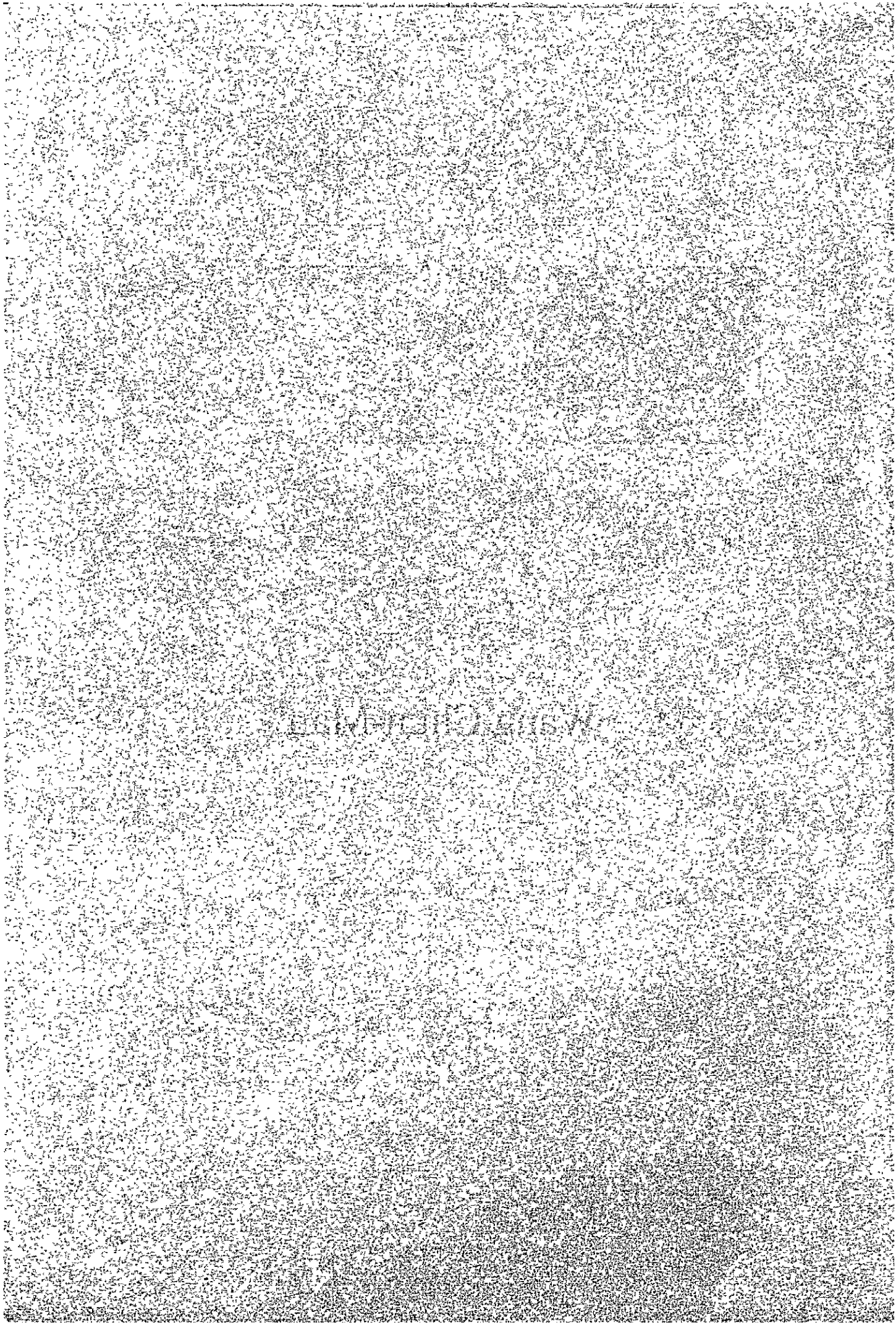
China

Wang Chun-Man



LAKE DONGTING

Wang Chun-Man

China

1. INTRODUCTION

Water is one of the primary element in biosphere. Fresh water is indispensable to human life. It exists in rivers, lakes, reservoirs, ponds and groundwater. Most of these water bodies is being used for many purpose such as irrigation, industry and drinking water supply, aquaculture, hydroelectricity, transportation and tourism. In spite of the wonderful gift of nature, man has abused its importance and polluted it in many ways with unplanned developments, and haven't realized the importance of the gifts: since now these gifts of nature have been polluted too much, we must not only prevent further pollution but also try to undo the bad done by man to these gifts.

China is vast in area. Lakes and reservoirs scattered all over like stars. The south-east area is very rich water resources and there it has lot of water related project such as hydropower houses, irrigation dams and reservoirs. However, with the industrial development, lots of lakes have a trend of deterioration of water quality.

Nowadays, more and more peoples are aware of this problems, and our Government is paying tremendous efforts to harness environment. Therefore, Minister of water resources, as main department for water resources utilization and exploitation, have more responsibility for water environment protection. Thus, as one of staff of this Minister, it is very necessary for me to learn advanced knowledge of management and research of lakes, reservoirs.

I will try to apply some appropriate ideas and knowledge gained by me during the Training here in Japan to harness the Lake Dongting environment.

Lake Dongting is the second largest fresh water lake in China, located on the north of Hunan province, between 110° and 113° E longitude, 28°30' and 30°20' N latitude, with a surface area of 2,619 square km (different period have different area). There are four inlets, called Songci, Taiping, Ouchi, Tiaoxian, respectively, to receive inflow from Yangtse River on its north, and four tributaries, named Xiangjiang, Zijiang, Yuanshui, Lishui, Jioning the lake form south. There are only one outlet which connect with the Yangtse River again on its east. All of the drainage nets forms a complex water system with the lake as its centre.

Lake Dongting is a shallow water pathway lake. Runoff of the lake is originated from the inflows from the Four inlets and Four tributaries. According to the hydrologic

data from 1951 to 1990, the mean annual runoff is 301.8 billion cu. m of which 112.0 billion cu.m from the Yangtse River, 164.7 billion cu.m from the Four tributaries and 25.1 billion cu.m from local runoff. In terms of percentage, they amount 37.1%, 54.6%, 8.35%, respectively.

The Lake is surrounded by four cities and sixteen counties with the territory area of 9,063 sq. km, out of which 3873 sq.km is cultivated land

2. PHYSICAL DIMENSIONS

Surface area	[km^2]	2619 during dry period
		3900 during flood
Volume	[10^9m^3]	33.8 during flood
Maximum depth	[m]	30.8 during flood
Mean depth	[m]	6.7
Annual water level		
variation natural	[m]	6.5--17.8
Theoretical filling time	[Yr]	0.12
Catchment area	[km^2]	262,823*
Mean annual runoff	[10^9m^3]	301.8
Mean annual runoff		
exchange coefficient		17.3

* This area does not include the catchment of Yangtse River

3. WATER QUALITY

Before 1981, the counties and cities used to monitor the part of the Lake and the channel in their respective area ,and there was no co-ordination. But after 1981, the water quality is monitored by several institute as per the guide lines issued by National Environment Protection Bureau.

3.1 Status of the Lake water quality

ITEM		RANGE*	AVERAGE
Water Temp.	[°C]	17.9--26.9	19.3
pH		7.4--7.9	7.7
TRANSP.	[m]	0.21--0.64	0.41
E.C.		156--257	194
SS	[mg/l]	23.6--293.2	75.0
DO	[mg/l]	7.3--9.1	8.2
COD	[mg/l]	1.6--2.44	2.17
BOD	[mg/l]	0.33--0.96	0.72
NH_3-N	[mg/l]	0.1--0.40	0.22
NO_3-N	[mg/l]	0.51--1.10	0.83
NO_2-N	[mg/l]	0.006--0.024	0.014
T--N	[mg/l]	0.80--1.53	1.13
T--P	[mg/l]	0.023--0.049	0.035
Vol-Phenol	[mg/l]	0.000	0.000
CN-	[mg/l]	0.000	0.000
Cr^{6}+	[mg/l]	0.000	0.000
Cu	[mg/l]	0.000--0.002	0.001
Pb	[mg/l]	0.000--0.005	0.001
Zn	[mg/l]	0.000--0.007	0.004
Cd	[mg/l]	0.0000-0.0001	0.0000
Hg	[mg/l]	0.00000-0.00002	0.00000
As	[mg/l]	0.001--0.007	0.002
T-Bacterium	[ind/ml]	209--842	519
Coil-index	[ind/l]	3057-17225	9231

*These data range is from thirteen sections of the Lake

3.2 Abstract status of the water quality

a. Monitoring data of all the sections from 1991 to 1992 indicate that total nitrogen, total phosphorus and coli-index commonly exceed the corresponding state standards, but all of rest parameters can be classified as class three of the National Environment Quality Standard for Surface Water (GB3838-88). In some areas the water quality standard requirement is class second and the parameters are within this standard.

b. Data recorded over the years indicates that annual quantities of pollutants entering the Lake have been increasing year by year However, the water quality is not so deteriorating. The main reason is that the Lake has a peculiar hydrologic and hydromechanical conditions and a large inflow. Especially in flood, water bodies exchange time is only seven days, the capacity of diluting, diffusing and self-purifying is strong.

c. Although T-N, T-P commonly exceed the National standards, the water bodies still belongs to mesotrophic. As the Lake is a open water way lake so the water bodies are exchanged with a high frequency. It is disadvantage for algae to reproduce, consequently no serious eutrophication has been observed in main area of the Lake.

d. The intake water from upstream contains high sand and soil concentration lead to the transparency value very low. Especially in flood period it looks like yellow water, the lowest transparency value is only 0.21 m. But in dry period, it can reach to 2-4m, this is to say the flood is the decisive factor which bring sediments and cause serious siltation in the Lake.

4. PROBLEMS

4.1 Pollution sources

a. Industrial pollution sources

As per the survey, 1,803 industries are pollution sources, out of which 141 are large industries. In the eastern side of Lake area there are textile mills and petrochemical works, but in south-western side of the Lake area there are paper mills, food processing industries. The total annual discharge of industrial wastewater is more than 300 million tons , but the treatment rate is only 36.45%. Recently, local industry (village industry -- township enterprise) are developing very fast. But these factories do not have enough resources for wastewater treatment and they discharge wastewater into the drain or sewer system. These are main sources of pollution as all wastewater finds its way into the Lake There is large growth of such industries after the Reforming and Opening of China.

b. Agricultural pollution

The Lake Tongting area is the important grain production base of Hunan Province even of China. Thus, in order to increase the grain production more and more pesticides and

chemical fertilizers are used in stead of traditional cultivational methods. The excessive use of chemical fertilizers and pesticides have led to contamination of water by high concentration of toxicity, nitrogen and phosphorus.

Additionally, the production of hemp is very popular. During the rotting hemp period, the inner lakes and channels are used as tank for rotting hemp, amounts of COD pollutants not only contaminated the inner water but also finally caused the deterioration of the Dongting Lake local water quality.

c. Domestic sewage

There are four large cities and sixteen counties towns around the Lake Dongting . Only Changsha city which is capital of Hunan Province with 1.1 million citizen, has two sewage treatment plants with present capacity 50,000 m^3/day, design capacity 90,000 m^3/day.

But other cities and towns have no domestic sewage treatment plants. Their domestic sewage is discharged directly into the drain system without treatment. The sewage do not include night soil which is usually treated in digestion tank, and in countryside, all of night soil is used as fertilizer .

The total discharge of domestic sewage is more then 45 million tons, about 35% only is treated.

d. Local contamination

Contain pocket of lake where the pollutants are discharge into lake, here the water quality is bad. There are four parts of water area which have been polluted seriously, sometimes, the value of COD is as high as 11.3 mg/l.

4.2 Sedimentation

The permanent catchment of the Lake is from four tributaries but during flood when the Yangtse River is flooded the water from four inlets enter into the Lake with lots of silt and speed of water is slow in the lake. Around the Lake due to growth of thick reeds and other plants, it deposit the silt into the Lake bed. The contribution of silt is 120 cu.m and the out carrying capacity of silt by water is only 30 million cu.m, about 90 cu.m of silt is deposited into the Lake. Thus cause a reduction in capacity of the Lake and there is always a danger of water outflanking the banks, especially western area where deposition is very large .

According to investigation results, the deposition rate was calculated to be 9.5 cm/yr. The Lake beach was higher year by year, and was dyked by farmer until the

Government forbid this activities by 1980s. The water area of Lake Dongting has reduced from 6,270 sq.km in 1640's to 3900 sq.km in 1990s .

4.3 Flood disaster

Almost every year there is flood, the reason is that there is heavy rainfall in the catchment of tributaries and Yangtse River. The rainfall is around 1200-1400mm annually and that too for a short period form May to September. The banks of lake overflow and sometimes the high banks can't resist water pressure and give-away. Thus causing flooding of villages which are at low level. The second reason is that due to lake siltation and initially long time reclamation for agriculture use.

In comparison to Lake Biwa whose surface area is 670 sq.km with 4,016 sq.km catchment area and almost the some rainfall intensity as comparing to Lake Dongting, i.e. 1 sq.km surface area bears only 6 sq.km of catchment area. But Lake Dongting surface area is 3,900 sq.km (maximum) with about 35,580,000 sq.km of catchment area, i.e. 1 sq.km surface bears 90 sq.km of catchment area. So in view of above factors, it is very difficult to control the flood water.

5. REMEDIAL MEASURES

Since 1970s China has implemented various environment policies overall management. But the problems are created between economic development and environment protection of nature.

The water & power department of Government as the water resource authority is playing an important role for water environment protection. In order to resolve above problems, the comprehensive development project has been enacted.

