Government of the Peoples Republic of Bangladesh
Flood Action Plan

FAP 17

Fisheries Studies and Pilot Project

FINAL REPORT

(Draft)

JUNE 1994

Supporting Volume No. 28

AN ANNOTATED BIBLIOGRAPHY OF THE QUALITY AND LIMNOLOGY OF INLAND FRESHWATERS IN BANGLADESH

ODA
Overseas Development Administration, U.K.

FAP 17

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Funded by ODA in conjunction with the Government of Bangladesh

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1 INTRODUCTION

The Flood Action Plan (FAP) involves proposals for extensive development of controlled flooding which by definition will result in changes in the timing of floods, their extent, magnitude and retention time on the floodplain. Such spatial and temporal changes in the quantity and distribution of floodwaters may result in changes in the quality of waters not only on the floodplains but also within the embanked rivers themselves. For example within embanked rivers, suspended solids which were previously deposited on the adjacent floodplain will be confined within the river channel and either deposited within it, raising bed levels, and thus increasing danger from breaches in embankments or else carried to the Bay of Bengal resulting in a series of complex changes in sedimentation and erosion patterns in coastal areas. Rivers passing urban centres are invariably used as depositaries for untreated domestic waste, sewage and industrial pollutants all of which can seriously reduce the quality of downstream surface waters and groundwaters and not only adversely affect aquatic life including fish but may also pose problems in terms of human health.

In flood protected areas, the reduction in river silts deposited on the land has been perceived by some to represent a potential loss in nutrient supply important for both agriculture and fisheries. In these areas future agricultural development will be heavily reliant on increased production of high yield varieties (HYV) of irrigated rice during the dry season. HYV rice varieties usually require increased inputs of fertilizers and pesticides which, in turn may adversely affect the quality of surface and groundwaters. The former acting through eutrophication processes possibly resulting in increased blooms of harmful algae or through excessive nitrate concentrations in groundwaters used for human consumption.

In the absence of a systematic national water quality monitoring programme in Bangladesh, information on the quality of open-waters is meagre. Most limnological investigations have focused attention on ponds and this is reflected in the greater number of local publications in this field. The following bibliography provides references, both published and unpublished, on the quality of open-waters i.e. rivers, floodplains, *beels* and closed waters such as ponds. It also presents information on various pollution studies including industrial, domestic and agro-chemical pollution. Because of the rather larger number of similar publications on pond limnology, the bibliography has been selective in this field but in others, as many references on possible have been included. It is hoped that this document will provide a useful source of background information for future workers in this much neglected area of research in Bangladesh.

2 BIBLIOGRAPHY

2.1 Water Quality and Limnology of Open Waters

1. Aziz, A. and Ahmed, Q. A. 1991.
   Occurrence and biomass of *Gloeotrichia* epiphytic on deepwater rice plants near Sonargaon, Bangladesh.
   Bangladesh. J. Bot. **20(1)**: 76-100.

Nitrogen fixing blue-green alga *Gloeotrichia* occurs as epiphyte on the tiller of rice plants in deepwater rice fields (DWRF). The abundances of *G. pisum* & *G. natans* were 53% and 23% respectively whereas *G. pilgeri* and *G. raciborskii* each showed 12% occupation in the field. After 30 to 75 days of flooding colony number and dry weight were high. Colony number ranged from 104 to 158 tiller^{-1} and the dry weight ranged from 3.26 to 5.82 kg ha^{-1}. Rice plants near the margin of DWRF harboured more *Gloeotrichia* than those of the centre. Vertically the alga colonized the tiller at around the middle of the water depth.

2. Aziz, A. and Ahmed, Q. A. 1992.
   Occurrence and biomass of algae epiphytic on deepwater rice plants near Sonargaon, Bangladesh.
   Arch. Hydrobiol. **125(4)**: 479-486.

Heterocystous blue-green algae constituted 60% of the total algal biomass in deepwater rice fields. From the beginning of flood maximum algal bio-volume (5.35 x 10^9 μm^3 tiller^{-1}) was attained after about 70 days of 140 days flood period. Green algae constituted 35% of the total biomass. Two species of diatoms, *Gomphonema*, were found epiphytic on rice plants.

3. Aziz, A., Alam, J. and Islam, A. K. M. Nurul. 1991.
   Studies on the members of Oedogoniales epiphytic on deepwater rice plants near Sonargaon, Bangladesh.
   Dhaka Univ. Stud. Pt. E., **6(2)**: 119-123.

Filamentous Oedogoniales (algae) epiphytic on deepwater rice plants have been investigated.

Five species from each of *Bulbochaete* and *Oedogonium* were recorded of these *Bulbochaete annularis* var. *annularis*, *B. pseudoelatior*, *Oedogonium bharatense*, *O. biforme* and *O. suborbiculare* var. *orbiculare* are new reports for Bangladesh.

4. Aziz, A. and Whitton, B.A. 1988.
Influence of light flux on nitrogenase activity of the deepwater rice-field cyanobacterium (blue-green alga) *Gloeotrichia pisum* in the field and laboratory. *Microbios* **53**: 7-19.

The response of nitrogenase in *Gloeotrichia pisum* to changes in light flux was quite rapid in the field and the laboratory. There was no indication of photoinhibition even when colonies taken from some distance below the surface were incubated at the surface. Both *in vivo* and *in vitro* studies indicate that almost all nitrogen fixation occurs by day.

5. B C A S. 1989.
Experimental project for improved management of open water fisheries in Bangladesh.
Final Report. Bangladesh Centre for Advanced Studies, Dhaka.

As part of a broader study on fisheries management approaches on jalmahal in different aquatic habitats, various physico-chemical parameters were recorded to provide background data. Data collections from rivers (Meghna, Padma) were made both in the dry and wet seasons on transparency, pH, cond., hardness, DO, CO_2, Cl, NO_3-N, PO_4-P and sulphate. Except for a lowering in transparency other parameters did not show any significant change during wet season. Similar studies were also carried out in *haor* (Kanglar *haor*, Karcha nadi, Arialkhan and Roail *beel*) and *baor* (Baluhar, Karincha, Kannadaha and Shimulia) ecosystems.

6. Begum, Z. N.T., Mandal, R. and Paul, A. R. 1988.
Succession of algal flora in deepwater rice field of Sonargaon Bangladesh. *Phykos* **27**: 15-27.

Except conductivity, total alkalinity and free CO_2 changes in pH and DO in water during

flooding were not statistically significant. Conductivity, alkalinity and DO varied from 41-25 μS cm^{-1}, 25-42 mg l^{-1} and 5.6-8.8 mg l^{-1}, respectively and that of pH from 5.2-7.2. Free CO_2 content was 20-42 mg l^{-1} from middle of July to the beginning of August, thereafter its concentration reduced drastically to 6 mg l^{-1} and remained almost unchanged except in few cases up to the month of October. Content of N in freshly deposited soil of the deepwater rice field increased slightly (preflood $\bar{x}$, = 0.152%, flooding condition $\bar{x}$ = 0.167%, postflood $\bar{x}$ = 0.158%). P changed little (preflood $\bar{x}$ = 422 ppm, flooding $\bar{x}$ = 387 ppm and postflood $\bar{x}$ = 411 ppm). A total of 9 algal genera was recorded during pre-flood but increased to 17 genera during flooding.

7. Catling, H. D., Martinez, M. R. and Islam, Z. 1981.
Survey of algae associated with deepwater rice in Bangladesh.
Cryptogamie, Algologie, **II(2)**: 109-121.

From the floodplains of the Ganges, Meghna and Jamuna a total of 139 species of algae associated with deep water rice was reported. On most floodplains clearwater flooding was usual and the water remained oxygenated until October. Water temperature (at Agarkhola 31°C $\pm$ 1.8) and light intensity were favourable for the growth of algae. Decay of algal material, submerged leaves and damaged culms of rice plants enriched the organic content of soils of rice fields.

8. Chowdhury, S. C. and Khair, A. 1982.
The phytoplankton members of Kaptai lake, Chittagong Hill-Tracts. I. Desmidaceae.
Chittagong Univ. Stud. Pt. II, **6**: 129-136.

Desmid algae of Kaptai lake have been studied and identified for the first time. A total of 10 genera and 53 species were reported with their illustrations.

9. Chowdhury, S. C. and Khair, A. 1984.
The plankton members of Kaptai lake, Chittagong Hill-Tracts. IV. Euglenophyceae, Dinophyceae and Cyanophyceae.
Chittagong Univ. Stud. Pt. II, **8(2)**: 87-90.

From the phytoplankton community of the lake, one species of Euglenophyceae, 4 species of Dinophyceae under 4 genera were described and illustrated in the paper.

10. Chowdhury, S.C. and Khair, A. 1993.
The phytoplankton members of Kaptai lake, Chittagong Hill-Tracts. III. Chlorophyceae.
Chittagong Univ. Stud. Pt. II. **7(2)**: 125-131.

From Kaptai lake 22 species of planktonic green algae belonging to 8 different families have been listed. Systematic account and illustration of the species were also furnished.

11. Chowdhury, S. H. and Mazumder, A. 1981.
Limnology of Lake Kaptai: I. Physico-chemical features.
Bangladesh J. Zool. **9(1)**:59-72.

Marked seasonal fluctuations in Secchi depth (0.38-3.44 m), water temperature (19-37.3°C), DO (6.5-10 ppm), CO_2 (5.83-11.83 ppm) hardness (50-66.67 ppm) and pH (5.31-6.92) were observed. Thermal stratification was recorded in summer and oxygen also varied with increasing depth. Annual fluctuations of nitrate and phosphate were 0.30-0.83 ppm and 0.27-0.83 ppm, respectively.

12. Das, N. G. and Das, S. 1980.
Two calanoid copepods from the Karnafully River estuary.
Chittagong Univ. Stud. Pt. II. **4**: 41-47.

During the high tide and at different seasons of the year two calanoid copepods were collected and studied. Systematic description of *Acartia tortaniformis* and *Labidocerea euchaeta* were presented.

13. Huq, S. M. I. and Kamal, G. M. 1993.
Characteristics and dynamics of wetland soils.
In: Freshwater Wetland in Bangladesh: Issues and Approaches for Management (Nishat, A., Hussain, Z., Roy, M. K. and Karim, A. eds.) pp. 33-64. IUCN, Gland, Switzerland.

Geomorphology, geology, physiography and nutrient dynamics of wetland soils were described. The pH of mineral wetland soils is around 7.0. Cation exchange capacity (CEC) ranges between 10 and 20 meq%. Physico-chemical changes in soil solution due to submergence were shown. Data on water quality such as suspended solid (SS), total nitrogen (NT), organic matter content (O.M.), total phosphorus (PT), potassium (K), sodium (Na) and iron (Fe) content of Hail *haor*, Kawadighi *haor*, Manu and Kushiyara rivers were presented. Characteristics of soil and water from various wetlands of Bangladesh were also presented.

14. Islam, A. K. M. Nazrul. 1993.
Ecological characteristics of freshwater wetlands.
In: Freshwater wetlands in Bangladesh: Issues and Approaches for Management (Nishat, A., Hussain, Z., Roy, M. K. and Karim, A. eds.) pp. 65-73. IUCN, Gland, Switzerland.

A classification of wetland ecosystems based on a hydrodynamic energy gradient were presented. Information on ionic composition, chemical composition of some wetland waters together with a list of macrophytes occurring in temporary marshes were also tabulated.

15. Islam, A. K. M. Nurul. 1974.
Preliminary studies on the food of some fish.
Dacca Univ. Stud. Pt. B, **22(1)**: 47-51.

Melosira, a diatom constituted 98% of the stomach contents of *Hilsha ilisha* caught from the river Meghna. From the stomach contents of *Mystus aor* a single vegetative filament of *Spirogyra* was detected. Presence of *Synedra* and daphnids were lesser in the stomach content.

16. Islam, A. K. M. Nurul, Anatunnesa and Haroon, A. K. Y. 1980.
Hydrobiological studies in and around Naogaon, Rajshahi.
Decca Univ. Stud., B, **28(2)**: 31-47.

Covering algae to angiosperms 168 species of hydrophytes were reported from Dublahati *beel* and some adjacent areas of Naogaon town. During May and June water temperature ranged between 25 and 31°C and during October 29 and 30°C. Aquatic ferns and angiosperms were represented by 34 species. A checklist and systematic account of some taxa were provided.

17. Islam, A. K. M. Nurul, and Aziz, A. 1977.
Studies on the phytoplankton of the Karnaphuli River estuary.
J. Bangladesh Acad. Sc. **1(2)**: 141-154.

The community of phytoplankton was represented by the occurrence of 42 species of algae (12 species of green algae, 17 species of diatom, 6 species of blue-green, 5 species of dinoflagellates and one species each of chrysomonad and euglenoid). The species were described taxonomically.

18. Islam, A. K. M. Nurul and Haroon, A. K. Y. 1975.
Limnological studies of the River Buriganga II. Biological aspects.
Dacca Univ. Stud. Pt. B. **23(1)**: 25-44.

Studies were conducted on plankton and periphyton of the River Buriganga near Dhaka city. From the benthic and planktonic flora, 137 species of algae were described. 15 species of zooplankton were reported. Details of the systematics with illustrations of the species were also provided.

19. Islam, A. K. M. Nurul, Haroon, A. K. Y. and Zaman, K. M. 1974.
Limnological studies of the River Buriganga 1. Physical and Chemical aspects.
Dacca Univ. Stud. Pt. B, **22(2)**: 99-111.

Seasonal changes in temperature (29-34°C), pH(7-7.8), DO (2.4-9.57 mgl^{-1}), total nitrogen (0.026-0.44 mg l^{-1}) and phosphate content (0.004-0.126.0 mg l^{-1}) of the river water from

Parzoar to Postagola were observed. *Microcystis aeruginosa* formed blooms from February to June. After its disappearance other phytoplankton started growing. Summer and winter were the seasons when maxima of phytoplankton and zooplankton occurred respectively.

20. Islam, A. K. M. Nurul and Khair, A. 1978.
Report of some phytoplankton from Lake Kaptai, Chittagong Hill Tracts.
Dacca Univ. Stud. B. **26(2)**: 53-61.

