ENVIRONMENTAL POLLUTION AND ITS IMPACT ON FISHERY MANAGEMENT IN LUNAWA LAGOON

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ABSTRACT

Lunawa Lagoon is one of the major lagoons close to Colombo which provided a livelihood for the fishing community in that area until the 1970s. This waterbody and it's aquatic resources have been degraded over the last two and a half decades, coinciding with the increase in the number of industrial establishments in the area, developed with little regard to environmental planning. The wastes generated by these industries and released untreated into the water have resulted in detrimental effects not only to the lagoon but also to the ground water resources.

A survey was carried out to ascertain the present status of the aquatic resources and to study the damage resulting from this unplanned industrial development. Results indicated that more than one hundred Jakotu fishery activities (which harvested prawns) were destroyed by the industrial releases into the drainage system. Fish catches of 50 kg/boat/day have been lost since 1979 and there has been a severe reduction of biodiversity in the lagoon. In addition, some areas of the lagoon have become breeding grounds for disease vectors, threatening the health of the surrounding population. Furthermore, deterioration of water quality and contamination of water with heavy metals were also observed. Dissolved oxygen availability in the water of the lagoon varied from sampling station to station with values ranging from zero to 14.6 mg/l indicating eutrophic conditions in some parts of the lagoon. Although pH values indicated slightly acidic conditions at some stations and slightly alkaline in others, no threatening levels of pH were observed at any station during this study.

For the rehabilitation of the area, an acceptable programme is needed for treating the liquid wastes generated by the industries and safely disposing of the treated effluent into the environment and should be introduced without further delay.

1. INTRODUCTION

Lunawa Lagoon is located south of Colombo in an area developed as an industrial and residential suburb. A large number of industries were established in the 1960s in the Moratuwa-Ratmalana area inter-mixed with residential and commercial establishments. A residential population of approximately 350,000 people is concentrated in this area which covers about 40 km^2. There are squatter settlements and low income families living along the canal banks and the periphery of the lagoon and their domestic waste water is directed to either septic tanks, soakaway pits or to drainage ditches. The high water table in this area and faecal contamination of ground water is also evident.

Recent studies recorded 225 industrial establishments in the study area with the predominant industries including garments & textiles, chemicals, metal finishing, food and asbestos products (Associated Engineering, 1994). The industries located in the Moratuwa Ratmalana area did not have waste water treatment plants and liquid wastes were discharged untreated into nearby storm-water canals. These releases aggravated the problems of water pollution and resulted in degradation of aquatic resources in the area.

The Lunawa lagoon, which is the major water body in the area receiving drainage water from the Moratuwa Ratmalana basin has been severely damaged as a result of this environmental degradation. The aquatic life of the lagoon has been greatly degraded due to contamination of its tributaries and the significant fishing industry supported by the lagoon two decades ago is now seriously threatened. Prior to 1979 there was a considerable amount of fishery activity with about seventy five fishermen in the lagoon and it was said that more than hundred Jakotu fisheries were also based in the lagoon. There was considerable biodiversity i.e. at least 22 fish species and six species of crustaceans were recorded from the lagoon.

A survey was conducted to obtain information regarding water quality, pollution and fishery aspects of the lagoon as a consequence of the industrial boom in the area during the 1950s and more intensively in the 1960s. This paper deals with the effect of such development on the aquatic resources and discusses possible management considerations to mitigate further deterioration.

2. MATERIALS AND METHODS

The physico-chemical characteristics of water have a dominant limiting effect on the aquatic environment. The chemical nature of the water determines the species that can survive and the population distribution of species. The following physico-chemical parameters were selected for this study to ascertain the quality of water.

A. Physical parameters

i. Turbidity
ii. pH
iii. Dissolved Oxygen
iv. Salinity

B. Nutrient parameters

i. Nitrates
ii. Nitrites
iii. Phosphates
iv. Ammoniacal nitrogen

C. **Pollution parameters**

i. Bio-chemical Oxygen Demand
ii. Organic matter concentration
iii. Oil and grease

D. **Heavy metals**

i. Manganese
ii. Zinc
iii. Copper
iv. Lead

E. Microbiological Parameters

i. Faecal Coliform count

2.1 Collection of samples

Water samples were collected from seven stations in the lagoon and sediment samples were also collectedfrom the same locations. Table I gives a briefdescription of selected sampling sites and Fig. I indicates their locations.

