WATER QUALITY CONTROL AND MANAGEMENT

By

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The Need for Water

Water is one of the prime needs of man. Consequently, planning and subsequent development of water resources dates back to antiquity. Since the water environment is unevenly distributed over the earth, man has learned how to manage it. The manipulation of water in early times was mainly for drinking and other domestic purposes, for agriculture and navigation.

A potable supply of water is required whenever a number of people live together in a community. However, the body or bodies of water can be rendered unpleasant and unhealthy if the community's liquid and solid wastes are not satisfactorily disposed of. To secure then the maximum benefit, these bodies of water must be protected.

The objective of modern communities is not simply the development of water resources to have sufficient water in the right place at the right time. Water resources of the right quality has also become man's concern. The objective of controlling water resources quality, which involves conservation, protection and improvement, has become a part of the worldwide consciousness on environmental quality and better quality of life. It is not satisfactory to simply have enough water, the need is for provision of an ample supply of wholesome water.

Unfortunately, quality is an abstract term. Other terms which are commonly used to identify various quality states of water; such terms as wholesome, pure, clean, dirty, polluted, are likewise abstract. Quality, derived from the Latin word "qalitas", refers to the characteristic or attribute of a substance and to the degree of grade of excellence. Waters in their natural state vary in quality. Inland waters, lakes and rivers, oceans, estuaries and groundwater differ in composition. Take oceans and estuaries. These waters contain salt which provide the proper quality needed by marine life. Rivers and lakes, springs and ponds are naturally formed from surface run-off (and rainfall) and from groundwaters. Thus, the quality of these bodies of water depends mainly on the nature and relative

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contribution from the sources. Therefore, in the sense that water as H_2O is a chemical compound of unvarying composition, natural waters are never pure. This does not mean, however, that natural waters are all polluted. Bodies of water can still be considered clean or dirty, wholesome or polluted. These terms become meaningful only if they are related to the use to which water is to be put. Water is regarded as contaminated if something is added to the water body that causes deviation from the average composition that it would have in the absence of human activity. The contamination also becomes pollution if it can adversely affect something that man values and if it is present in high concentration to do so. The water pollution which concerns us is man-made. It is an artificial alteration or impairment of the quality of water to such an extent that it results in the depreciation of utilitarian or environmental value of water.

The major water uses of interest from a pollution control point of view are the following: domestic, municipal, irrigation and livestock raising, power generation, industrial, fisheries, recreational and aesthetic purposes of a combination of any of these. Domestic use is the utilization of water for drinking, washing, bathing, cooking or other household needs, gardening and watering lawns, and for domestic animals; municipal water, for supplying water requirements of the community; agricultural use, for production of agricultural crops; power generation use, for the production of electrical and/or mechanical power; fisheries use, for the propagation and culture of fish and aquatic life; industrial use, for water needs of factories, industrial plants and mines; recreational purposes (water contact or non-water contact recreation), which include water for swimming pools, boating and other similar facilities, resorts and other places of recreation. The designation of water, quality depends upon the absence or presence of substances which determine whether the water will serve a particular purpose. It is possible to rate a given water good enough for one purpose but poor for a different intended use.

Whereas specific water quality is demanded by the uses mentioned above, these are the same activities which modify water quality. Actions of man which can be summarized as his living processes and his use of materials, his industry and agriculture and activities in exploiting land and waters cause water pollution.

Before industrialization, significant pollution or degradation of quality of rivers occurred only in large communities mainly as result of dumping refuse in rivers. With the advent of industrialization came economic growth as well as problems related to the water environment. These problems are generally related to industrial expansion, rapid urbanization and agriculture which grew in size as well as complexity due to technological advances. Return waters from modern agricultural use are more concentrated in salts, have higher amounts of nutrients specially with high rates or fertilization and have high amounts of insecticides and pesticides (Carson, 1962). In addition to the negative impacts of insecticides, pesticides and fertilizers on water, vegetation and animal and human health, another outcome is the development of pesticide-resistant parasites and harmful insects. Industrial projects, on the other hand, change the quality of natural waters because of their effluents. Cooling waters and process waters from industry have affected most rivers, lakes, streams and bays near or in urban areas. Process waters differ according to the type of industry, that is, effluents from: industries processing natural organic materials like food and drink preparation, paper mills, textile mills and tanneries; industries manufacturing heavy metals such as acids, alkalis, organic compounds and industrial gases; chemical and pharmaceutical manufacture; oil refining; sugar mills and alcohol distilleries; mining and other mineral extraction industries; vary in content and character. One can then say that "no two sewage are alike", however, undesirable effects mainly due to the waste composition are well documented (see Table 1).

Economic growth goes hand in hand with accelerated pace of industrialization and urbanization which in turn generate certain environmental repercussions. The objective now is to strike a proper balance of economic growth and environmental quality, in this case, quality of the water environment. An immaculately clean environment on the other. These are both possible through an effective water quality management program.

Water Quality Management

The central question in water quality management is that of the level at which the public or government is willing to forego some opportunity (or live with some particular problem or invest money to protect, improve or utilize a particular body of water. What should be made clear first of all is the water quality objective. The flow of events in setting objectives in water management programs should include the following: a) classification of waters according to use that may be possible under present as well as future development, (b) establishment of water quality levels for each of the water uses, c) water quality assessment of water, and d) examination of alternative water quality control devices which are available.

Water use goals are arrived at through a decision-making process which takes into account the needs for water of the general public, municipality, industry and agriculture as they relate to fisheries and other uses. The water quality criteria are selected to reflect these goals. The water quality criteria or water quality standards or requirements which should be met are formulated from experience or current practices, lessons from history, experimental investigations on laboratory animals, decisions formed by public clamor, even guesses, and future expectations.

Water quality criteria define the limiting levels of concentration or intensity of key quality parameters. The establishment of criteria is based on the *intended use* of the waters or the purpose which the water serves (see Table 2). When considerations of multiple use arise in practice, water quality standards are established by the *regulatory* authority (see Table 3). Considerations of water quality criteria for different beneficial uses; say A, B, C; with the standard, say S, can be illustrated (see Figure 1). The water quality standard takes either the maximum or minimum of the criteria depending on the parameter in question. As an example, when the standard is set to the maximum among the criteria, the parameter could be dissolved oxygen, DO.

Assessment of quality of streams, rivers and lakes and other bodies of water should establish: a) the present quality condition of the resource, b) how the quality changes under influence of events whether controllable or not, c) the quality of man-made additions of polluting matter and whether requirements are being met, and d) what control should be exercised and modified for effectiveness. Assessment of water quality must be specified in scientific terms, taking into consideration physical, chemical, and biological characteristics (or quality parameters) of waters. When these characteristics are altered to such an extent that they result to an unacceptable depreciation of the water's utility, there is water pollution. The basic problem is that of deciding what obsrvations should be made, and where, how often and at what time the observations should be carried out. A subsequent problem is the decision on how the data gathered is processed, interpreted, and presented for the quality control process.

