Dairy Products</u>

This section includes factories specializing in the manufacture of creamy and processed butter, natural and processed cheese, condensed, powdered and evaporated milk, fresh and preserved cream, ice cream and other dairy products like yogurts, dairy desserts and sterilized/pasterized milk.

Sources of Pollution

Because the manufacture of dairy products involves many processes the chemical composition of effluents will vary with the processes involved. The effluents will, however, be high in organic materials and have high pH and detergent content mainly from washing of tanks and bottles. Typical effluent composition is shown in Table 6.

TABLE 6 : Characteristics of Dairy Waste

Parameter	Typical Concentration
BOD_5 (mg/L)	1600 - 2500
SS (mg/L)	900 - 1400
COD (mg/L)	3000 - 4200
O/G (mg/L)	200 - 400
pH	4.5 - 10.0

ref : Award, H. (1986)

iii) Refining of Edible Oils and Fats

This type of operation is carried out in Papua New Guinea, New Caledonia, Guam and there are two factories in Fiji which refine edible oils and fats. The firms import crude edible vegetable oils such as soya beans, coconut (copra) oil, corn oil and mustard oil and refine these oils.

Outline of the Process

Crude vegetable oil is mixed with an alkali such as caustic soda and fed into a high speed centrifuge which separates impurities. The supernatent is then washed and spun through other centrifuges with water to remove all traces of the alkali. At this stage the oil is only partly refined because it still contains colour which is removed by bleaching. This is done by heating the oil under vacuum following agitation of the mixture with natural bleaching earth and vegetable carbon. The used bleaching earth and carbon are removed from the oil by filtration. Oil at this stage is called refined and bleached but needs further processing before it is considered edible.

The next stage in oil refining is called hydrogenation. This process leads to an increase in the degree of saturation and depending on this factor the liquid oils or semi-liquid oils may be converted to solids. The process involves heating refined bleached oils in closed vessels with a catalyst to assist reaction and gaseous hydrogen is introduced. After the reaction is complete the hydrogenated oils are filtered to remove the catalyst. The refined and bleached oil obtained contains minor traces of volatile impurities which can give an unpleasant taste and must be removed by deodorising which involves heating the oils with steam in closed vessels, cooling, and finally filtering to remove any suspended particles. Oil at this stage may be classed as refined and deodorized.

Sources of Pollution

The principal waste from this industry is the earth used for bleaching the oil. This solid residue can be disposed of at the municipal rubbish dump or used for land filling. The liquid waste from the factories contains soap, free vegetable oil and sodium hydroxide which is used for cleaning of tanks. Typical effluent composition is shown in Table 7.

TABLE 7 : Characteristics of Edible Oil Refining Effluent

Parameter	Typical Concentration
BOD_5 (mg/L)	100 - 500
COD (mg/L)	150 - 800
SS (mg/L)	130 - 600
pH	2 - 6

Source : H.E. Painter in Water and Water Pollution Handbook, Vol. I, L.E. Ciaccio, Ed., Marcel Dekker, New York, 1971, p.350

iv) **Canning and Preserving of Fruits and Vegetables**

These industries include those involved in canning and packing in air tight containers of fruits and vegetables, canning and bottling of fruit and vegetable juices, manufacture of jam, jellies, sauces and canned soups.

Sources of Pollution

The waste water from these factories will contain substantial amounts of suspended solids and organic materials which are highly putrescent and thus carry high bacterial population. Typical effluent composition is shown in Table 8.

TABLE 8 : Characteristics of Waste from Fruit and Vegetable Canneries

Parameter	Typical Concentration
BOD_5 (mg/L)	1000 - 3000
COD (mg/L)	2000 - 4000
SS (mg/L)	100 - 400
pH	4 - 12

ref : Award, H. (1986)

v) **Canning, Preserving and Processing of Marine Organisms (fish, crustacea, shellfish, clams, etc.)**

The industries included under this group include those canning fish, shrimps, oysters, clams, crabs and other sea foods.