Temperature, salinity, pH and dissolved oxygen were measured *in situ;* the rest of the parameters were analysed in the laboratory according to the techniques given by Department of the Environment (1980), APHA/AWWA/WPCF (1985) & Hanson (1973). In the case of saline

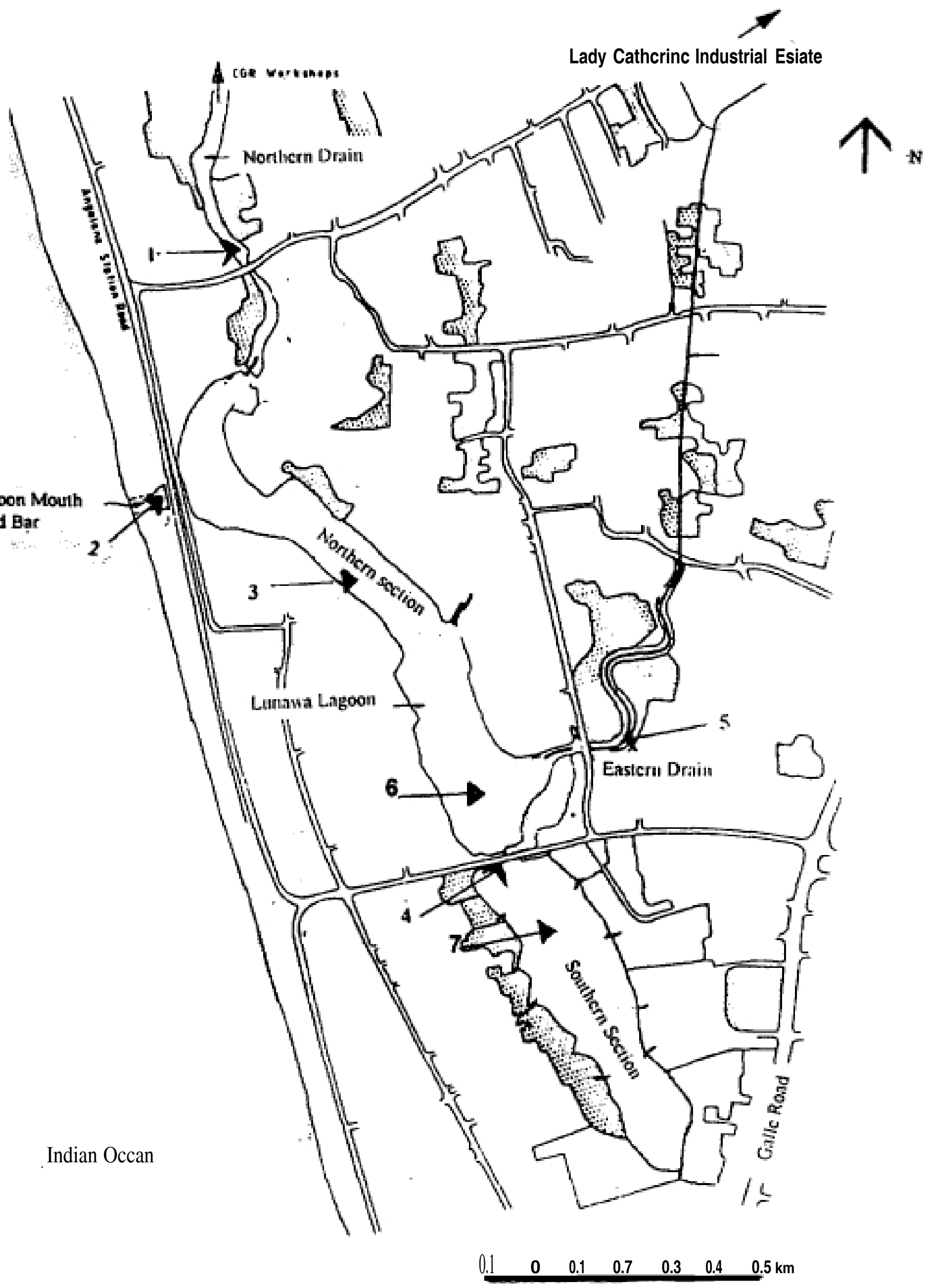

Fig. 1. Lunawa Lagoon, indicating location of sampling sites.

conditions, analyses were conducted according to Parson etal (1984). Discussions were also held with the fishermen who had experienced the ill effects resulting from industrial pollution.