Water pollution or impairment of quality can be appropriately classified as chemical, physical, and biological pollution which result from the action of man. Chemical pollution occurs when materials are added to the water which brings about an unacceptable depreciation of the value of water. As an example, presence of inorganic mercury may not depreciate the value of the water, but it is of special concern because of the bioaccumulation and biomagnification in the food chain. (Biomagnification is defined as the total accumulation of heavy metals through a series of organisms.) On the other hand, physical pollution occurs when there are alterations of the discharge or volume of water, subtraction or addition of heat, addition of gross solid refuse. One good example is the proliferation of algal growth in water which has suffered a considerable reduction of flow velocity caused by an abstraction. Lastly, biological pollution occurs when living things are added to the water like disease organisms of faecal origin and disease-bearing fish.

The quality parameters, essentially the core of water quality criteria, are used as measures of the aforementioned types of pollution. Among the most commonly used of these parameters are BOD, COD, heavy metals, TDS (total dissolved solids), DO, pH and acidity. The importance and significance of these parameters are known (see Table 4). Analytical methods of detecting and measuring amounts of water pollutants through appropriate parameters are available (ASTM STP 573, 1975).

Having obtained suitable quality and quantity of water by selection, treatment of water might still be necessary depending on the use. Different industrial uses, for example, require different quality for specific processes. Water for municipal use may still require improvement in quality before distribution. The treated water is delivered to the consumer via a complex distribution system. The domestic and industrial uses of water result in the deterioration in the water quality. The wastewaters must be collected and/or subjected to appropriate treatment before discharge to the nearby bodies of water. A typical water supply and wastewater disposal system (see Figure 2) involves water treatment as well as wastewater treatment. The first is treatment before the intended supply use and the second, before discharge of waste to the bodies of water. In both industrial and domestic wastes, the quality change in water is manifested in the increase in dissolved and suspended solids. In addition, many industries discharge wastes which are never found in natural waters (examples, heavy metals and organic matters) as well as discharge wastes which have unusually high temperature, turbidity, color, acidity, alkalinity and exceptionally high BOD as much as ten times more than ordinary domestic sewage (see Table 5). Most often, the waste is complex and consists of those pollutants which for all practical purposes do not decay with time (conservative waste) and those materials which decay with time (non-conservative pollutants).

There are different management approaches to better quality of water effluents. Technically, the control could be in terms of: a) stream flow regulation, b) waste treatment technology including advanced waste treatment, or c) a combination of a) and b). In connection with these, water quality standards may be based on two primary criteria: stream standards and effluent standards. The stream standards can be based on the dilution requirements or the receiving-water quality based on a threshold value of specific pollutants or a beneficial use of water. Effluent standards can be based on the concentration of pollutants which can be discharged or on the degree of treatment required. The treatment is either based on the maximum concentration of pollutant (in units of mg/1) or maximum load (in units of lbs/day) discharged to the receiving water. Effluent standards imply waste reduction at source. Effluent standards are easier to enforce but do not take into account the natural purification capacity of the receiving water. In contrast, stream standards could imply in-stream treatment as river aeration or increasing the flow of river to provide greater dilution and reduction of concentration of undesirable stream constituents. (Controversy arise because such devices invariably treat the symptoms of the problems and not the problem itself.) Most regulations in force at the present time are a combination of stream and effluent standards. The type of treatment used: primary, secondary or advanced treatment, and the accompanying percentage of waste reduction and cost of treatment (see Table 6) will depend on the standards and charges required if the standards are not met.

Control of water quality in an optional fashion implies control achieved either at maximum bet benefits or at least cost. Benefits of water quality improvement or protection from further degradation accrue from: a) improved quality of municipal and industrial waste supplies, b) increased recreational use of water, and c) improved commercial fishing catches. These benefits have often been considered unquantifiable and not subject to rational analysis (Thomann, 1972). The least cost allocation procedure has therefore been widely implemented since treatment costs are easily determined. There are three methods of cost allocation, namely; uniform treatment method, cost minimization method, and zoned optimization method (Rich, 1973).

The uniform treatment method requires that an identical percentage of raw BOD load the removed from each source before discharge into the receiving water. "Raw BOD load" refers to the BOD of waste before removal by treatment. Although this method of control is easy to administer, it is economically inefficient and inequitable. It is economically inefficient because waste sources in non-critical areas, those areas where the water bodies meet the water quality standards, are required to treat at the same level as sources in critical areas. Moreover, no allowance is made for differences in treatment cost. This approach also fails to recognize the fact that in the imposition of a fixed percentage of waste removal, municipal and industrial growth is not taken into consideration. This growth increases the raw load before treatment and for a fixed percentage removal, the discharged load then increases.

Cost minimization method selects the level of BOD removal which needs to be attained at each source. This method therefore singles out individual waste source and requires varying degrees of waste removal on an individual basis at minimum cost to the region. No unnecessary treatment is required. The method is equitable in the sense that a source which does not lower the dissolved oxygen incurs not cost. However, this method is inequitable in one sense. Take two industries located next to each other and discharging the same type of wastes but have different treatment costs. The industry with lower treatment cost will be required to attain a higher degree of BOD removal than the industry with high treatment cost. To mention disadvantages, this program would be difficult to implement. There is difficulty in administering this program because some waste sources would be required to treat at minimal levels while others would be required to treat to high levels.

In the zoned optimization method, a series of classifications or categories or zones are formed and within each category all waste sources are required to treat to the same level. The method combines the elements of uniform treatment and cost minimization methods. If only one zone is established, the method becomes one of uniform treatment. If zones are established at each source, the method becomes one of cost minimization. One obvious classification is to delineate the water body by geographical zones. Another could be classification by municipal and industrial discharges. This method is characterized by ease in implementation as in the uniform-treatment method and at the same time tends to minimize objections of individual dischargers regarding their treatment requirements as required with those of their neighbors. For purposes of water quality control management, this method then appears to be the best.

One last activity which is an important aspect of water quality control is surveillance and monitoring for maintenance of quality protection. In practice, this last aspect becomes the determining factor of the water quality management's success.

Management Crtical Path

The management of water quality systems requires a constant interplay between water disposer, water user and water quality enforcement agencies. Therefore, it is necessary to recognize socio-economic, cultural and political factors when dealing with problems of pollution control. Such factors are evident in the "critical path for effective environmental management" suggested by Schaumburg (UNESCO, 1977; see Figure 3). Social concern, the driving force or stimulus for achieving high water quality, must emanate from the people. This serves as the government motivation to establish an agency or ministry to develop and initiate an effective and enforceable management program. An important factor is the provision of adequate funding. Accordingly, laws and regulations to facilitate implementation of the program should be enforced. The industry or city, with the supervision of environment-conscious engineers, then treat wastes before discharge to the water environment. Lastly, proper operation and maintenance of well designed pollution abatement facilities ensure a good quality water environment.