The paper reports the occurrence of *Dinobryon cylindricum*, *D. cylindricum* var. *palustris*, *D. divergens* and *Centritactus belanophorus* for the first time from Bangladesh. Systematic descriptions of the reported species and illustrative accounts were presented.

21. Islam, A. K. M. Nurul and Paul, N. 1978.
Hydrobiological study of the haor Hakaluki in Sylhet.
J. Asiatic Soc. Bangladesh (Sc.) **3(2)**: 83-91.

The study reveals an acidic condition of the *haor's* water (pH: 5.0-5.5). Water temperature varied between 23.0-24.5°C. Altogether 68 species of algae from planktonic and benthic communities were recorded. A total of 52 species of macrophytes was recorded. A checklist with notes on economic importance of the macrophytes were provided.

22. Islam, A. K. M. Nurul and Zaman, K. M. 1975.
Limnological studies of the River Buriganga II. Biological aspects.
J. Asiatic Soc. Bangladesh (Sc.), **1(1)**: 45-65.

Community structure, periodicity and systematic account of some algae (mostly chlorococcoid and desmid) were described. Green algae dominated (56.19%) followed by diatoms (29.90%) and blue-green (10.31%). *Microcystis aeruginosa*, a bloom forming cyanobacteria invaded the community at the end of December and continued up to the middle of June, 1973. The relative abundance of algae was highest in the monsoon season.

23. Ittekot, V., Safiullah, S. Mycke, B. and Seifert, R. 1985.
Seasonal variability and geochemical significance of organic matter in the River Ganges, Bangladesh.
Nature **317**: 800-802.

The River Ganges with its high sediment load (1250 mg l^{-1} suspended matter) plays a significant role in the deposition of land-derived organic carbon in marine sediments. Between July and November each year >80% of annual water discharge occurs which accompanies >80% of annual sediment discharge. Concentration of dissolved organic carbon (DOC) varied between 1.4-9.3 mg l^{-1} reaching a peak value in July. Sugars in the dissolved and particulate fractions ranged from 46-119 μg l^{-1} and 138-1119 μg l^{-1} respectively. Corresponding values for amino acids were between 24 and 2395 μg l^{-1}, and between 156 and 638 μg l^{-1} respectively. Significant seasonal differences in the nature of organic matter and the total sediment load transported by the Ganges were observed. In n-alkanes, n-C_{17} and n-C_{18} were dominant together with other hydrocarbons in the river water. Oxbow lakes adjacent to the river played a major role in the organic input to the river.

24. Karim, A. 1993.
Plant diversity and their conservation in freshwater wetlands.
In: Freshwater Wetlands in Bangladesh: Issues and Approaches for Management (Nishat, A., Hussain, Z., Roy, M. K. and Karim A. eds.) pp. 75-104. IUCN, Gland, Switzerland.

Diversity, life form and community of freshwater wetland plant species were discussed and documented. *Aldrovanda vesiculosa* and *Rosa involucarta* were identified as locally threatened species while freshwater swamp forest consisting of *Barringtonia acutangula*, *Pongamia glabra* and *Crataevea nurvala* were considered to be the most threatened vegetation due to over-exploitation and sedimentation.

25. Khair, A. and Chowdhury, S. C. 1993.
The phytoplankton members of Kaptai lake, Chittagong Hill-Tracts, II Bacillariophyceae.
Chittagong Univ. Stud. Pt. II, **7(1)**: 77-82.

From the phytoplankton community of Lake Kaptai, 28 species of diatoms from 15 genera were reported. Systematic descriptions of each species with illustrations were presented.

26. Khan, Y. S. A., Salam, A. M. A. and Kabir, K. 1978.
Cladocera of the River Buriganga, Dhaka, Bangladesh.
Bangladesh J. Zool. **6(2)**: 73-83.

Taxonomic enumeration of cladoceran zooplankton from the River Buriganga was presented. A total of 15 taxa belonging to 12 genera was identified of which 14 were identified to species level and 1 to genus.

27. Mahmood, N. 1986.
Hydrobiology of the Kaptai reservoir.
Final report on the Kaptai Reservoir Studies Programme.
FAO/UNDP Aquaculture Development and Coordination Programmes.
Rome, Italy. Contract No. DP/BGD/79/615-4/FI. 190pp.

Mean annual values of water temperature 27°C, DO 5.3 mg l^{-1}, pH 7.2, conductivity 114 mhos cm^{-1}, calcium 27 mg l^{-1}, orthophosphate 0.53 mg l^{-1}, nitrate nitrogen 1.63 mg l^{-1} and primary productivity 1.64 g C m^{-2} d^{-1} of Kaptai Lake characterised its eutrophic nature. Blue-green, green and diatom algae dominated. The phytoplankton were very important food for clupeids and carps. Zooplankton community was completely dominated by rotifers. Bottom fauna predominantly consisted of chironomids, bivalve molluscs, annelids and chaoborids. Recommendations regarding the management of the reservoir were given.

28. Mahmood, N., Khan, Y. S. A. and Ahmed, M. K. 1976.
Studies on the hydrology of the Karnafuli estuary.
J. Asiatic Soc. Bangladesh (Sci.) **2(1)**: 89-99.

Karnafuli estuary is a tidal-dominant estuary. Water temperature was maximum (29.9°C) in June and minimum (22.7°C) in January. pH and DO varied from 6.9-7.8 and 3.62-4.97 ml l^{-1} respectively. These two parameters showed inverse relationship with temperature. Seasonal salinity changes of the estuary is a function of the annual rainfall cycle.

29. Mirza, M. J. A., Islam, R., Haque, A. K. M. A. and Chowdhury, M. Y. 1978.
Studies on the physico-chemical characteristics of the River Old Brahmaputra at Mymensingh.
Bangladesh J. Aq. Cult. **1(1)**: 33-41.

Water quality was monitored at monthly intervals between October 1975 to September 1976 parameters measured comprised water temperature, transparency, water levels, water velocity, pH, DO, free CO_2, total hardness, Ca, alkalinity, phosphate, nitrate. The pH of the river water was 7.3 $\pm$ 0.25. During the dry months water levels, current velocities, turbidity, phosphate and CO_2 decreased.

30. Mirza, M. J. A., Haque, M. R., Haque, A. K. M. A. and Chowdhury, M. Y. 1985.
Studies on the phytoplankton of the River Old Brahmaputra.
Bangladesh J. Aq. Cult. **6-7(1)**: 25-29.

A total of 43 genera of phytoplankton was recorded from the river. Cyanobacteria (blue-green algae) accounted 41.29% of the total phytoplankton. The next abundant group was diatoms (32.15%) followed by green-algae (20.26%). Changes in water level, current and transparency were the most important factors influencing the growth of phytoplankton. Phytoplankton showed direct relationship with physical factors rather than chemical factors of water.

31. Patra, R. W. and Azadi, M. A. 1987.

Ecological studies on the planktonic organisms of the Halda River.
Bangladesh J. Zool. **15(2)**: 109-123.

The ranges of various water quality parameters in the Halda River were: water temperature: 19.6-32.0°C; water velocity: 11.56-17.86 cm sec^{-1}; transparency: 13.62-28.58 cm; turbidity: 134.38-428.25 ppm; conductivity: 51.58-147.65 μS cm^{-1}; pH: 6.89-8.15; DO: 6.83-13.18 mg l^{-1}; free CO_2: 0-3.58 mg l^{-1}; calcium: 7.71-14.86 mg l^{-1} and phosphate: 0.13-0.21 mg l^{-1}. Relative abundance of copepods was higher in summer (41-66%). Crustaceans were more abundant in winter (80%) than summer. Common phytoplankton mainly comprised diatoms (54%). Zooplankton abundance decreased with increasing turbidity. No significant relationship was observed between phytoplankton and water quality parameters.

32. Rother, J. A., Aziz, A., Karim, N. H. and Whitton, B. A. 1988.

Ecology of deepwater rice-fields in Bangladesh 4. Nitrogen fixation by blue-green algal communities.
Hydrobiologia **169**: 43-56.

Maximum blue-green algal crops recorded for any field for floating colonies and epiphytes were 186 and 54.8 mg chlorophyll a m^{-2} respectively. Acetylene reduction activity (ARA) was adopted to determine the nitrogen fixing capacity of blue-green algae. ARA at night as percentages of 24 h total, ranged from 0.6-19.0% for free-living blue-green algae and 24.6% for *Azolla*. Total ARA activity ranged from 39.9-249 n mol C_2H_4 min^{-1}. Estimated N_2 fixed inside the DWRFs at Manikganj and Sonargaon were 7 and 2 kg ha^{-1} during 1983 flood season. High crops of heterocystous blue-green algae present in many fallow areas provide an important source of fixed nitrogen in the region.

33. Rother, J. A., and Whitton, B. A. 1988a.

Ecology of deepwater rice-fields in Bangladesh 5. Mineral composition of rice plant and other aquatic macrophytes.
Hydrobiologia **169**: 57-67.

During the second flood peak (23 Sept.), 32% of the mass of rice plant was out of water, 65% in water and 3% in sediment/soil. There were marked differences between elements in

their pattern of accumulation by deepwater rice through the season. In comparison with the final total of each element about 48% of N, but only 11% of P and 10% of Na had been accumulated by the time the flood water arrived. Aquatic root system of the plant doubled between two flood peaks and it is suggested the P uptake might have occurred through this. Na was always higher in stem and Zn in the basal roots. Between the first (10 August) and second flood peaks aquatic macrophytes (weeds) increased 0.4% to 4.0%. They competed effectively with the rice for nutrients.

34. Rother, J. A. and Whitton, B. A. 1988b.
Mineral composition of *Azolla pinnata* in relation to composition of flood waters in Bangladesh.
Arch. Hydrobiol. **113(3)**: 371-380.

Elements present in *Azolla pinnata* (a nitrogen fixing aquatic fern) did not show any relationships with the elements present in the flood water. Comparing with the other habitats of *A. pinnata*, environment of deep water rice field contained lesser amount of ions, but they grew in the same manner. Possible differences between other habitats and deepwater rice fields are higher K and lower Fe and Zn contents. Low concentration of phosphorus in the field produced red fronds (due to anthocyanin pigment) of *A. pinnata*. Similar effect however, was not found *in vitro*. Low population densities of *A. pinnata* in the deepwater rice field probably resulted from low ambient phosphorus and wind action which drove the fronds in more shady areas of the field.

35. Safiullah, S., Chowdhury, M. I., Mafizuddin, M., Ali, I. and Karim, M. 1985.
Monitoring of Padma (Ganges), the Jamuna (Brahmaputra) and the Baral in Bangladesh.
Mitt. Geol. - Paläont. Inst. Univ. Hamburg SCOPE/UNEP Sonderband **58**: 519-524.

The range of some limnological parameters collected (5 samples between April and December 1983) from Padma, Jamuna and Baral are: DO % Sat., 60-93; DO, 4.82-8.57 mg l^{-1} and alkalinity, 0.112-0.264 meq l^{-1}. For Padma and Jamuna TSS, DOC and DIC ranged from 97-786 mg l^{-1}, 1.1-7.8 mg l^{-1} and 7.8-21.7 mg l^{-1}, respectively. In the Padma River percentage of POC in suspended matter remained nearly constant throughout the year. TSS concentration increased with increasing river discharge in both Padma and Jamuna.

36. Safiullah, S. and Huq, S. 1990.
Biogeochemical cycles of carbon in the rivers of Bangladesh.
In: Environmental Aspects of Surface Water Systems of Bangladesh (Rahman, A.A., Huq, S. and Conway, G. R., eds.) pp. 136-144.
University Press Ltd., Dhaka.

Total flux of carbon through the rivers Ganges and Jamuna was shown graphically. pH of the River Ganges ranged between 7.45 (June-Aug.) and 8.28 (Jan.-May). DO content varied from 6.0-9.3 ppm with maximum values during Jan.-Feb. Free carbon dioxide, carbonate and bicarbonate ranged from 1-10, 1-12 and 12-32 ppm respectively. Phosphate remained within the narrow range 11-19 ppm. Plankton count shows the peaks in June, December and March. In the Brahmaputra DO, phosphate, DOC and DIC have lower values than those of the Ganges.

37. Shafi, M., Quddus, M. M. A. and Islam, N. 1978.
Studies on the limnology of the River Meghna.
Bangladesh J. Fish. **1(2)**: 85-97.

Water quality of the River Meghna at Daudkandi and Chandpur was studied. At both sites water temperature ranged between 20.0-31.2°C. Secchi depth varied from 0.63-1.40 m and 0.20-0.44 m at Daudkandi and Chandpur respectively. The value of turbidity coincided well (Daudkandi, <25 ppm and Chandpur, 40-100 ppm) with the Secchi depth indicating clearer water at Daudkandi. Turbidity was higher in August which declined to a minimum in January. pH varied from 6.79-8.41. DO was high in January (10.5 ppm) and low in May (5.25 ppm). Seasonal trends in pH and DO were similar at both stations. Some variation was found in phosphate (0.016-0.049 ppm) and total nitrogen (0.10-0.42 ppm). Plankton maxima at Daudkandi (total phytoplankton: 157.24 x 10^4 ind. m^{-3}) were very similar to those recorded at Chandpur (total phytopl. 159.42 x 10^4 and total zoopl. 19.83 x 10^4 ind. m^{-3}).

38. Whitton, B. A., Aziz, A., Francis, P., Rother, J. A., Simon, J. W. and Tahmida, Z. N. 1988.
Ecology of deepwater rice-fields in Bangladesh 1. Physical and chemical environment.
Hydrobiologia **169**: 3-67.

Limnological data on conductivity, pH, total alkalinity, DO, major metals (Na, K, Mg, Ca, Mn, Fe), heavy metals (Co, Ni, Cu, Zn, Cd, Pb), various fractions of nitrogen and phosphorus, Cl, SO_4-S and reactive Si were presented. Aerial and under water PAR (photosynthetic active radiation) was also monitored. The research was carried out covering two flood peaks (late July and mid-September) in different DWRFs of Meghna Jamuna and Ganges. Considering the concentrations of N and P the ecosystem may be regarded as mesotrophic (having moderate levels of nutrients). Filterable organic P ($\bar{x}$: 0.020-0.036 mg l^{-1}) was at least as important as filterable reactive P ($\bar{x}$: 0.005 - 0.038 mgl^{-1}). After the second flood peak upper water always remained oxic and occasionally super saturated with DO. However, DWR fields in south Bangladesh were entirely anoxic.

