Water Quality Management: Key to the Sustainable Development of Laguna de Bay

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INTRODUCTION

Dr. Guerrero gave us a good overview of the major freshwater aquatic ecosystems in the Philippines including a set of recommendations on how they may be properly conserved and managed. My reaction is to focus on one of these lakes, which is Laguna de Bay, in terms of the contemporary issues confronting the management and development of this lake. In particular, I shall focus on water quality as a key environmental indicator needed for sound management and sustainable development of the lake.

Laguna de Bay is the largest and certainly most important freshwater lake in the Philippines. It has an area of 90,000 hectares; it is situated between the provinces of Rizal and Laguna, including a good part of Metro Manila. Its watershed covers about 300,000 hectares and it had an estimated population of about 3.5 million people in 1988. In 1976, its average depth was estimated at 2.8 meters at the mean annual low lake level of 10.5 m which is equal to the mean sea level in Manila Bay. The lake is a tropical one with seasonal water temperature ranging from 25° to 32°C and hardly exhibits thermal stratification between the surface and bottom temperatures. The large surface-to-volume ratio, high nutrient level and high water temperature of the lake categorize it as a highly eutrophic lake.

The main uses of the lake include: (a) as a fishery for both open fishing and aquaculture; (b) for power generation and indus-

trial use; (c) agricultural uses for irrigation and livestock production; (d) for navigation and transport of goods and people; (e) for recreation and aesthetic use; (f) as a convenient dump for domestic, industrial and agricultural and other wastes; (g) for flood control; and (h) as source of public water supply.

These extractive demands coupled with the negative impacts of the wasteloads from natural and anthropogenic sources have resulted in the accelerated depletion of its resources and continued decline in its water quality thereby threatening the continued productivity and viability of the lake. The need for the rational utilization and holistic approach to the management of Laguna de Bay based on a sustainable development concept is imperative. The ecological monitoring of its water quality and institution of control measures to maintain desired water quality standards are prime requisites for the conservation and management of Laguna de Bay.

CONCEPTUAL FRAMEWORK FOR WATER QUALITY MANAGEMENT OF LAGUNA DE BAY

The conceptual framework for the assessment and management of water quality of Laguna de Bay (or any lake) is shown in Figure 1. The prevailing water quality of a lake is determined by the different factors obtaining in the ecosystem and its watershed. These factors include both controllable (e.g. point sources of pollutants, siltation rate, water flow rates, etc.) and noncontrollable (e.g. rainfall, solar radiation, weather, etc.) ones. The impact of all these factors may or may not be apparent in the short term because of the inherent resilience of balance natural ecosystems. Monitoring of the water quality which could detect subtle changes in the physical and chemical properties of the water provides a convenient way of assessing the impact of environmental stressess. Thus, water resources are classified according to their best uses based on prescribed water quality criteria and standards.

The conceptual model shows how the ambient water quality of the lake, as revealed by monitoring, is operationally assessed and compared with the water quality standards prescribed for the best use of the lake. In principle, water quality standards are prescribed based on water quality criteria which are established as a

result of research studies on ecotoxicological testing, bioassay and impact assessment. The setting up of water quality standards and criteria as well as the implementation of mitigating or control measures are subject to government intervention or policy which in turn are influenced by social, political and economic considerations. These factors certainly complicate further the management of water quality as affected by the different external variables or environmental factors. The extent to which this conceptual model operates in reality in the case of Laguna de Bay remains to be seen.

WHAT IS THE PRESENT WATER QUALITY OF LAGUNA DE BAY?

Laguna de Bay has been classified as Class C waters, i.e. good for fishery production. However, results of water quality monitoring studies have shown that many water quality parameters have exceeded the standards prescribed for class C waters indicating the worsening condition of the lake. Among these are temperature, turbidity, dissolved oxygen, ammonia-N, nutrients, coliform bacteria and heavy metals (See Table 1). This continued deterioration in water quality must be stopped by identifying and controlling the factors causing it.