In the Philippines, there are two inseparable problems, environmental protection and economic development. These two are looked upon as two sides of the same coin or two aspects to the fullest development of man and society. The concern for the environment has evolved from the various forest and fishing laws in the thirties to the reforestation and conservation of water quality and resources in the seventies. There has been remarkably intensifying degree or social concern and consciousness to water quality considerations. This is true of the metropolitan areas especially Metropolitan Manila where about 65% of the total number of industrial firms in the country are located. Complaints arising from water quality degradation, a clear indication of social concern, has been increasing in the past years (see Figure 4). The government has acted accordingly, through laws which aim to achieve optimum development of water resources as well as its conservation (RA 3931, Pollution Control Law, PD 984, National Pollution Control Commission Creation; PD 1067 , Philippine Water Code). Moreover, water quality control has been made an essential part of comprehensive laws concerned with projects which have considerable environmental impact (PD 1121, Creation of National Environmental Protection Council; PD 1151, Environmental Impact Assessment; PD 1152 Philippine Environmental Code). To date, the efforts of the government to improve and control water quality take form in activities such as: a) establishing minimum flows of river and streams and minimum water levels for lakes, b) establishing specific policies and water quality standards, c) protection of source of water supply, d) control of dumping wastes into bodies of water, e) regulation of fertilizer and pesticides use, and f) requiring inclusion of treatment month projects, whether government or private, which degrade water quality before start of operation. Control methods available and being used are: a) indirect controls based on encouragement (e.g., reimbursement of all duties paid on installed anti-pollution equipment that are imported abroad) or on disincentives (e.g., taxes and effluent charges) and b) direct control mechanism ranging from total prohibition of operation, legislative regulation and limitation on toxic substances and measures regulating the location of industries or human settlements. Important activities which are worth mentioning are the integration of environmental education in school curricula in all levels (PD 1152 Sec. 23) and the continuing efforts to arouse environmental consciousness through all media of communication. Enforcement of control rules and regulations is guaranteed by vesting authority to barangay leaders (PD 1160) and Armed Forces of the Philippines. Practically all aspects of the critical path of water quality management is incorporated in the system. How well the system works can be seen in the case Pasig River system. This body of water has been degraded seriously due to effluents from industrial firms along its banks. Records show an improvement in its quality since quality control activities has been initiated (see Figure 5).

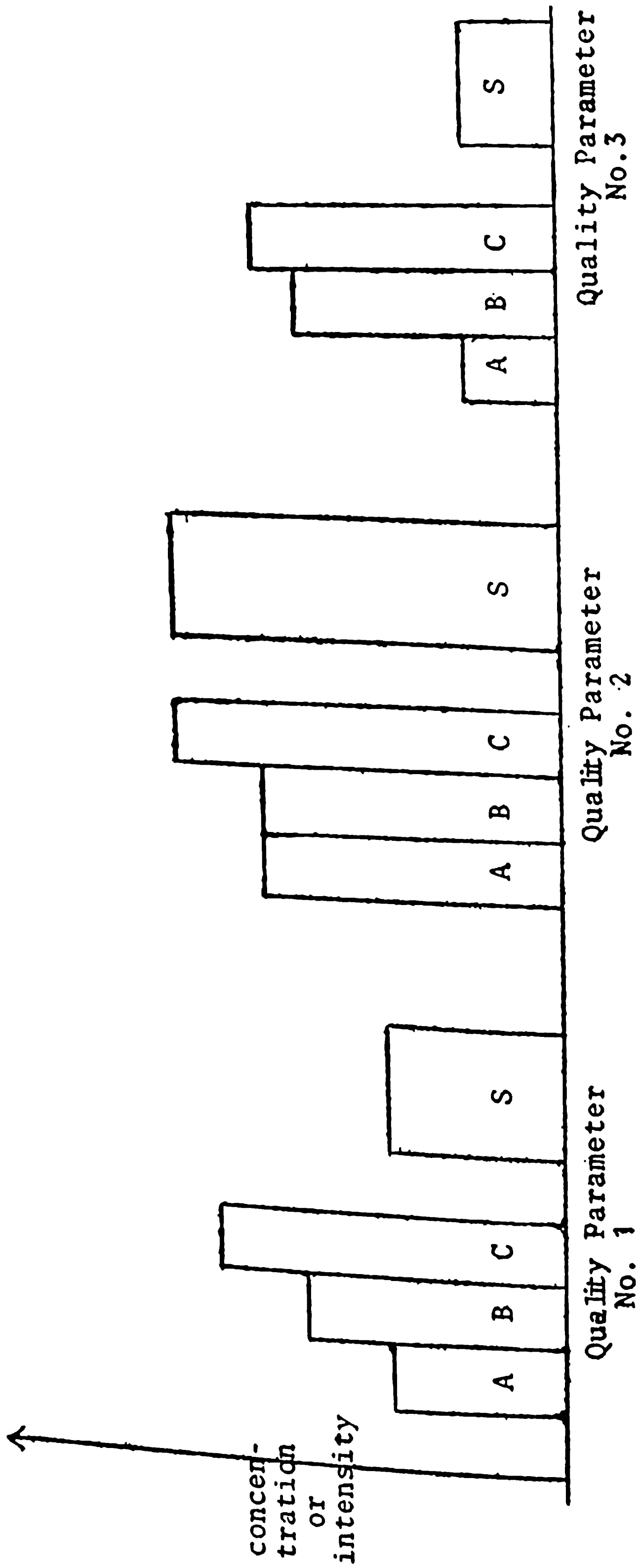


Figure 1. Correlation of Water Quality Criteria for Set Beneficial Uses A, B, C with Water Standard S