5.1 The comprehensive development project

Before 1984, the various works connected with the Lake were undertaken by the local Hunan Government. In 1984 the central Government formed LDCDP (Lake Dongting Comprehensive Development Project) The project has two phases, phase first was from 1984 to 1994, and phase second is in progress i.e. from 1994 to 2004. The main features of the project are:

a. Raising/Reinforcing the height of the dykes.
b. Construction and reinforcing of water gates.
c. Dredging of Lake bed and channel.
d. Construction and reinforcing of pumping stations.

e. Safety-alarm devices during flood .

5.2 Sedimentation control

Since most of sediments of the Lake Dongting about 83% are from the Yangtse River. Due to its large catchment and runoff this is the main reason why sedimentation control is too difficult to execute.

Although the central Government issued erosion protection law and launched several afforestation movements, but the achievements was not so affected because of with the rapid increase in population. The land was converted into the farm land, and the people living in the catchment area have not realized the effect of the erosion deeply, In view of above facts, Government decided countermeasures as follow:

a. The work of afforestation movement Water and Soil Conservation Project is in progress in up and middle reaches of Yangtse River.
b. Building Dams and Reservoirs. e.g. The Shanshia (The Three Gorges) Reservoir which will be the largest reservoir and water power plant in the world. It will also control flood about 30 billion cu.m and the installed capacity more than 13,000 MW. With the construction of this project, the problems of flood and siltation in the Lake shall be almost solved.

5.3 Water quality monitoring

Around the Lake Dongting, each city and county has its own environment monitoring agency to monitor the inner lakes, channels and part of main Lake. Two vocational institutes, one belongs to Water Deportment another belongs to Environment Agency, which are in charge of water quality monitoring in all lake. There are also some institutes and universities sometime monitoring the water quality of the Lake for environment science research.

Now, there are sufficient monitoring institutes, but there is lack of co-operation and water quality data is not exchanged frequently. There is also need to increase the number of monitoring stations. Hence it is necessary to carry out some agreements between the two department and lots of local monitoring agency.

5.4 Pollution load control

It is worth to put forward that our national laws for pollution controlling are stern, and regulations are strictly implemented for new projects, which have to pass the environment impact assessment report and the checking for environment protection facilities before acceptance.

As for old industries, the waste water is have to meet the national effluent standards. If they can not meet the standard, they will be fined even production can be stopped. Many village factories without having better treatments are closed or moved. For domestic waste, the sewage system treatment is the only solution to prevent pollution of water. but due to constraint financial resources, the work is being delayed and implemented step by step.

5.5 East Lake Natural Reserves

Eastern area of Dongting Lake is the important wetland of China. It is famous for migratory birds due to its geographical position is richly endowed. In winter, it is bird's-eye sight season, millions of birds form North of China and Siberia, such as storks, vultures, warblers etc. Many species of birds belong to rare bird which only can be observed in Dongting Lake area.

In order to conserve the multiplicity of biological species, we established an institute which named Eastern Dongting Natural Reserves Park, and delimited a boundary for it.

6. PERSONAL FEELINGS

Through the study on Lake Water Quality Management particularly Lake Biwa case study, I felt the urgency and formidability of our protection work for Dongting Lake. On one hand, we have no so good economical situation, on other hand we lack the appropriate technology and experience of management. Even this we have to do our best for environment.

I am deeply moved by what Japanese citizen's consciousness for environmental conservation. e.g. the housewives use soap powder to replace synthetic detergents even it's not so convenient. This is the issues on environmental education
and citizens' movement.

Then I think that, not only the facilities and financial capacity are important, but also the quality of each implements are more important. We should make known the importance of environmental protection from education of children.

As an environmentalist, no matter how hard is the situations, we must try our best to implement environmental conservation to save our natural resources. I will be very happy if I can perform my duty in this aspect.

ACKNOWLEDGEMENT

I would like to express my sincere thanks and appreciation to JICA and ILEC for offering me the opportunity to participate in this training course .

Thank you very much:

JICA and ILEC staff, you are so kind and generous .

Professors, for your excellent lectures

And other institutes, companies etc.

All participants and Kanematsu San, Toda San, for our marvellous two months. I consider myself fortunate to have such charming friends. I will remember you .

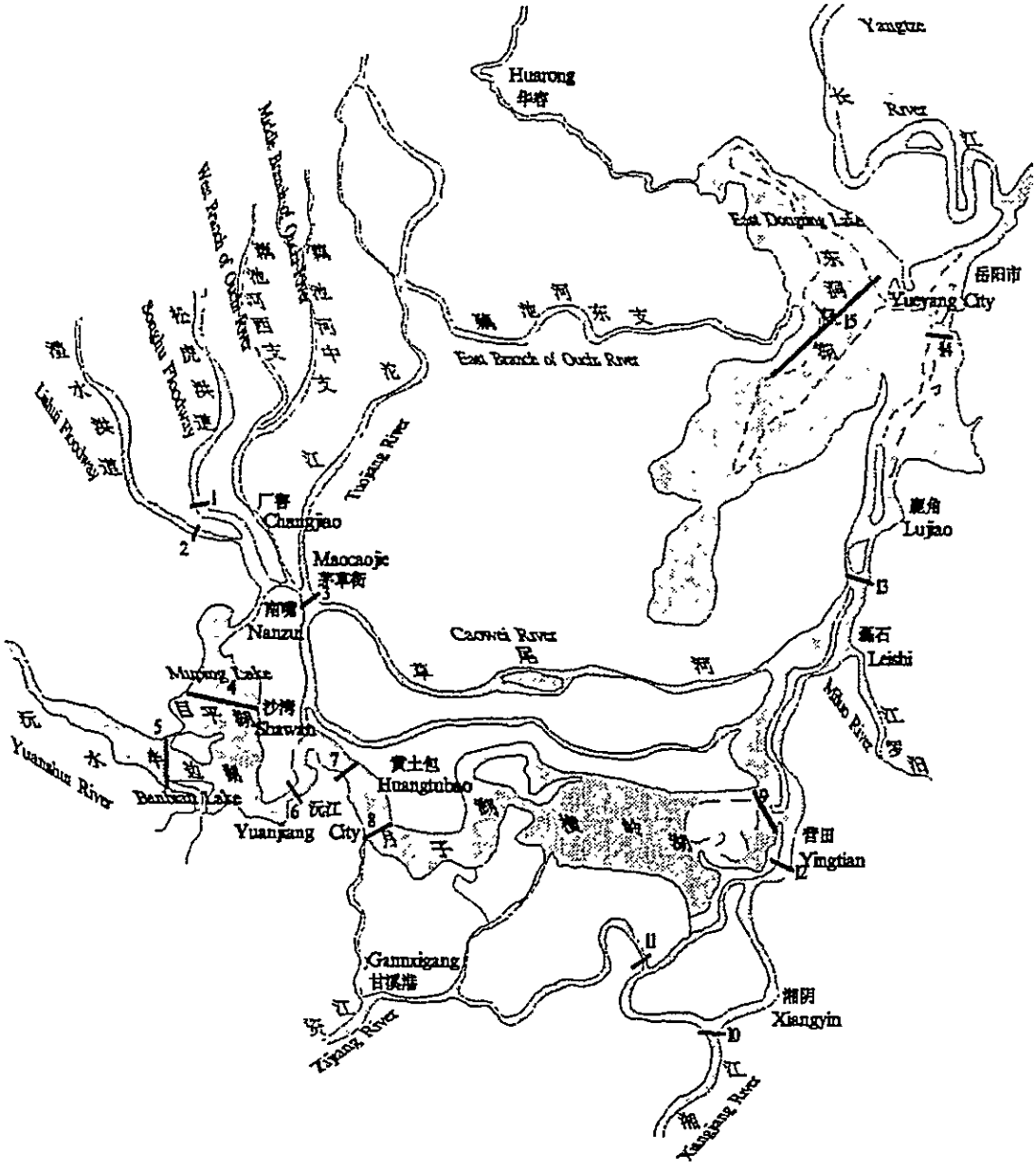
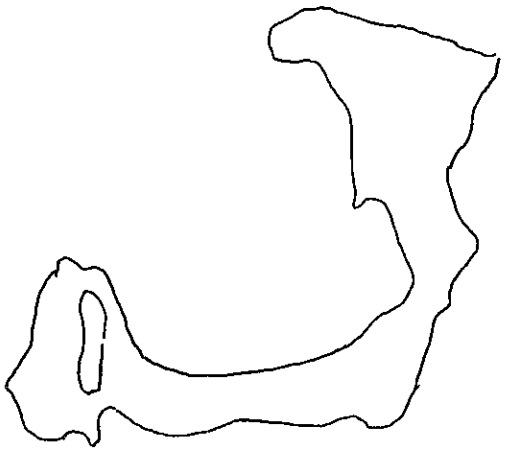
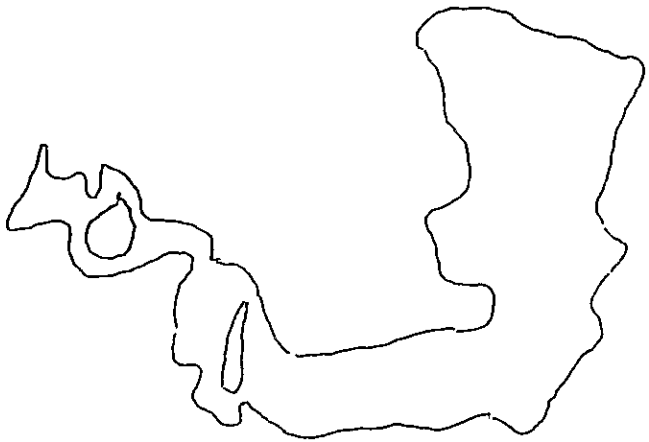


图 1 洞庭湖水环境监测断面分布图

DRAFT OF QUALITY MONITORING SCHEME
IN THE DONGTING LAKE AREA

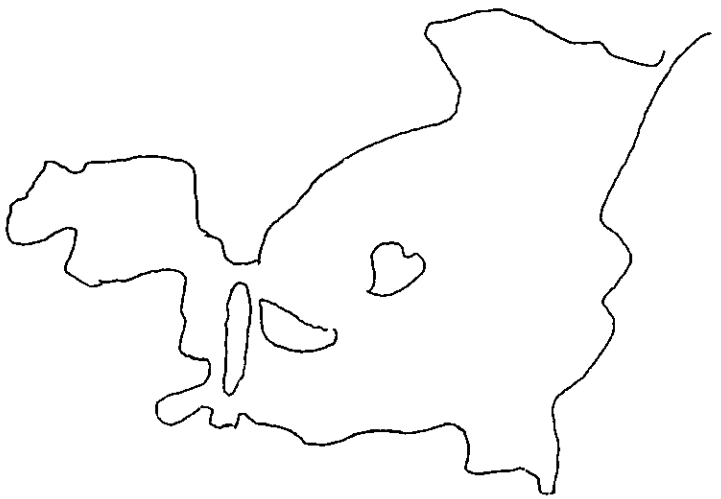


1950 – 1980



1916 – 1950

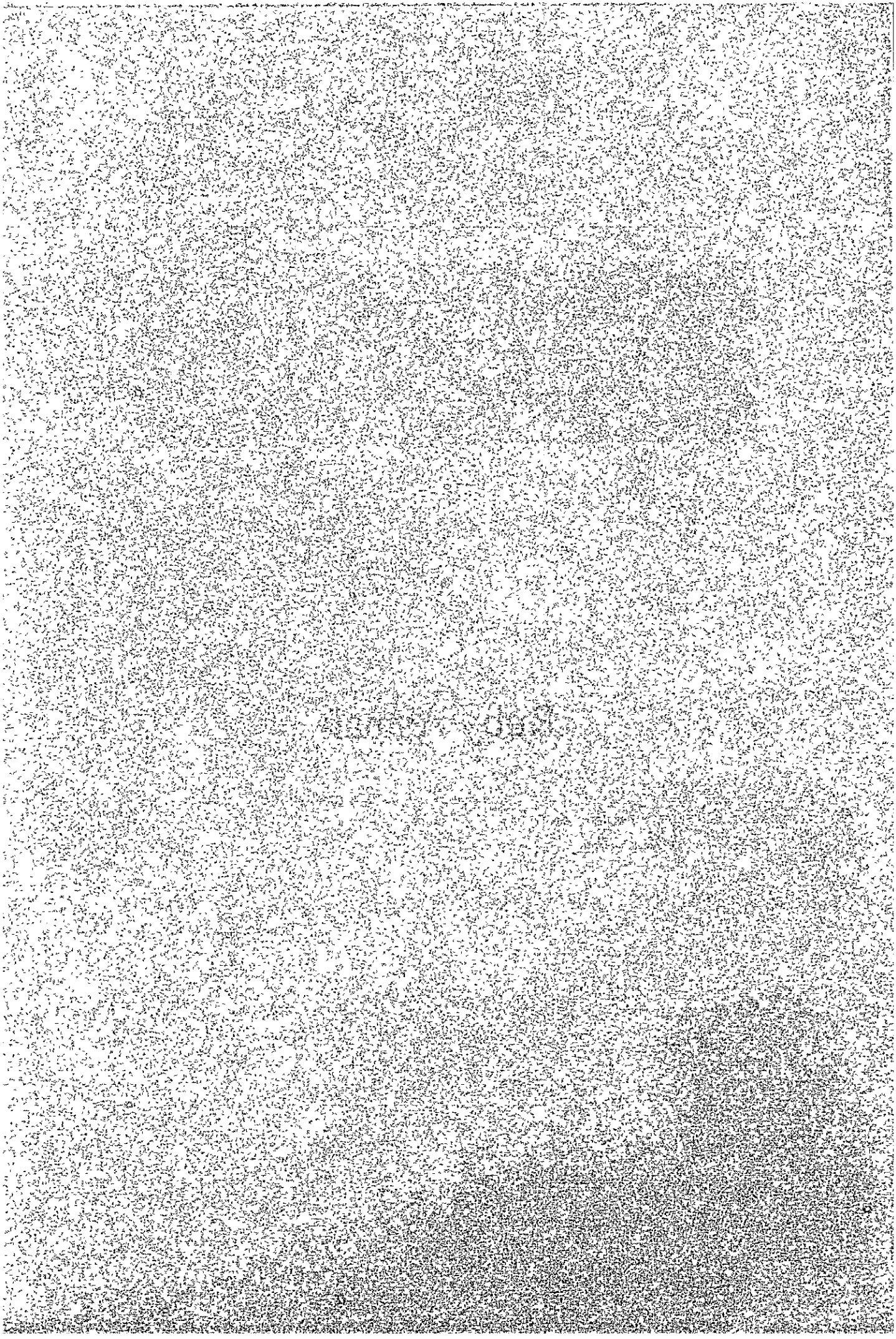
1644 – 1825



1826 – 1915

Ghana

Ruby Asmah



WATER QUALITY MANAGEMENT OF WEIJA RESERVOIR AND ITS DRAINAGE BASIN

Ruby Asmah

Ghana

1. INTRODUCTION

Lakes and reservoirs occupy less than 0.01 percent of all water on earth. They hold important great number of species in which there is much interact with each other. Everywhere in the world, lakes and reservoirs are becoming more and more important as dependable sources of water supply in large amounts. They are more attractive sources than rivers and underground waters for big water consumers such as cities and industrial centres. They also provide good fishery grounds for numerous communities, water for agriculture, hydroelectric power in some cases and unique recreational opportunities. In terms of size, number and distribution, man-made lakes today are quite comparable with freshwater natural lakes. Unlike rivers however, lakes have a more complex and fragile ecosystems They do not have a 'self cleansing' ability and therefore readily accumulate pollution. Sustainable use of lakes and reservoirs are currently being threatened in both developed and developing countries.