ENVIRONMENTAL PROBLEMS AND FACTORS AFFECTING WATER QUALITY OF LAGUNA DE BAY

The major environmental problems confronting Laguna de Bay and causing the deterioration of its water quality, general loss in its beneficial uses and aesthetic attributes, as well as posing health hazards to humans include the following:

a) Rapid siltation as a result of erosion of the watershed from forest denudation, infrastructure development and process of urbanization, etc. The change in forest cover in the watershed has been reduced from 93,000 ha in 1963 to less than 18,000 ha by 1988 which shows an average rate of decrease of 6.56% annually. On the other hand, as of April 1989, there are some 1,898 subdivisions in the watershed covering a total

area of 8,363 ha which contribute to land disturbance and erosion. The sedimentation rate in the lake has been estimated to be about 1.5 MCM/year.

b) Cultural eutrophication as a result of increasing wasteloads of nutrients from domestic households and expanded agricultural and livestock production and intensive fishpen operations.

c) Increasing wasteloads of toxic and hazardous substances from industrial activities including the operation of power plants. From 117 firms in 1963 the number of industrial establishments has reached about 1200 in 1988 (for an annual growth rate of 9.88%) with about 65% of them considered pollutive industries (Valerio 1990). Only about 50% of these pollutive industries have wastewater treatment facilities.

d) Increasing wasteloads of organic wastes and pathogenic organisms from the animal and livestock industry. The populations of poultry, hogs, cows, carabaos and ducks have escalated along with human population in the area.

e) Rapid population growth in the basin which exerts its pressure on human settlements both on the lowlands and uplands. Increase in human population in the Laguna de Bay Basin from about 0.85 million in 1960 to about 3.50 million in 1989 registered an annual growth rate of 4.9%

The complexity of factors causing water pollution and deterioration in the water quality of Laguna de Bay, as well as their impact on the lake ecosystem, is shown in Figure 2. The pollutants include chemicals (or toxic and hazardous substances), organic wastes, nutrients, pathogenic organisms, silt, oil, thermal, etc. They came from different sources, point and non- point, natural and anthropogenic. For the past 30 years or so, due mainly to man's activities in the watershed, the inputs of these pollutants have escalated in line with the exponential population increase in the area (see Table 2). The impacts of such unmitigated and continuous inputs of pollutants and environmentally disturbing factors are bound to destabilize or destroy any natural ecosystem, particularly where no concrete or effective steps are taken to

control pollution, as in the case of LDB. As an analogy, what can you say of an ecosystem like an aquarium if pollutants of all kinds were dumped into it until its water turned turbid, dirty and smelly, and all the rooted plants were gone, smothered by sediments. Certainly it is not balanced anymore. Yet such is the condition of LDB now, only on a much larger scale - with turbid, dirty and smelly waters with its rooted bottom aquatic plants entirely gone, covered and smothered by three meters of sediment. No wonder, people say, it is a dying lake, or worse, it is already biologically dead. This verdict is not without reason for among the negative impacts of pollution and water quality degradation are the following:

a. Decreasing productivity of the lake as reflected in decreasing harvests of fish, shrimps, snails, etc. as noted above. Capture fishery production decreased by 556% between 1963 and 1988 while yield of shrimps and snails decreased by 192% and 93%, respectively, for the same period. Fishpen productivity also decreased. With an average yield of 4,311 kg/ha in 1973 and a peak yield of 10,038 kg/ha in 1977, the yield decreased to 1,818 kg/ha by 1983 which means that there was more than five times decrease in productivity (LLDA 1988; BFAR 1988).

b. Fish Kills. As early as the seventies, fish kills had been reported in Laguna de Bay primarily due to its highly eutrophic nature.