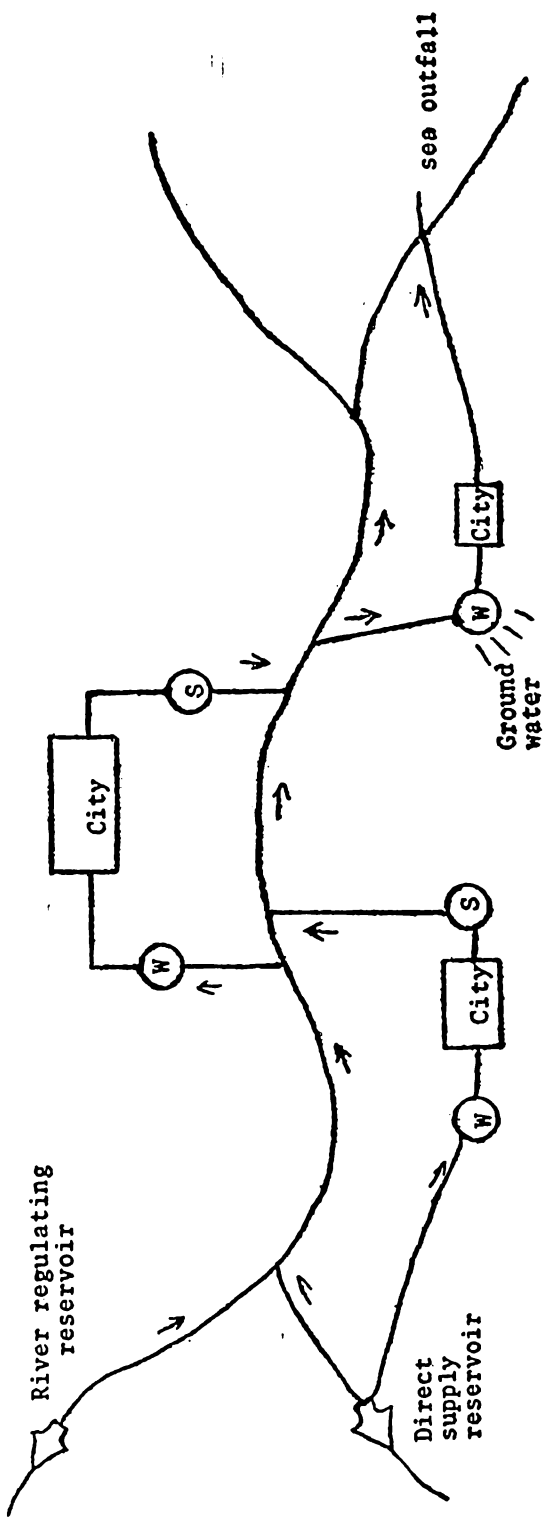


Figure 2. Typical Water Supply and Wastewater Disposal System

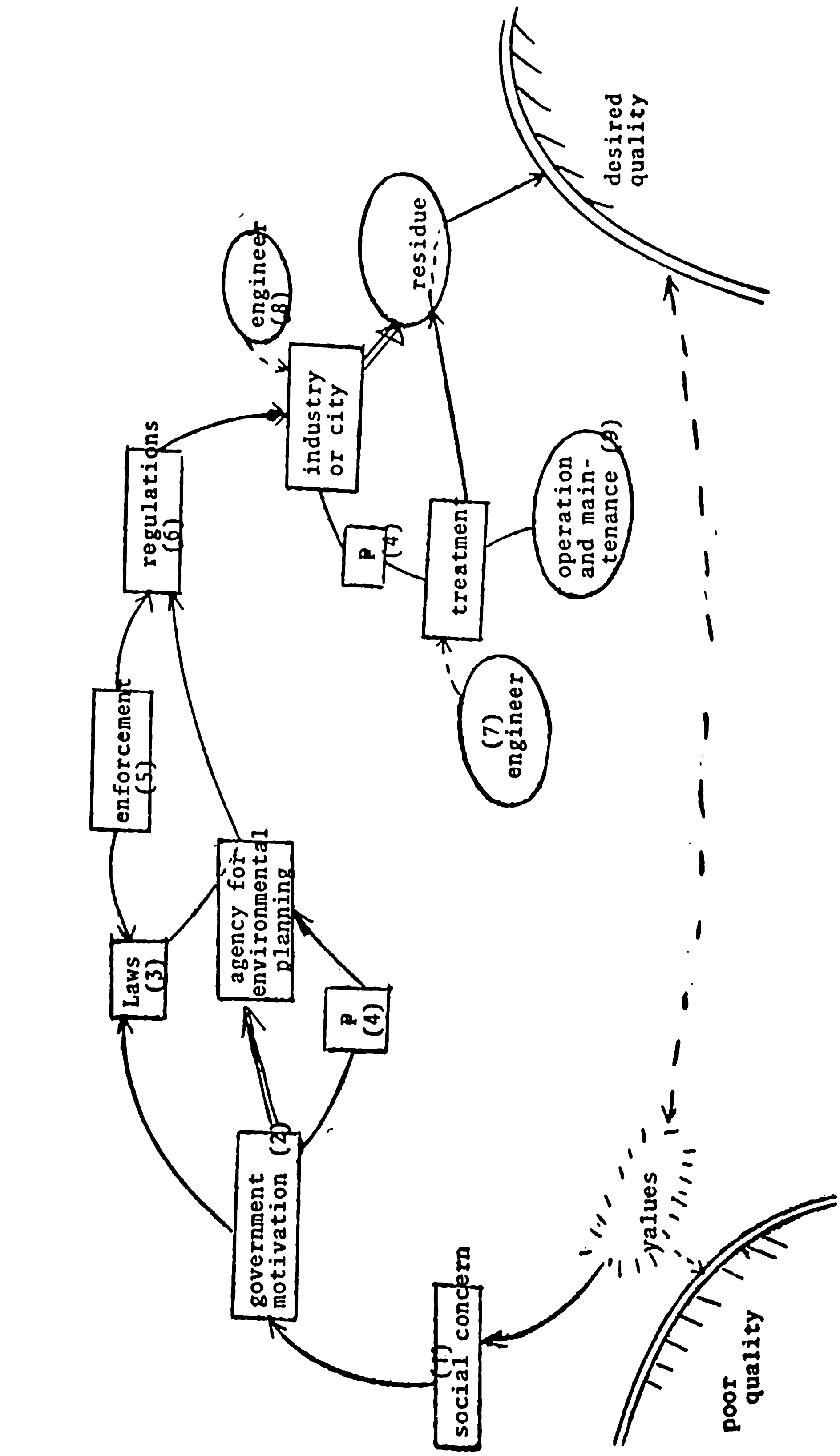


Figure 3. Critical Path for Effective Environmental Management

