Malaysia

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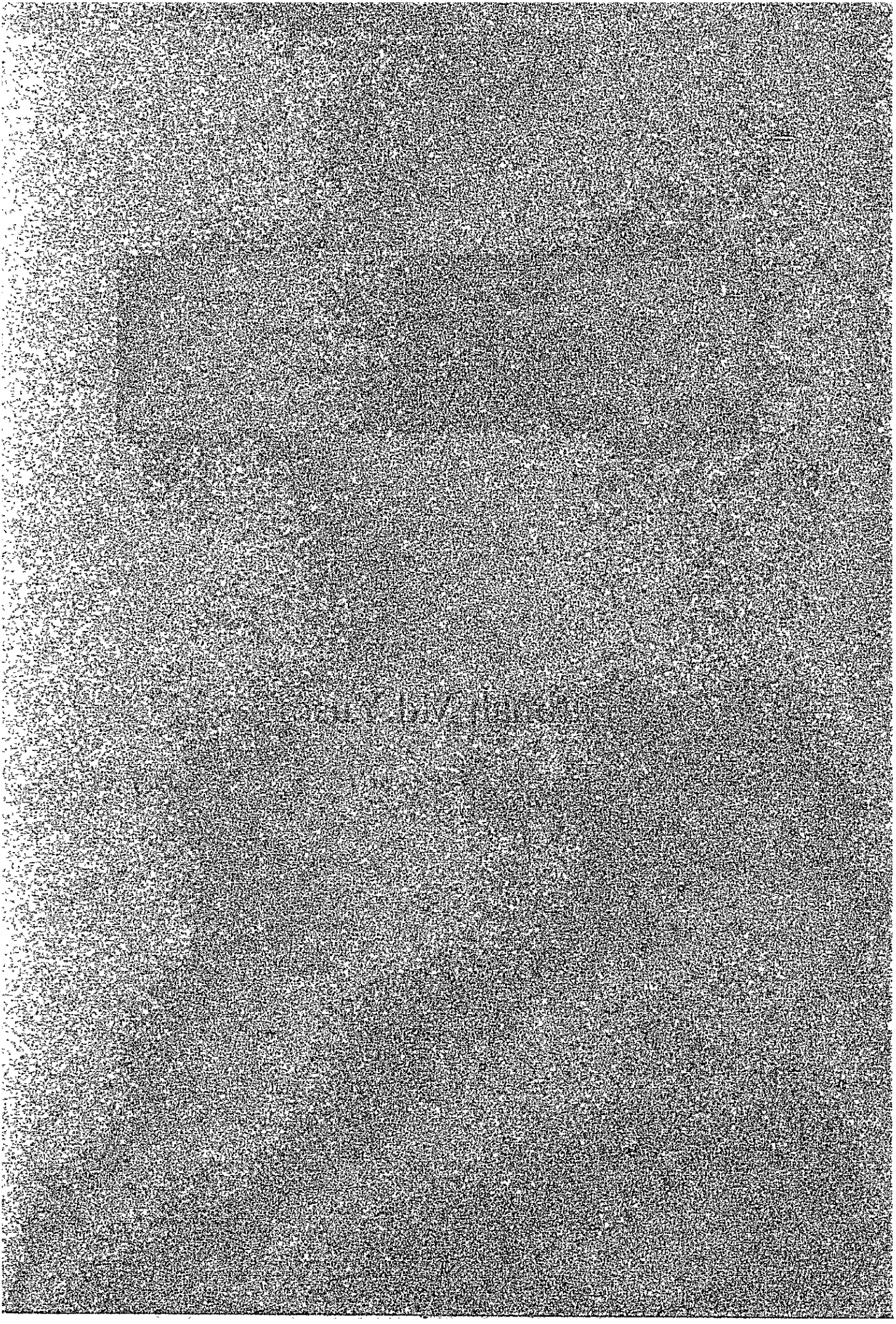

ENVIRONMENTAL MANAGEMENT OF LAKE KENYIR, MALAYSIA: PREVENTION OF EUTROPHICATION

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INTRODUCTION

In Malaysia, the need for hydroelectric power, irrigation, flood mitigation and domestic water supply has led to the construction of many dams, and today reservoirs represent a very significant inland water resource. Presently there are 51 reservoirs with a total impounded area of 160,000 ha (Ho, 1994) and the number is expected to increase over the next few years to meet the increasing demand for water and hydroelectric power.

Lake Kenyir was formed in 1985 when the steep valleys of Terengganu and Terenggan rivers were flooded to generate hydroelectric power. Located between 04° 47' to 5° 15'N and 102° 32' to 102° 55'E, the lake is the largest lentic system in Malaysia with a area of 360 km^2 and a mean depth of 37 m. Its catchment area of 2,600 km^2 consists mainly of tropical rain forests and most of the land (approximately 72%) has slopes between 10°-19°. The watershed consists of sedimentary rocks, mainly sandstone and shale, intruded by granitic masses.

The Lake Kenyir basin has a humid tropical climate dominated by north-east monsoon (November - January) and influenced slightly by the south-west monsoon (May - October). Annual precipitation for the period 1951 to 1992 varied between 1,724 to 4,142 mm with the highest falls during the north-east monsoon. Temperatures are relatively constant throughout the year with minimum and maximum daily means of 23.1 °C to 30.4 °C respectively.

A large area of the reservoir was not cleared prior to filling. Thus, the submerged tropical rainforest generates considerable amount of organic matter for the decomposition which causes nutrient enrichment in the lake (Table 1). Total ammonia-N ranged from 0.1 ug/L in the surface to 2690.0 ug/L in the bottom layer. Total phosphorus ranged from 245.0 ug/L in the hypolimnion to undetectable values in the upper waters. Dissolved oxygen concentration ranged from 6.80 to 8.00 mg/L in the surface but quickly diminishes to less than 0.1 mg/L below epilimnion (about 8-15 m depending on the season). This large difference of nutrients and dissolved oxygen between the hypolimnion and the epilimnion is due to the strong thermal stratification of the lake. Annual surface

temperature ranged from 24.2 °C in the wet season to 31.3 °C during the dry season and the bottom temperature ranged from 20.8 °C to 24.0 °C (Yusoff and Lock, 1995). Thus, nutrient rich anoxic waters are confined to the hypolimnion and nutrients are slowly released to the surface waters during epilimnetic intrusions. Due to the presence of the thermal barrier between the hypolimnion and the epilimnion, eutrophication in Lake Kenyir is suppressed. Based on phosphorus, nitrogen, chlorophyll a and Secchi disk transparency values, Lake Kenyir currently is in mesotrophic state. Phytoplankton communities is dominated by desmids, and chlorophyll a concentrations ranged from 1.07 - 38.45 mg/m^3.

There are about 35 species of fish in Lake Kenyir. The absence of natural lakes in Malaysia has pre-empted the evolution of true lacustrine fish species and therefore most of the fish colonizing reservoirs are riverine species. As such, they tend to confine themselves to the littoral zones and rivers. Assuming that only 10% of the lake area is being exploited, the current yield of the fishing grounds is about 20 kg/ha/yr, a rate predicted for a stabilized reservoir in this region (Furtado et al. 1977).

DEVELOPMENT PLANS AND POSSIBLE THREATS TO LAKE KENYIR

Although Lake Kenyir was constructed for the generation of hydroelectric power, it has become a multipurpose reservoir supporting small scale fisheries, aquaculture, flood control, transportation, recreation and ecotourism. The diverse range of natural attractions such as fishing, waterfalls and islands in the lake and rivers; and rainforest, wildlife, caves and mountains in the watershed form great assets of the area.

The number of visitors almost doubled from 1993 to 1994. For this reason, the State government, with the support of the Federal government of Malaysia, plans to develop the lake into a major tourist destination. A consortium of ten local private companies set up a Kenyir development fund in 1994 and amongst the proposed projects are hotels, golf courses, transport and water sport services. There are about 10 chalets located in the bays and islands, especially in the eastern basin of the lake. Basic amenities such as roads, water supply, electricity, housing, main port, jetties, campsites, offices, carports, chalets, boating and recreational facilities are being provided by the Government. It is envisaged that the lake will provide more jobs for the local people, especially in eco-tourism, recreational fisheries, capture fisheries and aquaculture. The availability of electricity, water and vast tracks of land may encourage the development of other sectors such as industries.

Possible threats to the lake ecosystem arising from this rapid development

include siltation from land-used activities, decrease in species diversity due to overfishing and habitat alteration, eutrophication from sewage, and decrease in aesthetic values. Since the development of Lake Kenyir area depends on natural resources such water, fishes, forest, soil and air, it is extremely important to take precautions to avoid these possible tragedies. The destruction of lake basin ecosystem means the collapse of the development programmes in the area.

EUTROPHICATION

Eutrophication is an accelerated organic pollution in water bodies due to nutrient loadings such as phosphorus and nitrogen. The sources of these nutrients are mainly from man-made activities such as domestic, agricultural, industrial, commercial and recreational activities. The symptoms of eutrophication include massive growth of algal blooms, such as blue-green algae, dinoflagellates and euglenophytes. Some of these algae produce toxin which are toxic to fish and water fowls and some produces geosmin which gives off-flavour to drinking water and fish. Decomposed algae and other organic matter also give off foul smell to the air. Under eutrophic condition, lake becomes anoxic especially in the night. Anoxic waters does not only kill fishes and other organisms, but also induces other chain reactions which result in water quality deterioration. In a eutrophic lake, its surface is usually covered with algal scums, and the water contains high concentrations of toxic compounds such as ammonia, hydrogen sulphide, nitrite and in some cases methane.

Under these deteriorated environmental conditions, lake species diversity will decrease as only a few rough species would be able to tolerate the adverse changes. Sensitive fish species which are usually of high commercial value would disappear and a few low-value species would dominate the ecosystem. With advanced eutrophication, capture fisheries will decline, aquaculture would be an unprofitable venture, water supply will be affected and the lake would loose its attractiveness and aesthetic values.

Therefore, it is in the interest of the government, investors, entrepreneurs, tourists and the local people to take appropriate steps to prevent the onset of the eutrophication in the lake, especially in the bays and littoral zones where most of the economic and social activities will concentrate.

PREVENTIVE MEASURES[1]

1. CONTROL OF NUTRIENT LOADINGS

i). Water quality conservation

In the initial development phase, untreated sewage from hotels, chalets, restaurants, shops, and houses would form the main sources of eutrophication. Grey waters from households and commercial centres would contain a large amount of nutrients. Currently, most chalets do not have any sewage treatment. Very few have aerobic digestors which only treat flush toilet wastes. Grey water of bathrooms and kitchens from chalets, shops and houses are discharged without treatment.

Since it is recognized that direct discharge of untreated sewage and grey water is a major cause of eutrophication in public waters, plans have to be made to install major and minor sewerage systems for treatment of domestic wastes and effluents from business establishments. In addition, night soil treatment facilities and refuse disposal plant have to be built. Suggestions to spray sewerage water on land may not be suitable as this may lead to the contamination of ground water.

The choice of sewage treatment system should be related to geographical condition, population density, the effects of facility installation and the cost effectiveness. The advanced treatment of sewage to remove nitrogen and phosphorus is very important to prevent eutrophication. Nitrogen from sewage can be removed by Nitrified Liquor Nitrification Denitrification process. Most nitrogen will be denitrified into molecular nitrogen in the denitrification tanks and released into the atmosphere. Nitrogen removal efficiency using this technology ranges from 70-80% (Shiga Prefectural Government 1993). Phosphorus is removed by reacting the influent water from nitrification tanks with Poly-aluminium chloride (PAC) and precipitated aluminium phosphate is transported to the thickener as excess sludge. Phosphorus removal efficiency using this technology is about 95%.

However, modern sewerage system requires a large capital investment and a long construction period that they are usually effective only in big cities. Gappei-shori Johkasou systems are known to be effective in small towns and villages. Gappei-shori Johkasou system treats both toilet and grey water. They are designed for BOD removal of 90% or more to achieve an effluent with BOD of 20 mg/L or less. The Johkasou system combines various units into a compact facility. These units include some sub-units to separate suspended solids from waste water through sedimentation, purify pollutants through a biological process, store separated sludge and disinfect waste water by using chlorine disinfectant. However, Johkasou system has to be properly managed by Johkasou maintenance and cleaning vendors, as the accumulated sludge may exceed the system's storage capacity. Therefore, the system must receive annual water quality examination. For individual house and shop, small scale Gappei-shori (combined treatment) Johkasou systems capable of processing effluents with BOD of less than 20

mg/L could be used. Cage culture practice can be a serious source of eutrophication as the excess feed placed directly in the lake water decompose to release plant nutrients. A number of steps could be taken to minimize the impacts of cage culture practice in generating eutrophication:

a). The number of cages have to be limited as not to exceed the carrying capacity of the surface water.
b). A simple technology to recover wastes from feeding and excretions under the cages have to be designed and used.
c). Formulation for feeding pellets should target at reducing phosphorus and nitrogen contents.
d).Use of natural live food, such as zooplankton and aquatic insects, for feeding fish. In this case, culture techniques of these feed items have to be intensified.
e). Floating gardens can be developed around cage culture areas such that excess nutrients can be quickly taken up by the plants. Like cages, these floating gardens can be moved around with ease to areas where they are required.