c. Habitat destruction and loss of endemic fish species. The present state of Laguna de Bay puts it in the category of a hypereutrophic lake, one fast approaching its death. Ecologically, it is a tragedy. Even before we could identify and classify all its indigenous fauna and flora, water pollution has decimated their numbers and changed their composition. Of the 23 or so species of fish and mollusks originally present, very few species remain. Freshwater fishes that thrive in clear waters like the therapon or ayungin, white goby or bia and shrimps which used to dominate the lake are now almost gone, replaced by new and hardy species like tilapia and bighead carp which could thrive even in muddy and dirty waters. Gone also are the rooted

aquatic plants that help to cleanse the water of pollutants and serve as fish habitats. They were overwhelmed and smothered by heavy siltation and toxic wastes.

d. Social unrest and plight of the small fishermen and the lakeshore inhabitants in general whose primary means of livelihood is threatened both from the increased encroachment of fishpen operators of the open fishing area and the decreasing productivity of the lake due to the deterioration of its water quality. There are 76,000 families which are directly dependent on the lake for their livelihood.

Since ecological impact increases more rapidly than any of the factors causing it, it is expected that as the magnitude of the different environmental factors involved increases, the ecological effects would escalate further. **Laguna de Bay could be on the threshold of an ecocatastrophe with very serious implications including social unrest and political upheaval.**

How then do we approach the management and conservation of this lake? Or more appropriately, how can we save Laguna de Bay?

WATER QUALITY MANAGEMENT STRATEGIES TO SAVE LAGUNA DE BAY

Considering the complexity of the environmental problems and their impacts upon the water quality and beneficial uses of Laguna de Bay, it seems that the only way toward its sustainable development and management is to adopt the basin or integrated system approach (in the context shown in Figure 1). This considers all the factors obtaining in the watershed which have direct and indirect impact upon the lake ecosystem. However, this approach is much easier to conceptualize than to implement particularly in an ecosystem like Laguna de Bay where various government agencies and other groups have overlapping operations and interests. It will certainly be a Herculean task to coordinate and harmonize the activities of these interest groups toward a common goal of sustainable development of the ecosystem. Yet it is precisely for this reason that the process

should and must be pursued with more vigor and determination. There is an urgent need to act swiftly and decisively if only to forestall the accelerating rate of degradation of the lake. No less than a strong political will is needed.

For my part, I wish to reiterate the following water quality management strategies or measures needed to save the lake: the first set I call *Urgent Measures* can not be postponed without aggravating further the sorry condition of the lake; the second set or long term *Ultimate Measures* which is bound to affect the physiographical structure of the lake, must be subjected to a critical and thorough environmental impact assessment before its implementation. Following are the proposed water quality management strategies for Laguna de Bay.

A. Urgent Measures

1. Zoning and limitation of fishpen areas corresponding to sustainable productivity. This was estimated to be 18,000 hectares in 1984, but is dependent on primary productivity. Results of latest observations show decreasing primary productivity of the lake due to high water turbidity and other factors, such as control of illegal fishing methods like "pukot" (purse seine) and "suro" (push net).

2. Control of agro-industrial waste input into the lake. Industrial and other waste sources must be identified and required to control and treat their wastes in order to minimize waste discharges into the lake. The concept of the industrial waste interceptor system, as well as the CALABARZON PROJECT must be reviewed and subjected to environmental impact assessment.

3. Strict implementation of land use policies and regulations particularly on forestry activities, and agricultural land management, infrastructure development, housing programs, etc. including a vigorous reforestation program in the watershed

4. Domestic waste treatment and control to minimize the discharge of nutrients (nitrogen and phosphorus) and

pathogenic organisms into the lake. The government should install community toilets and garbage collection system in the foreshore communities. An ecological solid waste recycling and disposal system must be adopted. In this system, wastes are segregated at source for recycling of paper, plastics, metal, and glass, while organic wastes are made into compost.

5. Clean-up and control of pollution in the different tributaries. Most of the major rivers and tributaries of the lake are highly polluted and they contribute a lot of wasteloads. They must be cleaned and dredged and all polluters must be made to treat their wastes.