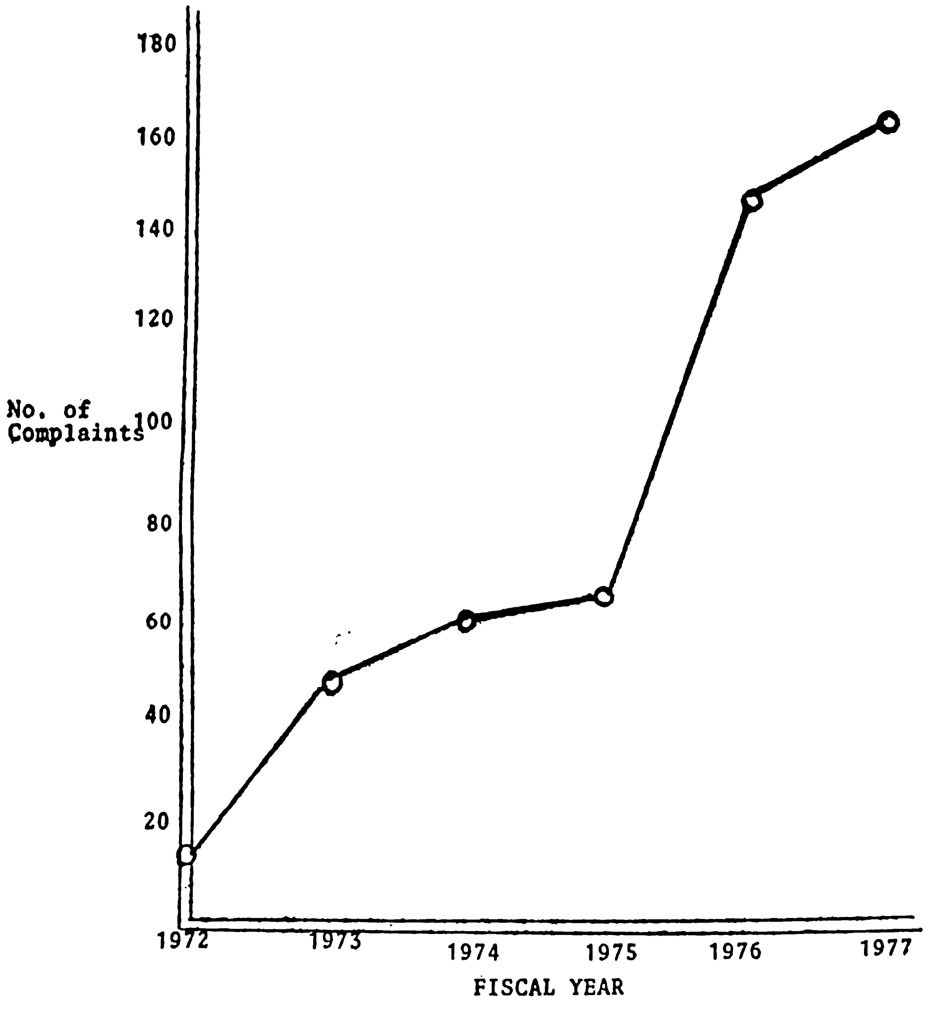


Figure 4. Investigation of water pollution complaints Source: NPCC

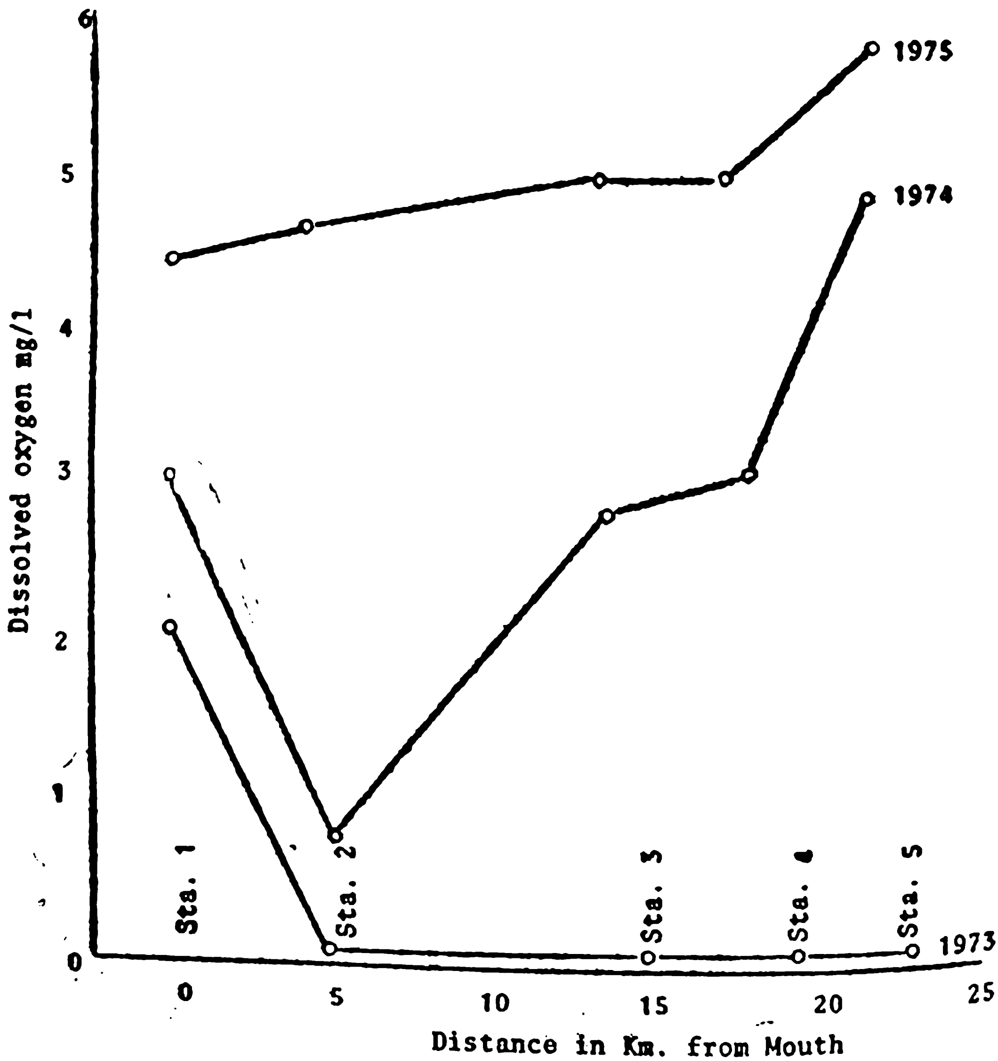
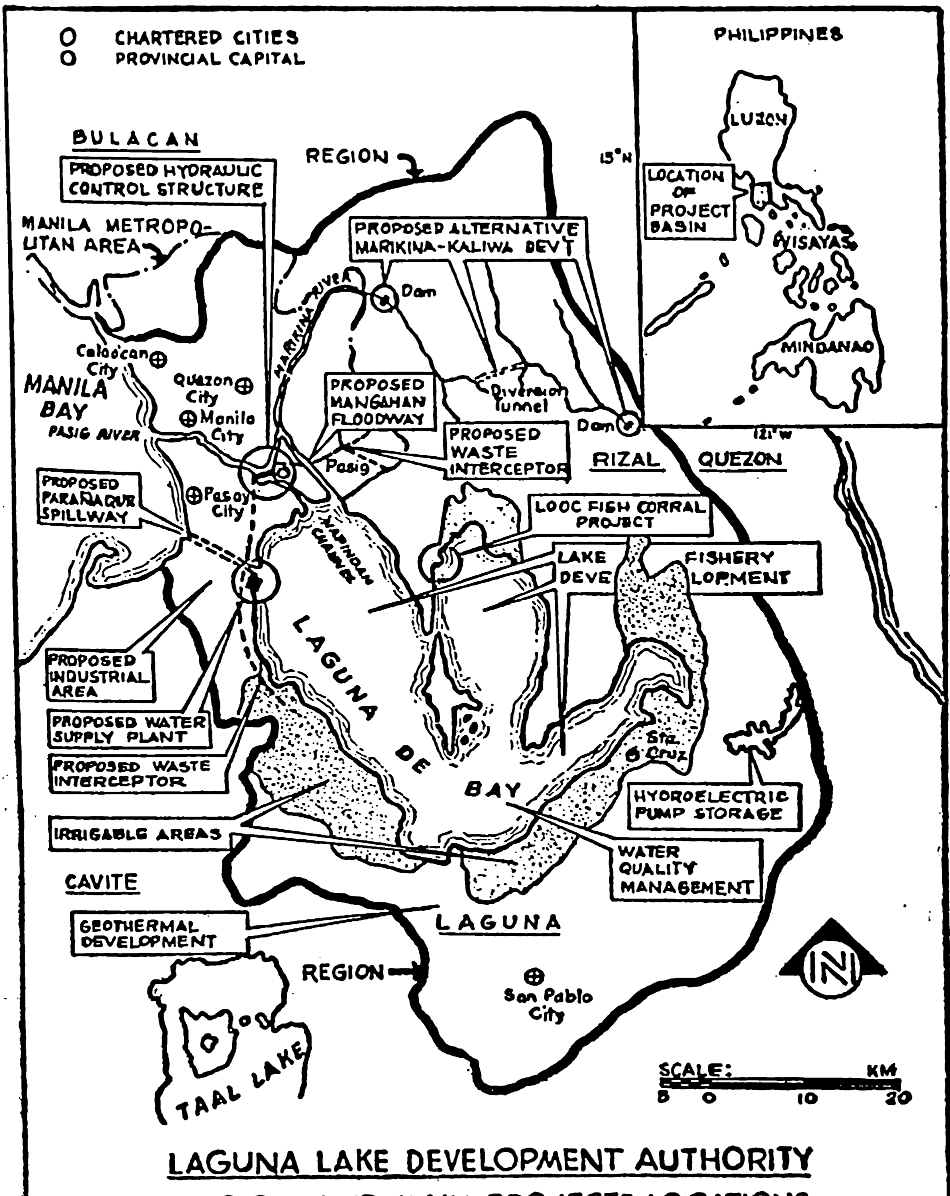