In addition, facilities for treating palm oil and other agro-industries should be constructed if these industries were to be expanded in the watershed area.

ii). Lake shore/basin conservation and management

Golf courses do not only contribute inorganic nutrients to lakes, but various pesticides which are detrimental to food chains including humans. There should be a forest belt of at least 150 m from the lake such that excess nutrients from the course would be trapped in the forest. In general, forest belt of 150 m should be maintained all around the lake and along river to provide an effective buffer zone between human activity areas and the water zone.

Macrophytes communities should also be encouraged to grow in the littoral zones of lakes and rivers to trap nutrients from non-point sources. This is because non-point sources such as effluents from villages, farms, estates and business centres contribute greatly to the deterioration of river and lake water quality.

In terms of development, the lake authority and related environmental agencies should only permit use of land and water to those enterprises whose plans have adequate pollution measures and safeguards from environmental degradation. No development should take place in steep terrains/slopes. The upper catchment area should be controlled as to ensure the continuous function of the hydrological cycle.

2. RESEARCH AND MONITORING

Research and development is important to find solutions to existing problems, to improve and upgrade current technologies, as well as to predict future changes in order to nip problems in the buds. Comprehensive ecological analyses on material balances of carbon, nitrogen and phosphorus have to carried out. Answers to specific questions on lake carrying capacity, eutrophication controls, pollution impacts on ecosystems, fish production enhancement, species diversity maintenance should be obtained. Models on lake behaviour and response to various climatic change and development activities should be developed and validated. After a series of sensitivity analyses have been conducted for various controlling factors, practical solutions to the existing and future water pollution problems should be identified and implemented.

Monitoring system should be developed for the lake basin. This would include provision of equipment and facilities to monitor and measure water quality of the lake, inflowing as well as outflowing rivers, in order to provide measures for improving water quality of Lake Kenyir.

Monitoring should also include obligation for the on-spot inspection and submission of reports by the hotels, golf courses and other business establishments in the lake watershed.

3. EDUCATION AND PUBLIC AWARENESS

History proves that education played a vital role in environmental pollution controls in industrialized countries such as Japan As early as 1950s, Japanese people understood scientific aspect of pollution. Intellectual and technical support provided by scientists, engineers, sociologists and lawyers made it difficult for the government to ignore the public opinion to be protected from pollution and live in healthy environment (Matsui 1992).

In developing countries such as Malaysia, public awareness on environmental issues are relatively low, especially in small towns and villages. In these area, the politically and financially powerful tend to benefit from causing environmental damage at the expense of the poor and the disadvantaged who often have no opportunity to express their concerns and grievances. Public have to be awakened to the importance of non-polluted environment. The presence of well informed public could be a major contributor to the maintenance of the pristine conditions of the lake in the face of rapid social and economic development in the lake basin. In addition, implementation of new rules and

regulations would be easier and more effective if the people involved understand the importance of environmental controls. In developing countries, the environmental concern is normally profound only after the impact of pollution is felt.

Thus, promotion of public environmental education to improve awareness about the environment and lake basin management should include emphasize on human rights for clean water, soil and air as well as health, education and equal wealth distribution. Mass media can be used as a major mechanism to alert people to the importance and potential hazards of environmental degradation. With strong environmental awareness and commitment, public would seek participation in major development decisions. Confronted with strong public voice, the government would have to recognize the importance of participation by those individuals who would be affected by the project (ASTEN 1994).

Some of the steps for increasing environmental education and awareness of the public include:

a). Establishment of training systems for the government officers and managers of all business operations in the watershed. This should include establishment of guidelines and organization of the technical training.

b). Steps should be taken by the lake authority to increase awareness amongst lake users including tourists.

c). At the national level, environmental education should be introduced relatively early in the school system. Environmental education at an early age is effective in increasing awareness and life-time commitment of individuals to the environmental conservation (Kawashima et al. 1996).

In addition, government officers, environmentalists, scientists, local people and entrepreneurs should form a team to perform public environmental education drive. Some of the immediate campaign activities should include:

a). Promotion of cleaner technologies than the `end of pipe methods'. For sustainable development, it is extremely important to stimulate the use of cleaner technologies and those which reduce the wasteful energy and water. The economic rationale for this perspective is also due to the tightening of environmental standards with time that in many cases it's cheaper to invest in advanced pollution control measures earlier than later.

b).Promotion of using phosphate free detergents to prevent high concentrations of this limiting nutrient in the lake water.

4. INSTITUTIONAL AND LEGISLATIVE SYSTEMS

The development of institutional and legislative systems in the federal government as well as local government is important for effective water pollution control and sustainable development of the Lake Kenyir and its watershed.

At present, KETENGAH (The Central Terengganu Development Authority), is the local authority responsible for planning and coordinating Kenyir basin development and resource management. In this case, the difficulties due to sectoral arrangements which may pose problems of coordination both at the plan formulation and implementation levels may not arise. The current emphasis of the authority is the economic development plan, especially in promoting eco-tourism. In spire of the many massive projects planned for the area, no continuous environmental monitoring has been implemented in the lake or inflowing rivers. Due to the fragility of the lake environment, it is suggested that pollution control should become a major issue in the integrated development and management plan of the lake basin.

Actual implementation of pollution control measures should include:

i). Establishment of local standards for the lake water

a. The standards for lake water quality should be more stringent than the existing national standard for water quality which was designed mainly for rivers. This is because lake ecosystem is more sensitive to pollution due to its long residence time. For example, river quality standard in Japan has 7 categories of water uses based on 5 parameters (pH, BOD: biochemical oxygen demand, SS: suspended solids, DO: dissolved oxygen and number of coliform group) whereas lake has 4 categories and 7 parameters (pH, COD: chemical oxygen demand, SS, DO, number of coliform group, total nitrogen and total phosphorus (Moriya 1994, Table 2).

b The standards should include eutrophication related parameters, especially total nitrogen and total phosphorus.

ii). Establishment of standards on the effluents

Establishment of standards and regulations on the effluents discharged from business establishments, agricultural activities and households should be based on human health and living environmental requirements.

iii). Immediate pollution control plans

The immediate concern and responsibility of the lake authority would be to

concentrate on eutrophication prevention strategies such as:

a. Accelerated construction of waste treatment systems for water quality conservation.
b. Lake shore/basin conservation and management.
c. Promotion of public environmental awareness and education.

iv). Enforcement of laws and regulations by the local government

a. Monitoring, regulating and enforcement of standards on effluent waters. There should be restraints in the discharge of nitrogen and phosphorus for those who use fertilizers (such as in agriculture) and feeding materials (such as in cage culture) in order to prevent the discharge of effluent including nitrogen and phosphorus in the lake/rivers indiscriminately.
b. Establishment of an institutional system that will stimulate all lake users to participate in the process of water quality management. In this connection, provision of relevant information is important to enable water users to appreciate the problem structure of water pollution to their lifestyle and economic activities. Water resource use and abuse by those who have access to capital and technology without due regard to the social and economic repercussions on others, a common event in developing countries, should be eradicated.

v). Effective implementation of Environmental Impact Assessment (EIA)

Malaysia has enforced the requirements of environmental impact assessment (EIA) for grand development projects. However, the effectiveness of EIA implementation is questionable since environmental conditions, including aquatic systems, continue to deteriorate and those which have degraded have not shown sign of recovery. Therefore, for effective implementation of EIA on projects in Lake Kenyir basin, the followings should be considered (Sanazami et al. 1996):

a). Legislation, rules and requirements of a formal EIA should be strictly complied by project planner and EIA personnel. EIA should not be implemented only to meet the requirements of funding agencies.
b). EIA data should be of high quality and sufficient. The competence and conscience of technical personnel, as well as methods and scientific techniques employed in the EIA process are vital to an effective EIA implementation.
c). Incorporation of outside input (public and any concerned parties) into the planning process, consideration of alternative plans and adjustment of the original proposal in response to reasonable suggestions and comments are also necessary for effective EIA implementation.

vi). Other considerations

a. Establishment of Prevention of Eutrophication Ordinance.
   Since eutrophication is currently an ubiquitous problem throughout the country, ordinance concerning the Prevention of Eutrophication should be seriously considered and enacted by the Federal Government. The creation of new reservoirs such as Pergau, Bakun and artificial lake surrounding the Malaysian new administrative capital, Putrajaya, make it imperative that the Eutrophication Prevention Ordinance be established to protect and sustain the lakes' original functions and purposes.
b. Implementation of the `pollution pays principle' to pay for cleaning up and compensation of the lost of clean water. In industrialised countries, extensive compensation and cleaning cost usually is larger than prevention cost. As a result, industry will eventually learn from the painful lesson that it is far cheaper to install antipollution equipment from the beginning than it is to pay compensation after problems have arisen. By taking preventive steps, companies also will realize that they can shield themselves from pollution's heavy social and political cost (Hashimoto 1994?). Obviously, enterprises make decisions about anti-pollution measures based upon financial self interest. Thus, they have to realise that pollution control measures are necessary to maintain and strengthen the sustainability of their own industry.
c. Establishment of environmental committee to assist small business in their efforts to prevent pollution in their operations and to meet standards set by the government.
d. Establishment of mechanisms to offer low interest financing by the government for the installation of pollution control devices. Financial support and special taxation measures such as tax reduction for those enterprises investing in environmental pollution control measures should be developed.

In general, development for eutrophication control measures makes the best progress when several conditions exist together. These include the establishment of stringent standards for public waters and enterprise effluents, public demand for environmental protection, the government response to this demand in form of regulations and enforcement, availability of funds and technologies, and the enterprise cooperation to meet the environmental controls requirements.

5. MANPOWER DEVELOPMENT

Manpower development is crucial in order to establish the institutional mechanisms with efficient administrative, technical and scientific competence to manage the water

resources and related ecosystems. Establishment of in-house training systems is necessary in all associated government departments as well as in industries. Local universities with adequate expertise in inland water sciences and management (such as University of Agriculture Malaysia (UPM), University Malaya (UM), National University of Malaysia (UKM), and University Science Malaysia (USM) should develop comprehensive curricula on fresh water resource management and related fields In addition, International cooperation through short-term training such as organized by JICA (Japan International Cooperation Agency) and ILEC (International Lake Environment Committee Foundation) also contributes to the development of human resources in lake management in developing countries.

CONCLUSION

Eutrophication is one of the most important and perhaps one of the first environmental disasters to occur in Lake Kenyir if adequate steps are not taken to prevent it. This is due to the fact that the lake water contains sufficient nutrients such nitrogen and phosphorus to make it hypereutrophic. Fortunately, due to the thermal stratification of the lake, these nutrient enriched water is confined to the dark bottom layers, thus unable to contribute to the proliferation of algae in the lake. However, inflow of nutrient rich waters from sewage and other organic-producing sources would encourage plankton blooms and lead to the eutrophication of the lake waters.

The social and economic implications of eutrophication are many and varied, including increased health hazards, damage to aquaculture and fisheries activities, increased cost of water treatment for water supply and reduction of recreational and aesthetic values. Therefore, development of an institutional system to coordinate development in the watershed should parallel the laws and regulations to prevent eutrophication. This institutional system has to be complemented by research and development in regulatory measures, appropriate technology for water pollution prevention, enhanced environmental public education and awareness, and adequate proficient manpower.

Relationship between development and the environment should no longer be perceived as a trade off. The government's medium and long term economic plans should incorporate the need for integrated, comprehensive and unified lake basin management and forecasts of the investments needed to enforce water pollution controls. Plans aimed at upgrading local living standards should consider making use of regional characteristics, enhancing local traditions and culture, and preserving the rich natural environment that

the Kenyir basin has plenty to offer.

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Footnote:

1 Views expressed by the lecturers and international participants in the JICA/ILEC Lake Water Quality Management Course (Shiga, Japan, January-March 1996), were very useful in completing this section.