6. Promotion of sustainable development concept through intensive educational campaigns on ecological awareness and resource conservation at all levels using the power of the media, schools, churches and every possible venue

7. Consideration of the plight of the fisherfolks including the provision of alternative means of livelihood to them. They must be consulted and involved in the development and management plan of Laguna de Bay.

B. Ultimate Measures

1. **Dredging and deepening of the lake to a depth that would promote sustainable development.** This is necessary to remove the sediments that have accumulated which are the main causes of the turbidity and decreased productivity of the lake. The heavy siltation is also the cause of the disappearance of the bottom aquatic plants which serve as nursery and breeding places for fish. Land that will be reclaimed can be used for residential, agricultural, industrial or tourist purposes. This will compensate for the cost of dredging. The lake will be cleaner and clearer which will be ideal for its multipurpose uses including recreational swimming, fishing and boating for tourists especially if the coastal highway suggested below will be built. This project on dredging must however, be subjected to critical EIA.

2. **Construction of Coastal Super Highway (CSH) on Reclaimed Area**

   a. *Phase I. Calamba-Los Baños-Bay CSH*: To connect present South Super Highway at Real, Calamba to the highway at Maitim, Bay, Laguna. This is the first phase which is urgent in view of the fact that at present the Calamba-Los Baños stretch is a very congested bottleneck. This is particularly true during weekends when Metro Manilans flock to the hotspring resorts in the area.

   b. *Phase II. Bicutan/Taguig-Pateros-Angono CSH.* To decongest the South Superhighway and part of EDSA and Ortigas Ave. and provide rapid access to Marikina Valley.

   c. *Phase III. Peripheral CSH Along Western and Southern Bay starting at Taguig and ending at Sta. Cruz, Laguna.* This tollway is the final phase which will promote the multipurpose uses of the lake especially the flow of tourists to the tourist spots in Laguna and Quezon.

Of course, the fishermen within the area covered by the CSH should be given access to the lake at strategic points through a system of underpasses, quays and landing areas.

CONCLUSION

To recapitulate, I have discussed the conceptual framework for the water quality management of Laguna de Bay as a key to its sustainable development and management. To what extent this conceptual model operates in reality amid the complex environmental problems and factors affecting the said ecosystem will determine the future viability and productivity of the lake. A lot depends upon the political will and the setting up of the mechanism for coordination and harmonizing of the different activities and interests of the different agencies and vested groups involved in the use and conservation of the lake. The tasks are complex and very difficult. But they must be tackled if we want Laguna de Bay to survive.