39. Whitton, B. A., Aziz, A., Kawecka, B. and Rother, J. A. 1988.
Ecology of deepwater rice-fields in Bangladesh. 3. Associated algae and macrophytes.
Hydrobiologia **169**: 31-42.

Fine leaved macrophytes such as *Myriophyllum* sp., *Najas indica* and *Utricularia stellaris* were abundant in the DWRFs. Dense masses of epiphytic algae were harboured by the aquatic roots, stems, leaf sheaths of rice plants growing in isolated and well illuminated places. Two well known nitrogen fixing algae *Aulosira fertilissima* and *Scytonema mirabile* successfully grew on rice field soils prior to flooding. During flood period these two species remained afloat on the water surface in dense masses. Inside DWRFs heterocystous blue-green algae were common. Non-heterocystous *Aphanothece stagima* sometimes formed distinct colonies. Differences in ability to tolerate anoxia may be a key factor in determining the success of algal and vascular plants within DWR-growing areas. *Navicula confervacea* was the dominant diatom in these habitats.

40. Whitton, B. A. and Rother, J. A. 1988.
Diel changes in the environment of a deepwater rice-field in Bangladesh.
Verh. Internat. Verein. Limnol. **23**: 1074-1079.

Diel changes in temperature, DO, and pH were observed. The differences between minima and maxima at any one position ranged from: 2.0-4.0°C, 9.9-10.9 mg l^{-1} O_2, 1.2-1.6 pH units. pH and O_2 both showed maxima in the afternoon. Water inside a DWR field showed an increasing tendency to become anoxic during the second half of the flood season. Diel ranges for pH and O_2 were higher in the fallow field than the DWR field, but anoxic conditions developed later.

41. Whitton, B. A., Rother, J. A. and Paul, A. R. 1988.
Ecology of deepwater rice-fields in Bangladesh. 2. Chemistry of sites at Manikganj and Sonargaon.
Hydrobiologia **169**: 23-30.

Chemistries of DWRFs at Manikganj (Jamuna floodplain) and at Sonargaon (Old Meghna floodplain) during the flood season were similar, apart from higher Mg($\bar{x}$, 3.57 vs. 1.8 mg l^{-1}), Ca ($\bar{x}$, 13.1 vs. 4.5 mg l^{-1}), pH and total alkalinity at the former. Oxygen and pH sometimes showed diel changes at 10 cm below the surface. Such changes were much greater in fallow fields. Between 1400 and 1600 h some habitats showed high pH associated with high O_2 values. These two parameters were higher in open areas and fallow fields followed by DWRFs and water under a carpet of water hyacinth. O_2 concentrations in excess of 15 mg l^{-1} and pH values of about 10 sometimes occurred in fallow fields rich in submerged plants and algal flocs. Gradual anoxia with increased nitrite and decreased sulphate were evident in the fields at the end of the season.

42. Yallop, M. L. and Whitton, B. A. 1982.
Physiological ecology of blue-green algae in deepwater rice fields of Bangladesh.
Physiol. J. **17(2)**: 241-

The aim of the work was to establish the role of blue-green algae on the growth of deep water rice. Both plants grow side by side in the floodplain areas of Bangladesh and are dependent on the intensity of flooding each year. Flood water was seen to be relatively soft

in nature (conductivity 50-190 μS cm^{-1}) with a minimum pH value close to 7.0. Floodwaters were poorly buffered and high pH values were recorded during peak photosynthesis at midday. Dominant algal flora were *Aulosira*, *Gloeotrichia*, *Spirogyra* and *Draparnaldia*. Rich algal flora also occurred with culms, nodal roots and the older leaves of the rice plants.

43. Zaman, M. 1991.

Studies on the algal flora of Chalan *beel* in relation to its physico-chemical conditions.

Ph. D. Thesis, Department of Botany, University of Rajshahi,.

Physio-chemical aspects of Chalan *beel* were discussed and their relationships with plankton abundance were established. Information on phytoplankton quality, quantity and periodicity was presented.

2.2 Water Quality and Limnology of Ponds

44. Alam, A. K. M. N., Islam, M. A., Mollah, M. F. A., Haq, M. S. and Rahman, M. S. 1985.
Growth of *silver carp Hypophthalmichthys molitrix* (Val.) with reference to some limnological parameters of rearing ponds.
Bangladesh J. Fish. **8(1-2)**: 9-15.

Pond no. 1 which differed from pond no. 2, 3 and 4 by having lower hardness (45.0 ppm) and phosphate (0.09 ppm) and higher phytoplankton standing crop (19792 cells l^{-1}) supported a better growth of *Hypophthalmichthys molitrix* (Val.). DO concentration <5 ppm was found detrimental for fish growth.

45. Alam, M. J., Habib, M. A. B. and Islam, M. A. 1985.
Multiple and linear correlations of some physico-chemical properties of water with abundant genera of zooplankton in nursery ponds.
Bangladesh J. Aquaculture. **6-7(1)**: 59-64.

Eight dominant genera of zooplankton (*Keratella, Brachiunus, Filinia, Daphnia, Bosmina, Diaphanosoma, Cyclops, Diaptomus*) correlated ($P<0.05$) with some water quality parameters (temperature, pH, O_2, CO_2, NO_3-N, PO_4-P, exchangeable K and Ca) from six nursery ponds. All genera showed inverse correlations with free CO_2, NO_3, PO_4, K, and Ca indicating their dependency on these factors. Direct correlations have been observed between the genera and water temperature, pH and DO.

46. Alam, M. J., Habib, M. A. B. and Begum, M. 1989.
Effect of water properties and dominant genera of phytoplankton on the abundance of available genera of zooplankton.
Pak. J. Sci. Ind. Res. **32(3)**: 194-200

Significant positive correlations were observed between various physicochemical parameters and abundances of algal genera like *Volvox, Ulothrix, Anabaena* and *Miorocystis*. All genera however, showed an inverse relationship with the concentration of free CO_2. Among

zooplankton *Filinia* and *Cyclops* had strong direct and inverse correlations with *Anabaena* and *Micorocystis* respectively.

47. Alam, A. K. M. N., Mollah, M. F. A, Islam, M. A., Haq, M. S. and Haque, M. M. 1987.
Status of phytoplankton in newly constructed ponds and their relation to some meteorological and limnological factors.
Bangladesh J. Fish. **10(1)**: 75-81.

Occurrences (as percentages) of four groups of phytoplankton (Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglenophyceae) in four newly constructed ponds were reported. Myxophyceae dominated in all the ponds followed by Bacillariophyceae, Chlorophyceae and Euglenophyceae. Total phytoplankton showed significant positive correlations with pH in all the ponds except Pond 2 where it was negative. Significant negative correlations were obtained between total phytoplankton and free CO_2 in all the ponds except Pond 2 where the relationship was insignificant.

48. Alam, A. K. M. N., Islam, M. A., Mollah, M. F. A. and Hoq, M. S. 1987.
Status of zooplankton in newly constructed ponds and their relation to some meteorological and limnological factors.
Bangladesh J. Fish. **10(1)**: 83-88.

In respect of numerical abundance Rotifera, Copepoda and Cladocera were the dominant groups in the ponds. Zooplankton populations were found to correlate ($P < 0.05$) directly with DO, pH while negatively with free CO_2. Combined effect of meteorological and limnological factors on the abundance of Rotifera in pond 3 and that on Copepoda in ponds 3 and 4 were statistically significant.

49. Ali, M. M., Islam, M. A. and Habib, M. A. B. 1985.
Monthly abundance of zooplankton and correlation of various dominant species and nauplius of zooplankton with some water characters in a pond.
Univ. J. Zool. Rajshahi Univ., **4**: 42-49.

Zooplankton population showed significant seasonal variation but their depthwise variation of abundance was insignificant. A total of 30 species and nauplius of zooplankton were recorded of which *Brachionus forficula* was dominant. *B. forficula* related inversely with transparency and *B. deitersi* showed direct relation with pH of water.

50. Ali, M. M., Islam, M. A., Habib, M. A. B. and Rahmatullah, S. M. 1985.
Effect of meteorological and some physicochemical factors of water on the growth of phytoplankton in a pond.
Bangladesh J. Aquaculture **6-7(1)**: 1-10.

Depthwise distribution and monthly abundance of phytoplankton varied significantly. Various meteorological factors and temperature, transparency and pH of water had a combined effect upon the population dynamics of phytoplankton but was not statistically significant. Species of phytoplankton (except *Melosira granulata*) showed inverse relationship with rainfall. Positive correlation between sunshine hours and abundance of various species showed the influence of former parameter on the latter.

51. Ali, S., Chowdhury, A. N., Chowdhury, D. R. and Begum, S. 1989.
Studies on seasonal variations of physico-chemical and biological conditions in a pond.
Dhaka Univ. Stud. Pt. E. **4(2)**: 113-123.

Pond water temperatures varied from 20.5 to 36°C, and pH values ranged from 6.7 to 8.4. The highest value of free CO_2 was recorded during summer (42 ppm). Carbonate alkalinity showed a range of 3.2 to 24 ppm peaking in September. Maximum bicarbonate alkalinity (170 ppm) was observed in October. DO content showed its maximum (13 ppm) in June and minimum (4.8 ppm) in August. Diatomaceae (70%), Rotifera (40%) and Oligochaeta (87.3%) were the dominant groups of organisms respectively from phytoplankton, zooplankton and benthic macroinvertebrates. Inverse relationships between phytoplankton and zooplankton and zooplankton and macroinvertebrates were observed.

52. Ali, M. M. and Islam, M. A. 1983.
Studies on the plankton of a lake in Bangladesh Agricultural University Campus, Mymensingh.
Bangladesh J. Aq. Cult. **2-5(1)**: 51-61.

The studied lake is actually a pond of 4 ha having a maximum depth of 2.0 m. Qualitative and quantitative aspects of phytoplankton and zooplankton were studied in the pond for 8 months (November to June). All the planktonic genera recorded were listed with their abundances against the corresponding date of collection. *Melosira* showed a peak (42.25%) in May, at other times *Anabaena* dominated (18.22%) over others. Among zooplankton maximum abundance of *Brachionus* (41.44%) occurred in June.

53. Ali, S., Majid, A. and Chowdhury, A. Q. 1985.
Studies on benthic macroinvertebrates in freshwater pond, Bangladesh.
Pakistan J. Zool. **17(3)**: 301-306.

Water depth of the pond (Chandpur, Fisheries Campus) fluctuated between 1m and 3.83 m. Temperature was highest (34.17°C) in May and lowest (20.33°C) in January. pH ranged between 8.3 and 9.0 showing an alkaline condition. DO was 11.27 ppm in May and 6.6 ppm in February. Total hardness ranged from 90 ppm (in April) to 123.33 ppm (in March). Monthly average population of benthic fauna (1981 ind. m^{-2}) indicated a productive condition of the pond.

54. Ali, S., Rahman, A. K. A., Patwary, A. R. and Islam, K. R. 1982.
Studies on the diurnal variations in physico-chemical factors and zooplankton in a freshwater pond.
Bangladesh J. Fish. **2-5(1-2)**: 15-23.

A peak at 15:00 h for most of the limnological parameters such as temperature, pH, DO and CO_3 have been observed. However, at the same time a fall in the values of CO_2 and HCO_3 was evident in the pond. The flux in the chemical parameter was perhaps due to the photosynthetic activity in water. Rotifer populations attained their maxima between 15:00 and 18:00 h. Crustacean abundances were lowest at night.

55. Ameen, M., Begum, Z. N. T., Mustafa, A. and Ali, S. 1988.
Seasonal and diel profile of temperature, light penetration, dissolved oxygen and free carbon dioxide of a fish pond from south of Bangladesh.
J. Zool. **3**: 1-8

Water temperature did not show any diel and seasonal variation with depth. Secchi depth (transparency) differed only upto 3 cm during the 24 h cycle in four seasons. DO was highest at the surface and lowest near the bottom in all seasons except summer when it was same (6 ppm) from top to bottom. Free CO_2 showed a reverse pattern of distribution as compared with DO.

56. Ameen, M., Begum, Z. N. T., Ali, S., Rahman, P. M. M. and Roy, T. K. 1986.
A comparative limnological study of two fish ponds in Raipur.
Dhaka Univ. Stud. Pt. E. **1(1)**: 25-34.

Limnological parameters (plankton abundance, water temperature, water depth, Secchi depth, pH, DO, CO_2 and HCO_3 concentrations) of one fertilised and one unfertilised pond were compared. In 8½ month period, fish (*Hypophthalmychthys molitrix*, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) production in the fertilised pond was 2305 kg ha^{-1} whereas in the unfertilised pond it was only 531 kg ha^{-1}. Thus the benefit of fertilizing fish ponds to increase fish production was demonstrated.

57. Anonymous. 1993.
Limnology of three ponds in Rajshahi hatchery.
M. Sc. Thesis. Botany Dept., Rajshahi Univ., pp. 155.

Some limnological parameters in the surface water of the studied ponds varied as follows: temperature: 17.0-32.0°C, pH: 6.8-8.4, free CO_2: 7-39 mg l^{-1}, carbonate alkalinity: 0-11 mg l^{-1}, bicarbonate alkalinity: 90-250 mg l^{-1}, DO: 0.83-9.65 mg l^{-1}, DO % sat: 10.5-128.0%, and Cl: 9.94-18.64 mg l^{-1}. The parameters in the bottom water ranged, temperature: 15.5-31.0°C, pH: 6.9-8.4, free CO_2: 6-42 mg l^{-1}, DO: 0.89-8.96 mg l^{-1} and DO % sat.: 11.1-108.6, Secchi depth varied from 18-46 cm. Gross and net primary productivity in the ponds varied from 0.32-4.82 mg C l^{-1} h^{-1} and 0.23-4.45 mg C l^{-1} h^{-1} respectively. A total of 44 genera of phytoplankton and 19 genera of zooplankton was recorded from the ponds.

58. B A F R U. 1990

A survey of fish farm water quality in Bangladesh.
Univ. of Stirling, Stirling, Scotland, pp. 92.