Sources of Pollution

Wastes from these factories are chemically similar to domestic waste and meat processing factories. These are wholly organic in character consisting of dissolved colloidal and suspended material. These will also contain considerable amounts of grease. The organic wastes are highly putrescible and carry high bacterial population. Typical effluent composition is given in Table 9.

TABLE 9 : Characteristics of Typical Fish Cannery Waste

Parameter	Typical Concentration
BOD_5 (mg/L)	3000 - 3500
COD (mg/L)	4000 - 5000
SS (mg/L)	1200 - 1600
O/G (mg/L)	40 - 60
pH	6 - 8

ref : Riddle and Shikaze (1973)

6. CEMENT

Cement is a complex calcium aluminosilicate material produced by the combination of limestone with material containing alumina and silica (usually clay). When mixed with water cement forms a binding material for aggregates in concrete.

Outline of Process

After the raw materials have been extracted and brought to the factory they are reduced in size by crushing and grinding. The ground limestone and clay are then blended to give a feed of the correct composition for the kiln in which they are heated to form the product known as clinker in the rotary kilns. The rotary kiln feed in the form of a wet slurry is introduced into the upper end of the kiln, while fuel for heating (coal) enters and is burnt at the lower end. In this way the feed is successively heated, dried, calcined and finally heated to incipient fusion when chemical reaction occurs and clinker is formed. This is cooled with air, ground to a fine powder and passed to packing and storage.

Sources of Pollution

The rotary kiln is the main source of dust emissions in cement manufacture. The hot gases produced by the combustion of the fuel are pulled by forced draught up through the kiln counter-current to the raw material flowing down it. The gases, therefore, carry entrained dust with them from the upper end of the kiln. Dust emissions are also produced in crushing, grinding, blending, clinker cooling, finish grinding and in moving finely divided material to silos and in packing. Waste waters are produced in cement manufacture during the blending process and from the use of wet scrubbers for removing dust from the kiln exit gases. These waters contain significant quantities of suspended (inorganic) solids and have a relatively high pH.

III REVIEW OF SELECTED OVERSEAS STANDARDS

Guidelines for effluent discharges for various industries in non-regional countries are presented in Tables 10-13. Most of these guidelines have been in force for some time and since there are no reports of major problems arising from their use, it is presumed that they are effective in the situations in which they have been applied. Unfortunately none relate directly to the small island/limited industrialisation situation found in countries of the SPREP region.

TABLE 10 : Guidelines for Effluent Discharges from Breweries into Coastal Waters

Parameter	India	Yorkshire, UK
Suspended solids (mg/L)	100	30
BOD_5 (mg/L)	30	20
4-hr permanganate value (mg/L)	-	25
Colour/odour	must be absent	-
pH	5.5 - 9.0	6 - 9

ref: WHO, Geneva, 1983. Compendium of Environmental Guidelines and Standards for Industrial Discharges.

TABLE 11 : Guidelines for Effluent Discharges from Raw Cane Sugar Processing Plants

Item	Louisiana, USA		FRG
	Max. for 1 Day	Max. Ave. 30 Conseq. Days	Max for 1 day
BOD_5(mg/L)	1140	630	30
Suspended solids (mg/L)	1140	470	
pH	6 - 9	6 - 9	

ref: WHO, Geneva, 1983. Compendium of Environmental Guidelines and Standards for Industrial Discharges.