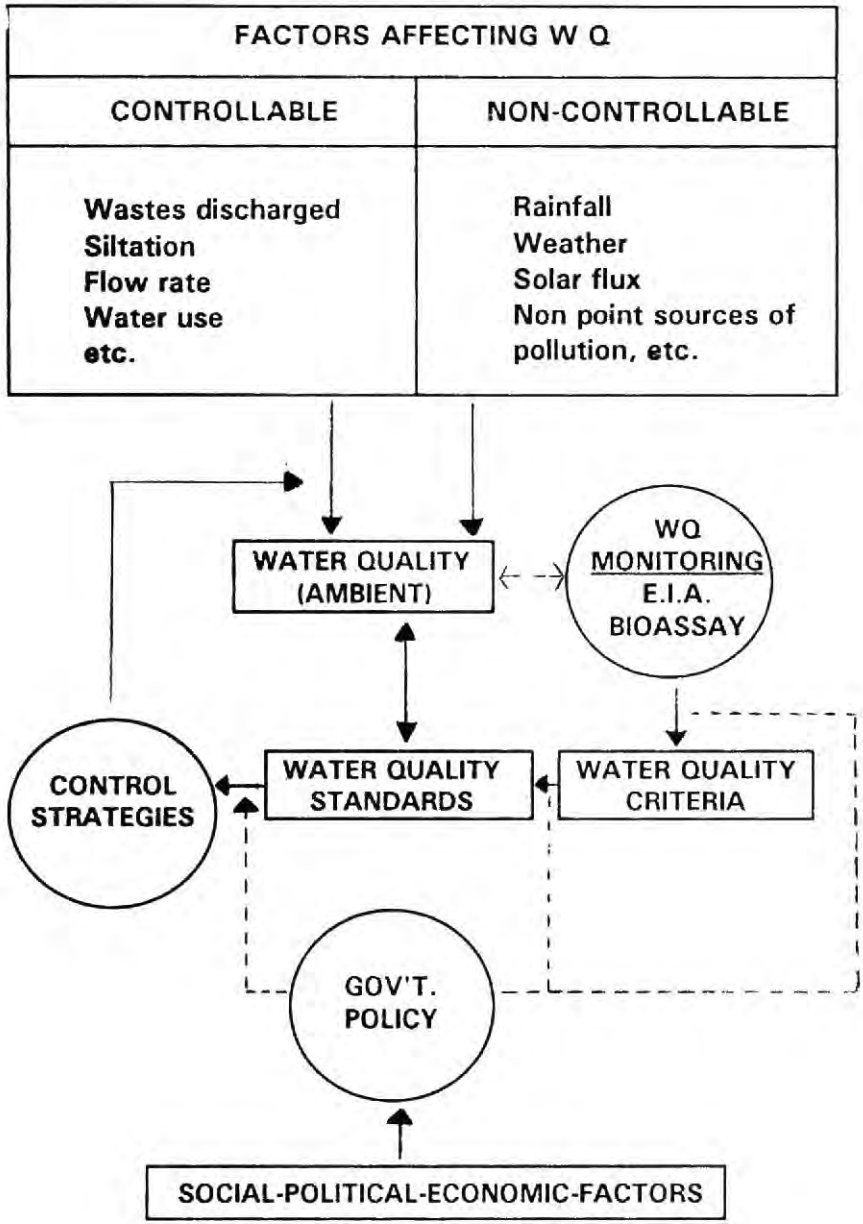

Fig. 1. Conceptual Framework for Water Quality Assessment and Management of Laguna de Bay