A total of 12 parameters (temperature, conductivity, total dissolved solids, pH, CO_2, total hardness, total alkalinity, turbidity, nitrate nitrogen, orthophosphate phosphorus, total iron, aluminium) was monitored in both hatchery supply water and pond water in Bangladesh. Correlations were found, between conductivity, hardness and alkalinity. All other water quality factors did not show any relationship. Results revealed that water of central west Bangladesh was harder and had higher conductivities and alkalinities than other regions. The most significant differences between unproductive and productive ponds were the hardness and alkalinity values.

59. Banu, A. N. H., Ali, M. M. and Islam, A. 1988.

Plankton study of some selected ponds in different locations of Bangladesh.
Bangladesh J. Aquaculture. **9(2)**: 55-59.

The dominant genera of phytoplankton in the pond were *Anabaena, Anabaenopsis, Microcystis, Chlorococcus, Pediastrum* and *Melosira*. On the otherhand *Brachionus, Keratella, Fillinia, Daphnia, Diaphanosoma* and *Cyclops* dominated the zooplankton community. Planktonic standing crop ranged from 4 x 10^3 to 352 x 10^3 individuals l^{-1}.

60. B C A S. 1989.

Environmental aspects of agricultural development and surface water systems of Bangladesh: An interim report.
Bangladesh Centre for Advanced Studies, Dhaka.

Water analyses of different ponds (in sun and shade) from Dhaka and Mymensingh area were presented. Ranges of different water quality parameters were: pH: 6.5-7.2; conductivity: 185.8-731.5 micro mhos cm^{-1}, chloride: 73-250 mg l^{-1}, total alkalinity: 5-150 mg l^{-1}, total hardness: 2.8-4.9 mg l^{-1}, DO: 1.3-8.5 mg l^{-1} (at different day hours), turbidity: 6.5-167.7 mg l^{-1}. Analyses of soil samples from the ponds showed: pH: 6.0-6.9, moisture content: 57.6-69.9%; conductivity: 26.9-256.0 micro mhos cm^{-1}, Na: 59.0-110.5 ppm and K: 41.0-51.0 ppm.

61. Begum, S., Chowdhury, A. N., Sufi, G. B. and Sultana, N. 1992.
Rotifers in a fish pond: their occurrence and seasonal variation.
Dhaka Univ. J. Biol. Sci. **1(1)**: 15-18.

In a rainfed perennial pond (area: 0.34 ha, maximum depth: 2.0m) in Dhaka cantonment some limnological parameters varied as follows: water temperature 23.6 - 37.3°C; depth of visibility (Z_s) 21.50-33.45 cm; pH 7-7.8; DO 11.10-16.20 ppm, and bicarbonate 55.0-80.30 ppm. During peak periods of rotifer abundance ($18.2x10^4$ ind. l^{-1}) water quality varied as follows, water temperature: 27.0°C; Zs: 25.74 cm; pH: 7.80; DO: 11.70 ppm and bicarbonate: 80.30 ppm. During minimum rotifer abundance (0.87×10^4 l^{-1}) the above mentioned parameters were, temperature: 37.3°C, Z_s: 21.5 cm; pH: 7.5; DO:12.4 ppm; and carbonate: 67.0 ppm.

62. Bhouyain, A. M., Hafizuddin, A. K. M. and Pasha, M. K. 1981.
Diurnal movement of plankton in a pond.
Chittagong Univ. Stud. Pt. II. **5**: 41-49.

Blue-green, green algae and diatoms were the dominating groups of phytoplankton in the pond while the majority of zooplankton belonged to the groups Rotifera and Copepoda. The physicochemical factors such as temperature, pH, light penetration, DO and CO_2 were also studied in relation to the vertical movement of plankton.

63. Bhouyain, A. M. and Sen, H. 1983.
Cladocera of Foy's Lake, Chittagong.
Chittagong Univ. Stud. Pt. II. **7(2)**: 29-35.

A taxonomic study of cladoceran zooplankton was carried out. The study reported 3 new records, a total of 13 species from 10 genera and 4 families. Systematic accounts and illustrations of each species were presented.

64. Bhouyain, A. M. and Das, D. K. 1985.
Primary production of a fish pond.
Univ. J. Zool. Rajshahi Univ. **4**: 55-58.

Primary productivity of a fish pond was studied in three different seasons. Winter was the season when average maximum net production, 47.64 mgC m^{-3} h^{-1} was recorded. Net primary production was minimum (33.36 mgC m^{-3} h^{-1}) in rainy season.

65. Bhouyain, A. M. and Sen, H. 1989.
Primary productivity of Foy's lake Chittagong, Bangladesh.
Univ. J. Zool. Rajshahi Univ. **8**: 77-84.

One year study (May 1981 - April 1982) on the primary productivity of an artificial lake was carried out by 'light and dark bottle oxygen technique'. The average maximum net productivity was observed as 66.93 mgC m^{-3} h^{-1} in April and minimum 1.87 mgC m^{-3} h^{-1} in July. Maximum and minimum gross productivity were 105.72 mgC m^{-3} h^{-1} (April) and 18.14 mgC m^{-3} h^{-1} (in July) respectively. The influence of temperature and light penetration were also recorded during the study.

66. Chowdhury, A. N., Begum, S. and Sultana, N. 1989.
Occurrence and seasonal variation of zooplankton in a fish pond in relation to some physico-chemical factors.
Bangladesh J. Zool. **17(2)**: 101-106.

Rotifers appeared as the dominant group (52%), followed by protozoans (16%) and ostracods (12%). Monthly fluctuations of the physical as well as chemical parameters of the pond were also noted.

67. Chowdhury, A. N., Begum, S. and Sultana, N. 1992.
Physico-chemical and biological parameters affecting the occurrence and seasonal variation of ostracods in a tropical fish pond.
Bangladesh J. Zool. **20(2)**: 315-323.

Annual ranges of water temperature, Zs, pH, DO, free CO_2 and bicarbonate concentration were 24.0-37.3°C; 21.5-33.45 cm; 7.0-7.8; 11.2-16.2 ppm, 25.0-64.0 ppm and 55.0-80.3 ppm respectively. The community of zooplankton was represented by Ostracoda (12.19%), Copepoda (6.71%), Rotifera (52.25%), Cladocera (4.36%), nauplius larva (7.94%) and Protozoa (16.44%). Ostracod population showed significant positive correlation with the depth of visibility, pH, free CO_2 and bicarbonate concentration.

68. Chowdhury, A., Khanum, H. and Karim, I. 1991.
Effect of soil conditions on the abundance of benthic macroinvertebrates.
J. Asiat. Soc. Bangladesh, Sci. **17(2)**: 155-161.

Together with benthic macrofauna pH, organic carbon and total nitrogen content of submerged bottom sediment of a pond were determined. Annual variation of pH, organic carbon and total nitrogen were 5.4-6.3, 0.48-1.67% and 0.06-0.13% respectively. The dominant macroinvertebrates in the pond were chironomids (76.77%) followed by oligochaetes (19.78%) and ceratopogonids (3.44%). Organic carbon showed a negative correlation with oligochaete and ceratopogonids.

69. Das, N. G. and Bhuiyan, A. L. 1974a.
Limnoplankton of some inland waters of Dacca city.
Bangladesh J. Zool. **2(1)**: 27-42.

The pH of two ponds (of Dhaka University Campus) ranged from 6.6-7.55 and that of two artificial lakes (of Dhaka metropolis) from 6.5-9.0. Nitrate was unusually very high in all sites (1.5-2.58 mg l^{-1}). Phosphate content ranged from 0.015 mg l^{-1} to 0.06 mg l^{-1}. Temperature and DO taken at different times of the day varied from 21-30°C and 3.62-8.25 mg l^{-1}, respectively. A total of 37 species of zooplankton was identified. Periodicity of plankton in each site was presented.

70. Das, N. G. and Bhuiyan, A. L. 1979.
The developmental stages of copepod larva of *Heliodiaptomus latifi* Das 1974 (Copepoda: Calanoida).
Chittagong Univ. Stud. Pt. II, **3**: 73-92.

Six developmental stages of copepod larva of *Heliodiaptomus latifi* Das, 1974 were experimentally reared in the laboratory and their illustrated descriptions were provided.

71. Das, N. G. and Bhuiyan, A. L. 1981.
Cladocera of Dacca city.
Chittagong Univ. Stud. Pt. II, **5**: 77-87.

Twenty species of cladocerans belonging to 13 genera from some water bodies of Dhaka city (same habitats as those mentioned under Das and Bhuiyan 1974a) are illustrated and described. An identification key was provided for each species.

72. Habib, M. A. B., Ahmad, M., Islam, M. A. and Haque, A. K. M. A. 1983.
A comparative study on monthly fluctuations of some important physico-chemical characteristics of water in two selected ponds.
Bangladesh J. Fish. **6(1-2)**: 19-25.

Data on water quality and bottom sediments namely, water temperature, transparency, total hardness, DO, free CO_2, nitrate nitrogen, phosphate, exchangeable K, Ca, Mg and Na were presented. Seasonal flux of the determinants was shown and discussed.

73. Habib, M. A. B., Rahman, S. H., Islam and Badruddin, M. 1984.
A comparative study on some chemical characteristics of pond bottom and their adjacent land soils of fourteen soil types of Bangladesh.
Bangladesh J. Fish. **7(1-2)**:61-69.

Levels of pH, total nitrogen, available P, exchangeable K, Ca and Na in pond sediments and their adjacent land soil were determined. Most of the pond bottom soils showed higher nutrient content than the land soils. It was noted that almost all the chemical properties of pond bottom soil had a direct correlation with that of their adjacent land soil.

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74. Habib, M. A. B., Islam, M. A., Mohsinuzzaman, M. and Rahman, M. S. 1984. Effect of some physicochemical factors of water on the abundance and fluctuation of zooplankton of two selected ponds. *Univ. J. Zool. Rajshahi Univ.*, **3**: 27-34.

The population of zooplankton mainly belonged to the groups Rotifera, Cladocera, Copepoda and Protozoa. They showed a peak production in November collectively. Pond I and II showed the presence of 13 genera and 12 genera respectively. *Brachionus* was the most dominant genus in both the ponds.

75. Habib, M. A. B., Ahmed, M. and Mohsinuzzaman, M. 1986. Soil water interactions in a pond and their correlations with meteorological factors. *Bangladesh J. Water Resource Research* **7(1)**: 15-23.

Increased air temperature and rainfall coupled with an increase in organic carbon, total N, available N, exchangeable Mg and Na of bottom soil enhanced the amount of CO_2 and N in water but strongly decreased the DO content. An increase in water temperature produced some effect on the water chemistry while an increase in total N and available N in soil supported a parallel increase in exchangeable K, Mg and Na.

76. Habib, M. A. B., Mohsinuzzaman, M. and Ali, M. M. 1988. Growth interactions in some genera of phytoplankton in two ponds. *Bangladesh J. Aquaculture* **10(1)**: 11-18.

Correlation studies between various genera of phytoplankton was generally positive which indicated that their growth and abundance were interdependent but they were not competitive with each other for nutrient and habitat. *Phacus* had maximum significant correlation values with other genera of phytoplankton in both the ponds. Inverse correlations shown by *Cyclotella, Diatoma, Nostoc, Anabaena* and *Euglena* with other genera of phytoplankton might be due to the secretion of toxins by them and competition among them for nutrient and habitat.

77. Habib, M. A. B., Mohsinuzzaman, M. and Rahman, M. S. 1988.
Combined and linear effects of dominant genera of phytoplankton on the abundance of eleven genera of zooplankton.
Bangladesh J. Zool. **16(1)**: 31-38.

Significant positive correlation were shown by *Keratella, Moina, Diaptomus* and *Difflugia* with seven genera of phytoplankton. On the other hand *Brachionus, Polyarthra, Asplancha* and *Lepodella* were inversely correlated with the genera of phytoplankton. This indicates inhibitory properties of phytoplankton upon zooplankton. *Difflugia* correlated strongly and positively with *Pediastrum, Scenedesmus, Chlorella, Volvox* and *Synedra*. Intergeneric correlations between *Diaptomus* and *Brachionus* and *Diaptomus* and *Filinia* were positive in nature. *Diaptomus* showed a negative correlation with *Lepodella*.

78. Hussain, M. G., Islam, M. A. and Chowdhury, M. Y. 1978.
A study on the relationship between primary productivity and some limnological parameters in a local pond in Mymensingh.
Bangladesh J. Fish. **1(2)**: 113-119.

The variation of water temperature (18.0-32.0°C), Secchi depth (31.0-40.0 cm), water depth (1.5-1.9 m), pH (7.3-7.9), DO (4.0-6.2 mg l^{-1}), alkalinity (49.5-64.5 ppm) from June to December were presented. Climatological data such as rainfall (0.41-77.03 cm), average air temperature (18.49-28.43°C) and solar radiation (monthly average, 0.3790-0.4468 cal cm^{-2} min^{-1}) were also presented. Gross- and net-primary productivity of phytoplankton and community respiration varied from 5.40-9.44 gC $m^{-3}d^{-1}$, 5.64-7.80 $gCm^{-3}d^{-1}$ and 0.09-0.18 mg O_2 $l^{-1}h^{-1}$, respectively during the study period in the pond. September was the month when highest primary productivity was obtained.

79. Islam, A. K. M. Nurul and Chowdhury, A. R. 1979.
Hydrobiological studies of Dhanmondi lake, Dacca II. phytoplankton.
J. Asiatic Soc. Bangladesh (Sc.) **5(2)**: 47-57.

An illustrated account of phytoplankton mainly belonging to desmid, diatom and chlorococcoid groups from Dhanmondi lake was presented. Altogether 91 species were identified and listed. Dominance of different phytoplankton species at different months was recorded.

80. Islam, A. K. M. Nurul and Mendes, F. 1976.
Limnological studies of a *jheel* in Sher-e-Bangla Nagar.
Dacca Univ. Stud., B. **24(2)**:63-71.

Data relating to the general limnology of the *jheel* were presented graphically. The effect of some physico-chemical factors (temperature, rainfall, DO, CO_2 and nutrients) upon the growth of *Lyngbya majuscula* (a member of blue-green algae) and *Azolla pinnata* (an aquatic fern) were also discussed. Ranges of water quality parameters of the *jheel* were: water temperature: 19-28°C, DO: 4.48-9.83 ppm, free CO_2: 2.0-29.3 ppm, total nitrogen: 0.025-108 ppm, P_2O_5: 0.15-2.32 ppm, H_2S:140.25-389.98 ppm, Sulphur: 136.00-367.04 ppm and pH: 7.5-8.5. Abundant growth of *L. majuscula* and *A. pinnata* occurred between pH 8.0 to 8.5.