Figure 5. Comparative Profile of Dissolved Oxygen Along Pasig River

Sta. 1 Del Pan Bridge
Sta. 2 Nagtahan Bridge
Sta. 3 Lambingan Bridge
Sta. 4 Guadalupe Bridge
Sta. 5 Bambang Bridge

NOTE: Dissolved oxygen content reflects the quality of a waterway; the higher it is, the cleaner is the river.



LAGUNA LAKE DEVELOPMENT AUTHORITY
REGION AND MAIN PROJECTS LOCATIONS

TABLE 1

UNDESIRABLE CHARACTERISTICS OF INDUSTRIAL WASTES

1. Soluble organics: dissolved oxygen depletion in streams and estuaries; discharge relative to assimilative capacity of water body or by effluent standard.
2. Soluble organics that result in tastes and odors in water supplies, e.g. phenol.
3. Toxic materials and heavy metal ions; e.g., cyanide, Cu and Zn: usually rigid standards as to discharge of such materials.
4. Color and turbidity: esthetically undesirable; imposes increased loads on water-treatment plants; example: color from pulp and paper mills.
5. Nutrients (nitrogen and phosphorus): enhance entropication of lakes and ponded areas; critical in recreational areas.
6. Refractory materials, e.g., ABS: results in foaming in streams.
7. Oil and floating material: regulations usually require complete removal; esthetically undesirable.
8. Acids and alkalis: neutralization required in most regulatory codes.
9. Substances resulting in atmospheric odors, e.g., sulfides from tanneries.
10. Suspended solids: results in sludge banks in streams.
11. Temperature: thermal pollution resulting in depletion of dissolved oxygen (lowering of saturation value).

Source: Eckenfelder (1970)

TABLE 2

NPCC RULES AND REGULATIONS

Sec. 71. *Water Usage and Classification.* — The quality of Philippine waters shall be maintained in a safe and satisfactory condition according to their best usage. For this purpose, all waters shall be classified according to the following beneficial usages:

1. Fresh Surface Water

Classification	*Best Usage*
Class AA	For source of public water supply. This class is intended primarily for waters having watersheds which are uninhabited and otherwise protected and which require only approved disinfection in order to meet the National Standards for Drinking Water (NSDW) of the Philippines.
Class A	For source of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the the NSDW.
Class B	For primary contact recreation.
Class C	For the propagation and growth of fish and other aquatic resources.
Class D	For agriculture, irrigation, livestock watering and industrial cooling and processing.
Class E	For navigational use.

2. Ground Water	
Class GA	For source of domestic water supply.
Class GB	For source of industrial water supply.
3. Marine & Estuarine Waters	
Class SB	For primary contact recreation.
Class SC	For the propagation and growth of fish and other aquatic resources.
Class SD	For industrial cooling and processing.
Class SE	For navigation

Sec. 72. *Water Quality Criteria.* — (1) Water Quality Criteria for fresh surface water are the following:

(a) *For Class "AA" Waters:—*

Quality Parameter	*Specifications*	
1. Physical, Chemical, Biological and Bacteriological	To meet the NSDW of the Philippines, except for coliform content which shall not exceed a monthly geometric average. Most Probable Number (MPN) of 50 per 100 ml. In addition, the following concentrations shall not be exceeded:	
	Arsenic	0.05 mg/1
	Cadmium	0.01 mg/1
	Chromium	0.05 mg/1
	Cyanide	0.05 mg/1
	Lead	0.05 mg/1
	Mercury	0.002 mg/1
	Selenium	0.05 mg/1
	Silver	0.05 mg/1
2. Organic Chemicals	Not to exceed the following limits:	
a) Synthetic Detergents (MAB)	nil	
b) Oil and Grease	nil	
c) Persistent Pesticides		
Aldrin	0.001 mg/1	
DDT	0.05 mg/1	
Dieldrin	0.001 mg/1	
Chlordane	0.003 mg/1	
Endrine	0.0002 mg/1	
Heptachlor	0.0001 mg/1	
Lindane	0.004 mg/1	
Toxaphane	0.005 mg/1	
Methoxychlor	0.1 mg/1	
2, 4-D	0.1 mg/1	
2, 4, 5-TP	0.01 mg/1	