In view of the importance and uniqueness of this limited resource, the physical and chemical degradation of lakes and reservoir should be considered as an emergent issue that needs world wide cooperation.

1.1 The Weija Reservoir

The Weija reservoir was created from the Densu river which has for years served as a source of domestic water supply to people living in the eastern part of Accra city and towns along the course of the river. It became necessary in 1974 to impound the River Densu, in addition to the Volta Lake, to create a larger reservoir to meet the increasing demand of water supply for drinking, irrigation, agribusiness and associated industries in the Accra-Tema municipality.

The impoundment of this once well aerated river was not without problems. Some of the initial problems encountered which are related to eutrophication included; complete depletion of oxygen, overgrowth of aquatic weeds, it was estimated that 70 percent of the water surface area between the dam site and Machigeni (Fig. 1) was covered by a mixture of the weeds, and nuisance blooms of algae, mainly diatoms and blue-green algae associated with water pollution, taste and odour (IAB., 1979).

There has over the years been a remarkable increase in dissolved oxygen concentration but eutrophication, growth of weeds and algal blooms are still problems that need urgent attention.

This report outlines activities polluting the reservoir and the Densu river, its main source of water inflow, directly through point sources such as domestic and industrial waste discharges and indirectly through non-point sources like agriculture and urban run-off. The report also outlines management plans necessary for the conservation of the entire watershed as a source of water supply.

1.2 Geographical Location and Size of Weija Reservoir

The Weija reservoir is located 17km west of Accra and about 8km from the sea between longitude and latitude 5 35 N and 0 22 W respectively (Fig. 1). It is an earth and rock-filled dam, 374.9m long with a 5-gated spill way. The maximum height of the dam above the river bed is 15.85m. The normal surface elevation of the dam is estimated at 14.33m with a maximum at 15.24m. At the normal water level (14.33m) the reservoir will cover an area of 33.6km^2 with a shoreline of 48km (IAB, 1979). The construction of the dam was completed in 1977.

Below is a brief description of the Densu river, the main source of water to the reservoir.

1.3 The Densu Basin

The Densu river is a coastal river and as a source of drinking water, it is one of the important rivers in the country. The river is approximately 115km long and drains an area of about 2564km^2 (Fig. 2). The main activity within this drainage area is agriculture (Fig 3). The river has a mean annual run-off of 385.0 x 10^6 m^3 at Manhia (Larmie, 1992).

The Densu basin comprises of moist deciduous forest to the north and a coastal savannah of thickets and grasslands to the south. However, due to the rapid expansion of the cocoa industry, very little of the forest remains and what is left is mainly secondary.

Current and projected populations by districts within the study area are presented in Table 1.

Table 1: Densu River Basin - Current and Projected populations by district

Name of District	Area Within Basin km^2	Population size x 10^3 1960	1970	1984	1990	1995	2000
Akwapim North	100.4	9.6	11.1	85.1	203.5	420.6	869.5
Akwapim South	240.9	31.1	38.8	91.5	132.3	179.7	244.2
East Akim	353.7	33.2	36.1	98.2	150.9	215.7	308.5
Kade/Akwatia	22.6	1.6	1.6	1.5	1.5	1.4	1.6
New Juabeng	155.6	85.4	110.7	92.5	85.6	80.2	75.2
Suhum	847.5	78.6	103.1	106.5	108.0	109.3	110.5
West Akim	128.0	13.3	14.2	46.3	397.5	914.2	1102
Awutu/Afutu	170.6	22.2	23.4	36.9	44.8	52.7	62.1
Ga Rural	434.0	19.5	33.4	136.4	249.1	411.6	680.2
Ga Accra	112.9	3.9	6.6	7.3	49.8	82.3	136.1
Total	2564	298.4	79.2	822.2	1423	2467.	4590

2. WATER QUALITY OF WEIJA RESERVOIR

Table 2. Water quality parameters of Weija reservoir from 1993 to 1995.

Parameter	1993	1994	1995
pH	7.3	7.2	7.3
Trans. *	0.73	0.66	0.76
SS (mg/l)	16.4	20.0	17.6
TDS (mg/l)	174.8	117.5	167.0
Cond ms/cm	359.6	337.0	334.7
DO (mg/l)	8.5	9.1	7.4
BOD (mg/l)	6.4	7.3	5.7
NO_3-N mg/l	0.17	1.21	2.47
NH_4-N mg/l	0.02	0.02	0.02
PO_4	0.01	0.05	0.13

* Transparency (m)

The pH conditions of water in the Weija reservoir is about neutral.

Conductivity of the water is relatively much higher than that of the Volta lake

due to the higher concentration of chloride ions in the reservoir.

Mean transparency value is less than 0.8m.

The reservoir is eutrophic. Nutrient concentration are generally high and there has since 1993 being a gradual increase in the phosphate (PO_4) and nitrate-nitrogen (NO_3-N) concentrations. Dissolved Oxygen concentrations exceed the WHO minimum limit of 5.0mg/l for drinking water (WHO, 1988). BOD on the other hand exceeds by far the minimum limit for drinking water. This condition of the reservoir can be attributed to the decay of organic matter continually discharge into the lake through anthropogenic activities.

3. THREATS TO THE WEIJA RESERVOIR AND THE DENSU BASIN

The most visible and common problem of the Weija reservoir is eutrophication and its associated bloom of algae and aquatic weeds such as pistia. These problems as stated above have been the result of accelerated nutrient loading and organic matter discharges from anthropogenic activities. The pollution sources may be classified in terms of non-point and point discharges.

3.1 Non-Point Source Pollution Discharges

These are pollution sources that cannot be easily identified and are not easy to control. Non-point source pollution discharges within the basin area are mainly from agricultural activities and urban run-off.

3.11 Agricultural Activities

Agriculture is a major non-point source pollution discharge to the reservoir. Eight major agricultural centres are located within the catchment area of the Densu basin (Fig. 3). Most of these farms are involved in the cultivation of cocoa which is a major foreign exchange earner for the country. A desire to increase yield and quality of the product has led to the increased use of fertilizers and pesticides leading to eutrophication and probable contamination by pesticide. Effects of the increased nutrient run-off from these farms can be observed from the increasing NO_3-N and PO_4 concentration from 1993 (Table 2).

Not much information is currently available on contamination by pesticide. Pesticide levels are however expected to be very low due to high rate of evaporated. There is also, in Ghana, a ban on the use and importation of certain types of pesticides thought to be very toxic or detrimental to the environment. All pesticide imports are currently discharge to farmers after they have been certified by the Environmental

Protection Agency.

3.2 Point Source Pollution Discharges

These are those pollution sources that can be identified and easily controlled through the appropriate technology. Examples are domestic and industrial effluent.

3.21 Domestic Activities

Besides agriculture, domestic activities is the next biggest source of pollution to the reservoir. Almost all the towns within the basin area are without sewage or solid waste treatment facilities. Household waste water are discharged indiscriminately usually in any available open space or sometimes into drains which carry the waste water to the river or a feeder stream untreated.

Solid wastes are usually discharged by individual households to areas designated by the local authorities where they are burned. The problem here is most of the dumping grounds are sited close to the banks of the river and the garbage are easily washed off into the river whenever there is a heavy down pour. Illegal dumping also is very common in these areas. These practices result in high concentrations of suspended solid.

3.22 Migration and Urbanization

There was massive influx of migrant fishermen from other parts of the country to the Weija lake within five years of the its creation to take advantage of the fishery potential of the newly formed lake. Most of these migrants, without a place of abode, set up squatter townships under 1km from the lake with no sanitary facilities or pipeborne water. They were totally dependent on the lake. These squatter do not only pollute the lake as a result of their insanitary practices but also spread urinary schistosomiasis. Schistosomiasis prevalence among the squatter have been estimated at 50 - 89% (Zuta, 1994).

Rapid urbanization has also been a major problem. The high rate of migration of people from the rural areas to the urban centres within the study area in search of none existing job has caused a rapid growth of population in these area. This has put so much pressure on the already inadequate sanitary facilities available in these areas thus making sanitary conditions very poor and waste management more difficult.

3.23 Industrial Activities

Intensive industrial development within the study area is quiet low. There is currently just one big food processing plant and a number of small scale industries which range from garages to unsupervised mining activities. There is some form of waste treatment by the

food processing factory but the effluent is still believed to contain high concentrations of organic matter which contribute to high BOD loads in the water. The small scale industries have no form of waste treatment. The waste waters are discharged untreated into the tributaries or the main river which finally end up in the reservoir.

3.3 Other Problems

3.31 Lack of Adequate Funds

The current system of collecting tax for solid waste treatment directly from homes has not been effective in generating enough funds for the purpose since most residence evade it. Thus, most municipal authorities lack the basic tools for solid waste collection and treatment.

3.32 Lack Environmental Awareness

There is low environmental consciousness and awareness among the people within the study area and the country as a whole. People's perception of the environment is so poor, they do not care what happens to it.

4. MANAGEMENT PROPOSALS FOR THE WEIJA RESERVOIR

Based on the problems listed above, management plans necessary to conserve and maintain the reservoir and the Densu basin as a sources of water are discussed below. These include proper management of point and not point source pollution discharges, environmental education, coordination between user agencies and monitoring.

4.1 Point Source Pollution Management Strategies

4.11 Industrial Pollution Management

- The first thing to be considered here is a law requiring all industries irrespective of size to have an efficient waste treatment plant.
- Effluent standards should be set up by the Environmental Protection Agency (EPA) for the industries and this should include random sampling and analysis of industrial effluent by officers of the EPA or contractors appointed by the Agency to ensure that set standards are complied with.
- Every large scale production industry (present and those yet to be established) should be required by law to establish an environment department with environmental specialist to handle waste generated.
- The EPA should be given the mandate to arrest and prosecute polluters. Those found

guilty should be made to pay for the cost of damage.

4.22 Domestic Waste Management

- Good drainage networks should be established in all the big town/communities to channel the waste to a central point where they are collected and treated before discharge into the river or the reservoir.
- Dumping of waste by individuals should be replaced with house to house collection to minimize illegal dumping.
- Dumping grounds should be sited far from the immediate banks of the river or reservoir.

4.3 Non-Point Source Pollution Management Strategies

4.31 Agricultural Run-off

Nutrient run-off from agricultural areas to the reservoir should be controlled through

- the creation of artificial lagoons along the shores of main tributaries of the Densu river. These will serve as traps for nutrient run-offs as well as trap for eroded materials. The artificial wetlands would be made quite effective by cultivating water plants such as reeds, which have some economic value in that they are used for roofing, or as screens for houses or certain types of fixed gear for fishing (Kada, 1991) in these waters.
- Based on the mean nitrogen and phosphorus contents in different organs of the plant, the corresponding annual nutrient uptake in Lake Biwa is estimated 200 - 250 kg N ha^{-1} yr^{-1} and 20 - 25 kg P ha^{-1} yr^{-1} (Kurata and Kira, 1990).
- The wetlands will be managed through periodic dredging of the nutrient rich bottom sediments which will be transported to the farming areas for use as fertilizers thereby reducing the use of chemical fertilizers. The water plants when removed will be put to the uses mentioned above. They can also be used as a supplement for chemical fertilizers

4.4 Other Management Programs

4.41 Environmental Education

Environmental awareness and consciousness among the inhabitants is effective in changing the attitudes of people towards the available limited natural resources. For example, the awareness created among house wives in Japan on the negative effects of phosphorus on Lake Biwa in 19.. led to a halt in the use of phosphorus containing detergents in the Shiga prefecture.

In Ghana, environmental education could be conducted through

- the elementary, junior and senior secondary schools. This should be made a part of their curriculum.
- Adults could be educated through the media and the current on-going adult literacy programs.
- Provision of necessary logistics to the Non- governmental Organization currently involved in the formation of environmental clubs in some of the schools in Accra so that they can expand their activities to other parts of the country such as the Densu basin area.

Environmental consciousness and a sense of responsibility should also be created in residents by involving them in issues relating to their surrounding and management of the river or reservoir.