81. Islam, A. K. M. Nurul, Khondker, M., Beugm, A. and Akter, N. 1992.
Hydrobiological studies in two habitats at Dhaka.
J. Asiat. Soc. Bangladesh, Sci. **18(1)**: 47-52.

Limnological data of a pond opposite to the Uttara Shopping Centre Dhaka were: pH: 6.5-7.6; Conductivity: 40-160 $\mu S\ cm^{-1}$; temperature: 25-30°C; free CO_2: 5.0-14.3 mg l^{-1}; alkalinity: 0.27-0.81 meq l^{-1}; Silicate: 0.39-3.99 mgl^{-1}; NO_3-N: 0-90.98 $\mu g\ l^{-1}$; PO_4-P: 12.12-46.36 $\mu g l^{-1}$; COD:3.44-8.24 mgl^{-1}; Chl a: 12.57-205.75 $\mu g\ l^{-1}$, phaeopigment: 0.17-68.05 $\mu g\ l^{-1}$ and DO: 6.86 -9.91 mg l^{-1}.

The above mentioned parameters in the nearby Khilkhet *beel* varied as follows: pH: 6.4-8.6; conductivity: 90-150 $\mu S\ cm^{-1}$; water temperature: 26-34°C; free CO_2: 3.0-14.3 mg l^{-1}; alkalinity: 0.21-1.03 meq l^{-1}; Silicate: 2.87-24.42 mg l^{-1}; NO_3-N: 0.08-269.63 $\mu g\ l^{-1}$; PO_4-P: 17.51-298.62 $\mu g\ l^{-1}$; COD: 2.56-6.40 mg l^{-1}; chl a: 0-55.53 $\mu g\ l^{-1}$; phaeopigment: 0-38.26 $\mu g\ l^{-1}$ and DO: 5.80-11.67 mg l^{-1}.

From the pond 22 species and from the *beel* 17 species of macrophytic plants were recorded.

82. Islam, A. K. M. Nurul and Moniruzzaman, K. 1981.
Euglenophyta of Bangladesh. I. Genus *Trachelomonas* Ehr.
Int. Revue ges. Hydrobiol. **66(1)**: 109-125.

Most of the materials for the work were collected from some polluted waters in the districts of Dhaka, Faridpur, Kushtia and Rangpur. The species of *Trachelomonas* commonly occur as plankton. In the study a total of 55 taxa was reported. Of these, 5 varieties (*Trachelomonas allorgei* var. *madaripurense*, *Tr. angaste-ovata* var. *ellipsoidea*, *Tr. armata* var. *rangpurense*, *Tr. hispida* var. *subcoronata*, *Tr. asymmetrica* var. *crenulata*) and one forma (*Tr. anguste-ovata* fa. *minor*) have been described as new to science.

83. Islam, A. K. M. Nurul and Paul, S. N. 1977.
Limnological studies on *Wolffia arrhiza* (L.). Wimm.
J. Asiatic Soc. Bangladesh (Sc.), **3(1)**: 111-123.

The smallest aquatic angiosperm plant, *Wolffia arrhiza*, was found to grow abundantly in a pond of Faridpur town. Two peak growths of the plant were observed, one in March and another in December. The following physico-chemical characteristics of the water were noted at the time of dense bloom formation in the pond: temperature: 24-25.5°C; pH:8.2-8.5; DO:2.16-5.9 ppm; free CO_2: 13-31 ppm; $CaCO_3$: 172-180 ppm; H_2S: 3.9-7.8 ppm and sulphur: 3.66-7.34 ppm. During the first and second peak growth the frond numbers of the plant were 414 cm^{-2} and 473 cm^{-2} respectively. Carbohydrate and protein contents of this plant were also analysed.

84. Islam, A. K. M. Nurul, Rahman, M. and Choudhury, A. R. 1979.
Hydrobiological studies of Dhanmondi Lake, Dacca. 1. Macrophytes and benthic flora.
J. Asiatic Soc. Bangladesh (Sc.) **5(1)**: 59-75.

Some water quality parameters of Dhanmondi lake varied (during September to April) as follows: water temperature: 18-30°C; DO: 2.7-8.2 ppm; total alkalinity: 93-181 ppm; pH:5.8-8.2; total nitrogen: 0.031-0.092 ppm. In all 64 species of macrophytes and benthic flora were recorded from the lake.

85. Islam, A. K. M. Nurul and Saha, J. K. 1975.
Limnological studies of the Ramna Lake at Dacca.
Dacca Univ. Stud. B, **23(2)**: 39-46.

Water quality data on pH (7.5-9.8); DO (3.51-4.59 cc l^{-1}); total nitrogen (0.26-6.0 mg l^{-1}); phosphate (0.02-2.80 mg l^{-1}) and $CaCO_3$ (1.24-1.80 g l^{-1}) were presented. A total of 88 species of algae, 25 species of zooplankton, 2 species of pteridophytes and 4 species of aquatic angiosperms were recorded. Inverse relationships between phytoplankton and zooplankton were observed.

86. Islam, M. A. and Islam, M. T. 1978.
Studies on the primary productivity of a pond in Bangladesh Agricultural University campus.
Bangladesh J. Aq. Cult. **1(1)**: 1-14.

Oxygen light and dark bottle technique was used to determine the rate of primary productivity in a pond at fortnight intervals. In addition, measurement of temperature, transparency, water level, dissolved oxygen, free CO_2, pH and alkalinity were also made (January to June). During a six month study gross primary productivity ranged from 3.63 gC m^{-3} d^{-1} (in January) to 19.50 g C $m^{-3}d^{-1}$ (in June). Mean gross productivity for the period of investigation was 9.21 gC m^{-3} d^{-1}. Highest and lowest net primary productivity were 17.71 gC $m^{-3}d^{-1}$ and 2.31 gC $m^{-3}d^{-1}$ respectively with a mean value of 7.75 gC $m^{-3}d^{-1}$. Primary productivity showed positive correlation with radiation, alkalinity and pH and negative correlation with transparency, water volume and rainfall.

87. Islam, M. A., Chowdhury, M. Y. and Karim, R. 1978.
A comparative study of some physico-chemical factors and the growth of major carps in ponds.
Bangladesh J. Aq. Cult. **1(1)**: 61-73.

Two carp ponds (village Boyra, Mymensingh) were monitored for 8 months (June to January) to record the following physico-chemical factors: air temperature, water temperature, transparency, DO, pH, hardness, CO_2, Ca, phosphate and nitrate. Water temperature related closely with air temperature. Maximum and minimum transparency were recorded

respectively in the month of June and January. DO, pH, hardness and Ca were higher in January but CO_2, phosphate and nitrate were highest during June and August. During 8 months *catla*, *rohu* and *mrigel* attained 11.5, 16.9 and 24.6 per cent growth in Pond 1 and 13.3, 16.7 and 21.4 per cent growth in pond 2, respectively.

88. Islam, M. N., Haque, A. K. M. A., Islam, M. A., Karim, R. and Mollah, M. F. A. 1978.

Pattern of recovery of physico-chemical qualities of water and bottom-soil of a derelict pond under natural conditions.

Bangladesh J. Fish. **1(2)**: 121-131.

A derelict pond (covered with a canopy of water hyacinth) recovered considerably after reclamation (done by dewatering and removal of hyacinth). Initial transparency, 6.5 cm (10 March) increased to 100.3 cm within 6 months (25 August). Similarly DO also improved from 2.66 ppm on 10 March to 6.73 ppm on 20 April. The maximum and minimum CO_2 in water as recorded on 10 March and 10 April respectively were 12.76 ppm and 1.42 ppm.

Soil pH changed from 5.80 (on 10 March) to 6.80 (on 25 June). Satisfactory changes also were found in cases of organic carbon and phosphorus but no change occurred in case of iron content. Removal of hyacinth, dewatering of the pond, rainfall, direct contact with air and radiation aided pond recovery.

89. Kabir, M. A. 1992.

Seasonal changes of phytoplankton primary productivity and its controlling components in a mesotrophic pond.

M. Sc. Thesis, Botany Dept., Dhaka Univ., pp. 100.

A study on the seasonality of phytoplankton primary productivity and its controlling components extending for one year (Sept., 1990 to August 1991) was carried out in mesotrophic Shahidullah Hall Pond. Physical, chemical and biological factors pertaining to the primary productivity processes of pelagic phytoplankton were described in detail showing their vertical distribution with time along the water column. Altogether nine physicochemical factors of the pond water and various other factors controlling primary productivity of phytoplankton were examined.

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90. Khondker, M. 1993.
The status of limnological research in Bangladesh.
Mitt. Internat. Verein. Limnol. **24**: (in press).

A review of limnology studies in Bangladesh emphasizing the pattern of inland water resources, their type, description and area was presented. Trends and needs of limnological research together with human influences upon inland waters of Bangladesh were discussed. A comparative limnological condition of three typical lentic water bodies of Bangladesh and pollutional aspects of some rivers closer to Dhaka metropolis were also described. The paper presents a conclusion about the future of limnological research in Bangladesh.

91. Khondker, M. and Chowdhury, S. A. 1993a.
Relationships of phytoplankton biomass to some water quality parameters in a mesotrophic pond.
Dhaka Univ. J. Biol. Sci. **2(1)**: 87-92.

Correlation studies between depthwise values of chl a and different limnological parameters were done for a mesotrophic pond. The relationship was significant with most of the parameters at 0.50 m and 2.5 m in depths. However, in the water near the bottom phosphorus showed significant correlation with biomass. Chl a correlated positively with conductivity, alkalinity, silicate, soluble reactive phosphorus and negatively with pH.

92. Khondker, M. and Chowdhury, S. A. 1993b.
Vertical distribution and periodicity of pelagic phytoplankton in a pond.
J. Asiat. Soc. Bangladesh Sci. **19(1)**:9-13.

From the pond 25 taxa of phytoplankton belonging to chlorococcoid, cryptomonad and dinoflagellate groups were recorded. Average annual cell counts at different depths were: 0.5 m: 215.36 x 10^3 cells l^{-1}; 2.5 m: 180.84 x 10^3 cells l^{-1} and the water near the bottom: 242.41 x 10^3 cells l^{-1}. *Cryptomonas ovata* and *Scenedesmus armatus* showed their continuous presence throughout the year at all depths.

93. Khondker, M., Islam, A. K. M. Nurul and Islam, R. 1988.
Studies on the primary productivity of Dhanmondi Lake.
Dhaka Univ. Stud. Pt. E. **1(1)**: 15-21.

Gross primary productivity in Dhanmondi Lake in Dhaka ranged from 0.17-2.71 mg O_2 l^{-1} h^{-1}. Water temperature, Zs (Secchi depth), pH, DO, free CO_2 and alkalinity were determined and their spatial and temporal variations were shown. Low Zs ($\bar{x}$ = 37.80 cm), low percentage saturation of DO ($\bar{x}$ = 47.79%) and high content of free CO_2 ($\bar{x}$ = 11.64 mg l^{-1}) indicated an overall deterioration of water quality.

94. Khondker, M. and Parveen, L. 1992.
Study on the physical and chemical limnology of a shallow, hypertrophic artificial lake.
Bangladesh J. Sci. Res. **10(1)**:9-16.

Due to reduced circulation, vertical distribution of temperature and DO in Dhanmondi lake (at the deepest place) showed stratified conditions throughout the year except January. Seasonal average of Z (depth), water temp., pH, conductivity, alkalinity, free CO_2, DO (surface), DO% sat., SRP and NO_3 ranged from 3.82-4.23 m, 22.98-31.30°C, 7.27-7.58; 420.71-731.67 μS cm^{-1}; 2.98-4.59 meq l^{-1}; 40.50-58.33 mg l^{-1}, 5.97-9.05 mg l^{-1}, 70.14-121.92%, 0.56-1.1 mg l^{-1} and 0.11-0.21 mg l^{-1} respectively. The concentrations of above mentioned parameters decreased during monsoon.

95. Khondker, M. and Parveen, L. 1992.
Species compositions, standing crop and seasonality of phytoplankton in a hypertrophic lake.
Dhaka Univ. Stud. Pt. E. **7(1)**: 49-55.

In a community of phytoplankton *Cryptomonas ovata* was found to be the most abundant alga. Other abundant genera comprised *Cyclotella, Rhodomonas, Pediastrum, Euglena* and *Phacus*. Three blooms were recorded (one by *C. ovata* and two by *E. minima*). Significant changes in the physical, chemical and productivity characteristics of the lake were observed between the blooms caused by *C. ovata* and *E. minima*.

96. Khondker, M. and Parveen, L. 1993.

Daily rate of primary productivity in Dhanmondi lake.

In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological Bases for Water Resource Management. (Tilzer, M. M., and Khondker, M., eds.). Botany Dept., Dhaka Univ., Dhaka.

Primary productivity of pelagic phytoplankton, their biomass and other relevant parameters were determined in hypertrophic Dhanmondi lake fortnightly for one year. The annual mean chl a and phaeopigment were 264.82 μg l^{-1} and 126 μg l^{-1}, respectively. The vertical attenuation coefficient varied from 3.00-3.89 ln units m^{-1}. It showed a positive correlation with chl a concentration. The mean daily primary productivity was 26.19 g O_2 $m^{-2}d^{-1}$. Intensity coefficient (I_k) and maximum assimilation (P_{max}) ranged 68-630 μE m^{-2} s^{-1} and 6.91-87.68 mg O_2 (mg chl a)$^{-1}$ h^{-1} respectively. The average community respiration was 5.56 g C $m^{-2}d^{-1}$.

97. Khondker, M. and S. Rahim 1991.

Investigation on the water quality in Dhanmondi Lake. I. Physicochemical features.

Bangladesh J. Bot. **20(2)**: 183-191.