Table 1
Description of Sampling Stations

Station No.	Specific Features
1.	Northern Drain, at the bridge on Angulana Station Road. This drain carries waste water from the CGR workshop.
2.	The point where the lagoon opens into the sea. Most of the time the outlet is closed due to formation of the Sand Bar.
3.	This point is located in the western bend of the lagoon. Densely populated area.
4.	The bridge at Lunawa Station Road. This is the narrow connection point between the Northern & Southern sections of the lagoon.
5.	Eastern Drain which carries polluted water from Lady Catherine Industrial Estate.
6.	This point is located in the lagoon proper at the Northern section in close proximity to the eastern drain outlet.
7.	This point is located in the lagoon proper-southern section which receives surface runoff & domestic waste.

3. RESULTS

Analytical results are presented in Tables 2, 3 and 4.

3.1 Basic physico-cheniical parameters

The variation in the temperature determined did not show any drastic changes during the short period of study. However, salinity varied from freshwater to saline conditions i.e. zero to 15 ppt. Turbidity varied from *5.8* to 29 NW, whereas pH values varied from 6.63 to 8.31 indicating slightly acidic and alkaline conditions at different locations (Table 2.)

Total lack of dissolved oxygen was reported from Station 5 whereas Station No. 1 too had a value less than 2 mg/l during the period of the study. Stations 2,3,6 & 7 indicated super saturation of dissolved oxygen varying between 7.2 and 18.6 mg/l indicating eutrophic conditions during daytime (Table 2)

Nitrate concentrations in the water varied from 0.11 mg/l to 5.74 mg/l whereas nitrite concentrations varied from 0.02 to *0.35* mg/l. Available phosphates in the water samples also varied between 0.08 and 1.31 mg/l all of which can contribute to the eutrophic conditions. Furthermore, sediments collected from the same locations contained large amounts of total phosphates (Table 2). In addition, ammoniacal nitrogen in the lagoon varied from 7.8 mg/l to 18.2 mg/l under drought conditions whereas concentrations varied between 0.38 mg/l and 33.9 mg/l alter rains. A high value was observed from station No. 1 which receives a storm water drain from the nearby area (Table 2)

Table 2.
Mean values of physico-chemical water quality parameters in Lunawa Lagoon.

Station	1	2	3	4	5	6	7.
Water temperature oC	28	28	27	26	28	28	26
Salinity ppt	0	7.5	2.5	2.5	0	0	0
Conductivity mS/cm	1.48	17.42	10.4	5.9	0.9	3.28	4.25
Turbidity NTU	17.8	7.9	7.9	11	19.5	17	8
pH	6.7	7.6	8.3	7.6	7.1	6.9	6.9
Dissolved oxygen mg/I	1.0	9.5	14.6	8.8	0.5	18.6	7.2
Oil & grease mg/I	1672	1972			2804	988	696
Ammoniacal nitrogen mg/I	26.05	8.12	7.8	13.8	15.4	0.48	0.38
Nitrate nitrogen mg/I	1.23	1.67	4.28	5.7	0.85	0.11	2.39
Nitrite nitrogen mg/I	0.21	0.015	0.07	0.02	0.02	0.04	0.34
Phosphate mg/I	0.78	0.13	0.11	0.12	0.36	0.17	0.15
BODmg/I	20	55	12.6	82.2	81	1.26	27.8
Organic matter mg/I	14	36	16	14	62	14	
Copper mg/I	0.01	0.013	0.013	0.061	0.014	0.007	0.011
Lead mg/I	0.002	0.005	0.005	0.004	0.003	0.003	0.004
Zinc mg/I	0.023	0.064	0.1	0.13	0.09	0.016	0.045
Manganese mg/i	0.1	0.067	0.036	0.05	0.34	0.086	0.019

3.2 Pollution parameters

BOD varied from 12.6 mg/l to 145.4 mg/l in the samples collected from the lagoon. The highest level of pollution was recorded at station 5. Organic matter concentrations varied from 6 to 62 mg/l. Stations 2 and 6 contained high levels of organic matter. Drains originating from populated areas release their organic loads into the lagoon in close proximity to station 2 (Table 2). Extremely high concentration of oil and grease, ranging from 0.9 g/l to 2.8 g/l, indicate heavy contamination of the water (Table 2)

Determination of concentrations of some heavy metals in the lagoon waters and sediment samples indicated that Manganese, Zinc, Copper and Lead were available in the sediment and in the water. Concentrations of manganese in the water varied from 0.02 to 0.37 mg/l; copper concentrations varied from 0.006 to 0.061 mg/l; zinc concentrations were found to be between 0.016 and 0.135 mg/l whereas lead levels were between 0.001 and 0.008 mg/l. As could be expected, the levels found in the sediments were higher than those in the water (Table 3).