Table 1. Water quality characteristics of Lake Kenyir during 1991-92 at two open-water stations (Stations 1 and 3) and a river mouth station (Station 5)(Yusoff et al. 1995)

Parameter	Station 1	Station 3	Station 5
Temperature (°C)	20.9 - 31.8	20.8 - 31.0	20.8 - 31.30
Dissolved O_2 (mg/L)	0.01 - 8.85	0.05 - 8.50	0.00 - 8.90
pH	6.0 - 7.8	6.0 - 7.4	6.1 - 7.6
Alkalinity (mg $CaCO_3$/L)	5.90 - 28.0	7.30 - 42.40	11.30 - 38.00
Conductivity (uS/cm)	28.0 - 100.0	28.8 - 170.0	32.0 - 115.0
Transparency (m)	2.7 - 4.6	2.6 - 5.4	2.6 - 3.9
Tot.Ammonia-N (ug/L)	0.1 - 1344.0	0.3 - 2690.0	2.0 - 1990.2
Nitrate-N (ug/L)	0.7 - 361.8	0.9 - 83.0	0.7 - 127.5
Nitrite-N (ug/L)	0.2 - 19.0	0.2 - 16.0	0.2 - 29.0
Chlorophyll a (mg/m^3)	1.07 - 8.54	1.07 - 38.45	1.07 - 13.88

Table 2. Comparison of lake/reservoir and river water quality standards for category 1 in Japan (Moriya 1994). BOD: biochemical oxygen demand, COD: chemical oxygen demand, and SS: suspended solids

Parameter	Lake/Reservoir	River
pH	6.5 - 8.5	6.5 - 8.5
BOD (mg/L)	-	1 or less
COD (mg/L)	1 or less	-
SS (mg/L)	1 or less	25 or less
Dissolved oxygen	7.5 or more	7.5 or more
No. of Coliform group (MPN/100 mL)	50 or less	50 or less
Total Nitrogen	0.1 or less	-
Total Phosphorus	0.005 or less	-

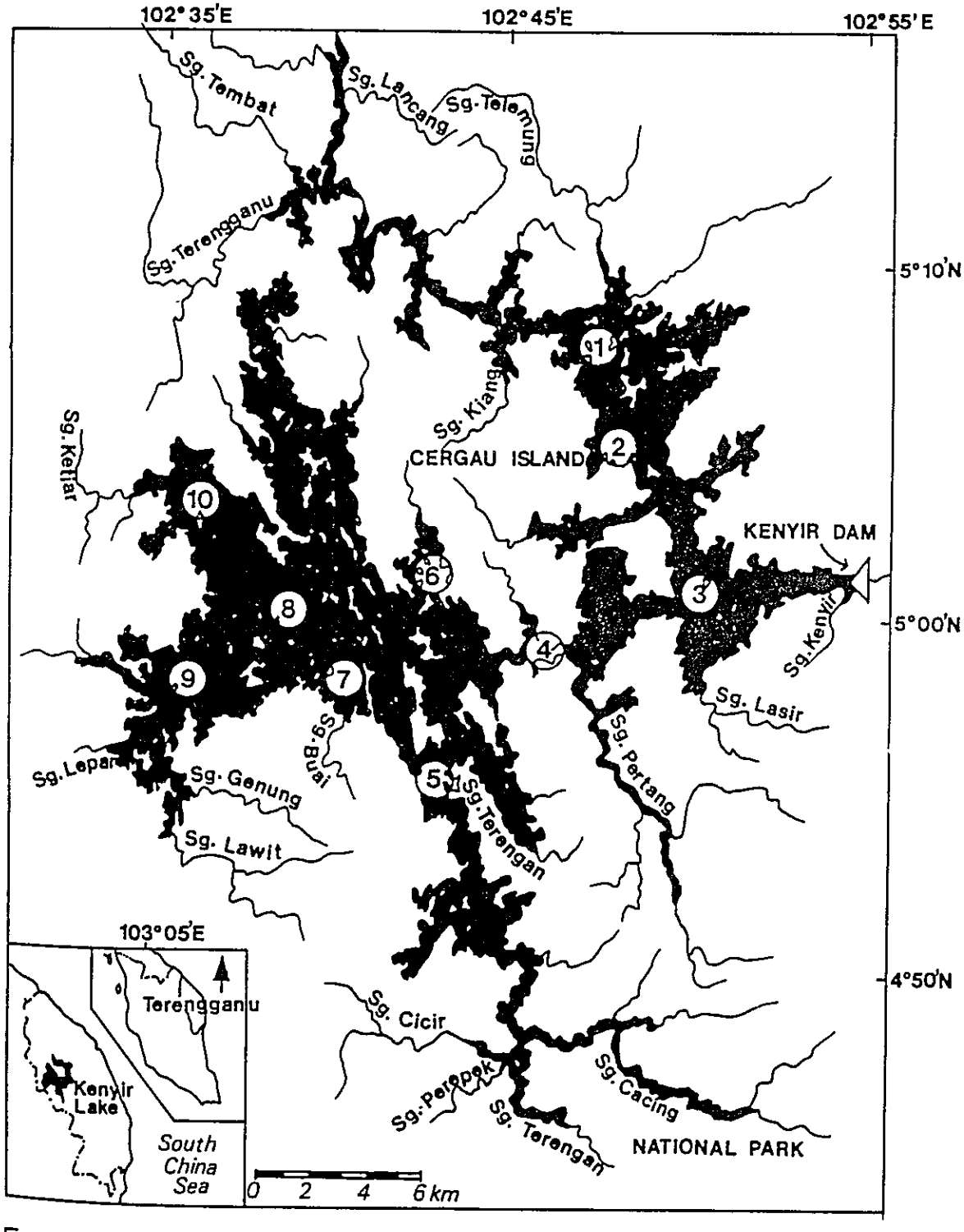


Figure 1. Map of Lake Kenyir showing sampling stations (after Yusoff and Lock, 1994)

Peru

Flor Zavala Delgado

URGENCY OF APPROPRIATE MEASURES TO CONSERVE THE "SYSTEM CHILI REGULATED" (RESERVOIRS AND RIVERS) AND ITS ENVIRONMENT IN AREQUIPA - PERU

Flor Zavala Delgado
Peru

1. INTRODUCTION

The mankind owes its healthy and cultural living to the great blessing of our planet's environment; this traditional friendly relationship between man and environment is the basis of our living with harmony and beauty.

Water resources, like lakes and reservoirs, have always played a major role in human activities but when mankind loses its awareness about this fact there is an unavoidable disruption of this friendly relationship, with uncontrollable consequences.

All of us, belonging to the present generation, are responsible for carrying out all possible efforts in order to protect our environment and to restore it by fighting against every type of contamination for the sake of future generations. This is the basis of SUSTAINABLE DEVELOPMENT.

When there is absence of an Environmental Plan or Management of Reservoirs, like in my city, and after having participated in this Training Course in Japan, I feel obliged to propose some urgent measures according to the reality of our situation, hoping that they will be the basis for present activities and for a future Integral Plan.

Despite the lack of basic information about the aquatic ecosystem I will try to present all I have here because it is very important to know it in an integral form.

2. DEMOGRAPHY

Peru is located on the west coast of the South American Continent, between latitudes 0° 01' 48" and 18° 21' 03" and longitudes 68° 29' 27" to 18° 19' 35" west of the Greenwich meridian.

Total population at 1993 census was 22,128,466. It is mosaic in terms of weather and geography, since it has 84 of the 103 life zones that the world theoretically has. This fact makes Peru the most varied country of the planet under an ecological point of view and one with a great variety of species and communities of wild flora and fauna.

Arequipa, the second city of Peru, is located in the southern part, exactly at the geodesic coordinates at latitude 16° 41' 8" south and longitude 71° 54' 7" west, at 2,360 meters above sea level. The city's population in the 1993 census was 940,481.

The weather is `desert-like` i.e. dry and windy and rain is scanty. This conditions along with the flow variations in the Chili river (the most important) has decisive influence upon the socio-economic development of the city and upon its sanitary conditions also.

3. ENVIRONMENTAL CONDITIONS OF "SYSTEM CHILI REGULATED"

3.1 Localization

The System is situated in the south-western part of Arequipa, in a region of pronounced seismic activities. It is practically the only water source. It is formed basically by three reservoirs El Pañe, El Frayle, and Aguada Blanca. There are no human settlements within the vicinity of the reservoirs (Fig. 1).

3.2 Climate

The System presents natural adverse conditions. The climate ranges sharply from semi-warm to polar conditions; it has desertic features, with high degree of luminosity (average 9,890 Kcal/m^2/d). The temperature in this region range from 15°C during the day to - 15°C (and down to - 25°C in June and July) during the night. This variation leads to thermal inversions in the distinct water layers of the reservoirs.

3.3 Hydrology

The hydrological conditions of this System is evaluated through several phenomena:

a. Rainfall

Average rainfall is about 100 mm/year. The lowest monthly rainfall of 4 mm is recorded between June and July. The precipitation are the main sources of water for the reservoirs.

The dry weather conditions are also represented by the low relative humidity (around 20%) and by a high evaporation potential (in the order of 940 mm/y).

b. Discharge fluctuation

The reservoirs are subject to strong level fluctuations caused by the scarcity of water (one year of filling up and two years of discharge). It can be seen in tables 1 and 2, regarding the most important reservoirs, El Pañe and El Frayle.

c. The soil erosion

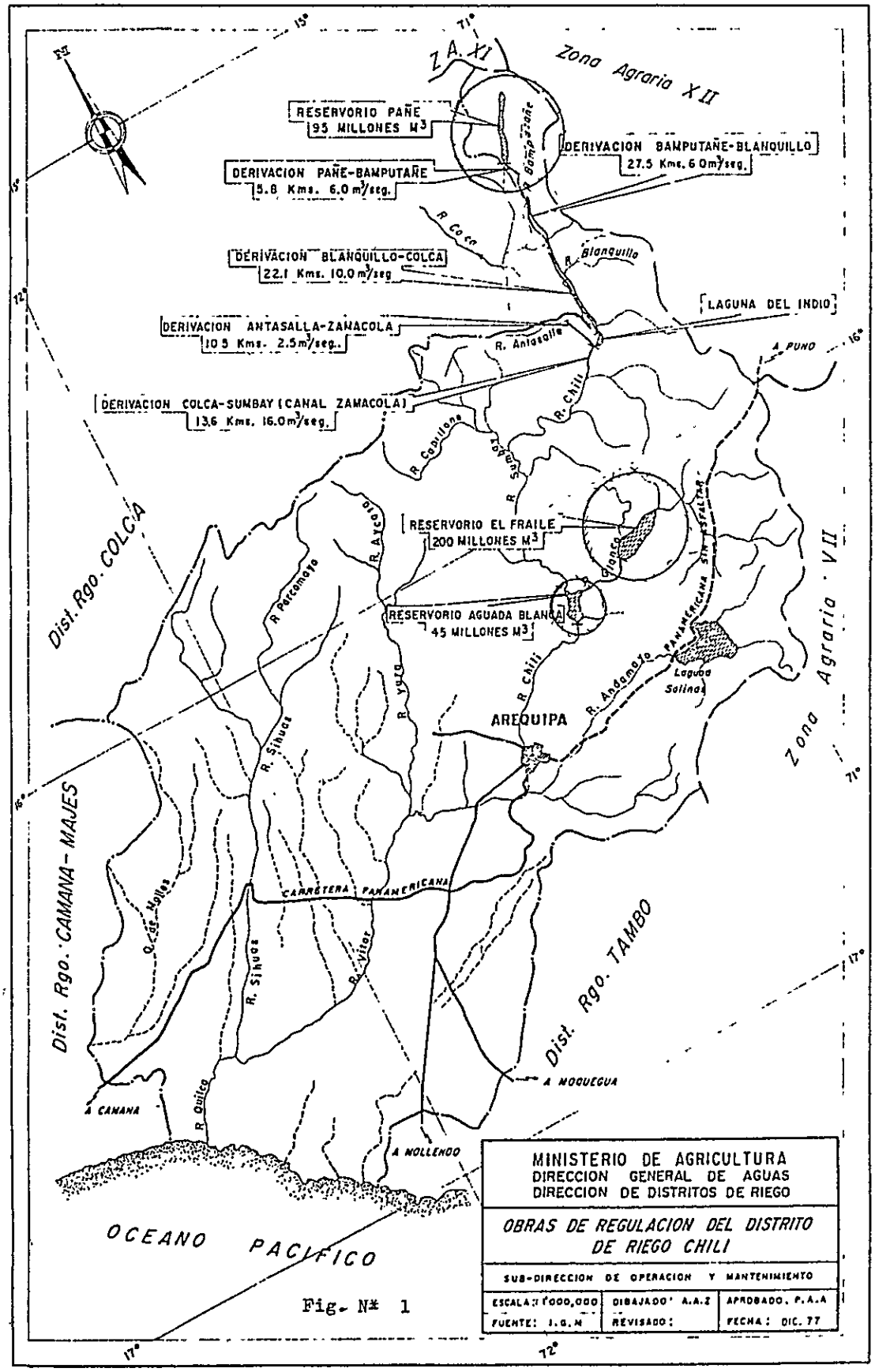

Z.A. XI
Zona Agraria XII
RESERVORIO PAÑE
95 MILLONES M3
DERIVACION PAÑE-BAMPUTAÑE
5.8 Kms. 6.0 m3/seg.
DERIVACION BAMPUTAÑE-BLANQUILLO
27.5 Kms. 6 0m3/seg.
DERIVACION BLANQUILLO-COLCA
22.1 Kms. 10.0 m3/seg
LAGUNA DEL INDIO
DERIVACION ANTASALLA-ZAMACOLA
10 5 Kms. 2.5m3/seg.
A PUNO
DERIVACION COLCA-SUMBAY (CANAL ZAMACOLA)
13.6 Kms. 16.0m3/seg.
RESERVORIO EL FRAILE
200 MILLONES M3
RESERVORIO AGUADA BLANCA
45 MILLONES M3
Dist. Rgo. COLCA
Zona Agraria VII
AREQUIPA
Laguna Salinas
Dist. Rgo. CAMANA-MAJES
CARRETERA PANAMERICANA
Dist. Rgo. TAMBO
A MOQUEGUA
A CAMANA
A MOLLENDO
OCEANO PACIFICO
R. Blanquillo
R. Antasalla
R. Chili
R. Sihuas
R. Vitor
R. Quilca
R. Majes
MINISTERIO DE AGRICULTURA
DIRECCION GENERAL DE AGUAS
DIRECCION DE DISTRITOS DE RIEGO
OBRAS DE REGULACION DEL DISTRITO DE RIEGO CHILI
SUB-DIRECCION DE OPERACION Y MANTENIMIENTO
ESCALA: 1'000,000
DIBUJADO: A.A.Z
APROBADO: P.A.A
FUENTE: I.G.N
REVISADO:
FECHA: DIC. 77