TABLE 13 : Guidelines for Discharges from Tanneries in Surface Waters

CHARACTERISTICS	FRANCE	FRG	INDIA	ITALY	SINGAPORE
pH	5.5-8.5	6.0-9.0	5.5-9.0	5.5-9.5	6-9
SS (mg/L)	30	-	100	80	50
BOD_5 (mg/L)	40	80	30	40	50
COD (mg/L)	-	400	-	100	100
O/G	-	10	-	40	10
Total Cr	-	2	-	-	1
Cr (VI)		0.5	0.1	0.2	-
Cl^- (mg/L)	-	-	1000	1200	600

ref : WHO, Geneva, 1983. Compendium of Environmental Guidelines and Standards for Industrial Discharges

TABLE 12 - GUIDELINES FOR DISCHARGES FROM METAL FINISHING PLANTS INTO SURFACE WATERS

CHARACTERISTICS	CANADA	FRG	INDIA	ITALY	SINGAPORE	YORKSHIRE, UK	USA (max. for any 1 day)
Total Suspended Matter (mg/l)	30	-	30	80	-	30.0	61
Cadmium (mg/l)	1.5	3.0	2.0	0.02	0.1	0.2	1.29
Total Chromium (mg/l)	1.0	2.0	-	-	1.0	0.5	2.87
Copper (mg/l)	1.0	1.0	3.0	0.1	0.1	0.5	3.72
Lead (mg/l)	1.5	-	-	0.2	0.1	0.5	0.67
Zinc (mg/l)	2.0	3.0	5.0	0.5	1.0	2.0	2.64
Nickel (mg/l)	2.0	3.0	3.0	2.0	1.0	0.5	3.51
Oxidizable Cyanide (mg/l)	0.1	0.1	0.2	0.5	0.1	-	-
Total Cyanide (mg/l)	3.0	-	-	-	-	10.0	1.3
pH	6.0-9.5	6.0-9.0	7.0-9.0	5.5-9.5	6-9	6-9	6-9
Free Chlorine (mg/l)	-	0.5	-	6.0	-	-	-
Fluoride Ion (mg/l)	-	20	-	6.0	-	-	-
Nitrite Ion (mg/l)	-	20	-	-	-	-	-

ref : WHO, Geneva, 1983. Compendium of Environmental Guidelines and Standards for Industrial Discharges.

IV. RECOMMENDED STANDARDS/CRITERIA

In order to prevent water pollution, it is essential to prevent the entry of chemicals into the aquatic environment. This is virtually impossible in the SPREP region considering the small size of the island nations and the number and amount of (potential) pollutants discharged from the various industries. It is therefore essential to ascertain levels below which the concentration of a particular pollutant may be considered safe for disposal into aquatic environment. Given that there is to be a discharge, the maximum environmental protection is obtained if the effluent is treated with the best available technology (BAT), i.e., regardless of cost, the treatment that provides maximum removal of the pollutant substance. Economic factors are, however, often taken into consideration and the level of treatment may be less than the maximum. This option, taking economic considerations into account, is described as the best practicable means available (BPMA).

Even when the BPMA option is adopted, there will be different standards adopted for different substances. Those of high toxicity and environmental risk must be much more rigorously controlled in terms of effluent quality and quantity than those of less serious risk. In drawing up the guidelines below an attempt has been made to assess what is achievable in terms of effluent quality. The assessment of quantity allowable must take into account local factors such as size, volume and nature of receiving water body (see later).

These approaches to environmental protection seek to reduce the potential impact of contaminants on the marine environment by reducing the input of toxic substances. Since the limits are based on practicable treatment technology they cannot guarantee complete protection of the environment on a site-specific basis. They have, however, the advantage of being relatively easy to monitor and administer and they do not require detailed investigation of environmental variables.

The control of effluent quality reduces pollutant levels in effluents, but may not completely prevent pollution. For example, while a large industrial plant discharging into a large estuary or onto an open coastline may produce no detectable effect, a small plant discharging into a small confined water body may have a disastrous effect. People responsible for applying effluent standards must take cognizance of the capacity of the local environment to assimilate wastes.

Protection of the marine environment is sought by assessment of the impact of various potential pollutants. For some, data (on toxicity, etc.) is plentiful, while for others it is relatively sparse. For the latter it is often useful to apply a safety factor in determining effluent standards. The resulting maximum allowable concentration in a marine environment is expected, under normal conditions, to maintain the vitality of that environment.