3.3 Species diversity

A considerable biodiversity i.e. at least 22 fish species and six species of crustaceans had previously been recorded (Table 4). With respect to the fishery in the lagoon, the fishermen claimed

Table 3.
Lead, copper and total phosphorus in the sediments of Lunawa Lagoon.

Station	1	2	3	4	5	6	7
Coppermg/kg	0.013	0.009	0.291	2.114	0.855	nd.	nd.
Leadmg/kg	0.023	0.028	0.139	0.145	0.036	nd.	nd.
Totalphosphorusmg/kg	85.6	55.53	372.4	169.4	99.7	nd.	nd.

that the species diversity changed and there was a high abundance of *Lepidocephalus thermalis* (Ahirawa) during 1979. Later Tilapia became dominant in the lagoon. A limited number of fish species are found in the lagoon at present but the fishermen claim their flesh is not edible due to the unacceptable oily taste. Similarly, phyto- and zooplankton diversity has been reduced and replaced by blue-green algae (*Spirulina* sp. and *Anabaena* sp. – filamentous blue greens) and a few tolerant zooplankton species (*Daphnia* sp. & *Brachionus* sp.).

4. DISCUSSION

The study revealed that the water in the lagoon is not only eutrophicated but also contaminated with heavy metals. A considerable area is covered by aquatic weeds mainly consisting of water hyacinth. Water stagnates in some areas and provides breeding grounds for insect vectors such as mosquitoes. The formation of the sand bar prevents fluctuations of sea water and aggravates the water quality problems. These observations on sand bar formation and water movements are in line with those of Jayakody (1988). The pH values recorded in his report are slightly acidic (4.2—6.2) whereas such low pH values were not recorded during the period of the present study. The recorded levels of dissolved oxygen in 1988 were found within the range of 3 and 4.2 mg/l whereas complete absence of dissolved oxygen was also recorded in some areas during this study.

Some areas ofthe lagoon are inaccessible due to siltation and the dense growth of water plants. Dissolved oxygen and biochemical oxygen demand were negatively correlated. All nutrients i.e. nitrates, nitrites, phosphates and ammoniacal nitrogen were found to be well in excess of levels which would indicate eutrophic conditions (Yoshikawa. 1985). Observations supported these results since aquatic weeds were thriving and covered a considerable area of the lagoon (BKH Consulting Engineers, 1987). Species diversity was observed to be very limited also indicating high levels of pollution. Nutrient loading would have resulted in the present eutrophic conditions under which excess oxygen is released during the day allowing the water to become supersaturated in the areas where there were high densities of algae. This was also evident from the green colour ofthe water in some places. Blue green algal blooms in some places were dominated by *Spirulina* and *Anabaena* sp. Dominant zooplankton populations varied from station to station and some areas which had less oxygen were dominated by species of *Daphnia.*

The levels of hydrogen sulphide observed in the lagoon exceeded the maximum allowable concentrations for a healthy aquatic environment. Where hydrogen sulphide levels exceeded the limits, little or no dissolved oxygen was determined. The toxicity of hydrogen sulphide itself can severely damage the fish population and is in line with the reported decline in fish catches. According to the fishermen in the area catches of fish and prawn catches to be 200 and 10

Table 4.
Fish and crustaceans found in Lunawa Lagoon prior to the pollution problem.

Common name (Sinhala)	Common name (English)	Zoological name
Thambaiaya	Red snapper	*Lutianus argentimaculatus*
Moda	Barramundi	*Lates calcarifer*
Gan koraliya	Pearl spot	*Etroplus suratensis*
llathtaya	Scat	*Scatophagus argus*
Kapuhanda	Mono	*Monodactylus argenteus*
Kawaiya	Climbing perch	*Anabas testudineus*
Madakariya	Green snake head	*Ophiocephaluspunciatus*
Lula	Striped snake head	*Ophiocephalus striatus*
Godaya	Mullet	*Mug/isp.*
Waligowwa	Ban eyed goby	*Glossogobius giuris*
Ahirawa	Malabar sprat	*Ehirawafluviatilis*
Wekkaya	Milk fish	*Chanos chanos*
Petiya	Olive barb	*Puntius sarana*
Paratiya	Yellow tailed scad	*Acute mate*
Katilia	Common glass fish	*Ambassis commersoni*
Hal messa	Anchovy	*Engraulis sp.*
Kalanda	Silver whiting	*Sillago sihama*
Kossa	Reefcod	*Epinephelus tauvina*
Anguluwa	Long whiskered catfish	*Mystus gulio*
Tilapia	Tilapia	*Oreochromis mossambicus*
Kalissa		*Penaeus* **monodon**
Malissa		*Penaeus dobsoni*
Kin issa		*Penaeus indicus*
Kakuluwa	Mud crab	*Scyla serrata*