(b) *For Class "A" Waters:—*

Quality Parameter	*Specifications*
1. Temperature	30°C
2. Dissolved Oxygen	Not less than 5 mg/1.
3. BOD_5 (20°C)	Not less than 5 mg/1.
4. pH	Not less than 6.5 nor more than 8.5
5. Bacteria	Bacteria of the coliform group shall not exceed a monthly average MPN of 5000 per 100 ml. nor exceed this number in more than 20 percent of the samples examined during the month, nor exceed 20,000 in more than 5 percent of the samples.
6. Phenolic Substances	Not to exceed 0.001 mg/1 as phenol.
7. Radioactive Substances	No radionuclides or mixtures of radionuclides shall be present at concentrations greater than those specified in the NSDW of the Philippines.
8. Trace Elements	Not to exceed the concentrations specified in the NSDW of the Philippines. In addition, the following concentrations shall not be exceeded:
	Arsenic 0.05 mg/1
	Cadmium 0.01 mg/1
	Chromium 0.05 mg/1
	Cyanide 0.05 mg/1
	Lead 0.05 mg/1
	Mercury 0.002 mg/1
	Selenium 0.05 mg/1
	Silver 0.05 mg/1
9. Organic Chemicals	Not to exceed the following limits:
a) Synthetic Detergents (MAP)	0.5 mg/1
b) Oil and Grease	2 mg/1
c) Persistent Pesticides	
Aldrin	0.001 mg/1
DDT	0.05 mg/1
Dieldrin	0.001 mg/1
Chlordane	0.003 mg/1
Endrine	0.0002 mg/1
Heptachlor	0.0001 mg/1
Lindane	0.004 mg/1
Toxaphane	0.005 mg/1
Methoxychlor	0.1 mg/1
2, 4-D	0.1 mg/1
2, 4, 5-TP	0.01 mg/1
d) Polychlorinated Biphenyls (PCB)	0.001 mg/1
10. Nitrate as NO_3	Not to exceed 40 mg/1
11. Nutrients	Shall not be present in concentrations to cause deleterious or abnormal biotic growth.

(c) *For Class "B" Waters:*

Quality Parameter	*Specifications*
1. Temperature	30°C
2. Transparency	Secchi disc shall be visible at a minimum dept of 1 meter.
3. Dissolved Oxygen	Not less than 5 mg/l.
4. BOD_5 (20°C)	Not more than 10 mg/l.
5. pH	Not less than 6.5 nor more than 8.5.
6. Phenolic Substances	Not to exceed 0.002 mg/l as phenol
7. Bacteria	Bacteria of the coliform group shall not exceed a monthly geometric average MPN of 1000 per 100 ml. and not to exceed this value in more than 20 percent of samples examined during the month; or shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml based on at least 5 consecutive samples during a 30-day period.
8. Trace Elements	Not to exceed the following limits:
Arsenic	0.05 mg/l
Cadmium	0.01 mg/l
Chromium	0.05 mg/l
Cyanide	0.05 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Selenium	0.05 mg/l
Silver	0.05 mg/l
9. Organic Chemicals	Not to exceed the following limits:
(a) Synthetic Detergents (MAB)	0.05 mg/l
(b) Oil and Grease	2 mg/l
(c) Persistent Pesticides	
Aldrin	0.001 mg/l
DDT	0.05 mg/l
Dieldrin	0.001 mg/l
Chlordane	0.003 mg/l
Endrine	0.0002 mg/l
Heptachlor	0.0001 mg/l
Lindane	0.004 mg/l
Toxaphane	0.005 mg/l
Methoxychlor	0.1 mg/l
2, 4-D	0.1 mg/l
2, 4, 5-TP	0.01 mg/l
(d) Nutrients	Shall not be present in concentrations to cause deleterious or abnormal biotic growth.

(d) *For Class "C" Waters:*

Quality Parameter	*Specifications*
1. Temperature	The maximum rise above natural temperature shall not exceed 3°C outside the mixing zone as determined by the Commission.
2. Dissolved Oxygen	Not less than 5 mg/l.
3. BOD_5 (20°C)	Not more than 15 mg l.
4. pH	Not less than 6.5 nor more than 8.5 Not change greater than 1.0 unit outside the estimated natural seasonal maximum and minimum.
5. Bacteria	Bacteria of the coliform group shall not exceed a monthly geometric average MPN of 5000 per 100 ml, nor exceed this number in more than 20 percent of samples examined during the month, nor exceed 20,000 in more than 5 per cent of the samples, except for commercial shellfishing, in which the MPN of water does not exceed a geometric average MPN value of 100 per ml. nor exceed 400 in more than 5 percent of the samples examined during the month.
6. Phenolic Substances	Not to exceed 0.02 mg/l.
7. Trace Elements	Not to exceed the following limits:
Arsenic	0.05 mg/l
Barium	0.5 mg/l
Cadmium	0.01 mg/l
Chromium	0.05 mg/l
Copper	0.02 mg/l
Cyanide	0.05 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Selenium	0.05 mg/l
Silver	0.05 mg/l
8. Organic Chemicals:	Not to exceed the following limits:
a) Synthetic Detergents (MAB)	0.5 mg/l
b) Oil and Grease	5 mg/l
c) Persistent Pesticides	
Aldrin	0.001 mg/l
DDT	0.05 mg/l
Dieldrin	0.001 mg/l
Chlordane	0.003 mg/l
Endrine	0.0002 mg/l
Heptachlor	0.0001 mg/l
Lindane	0.004 mg/l
Toxaphane	0.005 mg/l
Methoxychlor	0.1 mg/l
2, 4-D	0.1 mg/l
2, 4, 5-TP	0.01 mg/l
d) PCB	0.001 mg/l
9. Nutrients	Shall not be present in concentrations to cause deleterius or abnormal biotic growth.

(e) *For Class "D" Waters:*

Quality Parameter	*Specifications*
1. Temperature	The maximum rise above natural temperature shall not exceed 3°C outside the mixing zone as determined by the Commission.
2. Dissolved Oxygen	Not less than 3 mg/l.
3. pH	Not less than 6.0 nor greater than 8.5.
4. Total Dissolved Solids	Not more than 1000 mg/l.
5. Sodium Absorption Ratio (SAR)	Not less than 8 nor more than 18.
6. Trace Elements	Not to exceed the following concentrations:
Aluminum	5 mg/l
Arsenic	0.1 mg/l
Beryllium	0.1 mg/l
Boron	0.75 mg/l
Cadmium	0.01 mg/l
Chromium	0.1 mg/l
Cobalt	0.05 mg/l
Copper	0.2 mg/l
Fluoride	1.0 mg/l
Iron	5.0 mg/l
Lead	5.0 mg/l
Lithium	2.5 mg/l (Recommended maximum concentration for irrigating citrus is 0.075 mg/l.)
Manganese	0.2 mg/l
Molybdenium	0.01 mg/l
Nickel	0.2 mg/l
Selenium	0.02 mg/l
Vanadium	0.1 mg/l
Zinc	2.0 mg/l
7. Oil and Grease	Not to exceed 5 mg/l.
8. Nutrients	Shall not be present in concentrations to cause deleterious or abnormal biotic growth.

(f) *For Class "E" Waters:*

Quality Parameter	*Specifications*
1. Dissolved Oxygen	Not less than 2 mg/l.
2. pH	Not less than 5 nor more than 9.
3. Oil and Grease	Not to exceed 10 mg/l.

(2) *Ground Water*

(a) For Class SA waters:
Same as for Class "A" for Fresh Surface water.