The United States Environmental Protection Agency in its document "Quality Criteria for Water' (US EPA, 1976) describes the criterion as a designated concentration of a constituent that, when not exceeded, will protect an organism, an aquatic community or water. Thus, such a criterion represents the maximum safe level and is obtained for each component from solely scientific data. The US EPA description of criteria has been adopted as a definition in the preparation of the proposed guidelines. It is worth remembering that each criterion only serves as a rough guide when deciding the levels of contaminants which can be reasonably tolerated.

In drawing up standards for industrial effluent discharges into coastal and river waters the following parameters have been taken into consideration:

(a) Selected/available overseas standards
(b) Typical volumes and composition of effluents from factories

When applying these guidelines users are particularly asked to note

(a) The nature of discharging points such as coastal waters or rivers, e.g., whether river volume is high or low and mixing characteristics of the effluent and the receiving water. Adjustments to the guidelines may be required if mixing characteristics are poor.

(b) If discharge is into river systems where low flows are common (especially during the dry season) then standards will need to be adjusted downwards.

1) **Brewery Waste**

Brewery waste is characterized by a high BOD and a high carbonaceous soluble component. Typical parameters that need to be monitored are pH, BOD, chemical oxygen demand (COD) and SS.

TABLE 14 : Recommended Levels for Effluent Discharge from Breweries into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	20 - 30
SS (mg/L)	30 - 100
COD (mg/L)	<300
pH	5.5 - 9

2) Sugar Mills

Waste from cane processing plants can be characterized by high BOD and high suspended solids. Typical parameters that need to be monitored include pH, BOD, COD and suspended solids.

TABLE 15 : Recommended levels for Effluent Discharge from Sugar Mills into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	20 - 30
COD (mg/L)	<300
SS (mg/L)	30 - 100
pH	5.5 - 7.5

c) Metal Finishing

The effluents from these factories may contain phosphate, chromate (as chromic acid), cyanide, traces of toxic metals such as copper, zinc, nickel and lead. The pH will generally be low and this together with even low levels of cyanide will be very toxic to microorganisms and marine and estuarine organisms. Parameters likely to require monitoring from a electroplating and metal finishing waste include pH, copper (Cu), zinc (Zn), chromium (Cr III and Cr VI), nickel (Ni), cadmium (Cd) and cyanide (CN).

TABLE 16 : Recommended Levels for Electroplating Effluent Discharge into Coastal and River Waters

Parameter	Recommendation
pH	6 - 9
Cu (mg/L)	0.1 - 1.5
Zn (mg/L)	0.5 - 2.5
Total Cr (mg/L)	1.0 - 1.5
Ni (mg/L)	1.0 - 2.0
Cd (mg/L)	0.02 - 0.1
Total CN (mg/L)	0.3 - 1.5

d) **Tannery**

Tannery operations are basically a series of washings to remove all unwanted materials in the hide. Wash liquors are usually water (to remove salt from preserved hides), pickle liquors and tanning liquors (chromium). Waste water may be alkaline or acidic, have high oil and grease (O/G) levels and be highly coloured. Such wastes will generally have high BOD, COD, SS and odour.

e) **Manufacture of Food**

i) **Abattoirs and Meat Canning/Packing**

Abattoir waste is characterized by high BOD, SS and O/G. Parameters to be monitored include BOD, SS, COD, O/G and pH.

TABLE 17 : Recommended Levels for Effluent Discharge from Tanneries into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	30 - 50
COD (mg/L)	100
SS (mg/L)	30 - 100
O/G (mg/L)	10 - 20
Cr (mg/L)	2.0
pH	6 - 9

TABLE 18 : Recommended Levels for Effluent Discharge from Abattoirs into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	50 - 100
SS (mg/L)	30 - 100
COD (mg/L)	100
O/G (mg/L)	10 - 20
pH	6 - 8

ii) Manufacture of Dairy Products

Dairy wastes usually have very high BOD values. The pH of the effluents can be low too due to acid washings of the tanks. Parameters to be monitored for a dairy waste include BOD, COD, SS, O/G and pH.