4.42 Acquisition of Funds for Waste Treatment

- The current method of collecting tax for solid waste treatment directly from homes should be replaced with a system where by fund for waste treatment are deducted at source from the monthly incomes of workers as does the other taxes.

4.43 Coordination between user agencies.

Effective coordination must be established between the user agencies and researchers for effective monitoring and management of the reservoir and the Densu basin.

4.44 Monitoring

Monitoring may be defined as the continuous or periodic collection, collation and analysis of data and information for purposes of effective management of lake water.

The proposed monitoring plan which will form the basis for evaluation and management of the reservoir include four levels of monitoring - water quantity monitoring, Water quality monitoring, biological monitoring and environmental monitoring

4.44.1 Water Quantity Monitoring

Variables to be monitored are:

- inflows to the reservoir,
- outflows,
- water redrawals and losses
- water levels.

Information from this monitoring provides knowledge and understanding of the reservoir water balance which is essential or its sustainable management.

4.44.2 Water Quality Monitoring

Water quality monitoring is essential to understanding the state of the reservoir. Items to be monitored are physical parameters and chemical parameters.

A) Physical Parameters

The Items are:

- Water temperature
- pH
- Dissolved oxygen
- Transparency
- Conductivity
- Suspended solids
- Total dissolved solids
- Turbidity

B) Chemical Parameters

Items to be monitored are:

- Biological Oxygen Demand
- Chemical Oxygen Demand
- Total Nitrogen and Total Phosphorus
- Heavy metals (Zn, Pb, Cu, Cd, Mn, Fe, Hg and As)
- Pesticides (organochlorines)

4.44.3 Biological Monitoring

Biological monitoring can provide information on the overall status of the aquatic ecosystem of the reservoir as a whole since aquatic organisms can integrate the various factors affecting their surrounding environment.

Organisms and communities to be monitored will include;

- Plankton. Information on these organisms is important in assessing the quality of lentic systems (Biswas, 1991)
- Benthic macro-invertebrates.
- Fish populations. Besides being an important source of protein, fish act as bioaccumulators of undesirable contaminants, and thus could be used as a proxy for the overall problem;

4.44.4 Environmental Monitoring

The item to be monitored is schistosomiasis which is the main water related disease in the immediate communities of the reservoir

5. REFERENCES

Biswas, A. K., (1991) Guidelines of Lake Management, Volume 2, Socio-Economic Aspects of Lake Reservoir Management. pp. 83-96.

I.A.B., (1978) Proceedings of the Seminar on The potential for fishery in the Densu (Weija) Reservoir. I.A.B. Tech. Rep. No.

Kada, Y. (1991) Guidelines of Lake Management, Volume 2. Socio-Economic Aspect of Lake Reservoir Management. pp. 7-18.

Kurata A., Kira, T., (1990) Guidelines of Lake Management Vol. 3 Lake Shore Management. pp. 21-37.

Larmie, S. A. (1992) Climate induced trends in water quality. An investigative analysis for the Densu River in Ghana

Zuta, P. C. (1994): Preliminary investigation of the Prevalence of Schistosomiasis in the Weija lake 15 years after impoundment. I.A.B. Tech. Rep. No. 134.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude and appreciation to the Japan Government, through the Japan International Cooperation Agency (JICA) for giving me this rare opportunity to participate in the Lake Water Quality Management Training Course.

I wish to thank all staff of ILEC whose dedicated serve to us made our training program and our stay in Japan a success.

I am also very grateful to the Director of the Institute of Aquatic Biology for releasing from my office schedule to participate in the training program, to Dr. Nakamura and Dr. Matsui for guidance, all our lecturers, to my husband for his cooperation and moral support, to Toda-san, Kanematsu-san and all my co-participants.

Finally and most importantly, I wish to thank God Almighty for a successful trip.

FIG 1

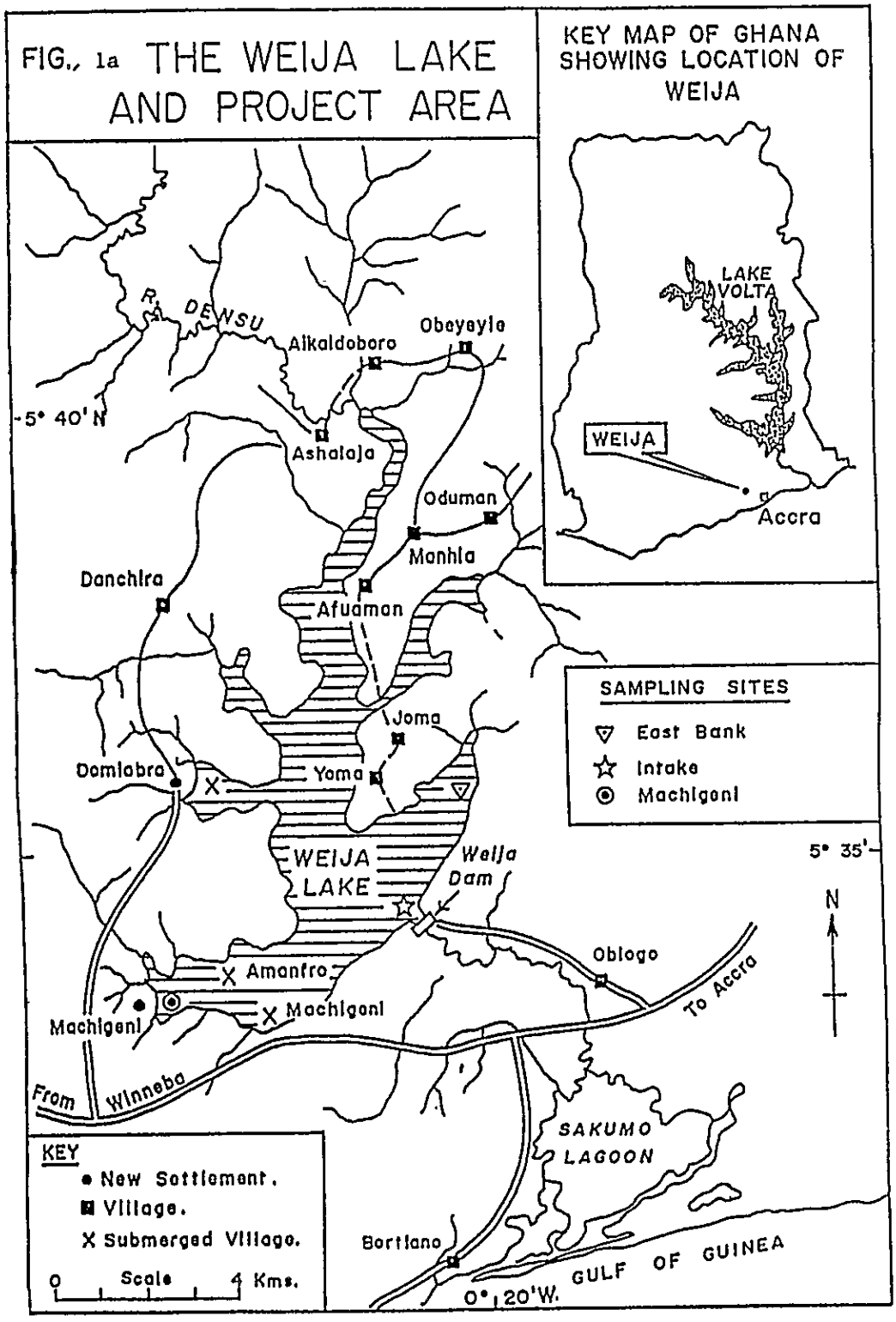


FIG., 1a THE WEIJA LAKE AND PROJECT AREA
KEY MAP OF GHANA SHOWING LOCATION OF WEIJA
LAKE VOLTA
WEIJA
Accra
R. DENSU
Aikaldoboro
Obeyeyie
5° 40' N
Ashalaja
Oduman
Manhia
Danchira
Afuaman
Joma
Domiabra
Yoma
WEIJA LAKE
Weija Dam
SAMPLING SITES
East Bank
Intake
Machigeni
5° 35'
N
Oblogo
To Accra
Amantro
Machigeni
Machigeni
From Winneba
SAKUMO LAGOON
Bortiano
0° 20'W.
GULF OF GUINEA
KEY
New Settlement.
Village.
X Submerged Village.
0 Scale 4 Kms.

FIG 2

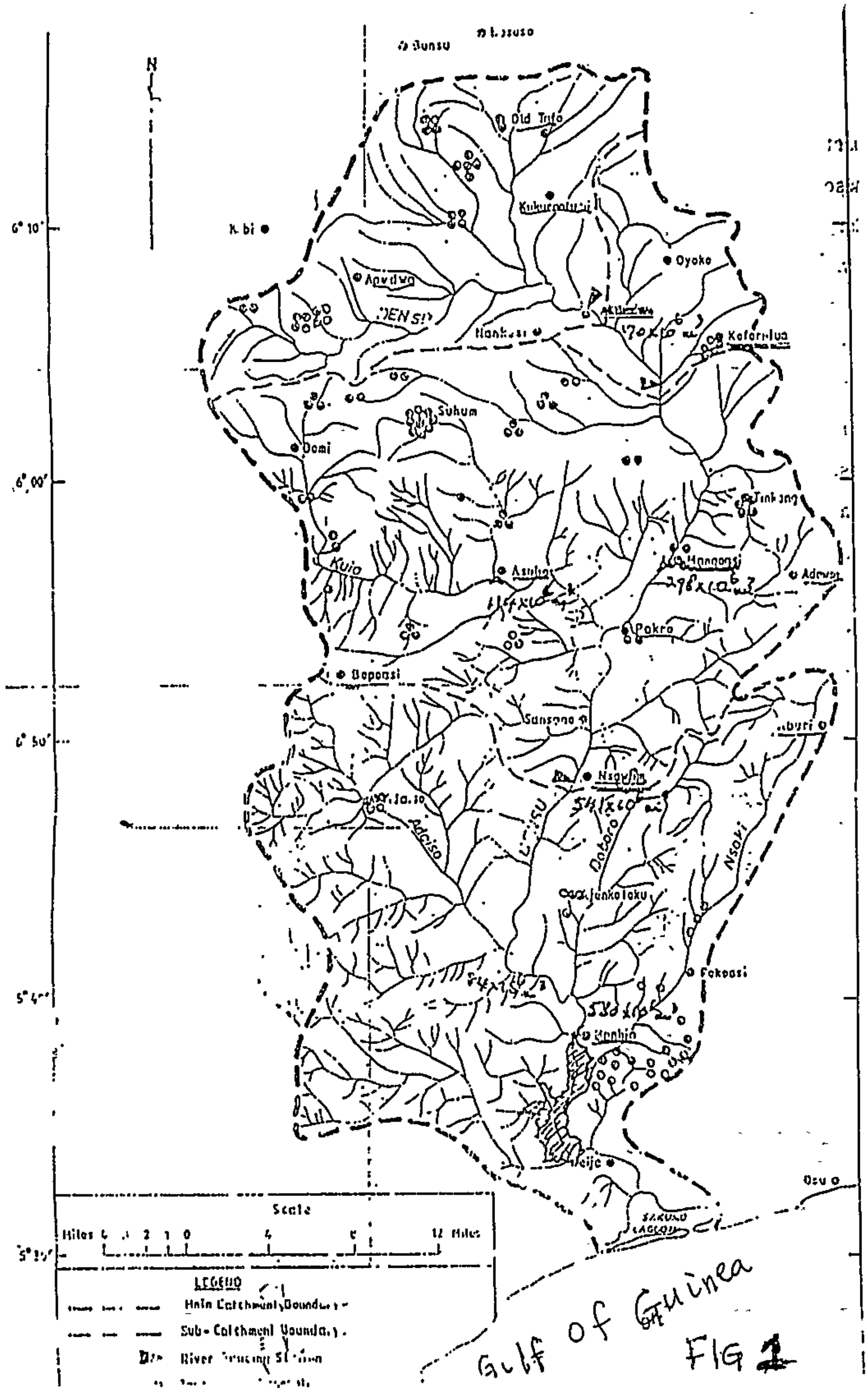
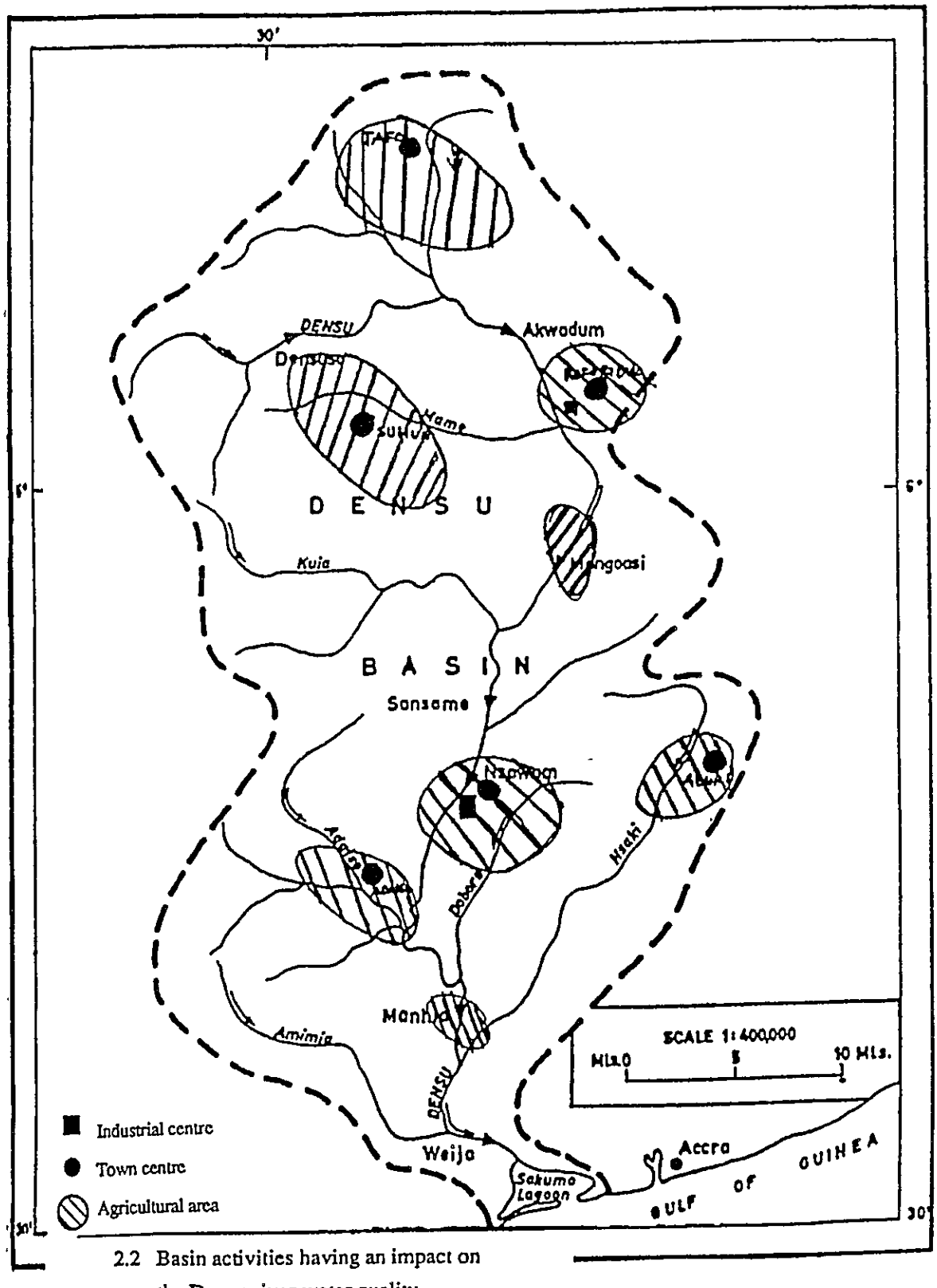