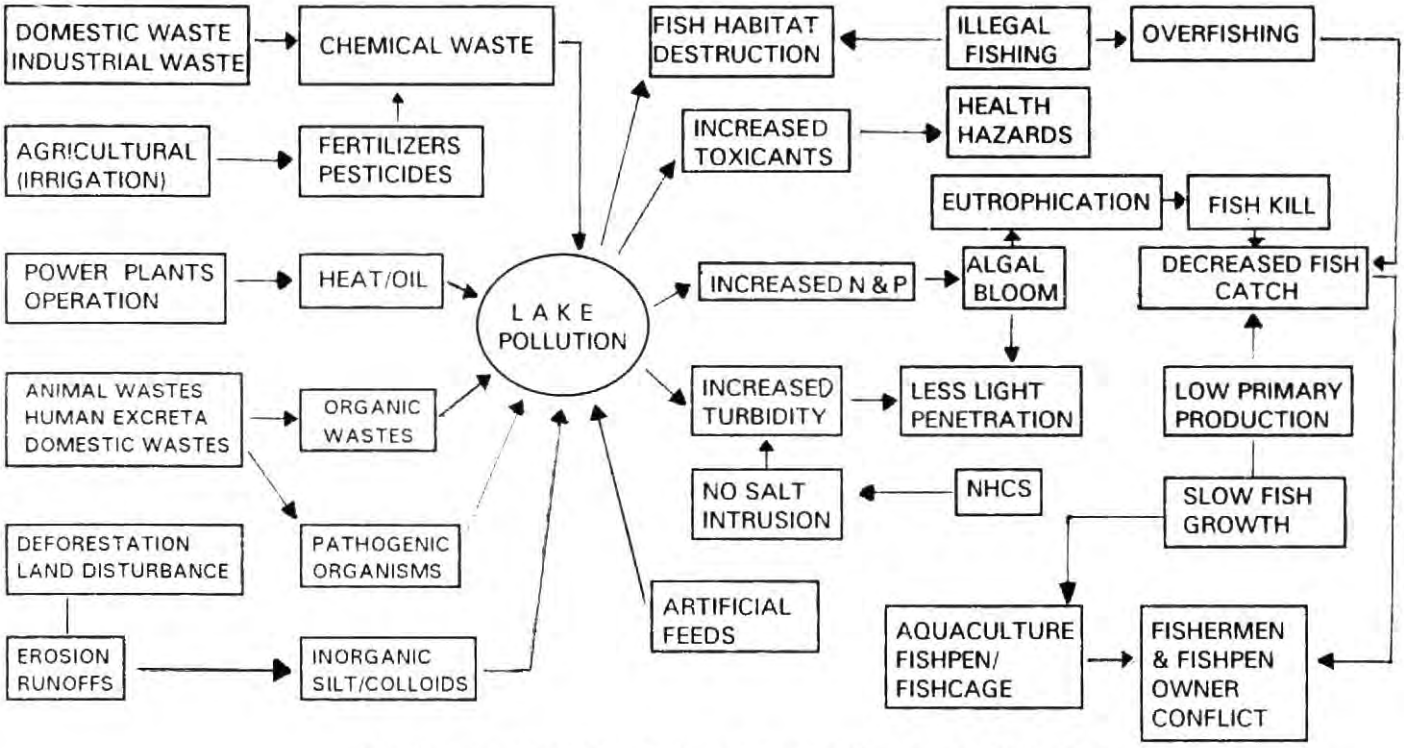

FIGURE 2. KINDS OF POLLUTION AND THEIR IMPACTS IN LAGUNA DE BAY

TABLE 1. Summary of Results of Water Quality Monitoring Studies in Laguna de Bay for the Period 1986-1989

Parameter	Average of Annual Means	Standard for Class C
Temperature (°C)		Rise not more
East Bay	Surface - 29.2 (25.0-32.2)	than 3°C of min. or
	Bottom - 28.3 (24.0-31.0)	max. value
West Bay	Surface - 29.9 (24.9-33.0)	
	Bottom - 28.8 (24.7-31.7)	
Transparency (cm)		no less than 100 cm
East Bay	1986 - 45 cm (15-75)	
	1988 - 41 cm (20-90)	
	1989 - 20 cm (5-40)	
West Bay	1986 - 59 cm (10-140)	
	1988 - 43 cm (10-75)	
	1989 - 19 cm (5-50)	
Ammonia-N (mg/L)		
East Bay	0.11 mg/L (nil - 0.369)	0.02 mg/L
West Bay	0.13 mg/L (nil - 0.348)	
Nitrate-N (mg/L)		
East Bay	0.124 mg/L (0.045 - 0.205)	0.30 mg/L
West Bay	0.146 mg/L (0.040 - 0.264)	
Ortho-P (mg/L)		
East Bay	0.080 mg/L	0.025 mg/L
West Bay	0.14 mg/L	
Total P (mg/L)		
East Bay	0.14 mg/L	
West Bay	0.19 mg/L	
Coliform Bacteria (counts/ml)		500 MPN/100 ml
Entire Lake	1984 - 3,290/ml (2,160-4750)	
	1985 - 12,580/ml (8,200-20,500)	

Table 1. Continued

Heavy Metals

Hg water - 0.23 mg/L (0.02 - 2.08 mg/L)
sediment - 0.64 mg/Kg(0.07 - 2.86 mg/Kg) (Reyes 1988)

sediment - 1.0 mg/Kg (LLDA 1977) 0.4 mg/Kg

Levels of Cu, Zn ad Pb are relatively higher than normal.

TABLE 2. Growth Rates of Population, Industry and Deforestation in Laguna de Bay Watershed. (Valerio 1990)

Item	*Annual Growth rate (period; number)*
Population	4.9% (1960-1989; 0.85M - 3.5M)
Deforestation	6.56% (1963-1988; 93,000 ha - 18,000 ha)
Industrial Firms	9.88% (1963-1988; 117 - 1200)

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