TABLE 19 : Recommended Levels for Effluent Discharge from Dairies into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	50 - 100
SS (mg/L)	30 - 100
COD (mg/L)	100
O/G (mg/L)	20 - 40
pH	6 - 8

iii) <u>Refining Edible Oils and Fats</u>

Effluents from oil refining plants are characterized by high BOD, COD and high pH. They are also accompanied by a oil and greasy appearance and a distinctive smell of oil.

TABLE 20 : Recommended Levels for Effluent Discharge from Edible Oil Refineries into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	30 - 100
COD (mg/L)	100
O/G (mg/L)	10 - 20
SS (mg/L)	20 - 50
pH	6 - 8

iv) <u>Canning and Preserving Fruits and Vegetables</u>

Waste from these factories are characterized by low pH and high BOD. Also if no screening facilities are available at the factory the effluents will have high suspended solids (peelings, skin, etc.). Typical parameters that need to be monitored include pH, BOD, COD and SS.

TABLE 21 : Recommended Levels for Effluent Discharge from Vegetable Canneries into Coastal and River Waters

Parameter	Recommendation
BOD_5 (mg/L)	30 - 100
COD (mg/L)	100
SS (mg/L)	50 - 100
pH	6 - 9

v) **Canning of Marine Organisms (Fish, Shellfish, etc.)**

Waste from fish canneries will be largely organic in nature, consisting of colloidal and suspended matter with considerable amounts of grease.

TABLE 22 : Recommended Levels for Effluent Discharge from Fish Canneries into Coastal and River Waters

Parameters	Recommendation
BOD_5 (mg/L)	30 - 100
COD (mg/L)	100
O/G (mg/L)	10 - 20
SS (mg/L)	30 - 100
pH	5.5 - 9

f) **Cement Manufacture**

The major waste discharges are particulate matter in the exit gases from the kiln and suspended solids and high pH material in the waste water.

TABLE 23 : Recommended Levels for Particulate emissions from Cement Works

Source	Emission Limit g/Nm^3
Existing kilns	0.150 - 0.250
New kilns	0.150

TABLE 24 : Recommended Levels for Effluent Discharge from Cement Works into Coastal and Ocean Waters

Parameter	Recommendation
SS (mg/L)	50 - 100
pH	5.5 - 9

RECEIVING WATER STANDARDS

An alternative procedure to facilitate control of the quality of coastal and riverine waters is to set standards for the waters receiving discharges or effluents which will ensure that the water remains suitable for current and planned uses. In this way the quality of the actual waters after receiving the discharges is measured directly, rather than indirectly from calculation of dilution, etc., after measurement of effluent concentrations.

To be effective, such a procedure requires a regular monitoring programme to ensure that established water quality standards are not exceeded. A mechanism for remedial action in the case where standards are exceeded also needs to be established before the use of receiving water standards is introduced.

Receiving waters include all coastal waters offshore from the mean high-tide level including estuarine waters, lagoons, bays, brackish and inland waters like rivers, creeks, streams and standing waters in lakes, swamps and reservoirs. Receiving water quality criteria will be different for different categories of water, the categories depending upon the primary use of the water.

Three major categories of water are widely used:

Category-1 Waters in this category are primarily for aesthetic enjoyment and recreation apart from protection of natural aquatic life. These waters should be kept free from pollution attributed to domestic, commercial and industrial discharges, shipping and intensive boating, construction and other activities which may impair their intended use.

Category-2 Waters in this category are primarily for marine biological activity and standards must ensure protection for marine organisms, particularly shellfish and coral reefs. Other important uses include mariculture activities, aesthetic enjoyment and recreational activities inclusive of whole body contact.

Category-3 Waters in this category are primarily for general use including commercial/industrial uses such as shipping, but should be of sufficient quality to protect aquatic life and permit limited body contact. Aesthetic enjoyment and recreational use should also be maintained.