N
6° 10'
6° 00'
5° 50'
Old Tafo
Oyoko
Suhum
Domi
Pokro
Nsawam
Adeiso
Nsaki
Fokoasi
Scale
LEGEND
Gulf of Guinea
FIG 1

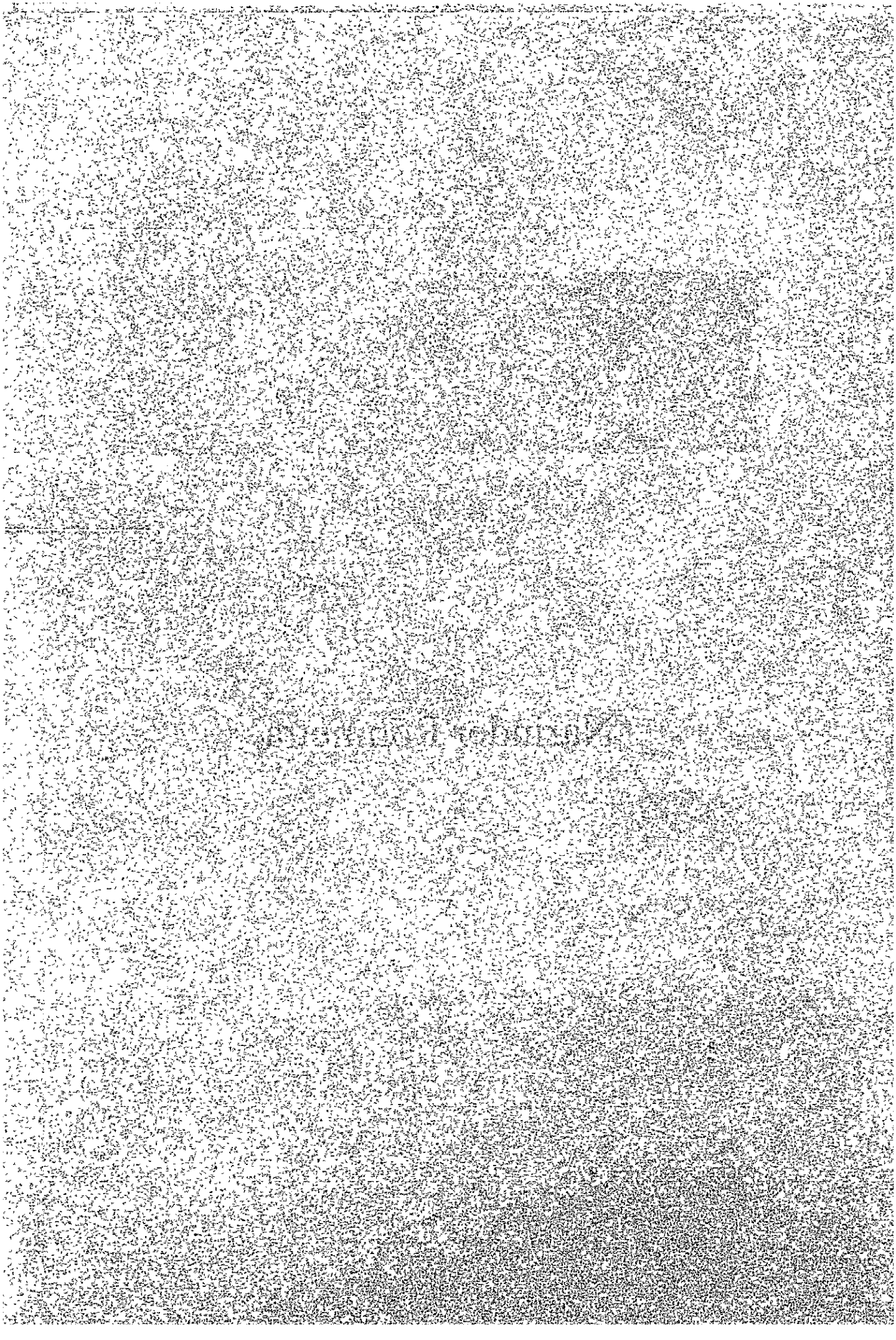
FIG 3



2.2 Basin activities having an impact on the Densu river water quality

India

Narinder Rohmetra



COMPREHENSIVE MANAGEMENT OF DAL LAKE, INDIA

Narinder Rohmetra
India

INTRODUCTION

The Jammu and Kashmir State has been gifted with a number of fresh water lakes dotting length and breadth of the area. The most spectacular among these water bodies is the DAL Lake which is situated in the heart of city of Srinagar.

BRIEF HISTORY

Although the Dal Lake has been cradle of kashmiri civilization since times of Ashoka the Great from 250 BC, yet nothing definite is known about its age nor there is any direct reference to Dal lake in Rajtarangni, the ancient history of Kashmir written by Kalhana in the 12th century.

The origin of lake is also controversial. One view is that lake has resulted from the progressive shrinkage of ancient glacial lake which existed during Pleistocene period. The lake is situated on the alluvium cover of karewa group of loamy clay bed interspersed with carbonaceous band over lying laminated marls, silts medium to coarse granular sand grit etc. However another view holds that the lake was a plain and lying in flood plains of River Jehlum whose broad meanders have cut the swampy low lands out of karewa terraces.

Up to beginning of the 16th century, the lake was untrammelled and unpolluted but after the visit of Mughal, the ingress of lake started. In the 18th and 19th centuries, Srinagar city started growing towards the lake. To facilitate pedestrian traffic bands were laid which divided the continuous sheet of water in three basins there by changing water flow pattern and that resulted in creation of large areas of stagnant water with little or no water renewal.

SIZE, CATCHMENT AND DRAINAGE

The lake is fed by a myriad of nallahs and streams around the shore line .However the main sources of its water is Telbal nallah draining the Dachigam valley. There are also springs in the lake bed which also contribute their mite. There are two outlet of the lake at present one being Dal gate through which lake is connected to river Jehlum via Tsunti kul

and other trough nallah Amir khan to Anchar lake. The lake is divided in to four zones:-

a House boat area.

b. Mini lake area with floating gardens.

c. Bod dal (Big lake) clear water lake.

d. Hazartbal lake.

As per the hydrographic survey conducted through the Minor Ports organisation in 1982, the area of the lake is as:-

Water body	=	15.42 sq.km.
Marsh	=	1.26 sq.km.
Built up	=	7.32 sq.km.
Total	=	24 sq.km.

Recent studies have shown that the water body has been further reduced to 11.5 sq.km.

The contributory catchment of dal lake is of the order of 314 sq.km. comprising of steep and precipitous rocky slopes in the upper reaches changing to moderate in mid reaches formed out of glacial moraines and terminating into flat and terraced terrain in the lower reaches formed out of clay/loam over burden over boulders.

IMPORTANCE OF THE LAKE

The lake is back bone of tourism and is of invaluable importance both from international tourist point of view and as various activities connected with the lake. The unique feature of the lake is presence of floating houses called house boats.

The lake is also a bird watcher paradise gliding along the marbled water of the lake, one can often observe white breasted King fisher. The lake is also important from economy point of view of farmer as four crops are grown in a year in floating garden. mportant crops grown are tomatoes, gourds, capsicum, chillies, cabbage, carrots, turnip etc. The average holding is 0.2 ha.

PHYSICAL DIMENSIONS

a. Location a.1. Latitude -34°18' N.

a.2. Longitude-74°9' E.

b. Altitude 1583 m M.S.L

c. Surface area 24 sq.km.*

d. Volume (average inflow & out flow balances)--291x10^6 cu.m.

e. Maximum depth 3.75m **

f. Average depth 2.0m

g. Annual water variation (regulated) --0.67m

h. Length of shore line 15.5km.

i. Catchment area 316 sq.km.

*-original area. **-Dal lake.

WATER QUALITY

The laboratory tests have revealed that the lake is grossly polluted in certain pockets. At Brari Nambal the DO is less than 5mg/land B.O.D is more than 150 ppm The position is equally bad in other areas like Habak, Nowpora, Jogilankar where SS has gone as high as 745mg/l.

The ANNEX in its report has stated that the lake is grossly polluted bacteriologically and coliform count has been estimated to range from 640 to 2400 +MPN/100ml.

Climatic 1977

Month	Jan	Feb	Mar	Apr	May	Jun
Mean Temp.[°C]	0	3	9	14	18	22
Precipitation [mm]	70	75	92	90	60	36
Month	Jul	Aug	Sept	Oct	Nov	Dec
Mean Temp.[°C]	24	23	20	14	3	5
Precipitation [mm]	55	62	40	26	11	38

Annual Precipitation--655mm

Water Temp.[°C]

Hazratbal [1983--1984]

Depth [m]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
0	3	6	19	21	23	26	25	24	21	15	9	7

Hazratbal [1983--1984]

Items	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trans.[m]	.89	.95	.53	.95	1.8	1.9	1.95	1.5	1.3	1.1	1.0	.98
PH	9.8	8.0	8.4	7.3	8.2	7.3	8.4	7.8	7.2	8.6	7.7	9.4
DO (mg/l)	4.4	7.8	3.6	4.0	5.6	6.4	4.8	1.4	9.6	12.3	10.2	--
COD (mg/l) 4.7	0.9	.52	.43	1.48	4.2	5.0	2.3	1.5	2.0	2.0	.28	
NO_3-N (ug/l) 175	73	73	80	380	22	1315	95	94	88	219	285	
T-P (ug/l)	104	69	81	46	138	35	577	138	69	58	162	46

Past Trends

	1965-66	1980-81	1983-84
pH	7.9	8.6	8.8
PO_4-P (ug/l)	20	92.6	115
NO_3-N (ug/l)	105	556	780
NH_4-N (ug/l)	250	730	850

DETERIORATION OF LAKE ENVIRONMENT

1. Enhanced siltation:-Total volume of silt deposited in lake in 1976 through Talbal channel was 36,200 cu.m. This represent an area of 3.6 ha. with a depth of 1m.
2. Eutrophication:-Excessive weed growth.

Nitrogen & Phosphorus loading (1977) (T/YR)

Sources	Industrial	Domestic	Agriculture	Natural	Total
T-N	0	359	275	0	634
T-P	0	39.9	6.4	0	46.3

Note:-The lake is getting rapidly eutrophied. The measure that are being implemented for rehabilitation include mechanical harvesting of weeds, removal of barricades to facilitate water circulation, moratorium on house boat construction and control on unlawful encroachments.

WASTE WATER TREATMENT

1. Generation of pollutant in catchment area: -Severe pollution with no waste watertreatment. Human waste and kitchen refuse are released from house boats in to

the lake water without treatment.

2. Approximate % of distribution of pollutant loads

	%
Non-point sources	55
Point sources	25
House boat and Hotel	20
Total	100

3. Sanitary facilities and sewerage:-None.

PROBLEMS

The time for the lake is running out. Within the living memory its open area has been reduced considerably. Out of total contributory catchment area of lake, 148 sq.km. area has been identified as vulnerable and prone to erosion contributing towards sediments and nutrients in flow. It has been estimated that 15t of phosphorus and 322t of nitrogen are contributed to the lake annually which in turn get locked up in macrophytes are deposited in the enriched benthal deposit of lake. An average 80,000t of silt flow annually in the lake resulting in siltation of lake and creation of marsh all around. The major problems with which the lake is bedevilled can be broadly summarised as:-

1. Inflow of liquid and solid waste from adjoining residential areas, hotels and guests houses.
2. Reclamation of lake by constant conversion of water in to floating garden and ultimate house construction.
3. Sedimentation and nutrient inflow from the catchment area and floating gardens.
4. Increasing number of house boats without adequate and safe disposal arrangements.

There is insufficient data on water quality to assess and determine the level of pollution in the lake. The data in respect of bacteriological quality is totally lacking.