Water quality of Dhanmondi Lake at a point of sewage contamination (Kalabagan area) was monitored for 12 months. The average values of different parameters were: Io (light intensity at surface): 1077.33 μE$m^{-2}s^{-1}$; Iz (light intensity at 10 cm depth): 551 μE $m^{-2}s^{-1}$; water temperature: 28.48°C; Z:1.42 m; Zs: 0.36 m; total seston: 83 mg l^{-1}; pH: 7.58; conductivity: 565.42 μS cm^{-1}; alkalinity: 3.62 meq l^{-1}; free CO_2: 38.05 mg l^{-1}; DO: 11.57 mg l^{-1}; DO% saturation:143%; COD: 5.97 mg l^{-1}; SRP: 0.78 mg l^{-1}; NO_3: 0.21 mg l^{-1} and Si: 30.55 mg l^{-1}. Low Secchi depth, high concentrations of biogenic gases together with high conductivity, alkalinity, COD, SRP, NO_3 and Si indicated pollution by organic matter.

98. Khondker, M. and Rahim, S. 1993.
Investigation on the water quality of Dhanmondi Lake II. Periphytic and planktonic algae as indicators.
Bangladesh J. Bot. **22(1)**. 49-53.

Cryptomonas ovata and *Euglena minima* in phytoplankton and *Nitzschia palea* and *Navicula cuspidata* in periphyton were the most dominant forms in Dhanmondi Lake in Dhaka. Phytoplanktonic Chl a and phaeopigment varied from 68.85-907.95 mg m^{-3} and 10.43-400.93 mg m^{-3} respectively. Very low species diversity (phytoplankton: 0.26-2.01 bit and periphyton: 0.69-1.1 bit), occasional blooms, and species composition indicate that the lake is meso-saprobic.

99. Latif, M. A., Ali, M. M. and Islam, M. A. 1986.
A comparative physico-chemical study of a well managed fish pond and a derelict pond.
Bangladesh J. Aquaculture **6-7(1)**: 71-78.

Submerged pond-bottom soil of a well managed and a derelict pond were analysed (from Feb. - July) for pH, organic carbon, nitrate nitrogen, available phosphorus, exchangeable potassium and exchangeable calcium. Both physical and chemical properties of water (air and water temperature, water depth, transparency, rainfall, DO, CO_2, pH, total hardness, nitrate, phosphate) were also determined.

100. Miah, M. I., Bhuiya, Z. H. and Hashem, M. A. 1985.
Phytoplankton of pond soils of Bangladesh Agricultural University Campus, Mymensingh.
Bangladesh J. Agril. **10(1)**:35-42.

Through culture studies of pond soil extracts twelve genera of phytoplankton (7 from Cyanophyceae, three from Chlorophyceae and two from Xanthophyceae) were isolated. Among the identified genera *Anabaena, Chlorella* and *Vaucheria* were dominant. The studied soils of the ponds were loamy type having pH 6.8-7.5 and organic matter from 0.9-1.3%. Systematic description of the plankton genera were furnished.

101. Miah, M. J. U., Islam, M. A., Das, M., Das, N. C. and Ali, M. M. 1983.
A study on the benthos of a one year old fish pond in Bangladesh Agricultural University Campus, Mymensingh.
Bangladesh J. Aq. Cult. **2-5(1)**:25-31.

Chironomid larvae dominated (39.46%) the bottom fauna followed by oligochaetes (26.72%) and molluscs (25.55%). An average of 1124.27 organisms m^{-2} occurred in the pond.

102. Mollah, M. F. A. and Haque, A. K. M. A. 1978.
Studies on monthly variation of plankton in relation to the physico-chemical conditions of water and bottom soil of two ponds. I. Phytoplankton.
Bangladesh J. Fish. **1(1)**: 29-39.

Qualitative and quantitative aspects of phytoplankton were studied for six months (April to Sept., 1976). In both ponds chlorophycean algae were dominant in all months except September in pond 1 when euglenoid algae dominated. These algae completely disappeared from the same pond in June. The physico-chemical factors of both water and soil produced some effect on the phytoplankton periodicity of both ponds.

103. Mollah, M. F. A. and Haque, A. K. M. A. 1978.
Studies on monthly variations of plankton in relation to the physico-chemical conditions of water and bottom soil of two ponds II. Zooplankton.
Bangladesh J. Fish. **1(2)**: 99-101.

Rotifera dominated the zooplankton communities throughout the entire period in both ponds. Physico-chemical characteristics of both soil and water were found to have some effects on the periodicity of zooplankton.

104. Mollah, M. F. A., Haque, A. K. M. Aminul, Eaqub, M., Idris, M. and Chowdhury, M. Y.
Interaction between pond-bottom soil and water qualities.
Indian J. Fisheries **26(1-2)**: 101-104.

Water quality data (April-Sept.) in pond 1 ranged for transparency: 0.76-0.99 m; total hardness: 71.0-87.0 ppm; DO: 1.19-2.57 ppm; and free CO_2: 14.64-29.49 ppm. Pond 2 differed in respect of the above mentioned parameters as follows: transparency: 1.07-1.12 m; total hardness: 64.37-82.89 ppm; DO: 6.57-7.74 ppm, and free CO_2: 1.04-2.58 ppm. Lower transparency in pond 1 was due to the loading of silts and organic matter from surface runoff and washout from adjacent agricultural fields. Pond 2 showed better standing crop of phytoplankton than pond 1. Exchangeable K of pond bottom soil and water did not show any correlation. However, in pond 1 calcium content of water related inversely with that of soil. Nitrate nitrogen of soil showed a weak inverse relationship with its content in water only in pond 2. A similar relationship was also observed in case of phosphorus in pond 1. Iron content of both water and soil correlated inversely in both ponds.

105. Mumtazuddin, M., Rahman, M. S. and Mostafa, G. 1982.
Limnological studies of four selected rearing ponds at the aquaculture experiment station, Mymensingh.
Bangladesh J. Fish. **2-5(1-2)**: 83-90.

Surface and bottom water temperature in all the rearing ponds differed (during July to Oct.) by 3 degree (the range was 28.0-31.0°C). However, water transparency varied substantially (25-55 cm) in the ponds. Ranges of free CO_2 in the four ponds (pond no. 79, 80, 81 and 82) were: 0.50-2.0 ppm, 1.00-2.00 ppm; 1.0-2.5 ppm; 0.5-2.5 ppm and 1.0-2.75 ppm respectively. pH values in all the ponds were at neutral (7.0) or little above neutrality. Hardness varied within 91.0-127.0 ppm in all the ponds. Plankton concentration in the ponds were moderate (zooplankton: 884-1062 indiv. l^{-1}; phytoplankton: 21.3 x 10^3 - 3000 x 10^3 indiv. l^{-1}).

106. Oppenheimer, J.R., Ahmed, M.G., Huq, A., Haque, K.A., Alam, A. K. M. A., Aziz, K. M. S., Ali, S. and Haque, A. A. M. M. 1978.
Limnological studies of three ponds in Dacca, Bangladesh.
Bangladesh J. Fish. **1(1)**: 1-28.

Data on physicochemical properties of water (depth, temp., turbidity, colour, Cl, total alkalinity, hardness, DO, pH, CO_2, nitrate-N, orthophosphate, total phosphate, iron, manganese, copper, chromium and conductivity), plankton and bottom fauna of three ponds

(one was eutrophic) were presented. Soil samples were analysed on one occasion (April 1976).

In terms of DO, CO_2 and pH, suitable conditions for fish existed for 10 hours a day on the average, with suitable conditions lasting for 14 hours a day at the surface and for 4 hours or less a day below 240 cm. Higher pH (9.0) was associated with planktonic peak photosynthesis. During the monsoon rains alkalinity and chloride concentrations decreased and this trend was also noticeable in terms of hardness, DO and pH. Horizontal bottom of the ponds were richer in nutrients than were the slopping sides, but the abundance of bottom fauna was higher on the sides probably due to low DO at the bottom region.

107. Paul, A. R. and Begum, Z. N. T. 1984.
Eichhornia is not a waste material.
Conservation and Recycling **7(2-4)**: 207-211.

Preparation of high quality compost and board from the most notorious aquatic weed, water hyacinth (*Eichhornia*) was described.

108. Quarrar, P., Ali., S. and Mustafa, A. 1992.
Estimation of chlorophyll concentrations in an aquatic ecosystem by spectral ratios.
Bangladesh J. Zool. **20(1)**: 161-168.

Using remote sensing technique concentration of surface water chl a in four water bodies of Dhaka metropolis have been estimated. Chl a varied: Dhanmondi lake: 30.78-252.72 $\mu g\ l^{-1}$; Ramna lake: 60.63-109.51 $\mu g\ l^{-1}$; Crescent lake: 37.05 - 152 $\mu g\ l^{-1}$; and pond near Kakrail Fisheries Project: 55.43 - 83.0 $\mu g\ l^{-1}$. Data indicates eutrophic conditions of those waters.

109. Quddus, M. M. A., Banerjee, A. K. and Das, H. K. 1987.
Monthly abundance of zooplankton in a nursery pond.
Bangladesh J. Aquaculture **9(1)**: 17-22.

The community of zooplankton in a nursery pond was represented by 6 members of Arthropoda and 3 members of Rotifera. Their abundances in the pond were observed for three months.

110. Rab, M. A., Islam, M. A., Eaqub, M. and Idris, M. 1978.
Studies on soil, primary productivity and growth rate of major carps (*Catla catla*, *Labeo rohita* and *Cirrhina mrigala*) in an artificial pond of village Boyra, Mymensingh.
Bangladesh J. Aq. Cult. **1(1)**: 42-51.

Chemical composition of the bottom soil were: pH: 5.8-6.3, organic carbon: 1.22-1.75 g%, NO_3-N: 3.66-3.78 mg%, NH_4: 8.0-9.90 mg%, total iron: 3.14-3.42 g%, exchangeable Ca: 2.30-3.42 mg%, exchangeable Mg: 1.86-2.64 mg% and exchangeable K: 1.96-2.52 mg%. Maximum gross primary productivity (9.44 $gCm^{-3}d^{-1}$) was found in September which showed a minimum value (6.48 $gCm^{-3}d^{-1}$) in June. Net primary productivity ranged between 5.61 and 7.80 $gCm^{-3}d^{-1}$. Primary productivity showed positive correlations with solar radiation, temperature, pH and alkalinity. During the period of study the growth of common carp varied from 9.3-19.1%.

111. Rahman, M. S., Chowdhury, M. Y., Haque, A. K. M. A. and Haq, M. S. 1982.
Limnological studies of four ponds.
Bangladesh J. Fish. **2-5(1-2)**: 25-35.

The research was conducted for three months (May-July, 1975). Data on average depth, temperature, DO, free CO_2, pH, carbonate, bicarbonate, total alkalinity, phosphate, nitrate, Ca and Mg were presented in the paper. Vertical variation of temperature and all the chemical factors were observed. Temperature, DO and pH were higher in surface water but free CO_2 was higher in the bottom water.

112. Rahmatullah, S. M., Islam, M. A. and Ali, M. M. 1983.
The qualitative and quantitative studies of phytoplankton of a pond within the Bangladesh Agricultural University Campus, Mymensingh.
Bangladesh J. Aq. Cult. **2-5(1)**:43-49.

A total of 32 genera of phytoplankton was recorded from the pond. Maximum genera belonged to Chlorophyceae (17) followed by Myxophyceae (7), Bacillariophyceae (6) and Dinophyceae (2). Average maximum standing crop was $510x10^3$ l^{-1} while its minimum represented 45 x 10^3 l^{-1}. The maxima and minima were recorded respectively in the month of August and June. Groupwise distribution of phytoplankton abundances were also given.

113. Zaman, L., Khondker, M. and Nabi, R. 1993.

A comparative limnology of three ponds in Jahangirnagar University campus: physical and chemical aspects.

Bangladesh J. Bot. **22(1)**: 81-87.

Limnological studies were carried out on three rainfed perennial ponds whose area and depth varied from 1.00-3.23 ha and 2.0-2.2 m. The annual mean of different water quality parameters of three ponds were: temperature 27.7°C, pH: 6.18-7.24; DO: 4.78-5.65 mg l^{-1}, CO_2: 9.76-11.42 mg l^{-1}, PO_4-P: 0.04 mg l^{-1} and NO_3-N: 0.03-0.04 mg l^{-1}. The ponds differed only in cases of free CO_2 concentration and pH. The result of the study indicates a poor nutrient status of the ponds and therefore appropriate fertilization is recommended to augment fish production in them.

2.3 Water Pollution

2.3.1 General

114. Ahmed, M. F. and Islam, T. 1979.
Study of surface water sources for water supply in Dhaka City.
J. Institution of Engineers **7(1)**.

Important water quality parameters such as solids content, turbidity, colour, pH, acidity, alkalinity, hardness, iron, chloride, conductivity, DO, BOD and bacterial counts in the Buriganga, Sitalakhya and Ballu rivers were studied at regular intervals for one year. The results were compared with international standards of water quality and found to be comparatively good quality for the construction of large-scale water works for the future expansion of Dhaka water supply.

Bacteriological examination of Buriganga river water showed coliform count in the range of 200-1700 $(100\ ml)^{-1}$ during dry season. Of the three potential surface water sources for Dhaka Metropolis (Buriganga, Sitalakhya and Ballu) water of Sitalakhya river was found advantageous over others as a potential source of supply water.

115. Anonymous. 1991.
The inventory of total nitrogen in the aqueous ecosystem of Bangladesh (Studies of nitrate, nitrite, cyanide and ammonia).
M. Sc. Thesis (Exam. Roll # 3408). Dhaka Univ., Dhaka.

River water was found to contain high nitrate and low ammonia which indicates a prevailing oxidation condition. High nitrate levels promote weed growth causing obstruction to water ways and depletion of DO content in water.

A range of domestic supply water, water from ponds, lakes, rivers and ground water were analysed. The content of ammonia was found to be high in domestic water but low in hotel water.

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116. Bhouyain, A. M. 1983.
Fresh- and brackish-water pollution in Bangladesh.
Fisheries Inf. Bull. **1(3)**: 32

Bangladesh has about 7000 small and large industries and most of them do not have efficient treatment plants for processing their self generated wastes and effluent waters. These industries discharge large quantities of liquid and solid wastes into rivers and are of major concern for fish disappearance. Many toxic pollutants, mercury, chlorine, mercurial fungicides etc. may reduce the photosynthesis of phytoplankton and may cause immense loss to the food chain. About 10-12 million gallons of untreated waste water are discharged daily in the Karnafully river critically affecting the fish fauna. About 10 tonnes solid wastes are dumped into Bhairab and Rupsa rivers from Khulna area. 70% of the total population suffer from water borne disease. In the agricultural fields a total of 5,578 tonnes of different chemicals were used during the year 1981-1982. A portion of those chemicals finally found their way into the aquatic ecosystems causing serious concern about the overall water quality.