In setting limits for receiving waters it is important to recognize that these limits are aimed at -

a) avoiding algal blooms (due to excessive nutrients) and subsequent water quality problems
b) avoiding direct toxicity to marine organisms (due to metals, hydrocarbons or pesticides)
c) avoiding significant bio-accumulation in food chains leading to indirect toxicity problems for fish and other life forms
d) avoiding health problems to water users (bacteria, viruses etc.)
e) avoiding significant changes in the redox conditions of the waters (BOD, COD, dissolved oxygen level changes)
f) avoiding serious damage to marine/coastal ecosystems due to the influence of sedimentation
g) avoiding damage to engineering facilities (pipelines, piers, dams, etc.) caused by changes in pH, redox conditions

The information given below should be used as guidelines. In any particular situation, the nature of the discharge site, the extent of mixing and the relative volumes involved plus the potential use of the water should be considered in defining locally appropriate water quality standards. A number of texts review methods of assessing the appropriateness of local standards (e.g. GESAMP, 1986; Baughman and Lassiter, 1978; Haque, 1980; Neely, 1980; WHO/UNEP, 1982).

Recommended Guidelines

A. General Criteria Applicable to All Waters

All waters should be

a) free from visible floating materials, debris, oils, grease, scum, foam or other floating matter

b) free from suspended materials that settle to form deposits or otherwise adversely affect aquatic life

c) free fom substances that are toxic or harmful to humans, animals, plants or aquatic life

B. Specific Numeral Water Quality Criteria

		Category 1	Category 2	Category 3
1.	Microbiological Standards NB: To determine compliance with these standards where a 30-day period is specified, a minimum of 4 samples shall be collected at approximately equal intervals NB: Where shellfish are collected for human consumption, the microbial standard for category 1 waters shall apply	Total coliform bacteria shall not exceed an arithmetic mean of 50 per 100 mL during any 30 day period nor should any sample exceed 500 per 100 mL	Faecal coliform count shall not exceed an arithmetic mean of 70 per 100 mL during any 30 day period nor shall any sample exceed 400 per 100 mL	Faecal coliform count shall not exceed an arithmetic mean of 200 per 100 mL during any 30 day period nor shall any sample exceed 400 per 100 mL
2.	pH	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0
3.	Dissolved Oxygen NB: Saturation can be estimated from the data in Table 25 below	> 75% of saturation	> 75% of saturation	> 75% of saturation
4.	Salinity			
	a) Marine waters	± 10% of ambient conditions	± 10% of ambient conditions	± 10% of ambient conditions
	b) Fresh waters	TDS < 500 mg/L or < 133% ambient conditions	TDS < 500 mg/L or < 133% ambient conditions	TDS < 500 mg/L or < 133% ambient conditions

		$Cl+SO_4$ <250 mg/L	$Cl+SO_4$ <250 mg/L	$Cl+SO_4$ <250/L
5.	Total Filterable Suspended Solids	<5 mg/L except when due to natural conditions	<20 mg/L except when due to natural conditions	<40 mg/L except when due to natural conditions
			< 10% above ambient at any time	< 25% above ambient at any time
6.	Clarity (Secchi Disc)	Shall not decrease by more than 1.0 m from ambient level except when due to natural conditions	Shall not decrease by more than 2.0 m from ambient level except when due to natural conditions	Shall not decrease by more than 5.0 m from ambient level except when due to natural conditions
7.	Radioactive Substances	No discharges at any time	No discharges at any time	No discharges at any time
8.	Temperature	Shall remain within $\pm$ 1°C of ambient outside an established mixing zone	Shall remain within $\pm$ 1°C of ambient outside an established mixing zone	Shall remain within $\pm$ 1°C of ambient outside an established mixing zone
9.	Oil and Petroleum Products	No visible film Sheen discolouration on surface; no odour	No tainting of fish or invertebrates, damage to biota, no objectionable taste on drinking	No formation of oil deposits on shores or bottom of receiving water body
10.	Toxic Substances	Concentrations of toxic substances (persistent or non-persistent, cumulative or non-cumulative) shall not exceed 0.05 of the 96 hour LC_{50} at any time or place, nor should the 24-hour average concentrations exceed 0.01 of the 96-hour LC_{50}, the LC_{50} values being determined by using the most sensitive species of aquatic organisms affected. Typical receiving water standards for toxic substances are given below.		