Fig. N° 1

REPRESA EL PAÑE

DESCARGA (m3/s) 1975-1993

Table 1

AÑOS	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC
1975	2,3			3,0	4,2	4,1	3,7	1,8			3,4	4,5
1976	1,6	0,7	0,1	4,7	3,0	6,0	6,0	6,0	4,2		1,7	5,5
1977	3,0	0,8		0,4	0,8				0,9	5,1	5,5	5,0
1978	0,5			0,3	1,4						4,5	3,8
1979	0,9	1,9	0,8	0,3					3,3	6,0	4,4	3,6
1980	4,2	3,3	0,3	0,3				1,8	2,2	3,9	3,0	4,9
1981	1,4					5,0	5,1	5,3	4,9	5,3	5,4	4,7
1982	0,1							4,4	5,5	5,0	3,5	3,8
1983	5,3	3,9	4,3	1,3	1,4	0,3						
1984			1,1	3,1	5,1	3,1	5,1	5,2	3,0	0,3		
1985	0,4	0,6	0,3	0,6	2,3	0,3	5,2	3,0	4,3	4,3	3,8	2,6
1986		0,1	4,4	3,2	3,3	3,3	3,3	4,0	4,9	1,3	0,3	1,3
1987	0,5			1,4	0,2	2,3	3,0	0,4				4,7
1988	2,3				3,4	1,3	2,0	3,1	4,3	3,0	3,8	1,1
1989	3,2	3,0	0,1		0,3	3,3	3,2	3,4	3,3	2,3	4,3	3,9
1990	0,7	0,7	0,7	0,1	0,3	4,0	2,3	0,7	0,1			
1991					5,0	4,9	5,1	4,0	4,2	4,3	4,1	3,3
1992	2,8	4,3	3,1	3,2		3,5	1,0	0,3	0,2			
1993							4,3					

FUENTE : DIRECCION REGIONAL DE AGRICULTURA - AREQUIPA
DIRECCION DEL SISTEMA DE REPRESAS

REPRESA EL FRAYLE

DESCARGA (m3/s) 1963 - 1993

Table 2

AÑOS	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC
1968									1,045	1,961	1,079	
1969	1,513		0,945	1,156	3,687	5,353	6,998	4,928	3,069	2,439	2,247	3,270
1970	2,584			4,554	6,351	6,986	6,441	6,774	6,224	3,529		1,542
1971	1,762				9,546	11,020	9,383	8,882	6,526		0,825	6,026
1972						6,219	6,303	6,271	6,828	8,506	4,983	3,044
1973	3,537		7,955	5,492	7,623	6,421	13,482	14,967	11,325	5,329	7,250	5,410
1974	4,533		2,370			5,825	12,132	11,054	8,490	5,956	6,421	7,189
1975	7,257				8,503	9,030	11,266	21,582	13,271	6,269	3,700	5,266
1976	3,853					9,338	6,471	6,170	7,974	5,923	1,761	4,191
1977	4,170	3,315			5,234	5,506	5,269	7,864	6,760	4,236		4,640
1978	3,152				4,901	5,428	5,509	5,916	5,897	4,537	3,366	
1979	2,966					3,439	3,905	5,025	3,793	2,305	2,020	2,577
1980	1,385	1,364	1,426		2,559	3,499	2,709	2,135	1,456	0,556		0,892
1981											6,845	
1982	4,315				3,353	4,720	4,676	2,919	1,739	1,804	2,259	5,920
1983	3,330	3,090	1,198	2,875	3,928							
1984									5,894	7,801	3,313	4,779
1985	7,503	7,809	3,679	4,524	1,214	3,670	5,267	6,178	7,442	7,368	9,523	1,292
1986		5,330	24,111	6,460		7,818	8,959	9,030	7,866	7,344	7,171	6,174
1987				4,534	6,210	5,706	2,473	2,048		6,203	8,764	3,489
1988	1,375					5,705	13,386		20,245	13,994		10,382
1989	9,373	2,559						3,205	5,307	6,396	6,420	6,949
1990	6,174	5,376	3,052	2,658	1,206	2,019		0,665	1,118	0,817	0,570	
1991						2,401	3,287	3,812	5,638	7,100	7,026	7,894
1992	3,383	1,550			2,080	1,978		3,598	3,554	2,881	0,880	0,887
1993						5,659	6,979					

FUENTE : DIRECCION REGIONAL DE AGRICULTURA - AREQUIPA
DIRECCION DEL SISTEMA DE REPRESAS

Due to natural deforestation and to the presence of strong wind currents, this phenomenon of intemperism and no regressive erosion causes severe damages in the open air channels of irrigation and in the structure of the reservoirs.

3.4 Natural eutrophication

It is the most difficult to treat, due to the conditions showed in the previous topic. Particles are carried out towards the water surface, hence affecting the concentrations of suspended solids, colloids, iron, manganese and, as most important components, total nitrogen, total phosphorus and plankton. Table 3 shows high concentrations of phosphorus (0.55 mg/l PO_4-P) in El Frayle); this consequently leads to an enhancement in the primary production and to algal blooms.

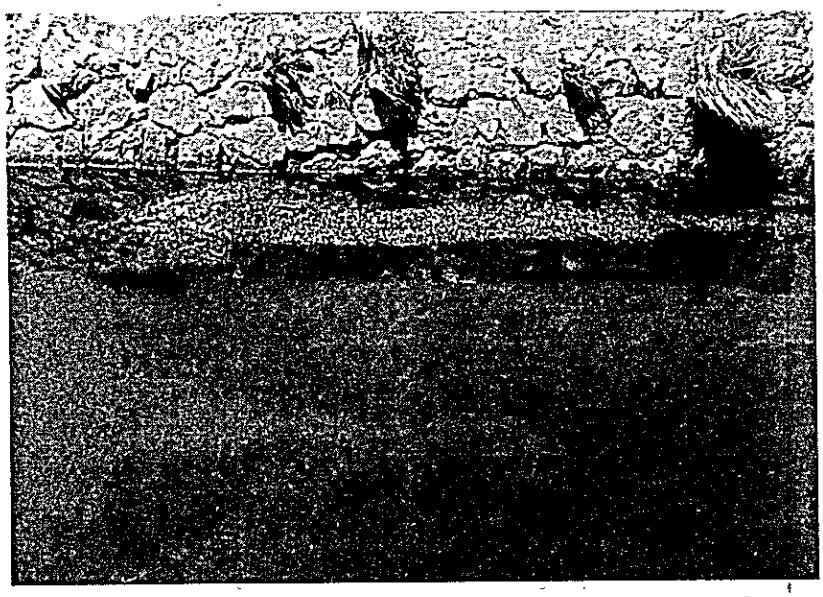
Moreover the particles sedimentation changes the water colour and reduce its transparency, increasing also the oxygen demand.

3.5 High biological activity

The strong solar radiation, especially over rivers and channels for water conduction, causes the undesirable growth of phytoplankton, especially aquatic macrophytes and algae.

In one study carried out by Professor Abraham Calla (Oceanographic Lab) Ecology Faculty of the National University some groups of algae are identified in the sample water of the reservoirs : *Cryptomonadacea*; *Epithemiaceae*; *Denticula elegans*; *Nitzschiaceae*; *Naviculaceae*; *Oocystaceae*; *Spyrogyra* and *Cladophora*.

The next picture shows one kind of macrophyte.



Universidad Nacional de San Agustín de Arequipa
Facultad de Ciencias Naturales y Formales
Unidad de Producción de Bienes y Servicios

Table N. 3

SERVICIOS QUIMICOS EN GENERAL
Ciudad Universitaria Pab. de Química
Av. Independencia s/n Tlf.

RESULTADOS DE LABORATORIO

006272

LABORATORIO: INVESTIGACION Y SERVICIOS N°300
CLIENTE : Srta. Ing° Flor Zavala Delgado
DIRECCION :
FECHA DE RECEPCION: _____ FECHA DE REPORTE: 96-01-03
SOLICITUD DE ANALISIS: Análisis de aguas
REFERENCIAS : Dos muestras de agua proporcionadas por el interesado.

Nº de Muestra (Laborat.)				
Nº de Muestra (Cliente)				

ANALISIS DE: Expresado en:				
	R. Aguada Blanca	R. El Frayle		
pH.....	7.5	7.65		
Conductividad UMhos/cm.....	625.0	795.0		
Dureza total mg/l $CaCO_3$.....	77.21	77.2		
Solidos Solubles mg/l.....	409.0	600.0		
Fosforo mg/L PO_4^{Ξ}	0.3	0.55		

OBSERVACIONES:

QUIMICO RESPONSABLE

QUIMICO RESPONSABLE

NOTA Este formato es el único comprobante para emitir resultados de análisis de la UPBS de la FCNF

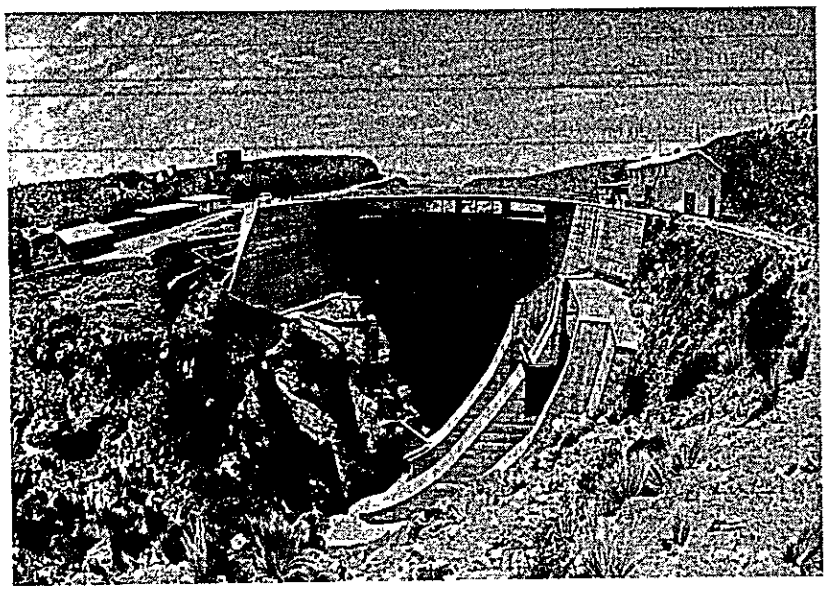
This plant mats, regionally known as "Llachos" grows densely and can obstruct up to 70 % the flow capacity of the open air channels leading to constraints in the water supply and to heavy costs for their removal. Also the large amount of the algae that are flushed to the Drinking Water Plant causes severe problems of filter clogging, reducing the wash time intervals in about 30%.

3.6 Technical features of Reservoirs

3.61 EL PAÑE

It was built in 1965, being located at 4,500 m.a.s.l. in the high basin of Colca River. The surface area of the basin is 135 km^2 with a total storage volume of 100 x 106 m^3. The reservoir is of rockfill type with soil core. Its maximum height is 13 m and it has a total length of 580 m and a crown of width 10 m.

3.62 EL FRAYLE



It was built in 1959, being located on the bed of Blanco River at 4 000 m.a.s.l. This reservoir is of concrete arch type with a basin surface area of 1087 Km^2. This work was complemented with a lateral reservoir called dike of bloques. Total storage volume is 208 x 10 m^3. Total useful limited volume by damage to the structure by intemperism is 135 x 10 m^3. The maximum height is 74 m and width of 72 m with a crown of width 5.5 m.

3.63 AGUADA BLANCA

This dam was built in 1971. It is located in the Chili river bed, at 3 666 m.a.s.l. It is of

rockfill with metallic protection. The surface area of the basin is 3 980 km^2, with a total storage volume of 43 x 10 m^3. The maximum height of the reservoir is 45.5 m, a crown width of 5.0 m and spillway overflow to a "Morning Glory", 3 666 m.a.s.l.

3.7 Pollution of Chili River

The Chili River is formed by the union of the Blanco and Sumbay rivers; it is indispensable for Arequipa's life. It crosses the city (Fig. 2) and reaches the ocean with the name of Quilca river. The city is currently going through a very difficult situation because of pollution by anthropogenic activities such as: domestic waste water, industrial waste water (especially the leather factories) agriculture and garbage.

3.8 Utilization

a. Source of Drinking Water

The drinking water supply in the region is under the responsibility of SEDAPAR. Total daily water flow average for the purification :1 250 l/sec (it corresponds to 16% of the water resource).

b. Production of Electric Energy :

The supply is under responsibility of EGASA, which administrates six power generation stations. The initial station is located at "Aguada Blanca". It uses 100 % of the water resource. None of the water is supplied for other uses. The power generations is distributed as shown below:

Central Charcani V	: produces	45 Mw
Central Charcani IV	: produces	13.5 Mw
Central Charcani VI	: "	9.0 Mw
Central Charcani III	: "	7.0 Mw

The total energy generation capacity has an average of about 60 Mw.

When the demand surpasses the generation capacity, it is completed with thermic production until the limit value of 72 Mw.

c. Agriculture :

These activities are developed near the city and are supplied with water from the Chili River and long irrigation channels. The farmers are united in a 'users' committee (Junta de Usuarios) they act over an area of about 15 000 ha.