kg/fisherman/day respectively but there is little orno fishery activity at present. Sand bar formation prevents the recruitment of fish and other resources as reported by Jayakody (1988) and the present quality of the water and sediment is a not suitable environment for many edible fish.

The heavy metal concentrations determined in the sediments and in the water column are fairly high and the lagoon at present receives untreated industrial effluent. According to Freedman (1989) background concentrations of heavy metals such as manganese, zinc, copper and lead in fresh water are 0.008, 0.0015, 0.003, and 0.003 mg/l respectively. The values determined for the same metals in Lunawa lagoon waters .exceeded those background concentrations indicating contamination of water due to the release of industrial effluents. There is no doubt that higher concentrations of these metals would be found in fish due to bioaccumulation. The presence of other toxic metals such as cadmium, mercury and chromium cannot be ruled out. Attempts were not made to determine the bioaccumulation of heavy metals in aquatic organisms.

The guidelines set for the marine coastal waters liable to pollution (Bureau of Ceylon Standards, 1987) specified that oil and grease in the surface layer should not exceed 0.1 mg/l.

Extremely high concentrations of oil and grease, ranging from 0.9 gll to 2.8 g/l indicated heavy contamination of the water and no doubt fish in the lagoon may also be contaminated. The major source of oil and grease could be the industrial estates/ industries in the area which are estimated to produce 66 kg/day, with 61 kg/day of this being from the textile manufacturing sector (Associated Engineering, 1994.). These contaminants have severely detrimental effects on aquatic resources such as the clogging of gills of fish as well as causing anoxia due to poor oxygen exchange between the atmosphere and the surface water.

Supporting evidence comes from the report of Associated Engineering (1994) to confirm that the catchment of the lagoon receives a heavy load of pollutants. The loading of waste water generated from industrial establishments per day is estimated to be 3272 m^3. This waste water flow has a BOD_5 of 1681 kg /d, COD, 3846 kg/d and Total Suspended Solids 368 kg/d whereas the total nitrogen released is 399 kg/d and total phosphorus 11 kg/d, all of which ultimately find their way to the lagoon contaminating water, soil, and to some extent the air as well. In addition domestic waste water loading contributes a further BOD_5 of 4413 kg/d, almost three times greater than the level of industrial releases to the environment.

It should therefore be noted that while the untreated wastes from the industrial establishments in the area are largely responsible for the degradation of aquatic resources, the residents living on the Lagoon reservation also contribute to the pollution of water and the pollution of Lunawa lagoon cannot therefore be reversed naturally. All parameters determined exceeded the environmental quality standards set for fishery activities and nature conservation drafted by the Central Environmental Authority(199l).

5. RECOMMENDATIONS AND MANAGEMENT ISSUES.

This study leads to the following recommendations for remedial measures to rectify the situation although it may take a long time for the lagoon to become a diverse, healthy aquatic system again.

i. Prevention of indiscriminate release of untreated liquid wastes generated from industrial establishments.

ii. Prohibition of disposal of solid wastes into feeder streams and marshy areas of the lagoon.

iii. Prevention of unsatisfactory disposal of sewage from housing complexes and low income squatter families.

iv. Designate and enforce a buffer zone surrounding the lagoon.

v. Construction and proper maintenance of silt traps wherever necessary.

vi. Dredging of the lagoon and removal of bottom sediment which is contaminated with heavy metals.

vii. Make necessary arrangements to provide industrial waste treatment facilities to the industrial establishments. (Attention be given to the the provision of a common sewerage treatment plant.)

viii. Prohibit release of treated effluent into storm water canal system and the lagoon.

ix. Removal of sand bar from time to time for the purpose of flushing the lagoon and recruitment of fish and prawn species.

x. Educational programmes for factories, households and schools in the area on the causes for degradation of the lagoon and the methods for restoration.

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