Accordingly a team headed by Dr. Riddle, professor of Cambridge university made a detailed study of the problems from August to October 1985. They recommended as:-

1. A permanent secretariat needs to be set up in the office of chief secretary for close and more systematic co-operation between different agencies concerned with the lake.
2. Since the data in respect of bacteriological quality is totally lacking, it is therefore necessary to establish a laboratory for hydrological and water quality monitoring

aspect of lake.

3. There is a wide divergence between the actual pattern of land and water holding and recorded representation. The undertaking of a cadastral mapping and aerial survey is therefore a must.
4. Strict limit should be placed on future tourism expansion in Srinagar and every attempt be made to promote diversification.

REMEDIAL MEASURES

Based on recommendation a revised plan for the lake was formulated by chief engineer urban environment engineering department Jammu & Kashmir and submitted to Government for approval. The plan has three phases:-

Phase -1

a. Cadastral mapping and aerial photography:-
   To know precise information about various aspects of land, water and other properties in and around the lake.
b. Establishment of laboratory for water quality monitoring After seeing the well established system of lake monitoring of lake Biwa, I felt the need of not only the establishing the laboratory is important but also the numbers and the placement of monitoring station is very important. The tests are to be carried out regularly.
   It may not be possible to install automatic monitoring station because of its cost. I will recommend first and foremost priorities should be installation of a laboratory.
c. R & D for conversation of weed into biogas.
d. Improvement to Dachigam, Dara & Danihama catchment area:-
   The priorities has been given to vulnerable area of 148 sq. km. out of total 314 sq.km. In Dachigam the work comprises of closure by fencing, plantation, other conservation works like check dams & gully plugging. The work for development of Dara Danihama, Chatarhama catchment comprises of plantation, nallah treatment, gully plugging etc. These works shall be jointly carried by Engineering, Soil Conservation, Wild life departments.
e. Selective deweeding:-
   For the purpose of selective deweeding four harvesters have already been procured .Manual deweeding is also carried out at some places where mechanical deweeding is not possible.
f. Marginal Dredging of Hazratbal lake:-
   The provision for purchase of dredger and allied equipment has been made in the

project. The dredged material is proposed to be utilised in filling the low lying areas on the periphery of the lake. The visit to the construction site in Lake Kasumigaura in Japan has helped me to actually see the operation of dredger and how the silt is pumped out automatically to the shore. With this, we can solve the problem of siltation of our lake

g. Construction of settling basin on Telbal nallah including its diversion-. The purpose of settling basin is to screen the highly silt laden water of Talbal nallah from the suspended solids comprising nutrient inorganic particulate matter so that further siltation is stopped.

h. Sewerage and drainage of Hazratbal & Habak area. -

Hazaratbal and Habak side area has been sprawling and extending towards lake. At present all the sewage and sludge finds its way through big drain in to lake owing to which the lake not only gets polluted but gives an ugly appearance. It is therefore has been proposed to trap incoming sewage and sludge into a deep drain and waste water thus collected will be treated in an oxidation pond and treated affluent led into lake.

i. Sewerage scheme of peripheral area:-

The entire peripheral area contributes raw sewage & sludge to lake which result into its gross pollution. To arrest the sewage, sludge and storm water on its periphery two decentralised sewerage systems are propsed. One from Nishat to Dalgate along Boulevard and another Saidapura to Khyam.

j. Low cost sanitation of peripheral area:-

There are a number of villages located in the peripheral area of the lake with scattered houses .Most of the people are poor and only a few houses are having bucket latrines. As a result the lake gets polluted in these areas. It is proposed to construct low cost sanitation unit in these areas.

k. Improvement to nallah Amir khan:-

At present the capacity of this channel which is an important link between Dal lake and Anchar lake is very inadequate. In the event of floods, the lake does not drain out quickly with the result flood condition are dominant for considerably long time and house of peripheral villages get flooded and even marooned. To obviate these difficulties it has been proposed to improve the capacity of Amir khan channel.

l. Improvements to water circulation:-

The water circulation is very important and can stop stagnation of lake. Intially cuts were given in Ishar bunds and Dal bund, subsequently it has been decided to completely remove the Ishar bunds and Kabutar khana bunds. The latter work has

been completed.

m. Construction of fore shore roads:-

The purpose of the construction of these roads is to delineate the lake boundary, check further encroachments and save the lake from pollution. Accordingly two fore shore roads and pedestrian malls have been proposed.

Phase--2

The provision has been made to provide alternative lands to the owner of houses, house boats, hotels and other establishment which shall be acquired with the implementation of phase -1.

Phase--3

Planned development of area along shore roads shall be made without disturbing the ecological balance. It is proposed to acquire the structure and floating gardens in the lake. These shall be developed as picnic spots. The lake shall also be developed for water sports.

Legislative for upgrading lake environments:-

1. National and local laws concerned.

a. The Environment protection act (1986)

Main items of control.:-Planning execution of a nation wide programme for the prevention, control and abatement of environment pollution. Laying down standards for the quality of environments and its various aspects. Examination of such manufacturing processes, materials and substances which are likely to cause environmental pollution.

Inspection of any premises, equipment, machinery, manufacturing or other processes, material or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution.

Financial status

The cost of the revised project for implementing the remedial measures comes to:-

1-Total cost as on 1993 price level :-RS400crores(120million$)

2-Exp. ending Mar. 1995 :-RS58.40CR.(17.52million$

3-Prov.for 1995-97 :-RS58.8OCR.(17.64million$

Balance cost as on 1.4.1997 :-RS282.80CR.(84.84million$

It has been recommended to the GOVT. that the project be completed with in five years. The year wise proposal made is as:-

1997-98----------RS40CR. (12 million$)
1998-99----------RS50CR. (15 million$)
1999-2000---------RS60CR. (18 million$)
2000-01----------RS70CR (21 million$)
2001-02----------RS62.80CR. (18.84 million$)
Total----------RS282.80CR. (84.84 million$)

Institutional Measures:-

1. Urban environment engineering department Jammu & Kashmir Government.
2. Department of environment, ecology, science and technology, Jammu & Kashmir Government.

Research institute engaged in lake studies.:-

1. Centre of research for development university of Kashmir.

ACKNOWLEDGEMENT

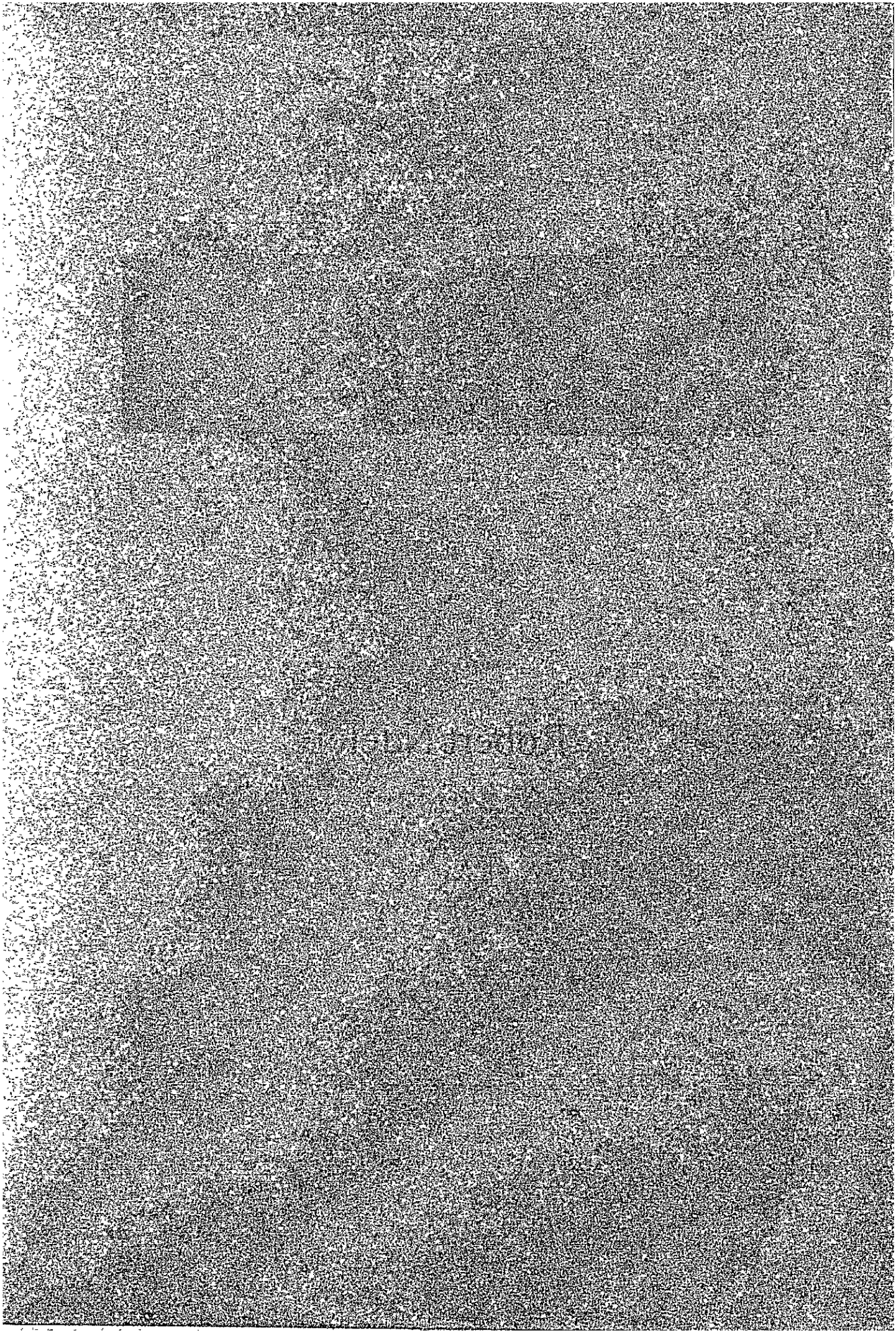
I am thankful to JICA for providing me the opportunity of learning the latest techniques and management of lake water monitoring.

SOURCES OF DATA

1. Chief Engineer Urban Environment Engineering Department, Jammu & Kashmir Government.
2. Paper of Prof. D.P. Zutshi (Centre of Research for Development, University of Kashmir, India)

Kenya

Robert Ndetei



LAKE NAKURU WATER QUALITY MANAGEMENT

Robert Ndetei
Kenya

ABSTRACT

This paper is a final report on Lake Water Quality Management organised by JICA. It reviews the state of Lake Nakuru, threats and strategies to elevate these threats, thereby improving environmental conditions not only for the lake, but the whole Lake Nakuru catchment Some of the techniques are what was learned from Japan, and includes modification of an on going water quality monitoring project in Lake Nakuru. Key factors included in strategies are serious active involvement of local communities in conservation, education, awareness and training; and legislation of environmental acts relevant to the catchment. Institutional support, collaboration and involvement is a corner stone in this project.

An appendix is attached on trade effluents, and a strong recommendation for a similar act for other pollutants.

1. INTRODUCTION

Lake Nakuru is world famous for its prolific bird life (450 species) and the first Ramsar site, (i.e. a wetland of international importance) in Kenya, established for its ornithological Biodiversity. This lake is one of a series of Alkaline-saline Lakes in the Eastern Rift Valley.

It is a eutrophic, alkaline-saline closed lake in a catchment are of 1,800 sq.km. This alkaline pan offers hostile conditions to most aquatic organisms, however it has a high productivity, producer and consumer Biomass ~500g/sq.m. dry weight (Vareschi E.& A., 1982). The lake is used for Tourism, Research and Education.

Wetlands are not wastelands, a tendency that Lake Nakuru had been inclined to till recently when expansion and rehabilitation of sewage works was instituted.

Low quality effluents, agro-chemicals and solid waste have had found their way into Lake Nakuru, there by threatening its ecological stability. Its only the quick bold decision by the government to rehabilitate sewage works, that has given a blink to the survival of this great ornithological spectacle on earth.

Anthropogenic activities within Lake Nakuru catchment have direct impact on

this enclosed saline pan Lake that supports diverse Biodiversity. Local community participation in conservation of Biodiversity is considered a key role in ecological survival of Lake Nakuru. All efforts should be put in place to achieve this noble task (Makenzi, 1992).

1.1 Location And Geology

Lake Nakuru is about 176 km, North-west of Nairobi, the capital of Kenya and at an altitude of 1757 m.a.s.l, and between latitudes 0 22 Sh and 36 05 E (Kutilek, 1974).

The area surrounding Lake Nakuru catchment belong to Tertiary-Quaternary volcanic materials associated with alkaline sediments (McCall, 1967). The soils are mainly volcanic in origin, light and easily leached (Kairu, 1991).

1.2. Climatological Conditions

Lake Nakuru, due to its close proximity to the equator has little seasonal temperature variations, however 24 hrs temperature fluctuations are pronounced. The Lake starts stratification at 09:00 hrs and at midday a thermocline is built between 30-100 cm depth. Stratification is disrupted by afternoon winds, lowering thermocline to between 50-150 cm., depending on wind force, incoming solar radiation and turbidity. The Lake remains weakly stratified at night, circulating in the early hours as a result of nocturnal cooling.

The Lake water budget is balanced by evaporation and rain, inflowing rivers and springs; and to a less extent by treated effluents and storm water from Nakuru Municipal town.

Surface area {sq.km}	42
Volume	Variable
Maximum depth {M}	2.8 Variable
Mean depth {M}	2.3 Variable
Shoreline length {KM}	36.5
Catchment area {sq.km}	1,800
Width {km}	7.5
Length {km}	17.5

Lake Nakuru Climatic factors

FACTOR	LEVEL
Temperature	min.6 -13°C, max.30-34° C
Rainfall	876+156 SD mm
Solar radiation	455-550 Kerg cm2sl
Humidity	20%-99%
Evaporation	1,600-1,800 mm/yr
Wind	0.2-20 m/s

1.3 Physical And Chemical Features

These show conditions that are unfavourable to most aquatic life. High conductivity and relatively low Chloride content characterize Lake Nakuru as "an alkaline-saline class III lake"; or a "concentrated sodium bi-carbonate low chloride lake".