The water demand for agricultural purposes reaches 80% of the flowing water in

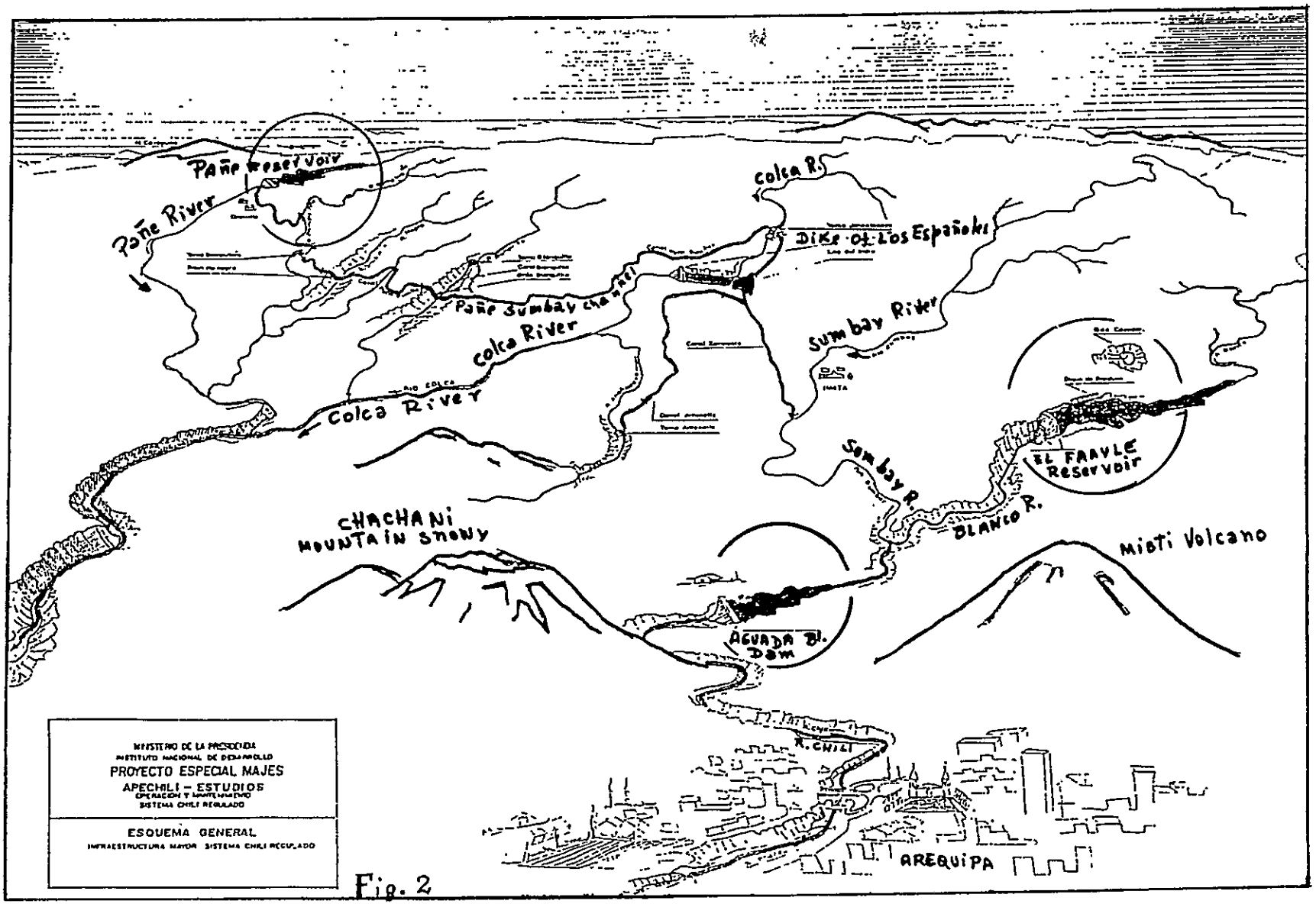

Paño Reservoir
Paño River
Colca R.
Dike of Los Españoles
Paño Sumbay channel
Colca River
Sumbay River
Colca River
Sumbay R.
EL FRAYLE Reservoir
CHACHANI MOUNTAIN SNOWY
BLANCO R.
Misti Volcano
AGUADA BL. DOM
R. CHILI
AREQUIPA
MINISTERIO DE LA PRESIDENCIA
INSTITUTO NACIONAL DE DESARROLLO
PROYECTO ESPECIAL MAJES
APECHILI - ESTUDIOS
OPERACION Y MANTENIMIENTO
SISTEMA CHILI REGULADO
ESQUEMA GENERAL
INFRAESTRUCTURA MAYOR SISTEMA CHILI REGULADO

Fig. 2

the System. There is no possibility of increasing the water production, the system therefore suffers from periodic water shortages.

d. Mining and industrial users :
The water supply is quite limited, reaching only 5 % of total demand.

e. Water Resources Control :
This control is under the coordination of DEPEMA (belonging to the Agricultural Ministry) and EGASA.

4. WATER QUALITY

The general problem can be summarized in the degradation of water quality due to natural and artificial factors. The water quality analyses (Table 4) is mainly centred on the determination of physico-chemical parameters, which show some variations along the year.

There is no institution directly responsible for the water quality control and its management.

5. PROPOSAL OF COORDINATION

A change in our priorities is urgently needed, considering the fact that we cannot go on sacrificing our precious natural environment for the welfare of a fragile economy, which is not able to project itself towards the future but, on the contrary, enhances heavy loads of underdevelopment.

5.1 Institutions

In Peru there are national regulations concerning the protection of the environment, which is accomplished by specific institutions. These are very poorly supplied with financial resources; nevertheless we could do far more than we believe, by considering and respecting the distinct contributions that originate from the coordinations with the public and private sectors and also from international institutions.
Some of the important institutions are listed below:

a. National Environmental Council (created in 1994).
b. Regional Environmental Committee, Arequipa (created in April 1995).
c. Municipality of Arequipa

SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE AREQUIPA "SEDAPAR"

REPORTE DE LABORATORIO DE ANALISIS FISICO QUIMICO Nº 050-95/F.C. TOM

REFERENCIA Table N. 4

Ing Flor Zavala Delgado
Reporte de Laboratorio Nº 050 95/F.C TOM

NATURALEZA DE LA MUESTRA

Nº	LUGAR	FECHA	HORA	Cloro Res
1	Represa El Frayle	95.12.18	14:30	—
2	Represa Agudo Blanco	95.12.18	11:30	—
3	Agua Cruda Ingreso Planta Tomilla	95.12.19	—	—

CONDICIONES DE LA MUESTRA Frasco simple de vidrio sin preservación en el transporte

RESULTADOS :

DETERMINACIONES FISICO QUIMICOS		1	2	3
Turbiedad en NTU		45	30	15
Color verdadero en Unidades Pt Co		20	20	15
Olor		No	Apre	ciable
Sabor				
Alcalinidad a la F exp ppm CO_3Ca		10,0	8,0	8,0
Alcalinidad a MO		96,0	86,0	88,0
Bicarbonatos exp.ppm CO_3Ca		76,0	70,0	72,0
Carbonatos		20,0	16,0	16,0
Hidróxidos		0,0	0,0	0,0
Dureza Total		240,0	200,0	180,0
Dureza Cálcica		160,0	140,0	120,0
Dureza Magnésica	Mg			
Sulfatos	SO_4	200	125	125
Cloruros	Cl^-	120	110	100
Fierro	Fe^{++}			
Cromo	Cr^{++}			
Cobre	Cu^{++}	0,0	0,0	0,0
Sólidos totales en suspensión		0,91	0,70	0,70
Sólidos disueltos totales exp en gr/l		0,46	0,35	0,36
Dióxido de Carbono libre				
pH		7,8	8,0	8,0
I.L. :		−0,01	+ 0,04	− 0,02
Aluminio		—	—	—
Temperatura °C (Lugar toma)		15	15	15

COMENTARIO :

El agua de ingreso a la planta Tomilla, es la que proviene de la cuenca del río Chili (Represas de El Frayle y Agudo Blanco)

Arequipa, 19 de Diciembre de 1995

CBM/...

Carlos Alberto Berrio Marañón
QUIMICO
Reg. Colegio de Quimicos del Perú Nº 306

FORMA No 9 SEDAPAR

d. National University San Agustin (UNSA)

e. Regional offices of the Ministries of Education and Agriculture.

f. Multisectorial Committee, formed by all the users concerning the System Chili Regulated (Fig.3); it has an outstanding importance for the development of the city, requiring the implementation of an office, laboratory and personnel responsible for water quality monitoring and control.

g. Pan-American Centre for Sanitary Engineering and Environmental Sciences (CEPIS).

h. Pan-American Health Organization

i. JICA (Japan International Cooperation Agency)

j. ILEC (International Lake Environment Committee Foundation)

5.2 Management of the rivers and reservoirs drainage basin

Measures To Be Taken:

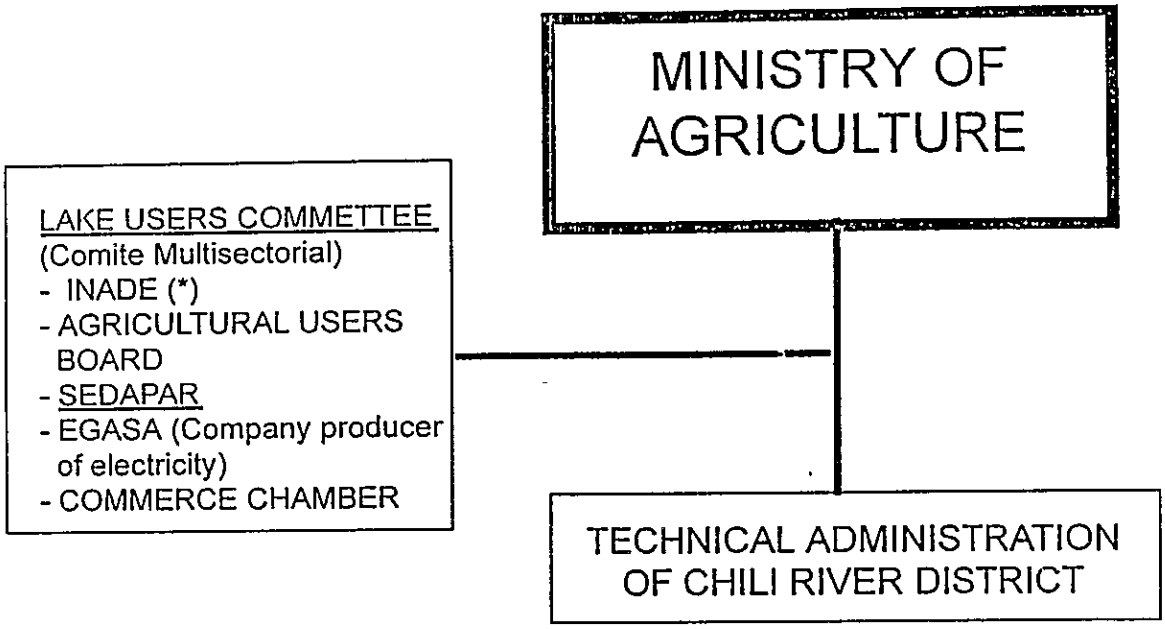
5.21 Permanent evaluation of the effects of wind action and erosion over the reservoirs structures and implementation of concrete steps for their restoration. Continuation of the studies about the use of geomembranes for protection of the conduction channels.

5.22 Afforestation

a) Studies should be carried out, with support of the University (in agreement with the Multisectorial Committee) about soil structure, type, nutrients and other issues which would provide us with the necessary information for proceeding to afforesting the area around the reservoirs. It should be investigated if there are some indigenous tree species able to resist to low temperature and dryness.

b) With the results obtained in topic a) it should be immediately proceeded to the first test regarding the cultivation of those trees in the shoreline of canal Pañe Sumbay .The soil should be adequately prepared with ditches; the trees could be fertilized with the sediments originated from the manual cleaning of the channel, naturally after carrying out analyses about their nutrients (Nitrogen and Phosphorus)contents. The planted trees would assimilate the nutrients, reducing hence the macrophytes and algae growth in the channels.

This task should be accomplished by (EGASA), since they are primarily affected by the here related problems.


MINISTRY OF AGRICULTURE
LAKE USERS COMMETTEE
(Comite Multisectorial)
- INADE (*)
- AGRICULTURAL USERS BOARD
- SEDAPAR
- EGASA (Company producer of electricity)
- COMMERCE CHAMBER
TECHNICAL ADMINISTRATION OF CHILI RIVER DISTRICT

(*)

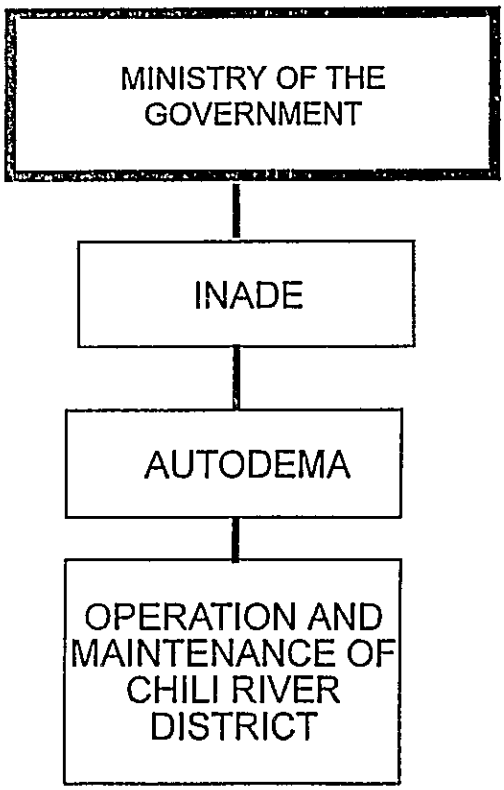

MINISTRY OF THE GOVERNMENT
INADE
AUTODEMA
OPERATION AND MAINTENANCE OF CHILI RIVER DISTRICT

Fig. N. 3

5.23 Water Quality monitoring

The monitoring should include the determination of the organic compounds, always trying to reduce the analyses costs. I think that SEDAPAR could carry out the monitoring using its own technical personnel and also try to implement a laboratory in the treatment plant "La Tomilla".