Substances	**Values**		
Lead	50 µg/L	50 µg/L	500 µg/L
Mercury	0.1 µg/L	1 µg/l	2 µg/L
Zinc	50 µg/L	5000 µg/L	10,000 µg/L
Copper	5 µg/L	1000 µg/L	50-2000 µg/L
Cadmium	0.2 µg/L	5 µg/L	10 µg/L
Selenium	10 µg/L	10 µg/L	20 µg/L
Arsenic	50 µg/1	50 µg/L	500 µg/L
Chromium	10 µg/1	50 µg/L	1000 µg/1

TABLE 25 : Saturation Concentrations of Dissolved Oxygen in Water*

Temp. °C	Water Type	Salinity	O_2 (Sat.) mg/L	75% Sat. mg/L
15	Fresh	0	7.05	5.28
	Marine	35	5.69	4.26
20	Fresh	0	6.35	4.76
	Marine	35	5.17	3.88
25	Fresh	0	5.77	4.32
	Marine	35	4.73	3.54
30	Fresh	0	5.28	3.96
	Marine	35	4.35	3.26
32	Fresh	0	5.10	3.82
	Marine	35	4.22	3.16

***Data from Riley, J.P. and Shirrow, G. Chemical Oceanography, Second Edition, Volume 4, Academic Press, 1975 pp 323-4. This reference contains additional data on oxygen saturation levels.**

SOME GENERAL COMMENTS

The industries in existence in the SPREP member countries are not sophisticated and routine monitoring of the effluents should not be a problem provided there are funds, equipment and expertise available in the respective countries. This is because the parameters that have to be monitored for 95% of the industries are pH, BOD, COD, SS and O/G. Each of these requires only the use of simple apparatus and a knowledge of basic chemistry. It is essential to have a calibrated pH meter for pH measurements. BOD can be measured with great sensitivity by use of modified Azide/Winkler method (APHA, 1980). In this method the raw effluents are diluted and aerated. One half of the solution is incubated at 20°C for 5 days in the dark and the initial dissolved oxygen is measured by means of titration in the other portion. Measurement of COD requires the use of a refluxing apparatus. If a refluxing set-up is not available in some countries this parameter can be eliminated since BOD provides a good estimate of biodegradable organic matter in most of the industries of concern. Suspended solids are simply determined by filtering a known volume of effluent through a previously weighed filter paper and finding the weight of residue after thorough drying. Determination of O/G also requires use of simple apparatus, namely a separating funnel. The only industry whose effluents may cause other problems in some countries would be a metal finishing plant since its effluent will contain toxic metals and ions. To detect low levels of toxic metals requires use of sensitive instruments such as an Atomic Absorption Spectrophotometer (AAS). Since this equipment is available in Papua New Guinea, Guam, Fiji, French Polynesia, New Caledonia, Solomon Islands, Western Samoa and Tonga, samples from other countries could be sent to these countries for analysis.

Analysis of these metals can also be performed by colorimetric or classical titrimetric methods where samples are titrated with reagents like EDTA (ethylenediaminetetraacetic acid, disodium salt) at different pH values, with the endpoint being detected by use of indicators. With the classical methods interference problems may be severe and longer analysis times are required; detection limits are also not as low as with AAS. Finally, with increasing development, the South Pacific will soon have to focus attention on management of discharges from agricultural oriented industries handling hazardous agricultural chemicals and pesticides. Legislation will have to be enacted and implemented if pollution of the aquatic environment is to be prevented.

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