PARAMETER	VALUE
pH	10.4
Temperature	8-30°C.
Conductivity	6,500-165,000uS/cm. at 20°C
Secchi depth	0.4 m
Dissolved Oxygen	5-28 mg/l
Alkalinity	5,000-90,000 mg/l CaCO3
Ionic Composition	96.4%Na+(cations)84% HCO_3- and CO_3--(anions)

1.4 Change in land use

Lake Nakuru catchment has undergone diverse changes in land use, below is a comparative change in land use table between 1970 and 1986, data from satellite image.

LAND USE	PERCENTAGE	COVER IN %	AREA
	Year 1970	Year 1986	
FOREST	47	26	400
LARGE SCALE	34	13	377
RANCH LAND	15	11	192
WILDLIFE	3	11	125
URBAN	1	13	90

2. THREATS TO THE ECOLOGY OF LAKE NAKURU

Lake Nakuru faces some potential threats detrimental to its ecological survival. These threats are man made rather than natural and are basically related to human activities, change in land use and land cover. They can be classified into point and non-point pollution sources.

Total heavy metal concentration range in Njoro River, Town sewage effluent and Storm drain. Concentrations in mg/l.

parameter	River Njoro	Town sewage	Storm drain
Titanium	30.5-90	1.01-3.29	0.012-3.07
Chromium	5.08-10.9	20.0-70.7	97-345
Manganese	6.57-10 .0	2.28-5.4	2.28-4.28
Iron	1.0-4.7	4.7-60.44	57.8-210.0
Cobalt	<0.01-0.5	139.6-145	<0.001-139.
Nickel	0.02-10.6	0.05-12.3	0.01-0.1
Copper	0.5-20.	21.1-118.9	289-352
Zinc	0.001-1 .1	130.3-448.2	3.7-110
Lead	0.1-22	21.8-350.3	275.9-805.0
Arsenic	<0.001- 0.06	0.005-0.006	ND
Cyanide	<0.001- 0.03	0.07-0.13	NA
Mercury	<0.001- 0.1	0.001-287	16.8-50.
BOD	50-325	45-932	600-2180
COD	132-520	88-1216	800-2900
Ammonia	93-150	1.56-69.8	3.44-34.9
Phosphate	35.4-56 .2	2.0-33.5	6.17-16.9
Nitrate	0.01-5	0.01-2	0.01-0.1
SS	50-110	250-310	2340-3540
Sulphide	0.1-2	0.1-7.3	NA
Oil(n-hexane	NA	NA	40.5-553.3
pH	7.7-8.3	7.3-9.4	7.2-7.6
Conductivity	170-213	6 0-1200	0-510
phenol	0.42-1.36	0.80-1.3	ND

2 .1. Point Source Pollution

These are those pollution sources that can be identified and are easily controlled through appropriate technology.

2.1.1. Industrial pollution

Most of the industries in Nakuru lack pre-treatment facilities or whose with them are inadequate or mul-functional; they therefore discharge low quality effluents directly into the public sewer whose waste biological treatment processes cannot easily and effectively remove heavy metals. Heavy metals may inhibit the increase of microbial biomass and lead to a reduction in efficiency of both aerobic and anaerobic processes, there by reducing biological treatment efficiency (Thomas & Swain, 1988).

High heavy metals' levels have been detected in treated effluents from the treatment plants and Lake Nakuru waters, though due to buffering effect in the Lake, their toxicity is rather low. Analysis of heavy metals in Lake biota has shown a tendency towards net bioaccumulation in the food chain. It is not clear weather heavy metal levels have passed buffering capacity for the Lake, hence a need to determine species tolerancy in the Lake. Reuse, recycle and recovery reduces quantities of wastes(Thomas & Swain 1988).

High Industrial nutrient loading if not carefully controlled can as well be detrimental to the ecology of the lake. Nitrogen and Phosphorous enrichment causes eutrophication especially considering amount of organic matter in some industrial effluents.

2.1.2. Domestic pollution

Domestic effluent is characterized by high nutrient levels in form of Nitrogen and Phosphorous compounds, and organic matter. The later can reduce oxygen level in the Lake as a result of oxidation of high BOD level. They all cause eutrophication as a result of high levels of nutrient enrichment in the lake. Levels of these have been detected at high levels.

In Japan Phosphorus loading has been controlled/reduced by banning use of synthetic detergents containing Phosphorus. Kenya can take this step to control eutrophication in fresh water lakes.

2.2. Non-Point Source Pollution

These are those pollution sources that cannot be easily identified and are not easy to control directly. These to a greater extent are as a result of people attitudes, littering and

poor or non integrated agricultural activities.

2.2.1. Agrochemicals

These are those Chemicals used in Agriculture to boast yield.

Lake Nakuru catchment is highly agricultural, and use of chemical fertilisers, pesticides and herbicides is imminent. When used poorly, they find (leaching) their way into the Lake via feeder rivers during heavy storms.

A survey carried out, and interpretation of land state imageries show drastic reduction or loss of vegetation cover to give way to cultivation. Poor soil and water conservation strategies lead to enormous transportation of silt and agricultural chemicals into the Lake.

2.2.1.1. Pesticides

These have found excessive use in high agricultural areas to maximise crop yield by reducing pest attack on crops. Organochlorines have high bioaccumulation in food chains. Though their use is banned, it is not clear as to their present use or being marketed under different trade names, for their derivatives have been detected in Nakuru waters.

Integrated farming methods should be encouraged in the catchment. Biological control methods should be researched into to give farmers alternative pest control strategies.

Mean pesticide residues in various tissue in 1970, 71, 72, 70 & 90

	DDT	DDE	DDD	Dieldrin	Aldrin
Tilapia muscle	ND	0.001	ND	ND	ND
Flamingo					
muscle	ND	0.004	ND	ND	ND
liver	0.006	0.0019	0.007	0.007	0.0016
fat	0.008	0.019	0.007	0.007	0.0016
Pelican					
muscle	0.016	0.34	0.037	0.029	ND
liver	0.016	0.15	0.095	0.088	0.009
Cormorant					
muscle	0.133	0.172	0.181	ND	0.004
liver	0.002	0.026	0.007	0.0008	0.003

Data source : Koeman et al 1972; Frank et al 1977; Lincer et al 1981; Greichus et al 1978 & Kairu 1991.

2.2.1.2. Fertilizers

Agrochemical fertiliers rich in Nitrogen and Phosphorous, that easily dissolve in the soil, and easily absorbed by plants are in great use in Lake Nakuru catchment. During rain and heavy storms, they are easily leached into the lake via rivers and streams. Impact of Nitrogen and Phosphorous loading leads to eutrophication. High levels have been detected in rivers and lake water. High nutrient loading in the lake cause algal blooms with subsequent algae crushes. During crush obnoxious smell is released, and it has been hypothesised that the rate of algae crush is directly related to amount of nutrients in the lake.

2.2.1.3. Natural Nutrient Loading

This is nutrient lake enrichment by natural causes, e.g. decomposition of organic matter in forests. This source is not a major concern in the case for Lake Nakuru provided other nutrient sources are controlled within acceptable, tolerable limits.

2.2.2. Garbage Accumulation

Surface run off from Nakuru Municipal Town finds its way into the lake during rain storms. These form suspended matter or solids, that act as vehicles for transportation of pollutants, and dissolved solids that have been detected in storm water. Oil and grease detected in storm water originate from open air garages.

Accumulation of garbage in Nakuru Municipal Town is the main source of suspended and dissolved solids found in storm water. these spoil the aesthetic value of the lake.

3. MANAGEMENT STRATEGIES TO CONSERVE LAKE NAKURU ECOLOGY

In response to environmental problems the Kenya Government drafted a National Environment Action Plan (NEAP), and ratified to the convention on Biodiversity. This gives the Governments' commitment to environmental protection and conservation.

Though Kenya Wildlife Service (KWS) has the mandate to manage and conserve Lake Nakuru, there are a number of key actors in Lake Nakuru Catchment who need to be involved actively in its conservation. As mentioned else where threats of Lake Nakuru are diverse and multi-dimensional, hence the need for multi-disciplinary approach for its conservation and management to maximum resource utilisation.

3.1. Role Of Local Residents In Conservation

Efforts are being made to educate local communities towards better understanding of catchment management through workshops, seminars and training. In 1994, 40 seminars were organised in Lake Nakuru Study Centre in this aspect (Kairu, 1995).

Lake Nakuru catchment has a population of about 900,000 and each individuals' altitudes towards environmental conservation has direct impact on the Lakes' ecology. Following are mitigating methods to involve local communities in Lake Nakuru conservation:

3.1.1. Agro-chemical pollution.

Fertilizers used in agriculture find their way into the lake, and can cause eutrophication. These can be reduced by cutting terraces along the contours to reduce surface run-off, that will contain dissolved organic salts.

Organize training for farmers in collaboration with ministry of Agriculture staff, and train them on soil and water conservation. This will reduce amount of silt and nutrient loading in storm run-off. Leaving buffer zones along the rivers will improve quality of surface run-off. These zones will act as wetlands, and can be utilized in growing commercial papyrus and reeds that can be used in making house hold goods and house decorations. Reeds can remove T-N and T-P by 40-50% and 50-60% after 5 hours retention (Pro. Takeda per. comm.)

Soil erosion can further be reduced by farm paddocking, growing podder crops for cattle. These can be harvested at the right times ensuring annual adequate ground cover, reduce soil erosion and increase moisture built up in the soil.

3.1 2. Lake Water Level Fluctuations

Rivers supplying Lake Nakuru of late have changed from annual to seasonal flow, which to a great extent has been due to inadequate ground recharge. Lack of adequate ground cover leads to serious soil erosion and inadequate moisture build up in the soil. The former leads to flooding and early lake ageing, and the later to serious fluctuations in river discharge rates.

To reduce this farmers in addition to terracing need to:

- practice stripe covering by growing grass on their grazing fields and nippier grass on top of terraces. The later can form adequate podder supply during dry season.
- practice afforestation. Collaborate with forest officers in setting up nurseries

and other relevant logistics to ensure successful afforestation programme. This will supply fuel and building materials, in addition to controlling soil erosion and improving the general environment ("green environment for better living").

3.1.3. Solid Waste Management.

Litter and garbage in Nakuru urban storm water act as vehicles for pollutants. These emanate from residents activities and altitudes, and can be minimised by being mindful of the environment. Adequate and wise disposal of waste can reduce pollution load from above source, and can be done by-

- Before disposal, house hold garbage should be sorted and disposed at those sights or points designated by the Municipality
- Frequent garbage collection (after every two days) and incineration by Nakuru Municipality.

  Nakuru used to be the cleanest town in Kenya, a dream that should be restored by effective waste management by the municipal council.
- Nakuru Municipality to provide adequate garbage disposal facilities at strategic points in public places, and residents to make adequate use of these facilities by disposing off litter and garbage where it belongs.

Storm water to be diverted to pass through wetlands, where any extra garbage can be collected from screens to be installed in storm drain before it gets to the wetlands.

It is evident from above that local residents play a key role in Lake Nakuru catchment management and should have the right to air their grievances when there are detrimental environmental issues, and the Government to be ready to solve them. This will eliminate nasty experiences like the ones experienced by Japan during Itai-itai and Minamata episodes.

3.2. Role Of Industries In Conservation

Failure of Technology is the beginning of pollution. Technological development must take into consideration environmental protection and develop adequate safety devices for its protection.

Nakuru Municipality has drafted and gazetted trade effluent by-laws (see appendix 1), that can only be of any meaning if industries see them as an indirect measure of industrial efficiency and ensure their discharge is within prescribed limits. Control of industrial waste is easy when carried out on-site or near the source. Industrial waste control starts with industrial process selection. In this aspect they can benefit by frequent

effluent monitoring. To achieve this:

- Organising awareness workshop or seminar for industrialists to discuss freely strategies for industrial waste management.
- A priority monitoring schedule to be drawn, with adequate follow-up.
- Setting and putting in place a monitoring programme. The recent water quality testing Laboratory set up by a JICA grant will assist in reliable analysis.
- Lake Nakuru Pollution Monitoring Committee which this participant is the secretary should play a crucial role in setting monitoring programmes, effective data analysis and interpretation.
- An independent body to set be up to act as a check and balance to ensure the industries discharge within the limits of the standards. In this aspect Lake Nakuru Pollution Monitoring Committee can take a leading role.
- Industries can form a forum where they can exchange data and technology, advise or ideas in waste management.

3.3. Zoning

Lake Nakuru shore can be distinguished into two ecological zones, the ecotonic North-South East shore and the bare North South-West shore. The former is of great ecological importance, for it has fresh water springs, a resource for Biota along the shore and contribute significantly to Lake water level and its sedge-reed community form an ecological niche for various Biota. Kenya Wildlife service needs to zone-off this section for conservation of prolific Biodiversity.

The bare shore can be zoned into a utilisation zone, with restricted activities. Tourists should not be allowed to drive 100 m from the Lakes' water.

This will reduce Waterfowl disturbance and subsequent shore erosion.

Kenya Wildlife Service, the sole manager of Lake Nakuru National Park has to beef-up on going regular garbage collection from the shore line and designated camp sites and picnic sites. There should be adequate information to guide Visitors to the Park on the dos and don'ts (park rules and regulations).