The monitoring program is within the real possibilities of the company ,at least until the installation of the corresponding office.

5.231 Biological Monitoring

It is necessary the implementation of a biological monitoring with its laboratory, which should be also under the responsibility of SEDAPAR, since we have different problems in the Plant caused by the big amount of algae.

5.232 Waste Water Treatment Plant

The existing Plant of Chilpina treats only about 30 % of the total waste water flow generated in the city. Plan for the construction of another waste treatment plant, which would then treat most of the generated waste water, is under way. This is being sponsored by the German Government. Meanwhile it is necessary, that the Regional Environment Committee and its members, enhance efforts to limit the continuos contamination of Chili River. This is a very urgent need, since the damages, when caused could, be irreversible.

5.3 Environmental Education

Arequipa is not a big city and in this sense the first steps have already been done but only superficially. May be the best strategy should be not a massive education, but one which would work with the different sectors, to create awareness among the citizens about the benefits of a sound environmental management.

Regarding this aspect the elementary and secondary schools, together with public Universities will be the easiest to be handled.

I enjoyed very much the visit to Karasaky Jr. High School, where I could observe how the students develop their capability of analysis and criticism. I will search the corresponding decision levels in my country and make specific proposals to enhance what has been already initiated.

It is also important to get in contact with farmers (assembled in their Committee) and show them the severe consequences derived from an excessive utilization of fertilizers and pesticides.

Also the women, who stay most of the time administrating their houses, should be informed by radio and television about the degree of contamination of Chili River.

Finally the people in general should be addressed by organizing concourses between districts and other measures for stimulating their participation.

5.4 Natural Resources

5.41 Fishery

At the moment there is no fishery or recreation in the reservoirs. Nevertheless the importance of fishes for the balance of the ecosystem is very striking. Since last year a fish culture was initiated through the introduction of about 100,000 trout alevins in the reservoirs and river basins under supervision of EGASA. Efforts will be made towards the participation and collaboration of other institutions in this activity.

5.42 Vicuñas

The "vicuñas", distant cousins of the camels, form a valuable natural resource that has not been sufficiently protected. These animals that furnish the finest and softest animalfibre in the whole world, have their habitat in the drainage basin of the reservoirs.

Recently (7 March 96) an important Japanese newspaper (The Daily Yomiuri) published a report about the economic potential and significant possibilities of development regarding the breeding of "Vicuñas.

6. CONCLUSION

It was very important for me, the opportunity of getting in contact with the experience and the high level of development of the Japanese people during the training course about Lake Water Quality Management. I could see a very good example of governmental organization and citizen participation in Shiga Prefecture. It has a solid structure and broad amplitude concerning Lake Biwa researches which included several participating institutions, high qualified personnel and adequate financial resource.

All these aspects show that is possible to surpass negative situations and that there is hope in the developing countries with limited resources like Peru.

I feel now strongly obliged to search for the best ways of implementing the suggested measures inside the political and institutional structure of the region.

It is necessary to identify the institutions that could participate in these important issues. The institution where I work (SEDAPAR) plays in this case a very important role

inside the User's Committee since it is responsible for water supply and waste water disposal for the local population.

As boss of the Water Production Sector(related with the water Treatment Plant) it will be possible for me to interact with Multisectorial Committee and to justify the necessity of :

a. Complementing the company's activities with the very important function of adequate environmental management;
b. having direct responsibilities concerning this management;
c. develop preventive politics through implementation of an Integrated Plan for several years.

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2. 6th Conference International Conference on the Conservation and Management of Lakes - Kasumigaura '95 .Vol 1
3. Guidelines of Lake Management Vol 1 S.E. Jorgensen.
4. Developing Countries and Environmental Issues Dr. M. Nakamura

ACKNOWLEDGEMENT

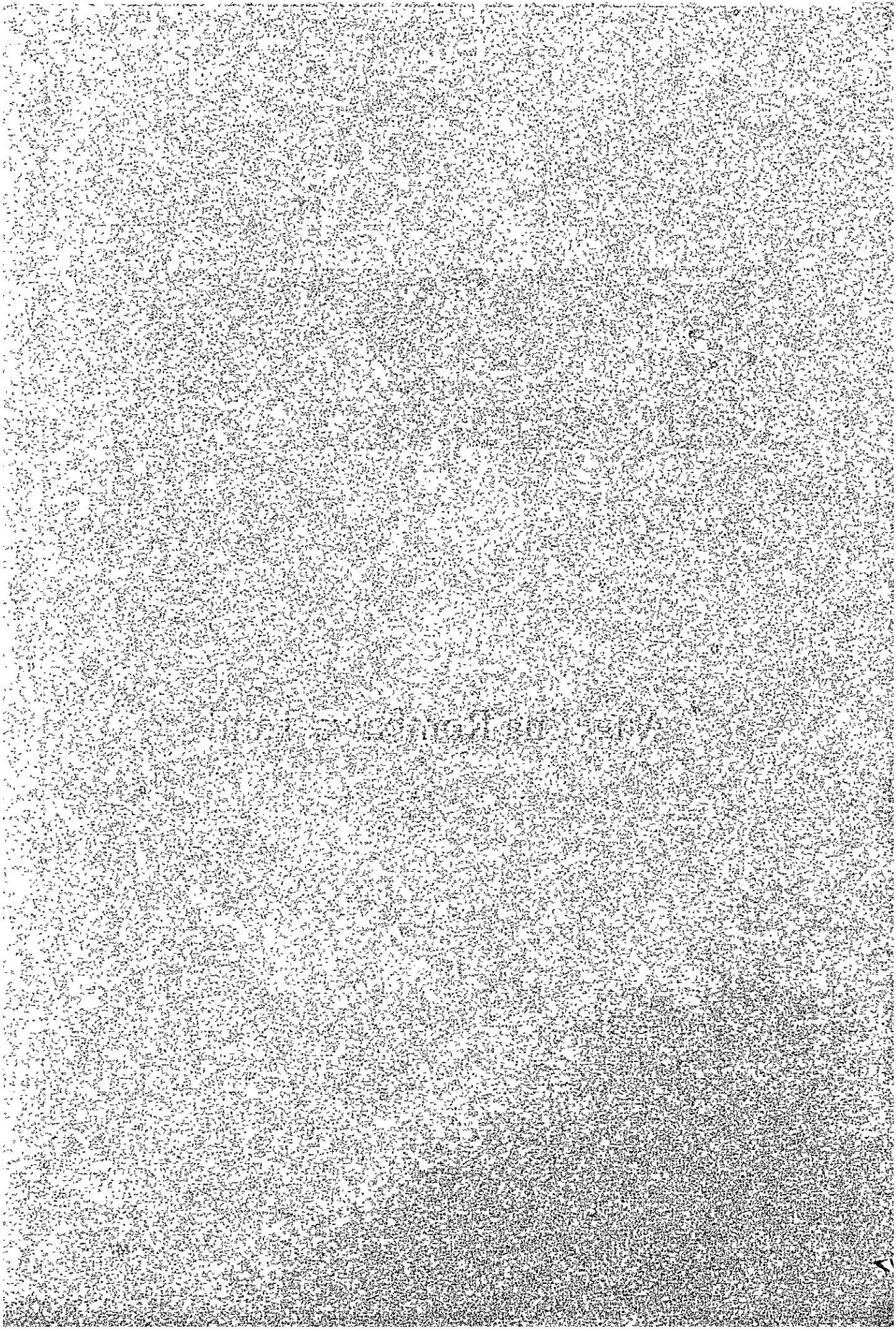
I would love to express my gratitude to Japan Government for giving me, through JICA and ILEC, this special opportunity. I would love also to thank all involved with our course for making efforts for arranging the course successfully.

Special thanks to Dr. Matsui, Dr. Nakamura, Oba San, Takeda San, Yasuko San, Toda San and Kanematsu San. Also my great appreciation to my co-participants, especially to Ruby from Ghana and Eduardo from Brazil who assisted by with translation.

Finally to SEDAPAR and my family.

The Philippines

Angelina Rombawa Tahil



WATER QUALITY ASSESSMENT AND MANAGEMENT OF LAGUNA DE BAY: PROBLEMS AND STRATEGIES

Angelina Rombawa Tahil
The Philippines

I. INTRODUCTION

Modern society has an affinity for numbers. When a number is attached to a problem, modern technology does it easily. But when numbers cannot be attached to a problem, modern man seems to be uneasy wishing the problem would go away and quantify itself.

Water quality degradation is one of the problem that resists quantification. When it occurs, something has gone wrong, but to what extent and exactly what manner is not clear. There are hardly any number to tell man what has happen or what he should do. Finding a solution is a never ending process. In fact, modern man can never find one to solve the whole problem. But one thing there is, in his mind, he can do something about it.

Japan has gone with this problem and has done something about it. Learning from its past experience and realizing that it is a continuing effort to maintain and preserve a rich nature, Japan's activities are now performing excellently with regard to this purpose and they have proven that environmental protection can go parallel with economic development.

The Philippines like Japan has also its share with the same problem, even worst. Unfortunately, we have not reached what Japan have accomplished with regards to the management of the environment particularly the management of water quality. It is in this context that the Philippines don't want to be left out. We have to learn from the Japanese experience too.

II. THE PHILIPPINES AND LAGUNA DE BAY

Right in the heart of Southeast Asia, lies a rambling chain of 7,107 islands and islets, The Philippines. (Figure 1) It has a land area of about 300,000 square kilometres, divided into three major island groupings, Luzon in the north, Mindanao in the south and in between, Visayas. Ninety percent of the area lies in the eleven largest islands, approximately two-thirds in the islands of Luzon and Mindanao, while 463 smaller islands have an area of 2,500 square kilometres. The entire island group is closely scattered within the zone bounded by latitudes 4.5 to 21 degrees and longitude 117 to 127 degrees which is in the