117. Hakim, M. A. and Haque, M. A. 1983.
Characteristics of estuarine of the Karnafully estuary.
Bangladesh J. Aq. Cult. **2-5(1)**:

Bacterial samples collected from surface to bottom of the Karnafully estuary showed the presence of about 70% gram negative bacilli, 20% gram positive cocci and 10% bacilli. Optimum temperature for maximum growth was 27°C. Chromogenic bacteria were also found in the Karnafully estuarine river.

118. Islam, A. K. M. Nurul. 1993.
Limnology and pollution of wetlands.
In: Freshwater Wetlands in Bangladesh: Issues and approach for Management (Nishat, A., Hossain, Z., Roy, M. K. and Karim, M. eds.) pp. 123-146. IUCN, Gland, Switzerland.

Historical transformation of wetland ecosystems of Bangladesh due to natural processes, pollutants, irrigation works etc. is discussed. Sources of major pollutants that cause environmental hazards in wetlands are discussed and a generalized overview of limnological

researches in Bangladesh is provided. Pollutants were considered to cause as many as 32 water borne diseases. Strategies and recommendations to conserve wetland ecosystems are provided.

119. Nuruzzaman, A. K. M. 1991.
Effects of environmental modifications on riverine fisheries in Bangladesh.
Paper presented at the World Fisheries Congress (WFC) held in Athens, Greece, 14-19 April 1991.

Negative impact on water quality due to FCD and FCDI projects, release of untreated municipal sewage and the expansion of shrimp culture areas are discussed. Fish disease, ulcerative syndrome might have spread in Bangladesh water due to water pollution. Effects of various toxicants upon fish are described.

The indirect impact of FCD projects is related to the agro-chemical pollution of waterbodies. Reports of fish kills from pesticides and fertilizers in different areas of Bangladesh are mentioned. Pollutants of agrochemical origin are listed and their possible effect upon fish are assessed.

120. Rahim, Z., and Aziz, K. M. S. 1992.
Isolation of enterotoxigenic and drug resistant *Aeromonas* sp. from the root system of common water plants of Bangladesh.
In: Plant Science and Man: Problems and Prospects (Islam, A. K. M. N., Fattah, Q. A., Muttaqi, I. A. and Aziz, A. eds.) pp. 59-63.
Bangladesh Bot. Soc., Dhaka.

Isolation of enterotoxigenic *Aeromonas hydrophila*, *A. sorbia* and *A. caviae* from the root system of some common water plants has been reported. Bacteria associated water plants were *Eichhornia crassipes, Telanthera philoxeroides, Ipomoea aquatica, Salvinia cucullata* and *Pistia stratiotes*. All the plants were collected from Gulshan lake, Dhaka.

2.3.2 Industrial pollution

121. Ahmed, M. F. 1985.
Waste disposal and degradation of water quality in and around Dhaka city.
Proc. SAARC Seminar on protecting the Environment, Dhaka.

From the city of Dhaka, inorganic and organic pollutants are dumped into the Buriganga River. A study of water quality of the Buriganga, Sitalakhya and Ballu rivers clearly revealed polluted conditions. The flow of the rivers in the monsoon season is considered sufficient to dilute the waste discharged but in the dry season the dilution is greatly reduced. The average BOD of Dhaka city domestic sewage is about 180 mg l^{-1} which requires 12 times reduction by an efficient treatment plant prior to river disposal. The Ballu River receives wastes and effluent from 29 industries from Tongi and the Sitalakhya River receives effluents from 42 major industries. The Buriganga River receives highly polluting wastes from 151 tanneries. The tannery effluent has pH values between 8.0-11.5, alkalinity as high as 2100 mg l^{-1}, chloride 480-2550 mg l^{-1}, ammonia 53.0-125.0 mg l^{-1} and chlorine in the range of 0.20-10.5 mg l^{-1}.

122. Ahmed, M. F. 1985.
Industrialization, modernization of agriculture and environmental pollution in Bangladesh.

Individual analysis of ground water samples does not show the presence of significant concentrations of nitrate to cause concern. In the dry season the self-purifying capacity of rivers is reduced considerably and consequently during this time industrial discharges into the rivers are one of the major concerns for pollution. Suggestions have been made for a more rational use of pesticides to avoid harmful effects in the future.

123. Ahmed, A. U. and Reazuddin, M. 1990.
Industrial pollution of water systems in Bangladesh.
In: Environmental Aspects of Surface Water Systems of Bangladesh (Rahman, A. A., Huq, S., Conway, G. R. eds.) pp. 177-179.
Univ. Press Ltd. Dhaka.

A background description of industrial pollution is given together with a specific case study regarding the pollutional contribution of the Karnaphully Paper Mills Ltd. to the Karnaphully River. Water quality 500 m upstream from the discharging point was, pH: 6.5-7.8; DO: 5-8 mg l^{-1}; BOD: 0.5-3.0 mg l^{-1}; COD: 10-30 mg l^{-1} and SS: 30-40 mg l^{-1}. At 500 m downstream from the discharging point water quality parameters were, pH: 7.1-7.8; DO: 3-5 mg l^{-1}; BOD: 1-8 mg l^{-1}; COD: 20-80 mg l^{-1} and SS: 50-200 mg l^{-1}. Extensive pollution and adverse effect on vegetation and human health in the neighbouring area were reported.

124. Alam, A. M. S., Haque, A. N. M. E., Ali, M. Y., Tarafdar, S. A. and Khan, A. H. 1993.

Heavy element contaminants in aquatic ecosystems.

In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological bases for Water Resource Management (Tilzer, M. M. and Khondker, M. eds.). Proc. Int. Symp. Limnol., Botany Dept., Dhaka Univ., Dhaka.

A method has been developed for the quantitative determination of metal ions in natural and industrial effluents. The method is based on the preconcentration of the dissolved elements on Zeo-Karb 225 cation exchanger and selective elution of the metal ions with ethanol, ethylene glycol and isopropanol in admixture with HCl for subsequent analysis by atomic absorption spectrophotometry. Concentrations of cadmium, lead, and chromium were estimated at different stations on the Buriganga and Sitalakhya rivers using this method.

125. Alam, A. M. S., Malik, K. M. A., Haider, S. Z., Amanullah, M. and Billah, M. 1991.

Environmental pollution with reference to effluents from sugar mills in Bangladesh: A case study.

J. Bangladesh Chem. Soc. **4(2)**: 225-229.

Mixed effluent from a sugar mill and distillery (Carew and Co., Chuadanga) at the point of outfall and at different points within a two km stretch of Mathavanga River carrying the effluent were analysed. Effluent analysis at the discharge point before going into river showed: temperature: 28°C, pH: 5.1, Conductivity: 21 x 10^{-4} $ohms^{-1}$ cm^{-1}, DO: 1.5 ppm, DO% sat.: 18.1, total hardness: 578.16 ppm, permanent hardness: 534.60 ppm and chloride: 3.09 meq l^{-1}. From the point of discharge to a two kilometre distance downstream in the

receiving river, water quality parameters varied: temperature: 25.2-26.0°C, pH: 7.2-8.0, conductivity: 34 x 10^{-5} - 71 x 10^{-5} $ohms^{-1}$ cm^{-1}, DO: 6.0-7.0 mg l^{-1}, DO% sat: 55.4-85.4, total hardness: 128.40-320.76 ppm, permanent hardness: 86.13-114.84 ppm and chloride: 0.29-0.42 meq l^{-1}. Effects of pollution were practically undetectable about two kilometres downstream from the outfall.

126. Anonymous. 1988.
Study of the extent of pollution of river Buriganga during the winter season.
In: Monitoring of Environmental Systems of Chemical Industries in Bangladesh (Haider, S. Z. ed.). pp. 237-239. Bose, Centre for Advanced Stud., Dhaka Univ., Dhaka.

The Buriganga River from Pagla to Rayerbazar Ghat was studied. The Buriganga River was slightly alkaline ($CaCO_3$, 10-30 ppm) and variation in pH values (7.42-7.75) was small at different points. However, conductivity (37-80 $ohms^{-1}$ cm^{-1} x 10^{-5}) increased sharply near the sewerage treatment outfall. It was reported that all samples contained high levels of Ba^{++} (37.0-136.0 ppm).

127. Basher, S. H. and Reazuddin, M. 1991.
International Union for Conservation of Natural Resources.
The World Conservation Union. Towards sustainable Development: Issues of Environmental Pollution in Bangladesh. Ministry of Environment and Forest and National Conservation Strategy Secretariat, BARC, Dhaka.

Complaints regarding the damage to aquatic ecosystems by the Urea Fertilizer Factory Ltd., Ashuganj Fertilizer Factory, Hazaribagh tanneries and Karnafully Paper Mills were registered. Both fertiliser factories were responsible for ammonia pollution in river water resulting in occasional fish kills. This results from absence or improper management and technical failure of treatment plants. The effects of various pollutants was described. Oil pollution in the Karnafully River, Chittagong was also mentioned.

128. B C A S. 1989.

Environmental aspects of agricultural development and surface water systems of Bangladesh: An interim report.

Bangladesh Centre for Advanced Studies, Dhaka.

Analyses of the main discharge drain of Hazaribagh tanneries revealed high values of BOD, COD, TSS, chromium and total alkalinity. Highest BOD was 430 mg l^{-1} and COD 4320 mg l^{-1} (in October). The ammonia content in the discharge drain of Ashuganj fertilizer factory was 735 mg l^{-1} and total alkalinity was 480 mg l^{-1} (in April). The discharge drain of North Bengal Paper Mills contained BOD: 200 mg l^{-1} (December). BOD at the main discharge drain of Karnafuli Paper Mills was recorded as 48 mg l^{-1}. TSS at the same place was 300 mg l^{-1}. In a pond at Mirpur, total viable coliform, total coliform and faecal coliform varied: 0.04 x 10^8 - 9.3 x 10^8, 1.5 x 10^3 - 5.8 x 10^3 and 0.007 x 10^5 - 3.8 x 10^5 respectively. Concentrations of metals at the discharge drain of Khulna News Print Mills were: K: 1.87 - 45.35 mg l^{-1}, Ca: 28.30-34.18 mg l^{-1}, Mn: 0.06-3.27 mg l^{-1}, Fe: 2.15-14.85 mg l^{-1}, Cu: 0.72-1.53 mg l^{-1}, Zn: 0.18-1.46 mg l^{-1}, As: 0.05-0.154 mg l^{-1}, Br: 0.04-0.38 mg l^{-1}, Pb: 0.04-1.06 mg l^{-1}, Ni: 0-0.05 mg l^{-1}, Sr: 0-0.21 mg l^{-1}, Cd: 1.2-4.25 ppb, Rb: 0-0.1 mg l^{-1} and Ti: 0-0.016 mg l^{-1}.

129. Begum, Z. N. T. and Hossain, M. A. 1993.

Physico-chemical aspects and phytoplankton of a pond receiving textile industrial effluents.

Dhaka Univ. J. Biol. Sci. **2(1)**: 93-99.

Limnological data from the receiving pond were as follows: water temperature: 18-39°C; pH: 5.45-7.28; DO: 0-5.9; free CO_2: 0-9; bicarbonate alkalinity: 0-19.5 meq l^{-1}, redox-potential: 0.43-0.29. A total of 308 species of phytoplankton were identified of which diatoms dominated the community (111 spp.) followed by green algae (79 spp.), euglenoid algae (71 spp.) and blue-greens (43 spp.).

130. Chowdhury, S. H. 1985.

Relative efficacy of indicator organisms in pollution detection, a case-study.

Proc. SAARC Seminar, Dhaka. Protection of Environment from degradation.

Effects of pollutant discharge by two industrial units (Karnaphuli Paper Mills and Karnaphuli Rayon Mills) were determined. pH value did not show any change in the 'control' stations compared to 'polluted' stations. BOD was high in polluted stations. Free CO_2, total phosphorus and nitrate in the control and polluted stations varied irregularly and did not show any consistent pattern giving no indication of pollution. Phytoplankton community in the controlled and polluted zones also gave no indication of pollution. Abundance of benthic fauna was high in all seasons except the monsoon.

131. D O E. 1980

Year Book of Environment Pollution Control. Vol. II.
Environment Department. Govt. of Bangladesh. 1975-1980.

At least 18 water quality parameters were determined during 1975 to 1980 from different industrial areas of Dhaka, Narayanganj, Sylhet, Khulna and Pabna. Pollutional state of some main and small rivers namely, Padma, Jamuna, Buriganga, Karnafully, Ballu, Surma and Bhairab were also monitored. Data have been tabulated in the report.

132. D O E. 1984.

Study on water pollution of Buriganga River by untreated sewage disposal from Dhaka city, Bangladesh.
Department of Environment, Pollution Control.

Based on analytical data, the extent of pollution of the Buriganga River adjacent to WASA sewage discharge pit at Pagla was not considered to be serious. The oxidation pond of WASA treatment plant (during the study period) did not receive raw sewage for 3-4 months so water quality was found to be acceptable. However, other parameters such as SS, ammonia, phosphate, and coliform count were high. Raw sewage was discharged into the Buriganga River through an open canal causing high contamination. The Buriganga River at the final discharge point was found to be in septic condition. A foul smell prevailed in the area and ammonia, phosphate and BOD levels were very high. DO levels were very low even during high rates of river discharge.

133. Eunus, M. M. 1988.

Monitoring the environmental systems of chemical industries particularly in fertilizer industries.

In: Monitoring of Environmental Systems of Chemical Industries in Bangladesh (Haider, S. Z. ed.) pp. 93-99. Bose Centre for Adv. Stud., Dhaka Univ., Dhaka.

Liquid effluent from urea fertilizer comprises: ammonia, hexavelant chromium, acid/alkali mud, aluminium hydroxide sludge, lubricating oil, gas condensate, thermal discharge, mono- and di-ethanol amine, arsenic, vanadium etc. Paper mills release mercaptans, sulphur, chlorine, bleaching effluent, mercury, phenol etc. into water. Liquid pollutants from T.S.P. plant include sulphuric acid, phosphoric acid, fluorosilicic acid dust, soluble fluoride and gypsum.