(b) For Class CB Waters:
Quality parameters same as Class "D" of Fresh surface water, excluding temperature, dissolved oxygen, oil and grease and nutrients.

(3) *Marine and Estuarine Waters*

(a) *For Class SB Waters:*
Same as for Class "B" of fresh surface water.

(b) *For Class SC Waters:*
Same as for Class "C".

(c) *For Class SD Waters:*
Same as for Class "D", excluding Total Dissolved Solids, Sodium Adsorption Ratio and Trace Elements.

(d) *For Class SE:*
Same as Class "E".

TABLE 3

PROPOSED WATER QUALITY STANDARDS FOR LAGUNA DE BAY AND ITS TRIBUTARY WATERS
Republic of the Philippines

These standards are established for the following designated beneficial uses: municipal and industrial water supply, fishery, agriculture, power generations, navigation and recreation.

Items	*Specifications* [a]	
	Maximum Allowable average of daily values for any period of 30 consecutive days	*Maximum Allowable for any one day*
Coliform — MPN/100 ml	1,000	10,000
Color — units	20	75
Odor — Threshold Odor No.	3.0	8.0
Temperature — °C (°F)	30 (86)	34 (93)
pH	6.5-8.5	8.5
Specific Conductivity mhos x 10^{-6} at 25°C		500
Floating Solids (of waste origin)		None
Total Solids — mg/l	500	1500
Hardness — mg/l	150	250
Fluoride — mg/l	1.0	1.4
Iron — mg/l	1.5	3.5
Manganese — mg/l	0.1	0.5

[a] Maximum allowable of daily values for any period of 30 consecutive days. This is the allowable daily average (arithmetic) values of all samples collected during any consecutive calendar days. Where three (3) or less samples are taken during any 30 consecutive calendar days, this average does not need to be determined.

Maximum allowable for any one day. This is the allowable daily average (arithmetic) of multiple samples any one day (1) from any areas immediately outside of a mixing none which will be defined specifically for each discharge by the regulatory agency and (2) from any creeks, streams and rivers flowing into the lake from the drainage basin. Where only one sample is taken, this shall be the maximum daily value considered.

Items	*Specifications (a)*	
	Maximum Allowable average of daily values for any period of 30 consecutive days	*Maximum Allowable for any one day*
Copper — mg/l	0.1	0.15
Zinc — mg/l	1	5
Calcium — mg/l	75	200
Magnesium — mg/l	50	150
Sulfate — mg/l	200	400
Ammonia as N — mg/l	0.1	0.15
Nitrate as N — mg/l	1.0	10
Phosphate as P — mg/l	0.1	0.5
Chloride — mg/l	200	600
Phenolic substance — mg/l	0.001	0.002
Oil — mg/l	Nil	Nil
BOD (5-day) — mg/l	2.0	10
Dissolved Oxygen — mg/l	5.0 (min.)	4.0 (min.)
Radium 226 — uuc/l	3.0	3.0
Strontium 90 — uuc/l	10.0	10.0
Alpha emitter — uuc/l	1.0	1.0
Beta emitter — uuc/l	40	40
Arsenic — mg/l	0.05	0.1
Barium — mg/l	1.0	1.0
Boron — mg/l	0.5	0.5
Cadmium — mg/l	0.01	0.01
Chromium (total) — mg/l	0.05	0.05
Cyanide as (CN) — mg/l	0.005	0.02
Mercury — mg/l	Nil	Nil
Selenium — mg/l	0.01	0.05
Lead — mg/l	0.03	0.03
Silver — mg/l	0.05	0.05

Pesticides are toxic at certain concentrations. Standards will be set in case to case basis as their degree of toxicity are known.

TABLE 4

Parameters	*Significance*
BOD	oxygen demand (to break down biodegradable organics). This parameter is most widely used measure of organic pollution applied to wastewater.
COD	used to measure non-biodegradable organics (such as pesticides) which can have adverse long-term effects and can contribute to taste, odor and color problems in downstream water supplies. COD value also reflects the biologically degradable materials, therefore COD is always higher than BOD.
phosphorus and nitrogen	presence can stimulate undesirable growth of algae in lakes and streams, this interferes with boating and recreation; cause unpleasant taste and may exert significant ocygen demand after the death of algae.

heavy metals	can cause fish kills if present in sufficiently high concentration and create problems in downstream water supplies, have certain effects in human metabolism.
TDS	inorganic salts which results in unpalatable tastes, calcium and magnesium contribute to downstream water hardiness.
turbidity	a property which results from the dispersion of different materials alone or in combination.
DO	one of the most important water indicators. DO reflects the general level and health of a body of water and is a quality variable that reflects the capacity of the river to support a balanced aquatic habitat since oxygen is indispensable to fishes and other aquatic organisms. Among many of the field investigations requiring precise analysis for dissolved oxygen are: the measurement of effect of specific oxyphilic pollutants, the charting of stream pollution, the computation of maximum load of organic pollution which any given mass of water can tolerate and still remain habitable for aquatic life.
acidity and alkalinity	establish the capacity of a stream to neutralize many types of wastes efficiency of buffering in a given water
suspended matter	bottom conditions, light penetration, bacterial content and various other features of the aquatic complex can be modified seriously by suspended matter.
Copper Zinc	copper salts on the mucous covering the kills of fishes precipitate a coating on the gills which interfere with respiration.

TABLE 5

BOD Wastes from Selected Industries

Source of waste	5-day, 20°C BOD of waste, mg/l
best sugar refining	450 — 2,000
brewery	500 — 1,200
beer slop	11,500
cannery	300 — 4,000
grain distilling	15,000 — 20,000
molasses distilling	20,000 — 30,000
laundry	300 — 1,000
milk processing	300 — 2,000

Typical Concentrations of Pollutants in raw, untreated municipal wastewater

BOD	150 — 250 mg/l
COD	300 — 400 mg/l
suspended solids	150 — 250 mg/l
K	5 — 10 mg/l
N	15 — 25 mg/l
TDS	400 — 500 mg/l

SOURCE: EPA-625/5-76-012

TABLE 6

Raw Sewages		A	B	C	D	E (effluent quality)
200	BOD:					
	mg/l	20	5	2	2	1
	% removal	90	97.5	99	99	99.5
400	COD:					
	mg/l	80	40	35	35	10
	% removal	80	90	91	91	97.5
200	Suspended Solids					
	mg/l	20	5	0	0	0
	% removal	90	97.5	100	100	100
20	Nitrogen					
	mg/l	18	18	18	2	1.5
	% removal	10	10	10	90	92.5
10	Phosphorous					
	mg/l	9	9	0.1	0.1	0.1
	% removal	10	10	99	99	99

List of treatment from lowest to highest cost

A — secondary treatment (activated sludge)
B — A and coagualtion-sedimentation
C — B and filtration
D — C and nitrogen removal
E — D and carbon adsorption

SOURCE: EPA-625/5-76-012

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