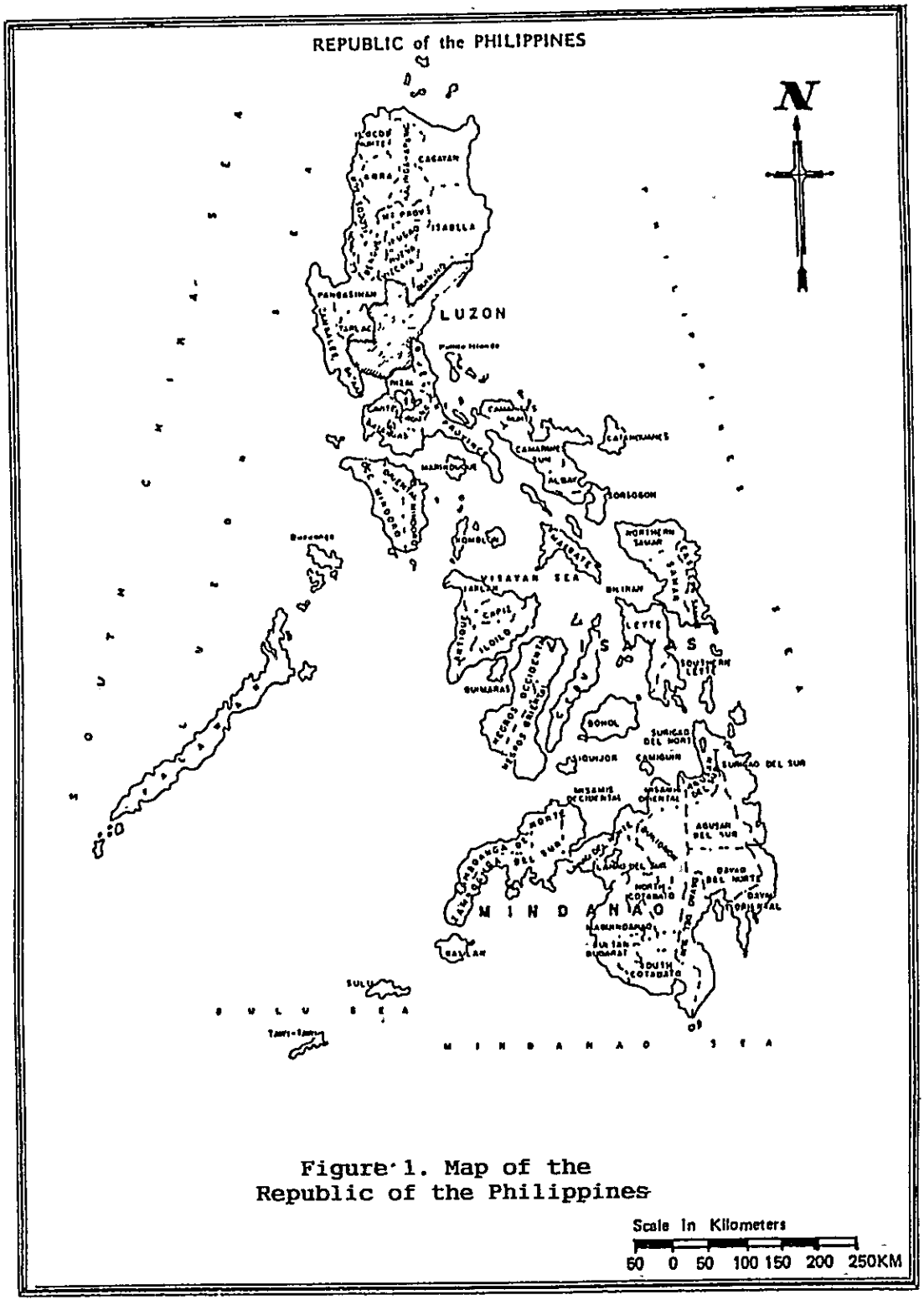
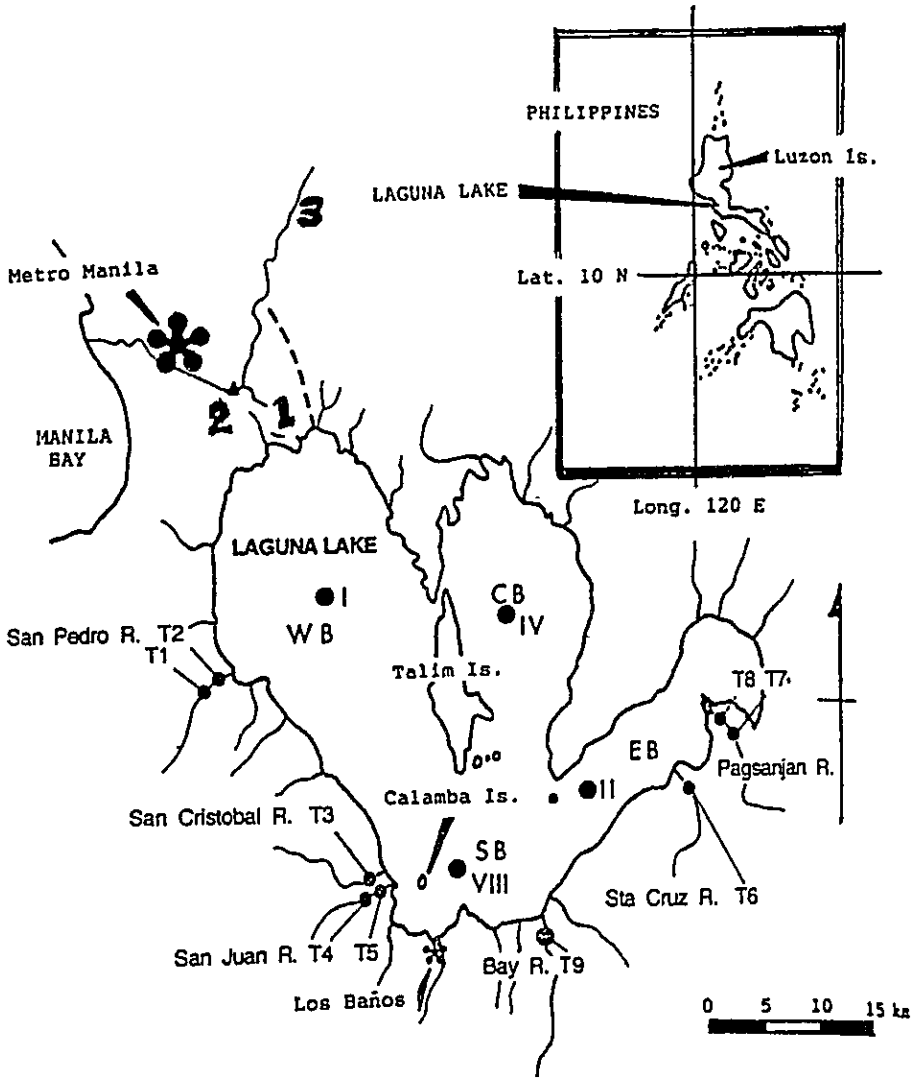


Figure 1. Map of the Republic of the Philippines



WB West Bay EB East Bay
CB Central Bay SB South Bay

1. Lake Outlet (through Napindan Channel and Pasig River
2. Napindan Hydaraulic Control Structure
3. Marikina River

Figure 2. Sampling Stations (LLDA)in the Laguna Lake Basin

tropical belt.

The Philippines is one of the countries in the world blessed with the abundance of water resources. It has about 421 principal rivers and 59 natural lakes. Laguna de Bay, being the largest inland water body, plays a key role in the national economy. It is located near the country's capital region of Metro-Manila, the centre of government, business and education and most of Metro Manila is located in the lake basin area, thus a considerable proportion of the Philippine population resides within its area. Also, most of the country's industrial establishments are distributed within the Laguna Lake Region.

General Features of Laguna de Bay

Laguna de Bay popularly known as Laguna Lake, lies at the core of 3,720 square kilometre Laguna de Bay Region. It includes the province of Batangas, Cavite and Quezon, the chartered cities of Manila, Quezon, Pasay, Caloocan and San Pablo and portions of Metro Manila.

Laguna de Bay is considered to be the largest fresh water lake in Southeast Asia covering an area of about 900 square kilometres, a shoreline of 220 km, a total volume of 3.2 x 109 m^3 and an average depth of 2.8 m.

There are about 21 major tributary rivers that drain into the lake. The only outlet is the Napindan River. The Pasig River serves as link between Laguna de Bay and Manila Bay and is joined by the Napindan and Marikina River at a Y-shaped junction. (Figure 2)

Existing and Potential Uses of the Lake

Laguna de Bay is a multi-purpose resource. At present, it is used extensively for aquaculture by means of fish-pens and fish-cages. The combined fishery produced more than two-thirds of the freshwater fish requirement of Metro Manila and the surrounding provinces at the height of its production during the late 1970s. Likewise, more than 15,000 small-scale fisher folk engaged in open lake fishing depend on the lake for livelihood.

Lake water is also used for irrigation. At present, there are about 30,000 ha of irrigated land. More than 12,000 ha received pump water and the area is expected to increase by another 13,000 ha upon the completion of the Cavite Friar Lands Project.

Some industries also depend on the lake for cooling water, power generation and the navigation for commercial and industrial goods such as bunker oil, fingerlings, consumer products and passenger services.

Unfortunately, the lake also serves as a sink for wastes generated by industrial, community and agricultural activities within the watershed. Findings in the past adjudged

that the water of the lake was the most economical source of water supply for Metro Manila, nevertheless, the plan was dropped because of the uncertainties of its water quality.

This variety of utilization demand particular often conflicting levels of water quality and quantity. As with other lakes in the world experiencing population pressure, urbanization and industrialization, Laguna de Bay represents a great challenge to environmental and resource managers.

III. LAGUNA DE BAY, A VICTIM OF GREED AND IGNORANCE

At the same time that man used water for good, he managed, either through ignorance or greed, to abuse it. Today's reality is that 3.0B people are forced to drink filthy contaminated water and as many as 25,000 people die each day as a result of bad water management.

The Laguna de Bay, as a common source, is a victim of this abuse. The big fish-pen operators. for example, would occupy hundreds of hectares of its water simply because the bigger the fish-pen, the bigger the income they could have. However, these fish-pen operators are not the only "criminals". Equally "guilty" are the wicked fishermen who use illegal and ecologically damaging fishing methods such as fine mesh nets and electrofishing which harvest both adult and juvenile fish including eggs. They never cared about the impact of such operations on the rate of depletion of the lake resources, much less about the sustainability and viability of the ecosystem.

Today, Laguna de Bay is but a silhouette of its former spell and beauty. Its naturally clear and blue water and splendid lakescape is now a frustrating view with brownish and turbid water and rows and rows of disorderly fishpens. True to say, Laguna de Bay is in great danger, even threatened with extinction.

IV. WATER QUALITY ASSESSMENT OF LAGUNA DE BAY

In spire of all the development in the region, the lake's water quality generally meets Class C standards which define the minimum water needed for fisheries However, this class standard is not met in areas of the lake near the mouths of polluted rivers, such as the San Pedro River which drains into the bay. The quality of this river reflects the effect of the uncontrolled development and industrialization of the area.

There is a need to continuously monitor and assess the water quality of the lake as an important criterion for its resource management. Unfortunately, although a number

TABLE 1. EXISTING WATER QUALITY STANDARDS
FOR RECEIVING WATER CLASSIFICATION
(Source: NPCC,1978 Water Quality Criteria)

Class	AA	A	B	C	D
Color,Units		75	50	50	
Temperature		30	30	3[4]	3[4]
Transprency			(c)	(c)	(c)
Dis.Oxygen		5	5	5	3
5dayBOD20°C		10	15	20	
TDS				1000	1000
TotalSolids	500	(a)		2000	2000
pH	6.5-8.5	6.5-8.5	6.8-8.5	6.5-8.5	6.5-8.5
Coliform, MPN/100 ml	50	5000	1000	5000	
PhenolcSubs	0.001	0.001	0.002	0.02	
TraceMetals					
Aluminum					5
Arsenic	0.05	.05(.1)	0.05	0.05	0.1
Barium	1	1(1)		0.05	
Cadmium	0.001	0.001	0.01	0.01	0.01
Cobalt					0.05
Chromium	0.05	0.05	0.05	0.05	0.1
Copper	1	1		0.02	0.2
Cyanide	0.05	0.05	0.05	0.05	
Flouride	0.6	0.6			1
Iron	1	1			5
Lead	0.05	0.05	0.05	0.05	5
Manganese	0.5	0.5			0.2
Mercury	0.002	0.002	0.002	0.002	
Selenium	0.05	0.05	0.05	0.05	0.02
Silver	0.05	0.05	0.05	0.05	
Zinc	5	5		2	2
Synthetic Detergent	nil	0.5	0.5	0.5	

TABLE I...(continuation)

Oil&Grease	nil	2	2	5	5
Ammonia		0.01			
Calcium	75	75			
Chloride	200	200			
Magnesium	50	50			
Nitrate	30	30			
Sulfate	200	200			
Nutrients		(b)	(b)	(b)	(b)

All units in mg/L except those indicated

Remarks:

(a) National Standards for Drinking Water in the Philippines
(b) Shall not be present in concentration to cause deleterious or abnormal biotic growth.
(c) Secchi-disk shall be visible at a minimum depth of 1 m.
(d) Rise in temperature.

All values are maximum permissible except for dissolved oxygen which is minimum permissible.

TABLE II. WATER QUALITY DATA OF LAGUNA DE BAY

Parameters (annual average)	Stations West Bay	Central Bay	East Bay	South Bay	Class C Standard(1978 NPCC Rules & Regulations)
Ammonia,ug/L	47.5	36.5	37.2	25.9	
Nitrate,ug/L	150	198	151	145	
Inorganic Phosphate,ug/L	88.4	104	90.7	91	
Dissolved Oxygen,mg/L	7.4	7.5	7.6	7.3	5
pH	8	8	8	8.2	6.5-8.5
Temperature oC	29	29.1	29.2	29.6	
Turbidity, mg/L SiO2	42	38	38	33	
Total Dissolved Solids(mg/L)	389	384	295	323	1000
MPN Coliform, (unit/mL)	1290	2750	1290	4720	5000
Net Primary Prod.(gC/m2/d)	0.66	0.69	0.6	0.67	

(Source: Water Quality Data on the Laguna Bay & Tributaries, Vol. 5, LLDA, 1988)

of laboratories in the Philippines are conducting some monitoring studies, no single analytical laboratory has been analyzing all the water quality parameters prescribed in Table I- "Standards for Receiving Water Classification". Therefore, assessment of the water quality of Laguna de Bay must be based primarily on parameters for which the data is available. Presented in Table II is the Water Quality of the Lake.

V. WATER QUALITY MANAGEMENT OF LAGUNA DE BAY

The production of pollutants is a continuing operation, 24 hours a day, every day of the year. In the face of the development and pressured further by the expanding economic development program, the basin resources are under severe conditions.

Water quality management involves the formulation of plans and strategies needed to maintain the water quality of the body of water prescribed for its intended use. Considering the complexity of environmental problems as well as the social, economic and political issues confronting the development, it seems best that management adopt a basin or integrated system approach which considers all the factors in the watershed that have direct and indirect impact upon the Laguna de Bay ecosystem.

Water Quality Management Problems

The conversion of the lake into a multi-purpose resources has increased food production, fish production, generated more power and created employment in the basin. However, the same processes that brought these gains also caused negative effects in the environment upon which these program depends.

Major environmental problems confronting Laguna de Bay causing deterioration of water quality, general loss of beneficial uses and aesthetic attributes and posing health hazards to residents of the basin include the following:

* Rapid siltation occurs as a result of erosion in the watershed due to forest denudation, infrastructure development and the process of urbanization. The need for a sound land use policy is to be considered.
* The cultural eutrophication of the lake occurs as a result of increasing waste loads from domestic households, expanded agricultural and livestock production and intensive fish-pen operations. This is made evident by seasonal algal blooms of massive levels which points to a high degree of over-fertilization.
* There are increasing wasteloads of toxic and hazardous pollutants from industrial activities including the operation of power plants. Most of these

industrial establishments are located in the western shore. They generated waste water which contribute significantly to the pollution loading of the lake. Furthermore, an increasing number of toxic and hazardous substance exceed the chronic criteria for the protection of aquatic life. Some of this toxic and hazardous substances are not included in the existing water quality criteria and standards. This situation clearly calls for an intensive and rational waste treatment and disposal system.