3.4. Institutional Support

Funds for Environmental conservation may not be easily available and various Government departments and NGOs within Lake Nakuru catchment have funds or projects related to environmental conservation that can conserve ecology of Lake Nakuru. There is need for all these Departments to interchange intelligence and experience in environmental conservation; thereby avoiding duplication, waste of funds and time, hence

need for coordination and collaboration of all the activities. There is need to involve National Universities in these projects.

A comprehensive action plan drawn by all the actors can boost Lake Nakuru conservation. A joint forum should be instituted and an action plan drawn that will actively involve all the departments. Kenya Wildlife Service that has the responsibility to conserve Lake Nakuru should take a leading role towards this goal, monitoring and evaluation of the plan.

3.5. Monitoring

This will form basis for evaluation of Lake Nakuru conservation and management plan, and will comprise planned monitoring; frequent sampling; standard sample analysis techniques, data processing, analysis and interpretation; and evaluation of plan. Collected interpreted data will in a simple language be made available to decision makers and local communities.

Sampling points by Kenya Wildlife Service will comprise the lake; feeder rivers and springs; and sewage outlets. Nakuru Municipality will monitor industrial effluents and sewage inlets and outlets to determine treatment efficiency.

Independent random spot inspection will be done in industries.

The two organisations (KWS & MCN) will exchange data, and from time to time address areas of concern.

Principal actors involved in catchment management will discus the results twice in a year, evaluate conservation methods with necessary amendments. Tangible rewards need to be made to cooperative communities to encourage and boost conservation moral (motivation).

3.5.1 Water Quality Monitoring

Eleven sampling points have been identified in the Lake, feeder rivers and sewage outlet for physical parameters, and five for heavy metals and chemical pollutants.

This is an on going project being under taken by this participant.

The main objectives of this project are to assess water quality situation of the lake and rivers, identify pollutants, their sources, pathways and effect on Biota; and make appropriate recommendations for remedial measures.

3.5.1.1 Monitoring Programme And Items To Be Monitored

This will continue as per monitoring schedule, physical parameters once in a week, chemical and heavy metal parameters once in a month and biodiversity once in every two

months.

3.5.1.1.1. Physical Parameters

These will be measured insite and are-

- Water temperature.
- pH.
- Dissolved Oxygen.
- Transparency.
- Wind speed.
- Discharge rates.
- Lake levels.
- Conductivity.
- Atmospheric meteorological data (rainfall, Humidity, temperature, evaporation and radiation).

3.5.1.1.2. Chemical Parameters

This will assess concentrations, distribution, and dynamics of chemical substances temporal and spatial changes of concentration. These will analysed in water and sediments using standard Laboratory techniques, and are:

Heavy metal

- Total Chromium and Hexvalent Chromium.
- Cadmium
- lead
- Total mercury and alkyl mercury
- Arsenic
- Cyanide
- Cobalt
- Copper
- Zinc
- nickel
- BOD AND COD
- T-N & T-P
- T-C & TOC
- Alkalinity
- TDS & SS

Pesticides

- Organochlorines
- Chlorophenoxyacid compounds.

3.5.1.1.3. Biological Monitoring

This will be done to determine Biodiversity dynamics and correlate it with above parameters. This will include waterfowls, diatoms, zooplanktons, phytoplanktons and benthos.

Biological monitoring can provide overall information on the status of aquatic ecosystems, for they can integrate the various factors affecting their surrounding environment. Most vertebrate in Lake Nakuru is migratory, except Tilapia fish. These will be used as bio-indicators and level of contamination will be determined from selected tissues.

3.5.1.2. Data Analysis

Statistical techniques will be applied in data analysis and evaluation. An attempt will be made to model the Lake, and use the same data in decision making.

3.6. Public Awareness And Training

This will involve ways and methods to make local communities more aware of their role in conservation and how their activities affect the environment. Strategies will be inseminated in public meetings and through mass media. National, regional and local press articles, radio and television programmes are a potential source of environmental conservation information (Tunstall *et al*, 1995). This should include interpretation of information from other sources, statutory and voluntary bodies. The media should therefore be viewed as a part of a process of influence and interpretation(Tunstell *et al*). Local communities will be given an opportunity to discus and implement environmental conservation strategies in ways suitable to them.

A well educated and aware society can effectively conserve the environment. Targeting Youth will be a priority, and on going conservation projects in schools will be boosted.

Organizing conservation rallies with awards for well interpreted conservation techniques can enhance conservation moral. ILEC School project is a good example to be illuminated (Kawashima, Shiga University).

ACKNOWLEDGEMENT

I would like to thank Japan Government through JICA for sponsoring and accepting me to participate in this Training course and ILEC for hosting it. Kenya Government for nomination to attend the course and Director Kenya wildlife Service for permission and other logistics. Nippon Koei company for logistic support, and my wife Rose and family for being patient for the days I had to be away.

Literature review

1. Vareschi, E & A., Ecologia 1978/82, the ecology of Lake Nakuru.
2. Kagiri. J,W., Farming in Njoro and its effects on Lake Nakuru.
3. Koeman, J. H., Penning, J. H., de Goeiji, J. J. M., Tjioe, Olindo. P, S. A preliminary survey of possible contamination of Lake Nakuru in Kenya with some metal and chlorinated hydrocarbon pesticides.
4. Motelin, G., Ayieko. J., Yaban. W., Ndetei, R., Mysterious Lesser Flamingo deaths in Lakes Nakuru and Bogoria.
5. Matsui, S., Industrial pollution control in Japan.
6. Tunstall, S., Fordham, M., Green, C., House, M., Tapsell, S. Public perception of Freshwater quality with particular reference to Europe.
7. Mastui, S., Movement of Toxic substances through Bioaccumulation.
8. Biswas, A. K., Effective monitoring of Lake Waters.
9. Nakamura, M., Hashimoto, M., Tundisi, J.G. & Bauer, C., Planning for sound management of Lake Environments.

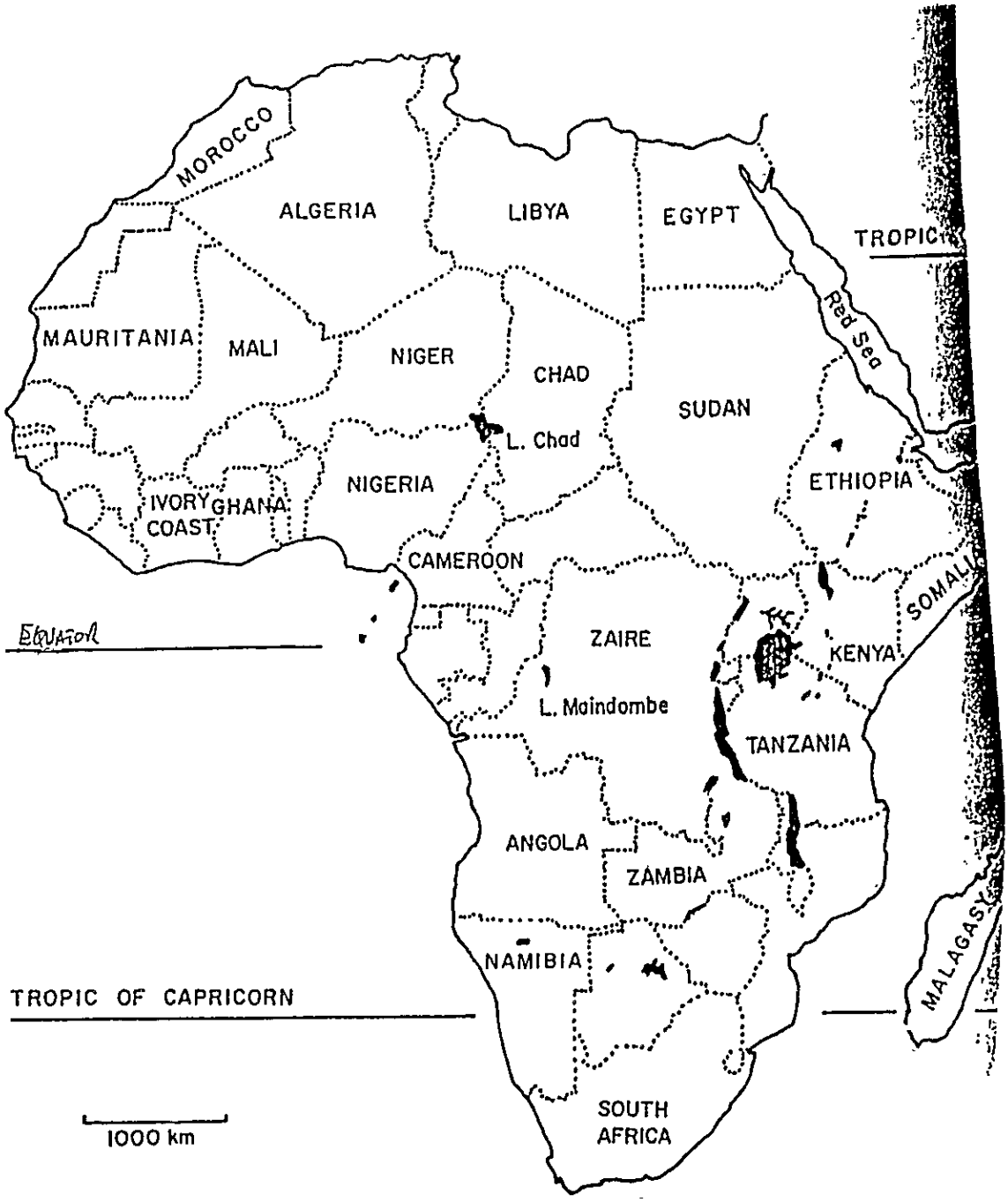
Table F-4 Trade Effluent Standards for Discharge into Public Sewers

(Unit: mg/L)

Item	Concentration
Total Suspended Solids	600
Total Non-volatile Dissolved Solids	3,000
BOD_5 at 20°C	500
COD	1,000
Phenols (total at connection point)	10
Detergents	15
Soaping oils and fats	10
Hydro carbons	20
Silver (Ag)	0 02
Arsenic (As)	0 02
Barium (Ba)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	1,000
Cyanide (CN^-)	0.02
Cyanide (CN) total	1
Cobalt (Co)	0.05
Hexavalent Chromium (Cr^{6+})	0.05
Total Chromium	3
Copper (Cu)	0.5
Mercury (Hg)	0.01
Ammonical Nitrogen	20
Nickel (Ni)	0.5
Free Ammonia	10
Total Kjeldahl Nitrogen	Nil
Nitrite	0.5
Lead (Pb)	2
Total Phosphate	30
Selenium (Se)	0.5
Tin (Sn)	0.5
Sulphite (SO_3)	2
Sulphate (SO_4)	1,000
Zinc (Zn)	0.5
Total Nonferrous Metals	0.5
Total Soluble Nonferrous Metals	30
Pesticides	Nil
pH	6.5 - 8 0
Temperature	Not exceeding 35°C
In addition, effluent should not contain any toxic matter or any matter that will cause blockage and damage to sewers. Inflammable material and tar should not be present in the final effluent entering the sewer	

(Data Source : NMC)

MAP OF AFRICA



RIFT VALLEY LAKES.

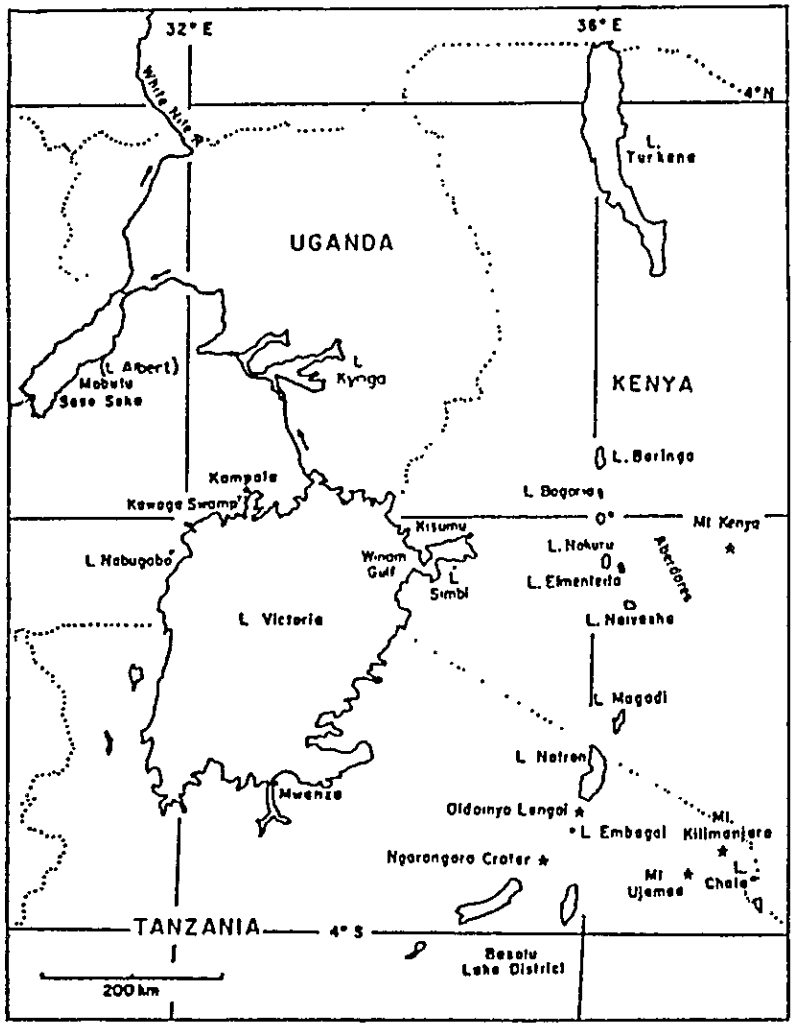


Fig. 19.3. Equatorial lakes. The Eastern or Gregory Rift extends from Lake Turkana to Basotu. The Western Rift includes Lake Mobutu Sese Seko (Albert).