* The Pasig River back-flow that usually occurs in the dry season when the water quality is at its worst. The water is deoxygenated and polluted with industrial effluents and domestic wastes. Pasig River is considered to be the largest contributor of pollutants and nutrients to the lake contributing 930 t of total nitrogen and 420 t of total phosphorous in the backflow volume estimated to be about 2 x 108 m^3.
* With the introduction of aquaculture techniques in the early 1980s, a decline in the availability of natural food was experienced; artificial food is used to support intensive culture. Direct loadings of nutrients occur in the form of unassimilated food and organic wastes originating from the fish-pens and fish-cages. This structures also serves as physical barriers which can impede water movement affecting the distribution of natural food and nutrients. They can also be an important factor in the growth and proliferation of water hyacinth and in the occurrence of algal blooms.
* The influence of water hyacinth in the encroachment of shorelines upon the open lake is already visible. The uncontrolled proliferation of this plant could be the major factor in shortening the life of Laguna Lake. More effective methods in the control of water hyacinth is needed.
* During the height of an algal blooms which reflects the eutrophic character of the lake, water consistency can be that of a "pea soup", this condition imparts and objectionable taste and odour to the fish. Algal blooms can also cause massive fish-kills due to oxygen depletion.

On the other hand, the major social and economic problems include the following:

* The plight of the small fisherfolk and the lakeshore inhabitants, in general, reflects the threat to their primary means of livelihood by the encroachment of fish-pen operators upon areas of open lake fishing, and by the decreasing productivity of the lake due to the deterioration of its water quality. There is a need for a clear cut policy on fish-pen zoning and operations, and control of

illegal fishing methods.

* Rapid population growth in the basin exerts pressure from the human settlement both in the lowland and upland areas. Strong policies to control land use, forestry, resettlement and reclamation of foreshore areas are required.

Ecological Impacts

Among the ecological impacts resulting from the siltation, waste discharges and effect of other human activities are:

* Decreasing harvest of fish, shrimps and snails.
* A widening gap between demand and total fish-catch in the Laguna de Bay Basin.
* Fish-Kills primarily due to its hypereutrophic nature.
* Decrease/loss of other beneficial use e.g. aesthetic and recreational use.

Since ecological impacts increase at least as rapidly as the different causal factors, natural and man-made, ecological effects will escalate further. Laguna de Bay could be on a threshold of an eco-catastrophe with very serious repercussions.

VI. WATER QUALITY MANAGEMENT STRATEGIES OF THE LAGUNA DE BAY

Rapid economic development of the lake is threatening the very resources themselves. Unless this cycle is controlled in all respects, the degradation of this resource will pre-empt the objects of development, which is directed toward the ultimate goal of improving the quality of life.

The proposed water quality management strategies for Laguna de Bay are discussed in the following. Some strategies proposed are based on the Japanese Experience.

Regional Wastes Control Plan

This is seen as a rational approach to a basin-wide pollution control. The regional plan would encompass concepts of economy of size and conservation of water resources through reclamation of by-products and treated wastewater for agricultural irrigation. The concept of economy of scale is particularly important to industry since the large expenditures are forecasted for industrial waste control in the basin. In lieu of waste

treatment plant at each industrial site, regional treatment facilities can reduce overall capital investment demands of industry as well to introduce economy through the inherent nature of large regional facilities.

The agricultural land waste control plan will cope with the many commercial feedlots of hogs, chicken and ducks, which are the source of large quantity of pollutants to the lake. At the same time, irrigation return water from the extensive rice fields in the basin, which contain residual fertilizers and pesticides will be controlled.

Finally, the waste from human sources and habitation must be reduced for this represents major contributions of pollutants to the lake. The ultimate goal of the regional pollution plan is to control the total pollution load reaching the lake. Since it has been determined that nitrogen and phosphorus are the principal cause of stimulant for algal blooms in the lake, the plan is directed toward the reduction of nutrient loads from waste water. This is not to indicate that other pollution problems as organic, toxic and hazardous substances in industrial wastes should be disregarded because this may have a long term irreversible effects on lake water quality but that the basin pollution control strategy should be nutrient control oriented as a primary goal.

Solid Waste Management

Nutrient inflow of the lake from solid waste are relatively minor importance. However, the problem may be serious in the future as less land is available for proper solid waste disposal. Garbage collection system in the lakeshore communities should be installed. Adoption of a garbage collection and disposal system wherein the different kinds of garbage are segregated at source for recycling of papers, metals, glass and plastics would be ecologically beneficial. Organic waste should be converted into compost.

Land Use

It has been said that the most effective means to control pollution is to control land use. Therefore an important element of the water quality management plan is the preparation of a land use plan covering the entire basin, from the urbanizing areas close to Metro Manila to the more remote mountainous areas. This would identify present and potential land utilization of the basin from which planners can prepare zoning regulations reflecting these potentials and at the same time incorporating needs for environmental protection. When enforced by the local authorities, the land use plan and zoning regulations would form powerful means to regulate pollution sources and the general environment of the basin.

Fishery Management

Zoning and limitation of the fish-pen area to correspond with sustainable productivity. Results of latest observations show decreasing primary productivity in the lake, due to high water turbidity and other factors; the carrying capacity of the lake may need to reassessed. Related to this, is the control of illegal fishing methods.

Lake Shore Management

Aside from the standpoints of fisheries and landscape conservation, lakeshore ecosystem must be carefully manage in order to have a good water quality.

The transition or buffering zone should be maintain to meet specific goals as:

* Maintain the water quality of the transition zone as well as that of the lake.
* Reduction of erosion.
* Protection from flood.
* Provide a buffer zone between human settlement and the lake.
* Maintain a gene pool of plants and animals.
* Control insect populations.
* Provide habitats for fish spawning and bird nestling.
* Produce renewable resources Phragmits are, for instance, used for instance, in many European countries as roof materials.
* Provide aesthetic support for human beings.

Water Quality Monitoring, Surveillance and Enforcement

Research managers need to be provided with data and information on the ecological state of the lake as well as the qualitative and quantitative aspects of waste loads reaching the lake. A continual program of monitoring the lake coupled with the surveillance of waste sources is a vital and viable part of the management plan. To facilitate this need, water quality monitoring program has to be improved and the installation of Automatic Water Quality Monitoring Station of the lake and its tributaries is needed to intensify the monitoring of the lake.

Furthermore, frequent examination of wastes from the industries must be made. All industries must have the permit for waste discharges including submittal of routing reports. Producers of dangerous waste substances must exercise constant testing and control and demonstrate this in their regular report.

Provisions for enforcement action on violators, will be needed to discourage the discharge of waste beyond permissible limits and will form a basic strategy to preserve the lake for the many beneficial uses. The threat to monetary fines and imprisonment remain

the ultimate deterrent in this program.

Dredging and Deepening the Lake

Lake sediment could be used to help reclaim load for residential, agricultural or recreational uses. This would compensate the cause of dredging. Eventually, the lake would be cleaner and this would benefit multi-purpose use, including recreational swimming, fishing and boating for tourist.

Clean-Up and Control of Pollution in the Different Tributaries

Rivers and streams which are highly polluted, need to be cleaned and dredged. These dredged materials could be combined with lake sediments in landfill, waste should be treated before discharge.

Intensive Educational Campaign

Environmental Education will serve as a key role to raise the level of environmental awareness and to avoid the irreversible ruin of the environment. This must imparted to the younger generation for them to continue as a lifetime learning process. Environmental Education should be initiated in schools giving classes centring on regional aquatic environments and developing teaching materials and curricula with the students' participation.

Power of the media which includes newspaper, periodicals, booklets, educational films and videotapes is also major influence in alerting the people to the importance and potential hazard of environmental degradation.

Professionals, science writers should be asked to aid in carrying out this program and scientists and engineers who have been active in water quality management should provide the background information needed by media representatives.

Legal, Institutional and Administrative Arrangements

While there is an urgent need for water resource development, there is also an equally confronting necessity to manage the environment. In the development of the Laguna Lake Basin, numerous agencies are involved with a variety of conflicting interests in the management of water quantity, but for water quality management, conflicts do not exist in the sense that everybody wants lake water quality to be improved.

The establishment of legal and institutional arrangement represents a mandatory first step, For this purpose, the Government has designated the Laguna Lake Development authority (LLDA), a government corporation, as a primary agency

responsible for the development of the basin and protection of the resources and most importantly, to settle conflicts.

To strengthen the goal to preserve the lake, all government agencies should take environmental matters more seriously with respect to the implementation of environmental laws and regulations.

Research Development

Research and technology transfers are necessary for the sound management of lake, and should be pursued with more vigour and intensity. Some of the projects that are needed include:

* A program on limited research on limnology and inland water with recognition with the massive efforts in the field conducted in developed countries, so as to avoid needless duplication.
* Special efforts will be devoted to the area of low cost treatment by natural ponds or lagoon systems which encompasses reclamation and conservation principles.
* Conservation of reed colonies not only as a natural way in the purification of lake water quality, but also as a protection of the lake shore from erosion and valuable habitat for the birds and aquatic organisms.
* Purification of sewage by a self-cleansing snail called "Sinotaia quadrata histrica".
* Extensive study on toxic and hazardous substances in lakes and reservoirs such as Trihalomethane (THM) and Dioxin which pose a threat not only to water body itself but also to human health.
* Monitoring and collection of more baseline data on environment quality parameters, processing this data, and storage in computerized databases.
* Maintenance and improvement of genetic stocks, including the development of broodstock for the aquaculture industry.
* Further research on eutrophication which includes:

- Long term multi-disciplinary studies should be established to improve understanding of the mechanisms and processes of eutrophication and to formulate feasible management procedures both preventive and corrective.
- Development of information on the potential value of algae and rooted aquatic plants as crops, food or as a source of pharmaceutical or other biochemical products.
- Further research on the role of water hyacinth for large-scale nutrient removal

and water purification and its production of massive quantities of desirable products such as high quality vegetable protein, vitamins, minerals, energy (in the form of biogas), fertilizers and chemical fibres.

* Extension and action programs related to environmental awareness, family planning, proper waste disposal and other key environmental and related socio-economic issues in the basin.
* A study on the proposal in the management of the lake to phase out in three years all fishpens and allow the lake to rest to recover its ecological balance. A two-year rest period follows during which the Bureau of Fisheries and Aquatic Resources will conduct fish stocking in open water. Then, the Laguna Lake Management Authority (LLDA) will allow the gradual phase-in of fish pens in the lake but only to some portion. Alternative livelihood industries such as mushroom cultivation, vegetable farming and other form of horticulture could de developed.

Human Resource Development

The complexity of environmental problems confronting management of lakes and reservoirs intensifies the continuing need for highly skilled manpower to staff the various agencies engaged in the protection of the environment. In order to provide a steady source of supply for trained manpower and to keep abreast with current trends in environmental protection, staff expertise should be developed through participation in local and foreign training programs in the field of water quality management.

VII. LOCAL COMMUNITY RESPONSE TO ENVIRONMENTAL PROTECTION OF LAKE BIWA, AN INSPIRATION

This is one of the most important factors in the realization of the goals of water quality management. Without the concern of the people, water quality management plans and strategies remain futile.

The following shows the willingness of the Japanese people to maintain a rich and liveable nature which will serve as an inspiration not only for the Filipinos but also for people in other countries.

Residents Movement for Environmental Protection

1. Movement to Make Lake Biwa Beautiful

The Shiga people voluntarily clean the lake, its shore roads, parks and square.

2. Local Effort to Build Liveable Environment

Today's culture marked the preference for material satisfaction and convenience. Considering this change, the Shiga people launched an earnest and low-profile effort to create an elegant and relaxing environment, wherein historical heritage is preserve and brings back the face to face relationship of the people.

3. Movement to Promote Lifestyles Beneficial to the Water Environment

Doubts were expressed over the safety of synthetic detergents with regard to the impact on living creatures in Lake Biwa. The movement for the promotion of the use of soap powder is built. A Consumer Cooperative was also established with a view to selling environment-friendly products.

Solidarity of the Japanese People

The solidarity, patience and optimism of the people to content their right to be protected from pollution and to live in a healthy environment to a triumphant end is something admirable, which is evident in the following discussion.

1. The victims of Itai-itai decease, Minamata Decease and Yokkaichi Asthma brought the case to the court and after a long and politicized debate, the suit were settled in their favour and they receive full compensation.

2 In Shiga, the residents in Maibara Town filed a lawsuit against Antimony Smelting and an agreement was settled to improve pollution equipment and compensation for damage suffered

3. PCB contaminated some fish and fishermen were dissatisfied and were so angry to find no demand for their fish, that they damped truckloads of unsold fish at the entrance of Prefectural Government Building. The government set about investigating what was responsible for the pollution. In the meantime, the residents formed a conference and organized study by themselves. At the end, the company agreed to pay.

VIII. CONCLUSION

Japan has made it clear that development and protection of the environment is never a hindrance in the national goal to improve the quality of life of its people in both

economical and environmental terms.

Though it is still far from reality, we will also reach this scenario inspired by the Japanese experience.

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MARAMING SALAMAT PO SA INYONG LAHAT... DOMO ARIGATOO GOZAIMASHITA !!!