134. Haider, S. Z. 1988.

River pollution in Bangladesh with special reference to tidal waves.

In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.). pp. 217-223. Bose Centre for Adv. Stud. Res., Dhaka Univ., Dhaka.).

About 30-40% of the input of fertilizers and agrochemicals in the form of insecticides are generally washed down the rivers and the shallow lakes during the rainy season. Almost all industries in Bangladesh are situated on the bank of rivers which create heavy localized pollution. Indiscriminate use of agrochemicals and fertilizers need to be decreased and replaced by compost from water hyacinth.

135. Haider, S. Z., Malik, K. M. A. and Rahman, M. M. 1984.

Mechanism of absorption of chemical species from aqueous medium by water hyacinth and prospects of its utilization.

In: Economic utilization of water hyacinth (Haider, S. Z. ed.) pp. 27-36. Dept. Chem., Dhaka Univ., Dhaka.

Based on the absorption properties of water hyacinth, a dynamic process has been outlined for the control of pollution of industrial waste waters using water hyacinth tanks and lagoons in conjunction with a monitoring device in order to measure some parameters of aqueous flow. After periodical harvest the plant may be used for making compost or paper board.

136. Haider, S. Z., Malik, K. M.A., Rahman, M. M. and Ali, M. 1984.
Pollution control by water hyacinth.
In: Economic utilization of water hyacinth (Haider, S. Z. ed.) pp. 37-41. Dept. Chem., Dhaka Univ., Dhaka.

Uptake of pollutants has been tested with the absorption properties of water hyacinth using industrial wastes from Sylhet Paper and Pulp mills, Tanning industry, and fertilizer factory. In the treatment although the plants health deteriorated after 3-4 days, the concentrations of the chemical species in the bulk solution continued to decrease. It has been concluded that water hyacinth lagoons could be most economically used for pollution control of industrial waste effluents passed through zigzag channels with monitoring devices to check the waste discharge to the river.

137. Hossain, M. A. 1988.
Monitoring and analysis of waste sludge of urea fertilizer factory, Ghorasal.
In: Monitoring of Environmental Systems of Chemical Industries in Bangladesh (Haider, S. Z. ed.) pp. 127-132.
Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

Sludge formed in the CO_2 absorption (done by GIAM AC0/VETROCOKE solution containing K_2CO_3-200 g l^{-1} as K_2O, As_2O_3-140 g l^{-1} and As_2O_5-10 g l^{-1}) tower was analysed and it was found that the sludge contains 40% arsenic on an average. The sludge is usually burried underground in concrete pits within factory premises but the process might cause serious pollution problem in the near future if the pits crack. It is therefore, recommended that arsenic must be removed before disposal. Recovery method of arsenic from sludge of arsenic in water is 0.05 mg l^{-1}. It is highly toxic therefore monitoring the disposal of sludge and any water containing arsenic is essential.

138. Hossain, M. H., Bhuiya, M. R. H., Gheyasuddin, S. and Rahman, M. A. 1988.
A preliminary study on river-water due to industrial wastes at some selected sites in Bangladesh.
Bangladesh J. Fish. **11(2)**: 59-65.

At two selected industrial sites of the Buriganga River namely, Hazaribagh and Postagola

some water quality parameters were DO: 1.12 and 7.17 ppm, free CO_2: 19.22 and 1.06 ppm, pH: 6.20 and 7.23 and BOD: 121.50 and 44.75 ppm respectively. In the Sitalakhya River at three places namely, Ghorasal, Demra and Narayanganj the values were DO: 5.27, 7.38 and 7.52 ppm, free CO_2: 3.37, 1.12 and 1.18 ppm, pH: 8.91, 7.32 and 7.24 and BOD: 67.68, 45.5 and 45.8 ppm, respectively. Studies at Chandraghona, Kalurghat and Patenga of Karnaphully River showed, DO: 3.23, 7.23 and 6.39 ppm, free CO_2: 12.54, 1.70 and 4.80 ppm, pH: 7.01, 7.35 and 7.10 and BOD: 74.5, 43.0 and 54.0 ppm respectively. Data on Turag River at Tongi were as follows: DO: 6.29; free CO_2: 2.37 ppm, pH: 6.95 and BOD: 57.23 ppm. Concentration of metals, suspended solids and hardness from the above mentioned sites were shown in bar charts.

Water quality characteristics of waste stream from a textile plant was COD: 303 mg l^{-1}, BOD_5: 46 mg l^{-1}, TOC: 73 mg l^{-1}; pH: 6.75; alkalinity: 54 mg l^{-1}, hardness: 56 mg l^{-1}, total solids: 935 mg l^{-1}, volatile solids: 180 mg l^{-1}; dissolved solids: 881 mg l^{-1}; suspended solids: mg l^{-1}; colour: 757 pt-Co. units, turbidity: 39.4; conductivity 1290 m mho cm^{-1}, Ca: 1.4 mg l^{-1}, Zn: 3.8 mg l^{-1}, Mg: 2.9 mg l^{-1}; Cr: 0.13 mg l^{-1}, Cu: 0.11 mg l^{-1}, Fe: 1.2 mg l^{-1}, Hg: 0.76 mg l^{-1}; Mr: 0.1 mg l^{-1} and Na: 290 mg l^{-1}. BOD of suspended solids were above recommended levels (20-30 mg l^{-1}) but the concentration of Mg, Ca, K and Fe were found within permissible range.

139. Khair, A. 1988.
Monitoring and control of toxic chemicals in chemical industries.
In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.) pp. 133-142. Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

Types of pollutants in wastewaters from selected industries (urea, TSP, cotton textile, paper pulp, refinery, tannery, viscose rayon, electroplating, caustic chlorine, pesticides and sugar) were tabulated. pH values of waste water from urea, cotton textile, paper and pulp, tannery and viscose rayon mills were reported as 8.0, 7-10, 6.5-8.3, 8.0 and 2.8-4.1 respectively. Liquid-waste characteristics of a typical urea plant showed temperature: 40°C; flow rate: 60-800 m^3 d^{-1}, pH: 9.12, urea: 2500 ppm, chromate: 25 ppm, and COD: 150 ppm. Control methods and monitoring of different pollutants were discussed.

140. Khan, A. H. 1989.

Monitoring of heavy pollutants from industrial emissions and effluent. Coordinated research programme on the use of nuclear and nuclear related techniques in the study in the environmental pollution associated with solid wastes. Report on the second research co-ordination meeting Jakarta, Indonesia, 20-24 Nov. 1989.

Using the existing standard, analytical techniques of source-excited nuclear methods and flame method, 34 effluent samples from paper, tannery and fertilizer industries were analysed and compared.

141. Khan, M. R. and Ahmed, Q. S. 1977.

Studies on the microorganisms isolated from the industrial acid drainage and its acidic surroundings.
J. Bangladesh Acad. Sci. **1(2)**: 113-140.

From a total of 151 isolate strains, 9 selected strains were characterised and identified. The pH values and the selected isolated bacterial strains (within parenthesis) from different industrial drainage sources were: Fenchuganj Fertilizer Factory: 2.7 (*Bacillus subtilis*); Fenchuganj Fertilizer Factory: 2.0 (*Bacillus cereus*); Karnaphuli Paper Mills: 5.0 (*Bacillus alvei*, 1), Karnaphuli Rayon Mills: 0.2 (*Bacillus alvei*, 2); Fenchuganj Fertilizer Factory: 3.5 (*Bacillus coagulans*); HCl Plant Chittagong: 4.5 (*Bacillus pantothenticus*); and Karnaphuli Paper Mills: 3.5 (*Pseudomonas effusa*). Results suggested that these organisms were adapting to an acidic environment and in course of time, could possibly evolve as acidophiles.

142. Khan, M. R., Alam, A. M. S., Saha, M. L., Rahman, M. M. and Islam, M. 1993.

Microbial management of chemical pollutants in water bodies.
In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological Bases for Water Resource Management (Tilzer, M. M. and Khondker, M. eds.) Proc. Int. Symp. Limnol., Botany Dept., Dhaka Univ., Dhaka.

Forty-six bacterial strains were isolated from natural waterbodies polluted with tannery wastes having chromium as one of the chemical pollutants. Nineteen of the isolates were found to grow under varied concentrations of chromium. Seven isolates were capable of

growing under very high concentrations (450 mg l^{-1} chromium) which indicated their possible role in detoxification of polluted water.

143. Khan, M. R. and Alim, S. A. 1983.
A micro-biological survey of the ice-cream and water samples collected from different factory sites of Dhaka city area.
Bangladesh J. Bot. **12(2)**: 139-145.

The study was carried out on samples of ice cream and factory waters at different sties of Dhaka city. Microbiological studies revealed high levels of faecal coliform bacteria, fungi and even eggs of insect (appeared as larva in the culture) in the samples. The results indicate a direct threat to public health particularly to the health of the more delicate and vulnerable part of the population, the children.

144. Rahman, S. 1988.
Environmental management in TSP complex Chittagong: A case study.
In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.) pp. 105-108. Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

Phosphate rocks used in the TSP complex for manufacturing phosphoric acid contain normally 3-4% fluorine. About 40% of the total fluorine content is condensed with water and drained. This drainage of resulting fluorosilicic acid causes pollution of river water and surrounding atmosphere. To control the pollution level, recovery of fluorine in the form of fluorosilicic acid is recommended.

145. Rashid, M. A. 1988.
Newsprint mills effluent and environmental pollution.
In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.) pp. 203-204. Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

The hourly intake of water from the Bhairab River by Khulna Newsprint Mills is about 5000

m^3. From this about 4500 m^3 h^{-1} is used as cooling water for turbine condensers and is discharged directly into the Bhairab River after mixing with mills effluent at two separate points. The pH and BOD recorded at the effluent discharge point are: 7.7-7.9 and 0-1 ppm, respectively. About 20 feet downstream from the discharge point the values are: for pH 7.5-7.6 and for BOD 1-3 ppm. The flowing river water showed a range of pH: 7.2-7.4 and BOD: 6-7 ppm.

146. Safiullah, S. and Mafizuddin, M. 1988.
Biogeochemical parameters in river waters in the industrial belts of Bangladesh.
In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.). pp. 69-82. Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

Mean discharges at the confluence of the Ganges and Brahmaputra in the years of 1981 and 1984 were 28 x 10^3 m^3 sec^{-1} and 32 x 10^3 m^3 sec^{-1} respectively. The fluxes of total carbon at the same place were: DIC: 12.6 x 10^6 MT y^{-1} (1981); DOC: 2 x 10^6 MT y^{-1} (1981), DIC, HCO_3^-, CO_3^{2-}: 15 x 10^6 MT y^{-1} (1984) and DOC: 2 x 10^6 MT y^{-1} (1984). Various types of industrial pollution are described and remedial measures are discussed.

147. Salam, A. 1988.
Environment management in chemical industries.
In: Monitoring of environmental systems of chemical industries in Bangladesh (Haider, S. Z. ed.) pp. 33-38.
Bose Centre Adv. Stud. Res., Dhaka Univ., Dhaka.

The paper identified some of the environmental hazards with special reference to Chittagong Chemical complex and outlined the measures adopted to bring those hazards within safe limits.

148. Shekhar, H. V., Haque, M. E., Hossain, S. A. and Yusuf, Z. 1993.
Environmental pollution due to effluents from sugar and sugar based industries in Bangladesh.
Dhaka Univ. J. Biol. Sci. **2(2)**: 209-213.

Raw sample prior to discharge into the river (Mathavanga) by Carew & CO. (Sugar and distillery industry at Chuadanga) contained pH: 3.61, DO: 1.52 mg l^{-1}, DOC: 2273.03 mg l^{-1}, BOD_5: 786.0 mg l^{-1}; TSS: 82.0 mg l^{-1} and TDS: 1034.6 mg l^{-1}. Changes in the water quality in terms of the above mentioned parameters at 100 m upstream, 10 m downstream and 200 m downstream were: pH: 8.14, 7.69 and 8.14; DO: 9.66, 4.46 and 9.30 mg l^{-1}; COD: 44.43, 44.46 and 72.96 mg l^{-1}, BOD_5: 17.06, 16.0 and 16.15 mg l^{-1}; TSS: 156.66, 134.66 and 167.50 mg l^{-1} and TDS: 233.0, 501.66 and 330.75 mg l^{-1}, respectively.

Jamuna Distillery Ltd. (at Natore) releases its spent wash (15% of the total and containing major pollutants) into 5 ponds. The rest (85%) including effluents from cooling water, condensates, vats etc. is discharged into the nearby river (Narode) through a concrete pipe. Spent wash prior to discharge into the ponds contained pH: 4.38, DO: 3.76 mg l^{-1}, COD: 69853 mg l^{-1}, BOD_5: 21000 mg l^{-1}, TSS: 3763 mg l^{-1} and TDS: 13116 mg l^{-1}. Effluent quality discharged into the river comprised pH: 7.76; DO: 8.7 mg l^{-1}, COD: 183.0 mg l^{-1}, BOD_5: 1.8 mg l^{-1}; TSS: 44.0 mg l^{-1} and TDS: 385 mg l^{-1}. Temperature for spent wash was between 65 and 100°C and for others between 37 and 40°C. Fishes of the rivers where the wastes are discharged are not at all edible and usually discarded by the local people. The people in the area very often suffer from various skin diseases.

2.3.3 Domestic pollution

149. Ahemd, M. F. 1993.
The effect of bio-degradable organic pollutants on aquatic ecosystem of the Buriganga.
In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological Bases for Water Resource Management (Tilzer, M. M. and Khondker, M. eds.) Proc. Int. Symp. Limnol., Botany Dept., Dhaka Univ., Dhaka.

Simplified version of dissolved-oxygen-sag model was found useful to describe the observed variation of dissolved oxygen along the river. The discharge rates of effluents from 5 drains and outfalls ranged from 0.60 - 2.85 $m^3 s^{-1}$. Analyses of those waters showed BOD: 68-110 mg l^{-1}, DO: 0.10-3.50 mg l^{-1}, BOD reaction rate constant k_1: 0.160 - 0.245 d^{-1} and coliform bacteria: 5 x 10^4 - 120 x 10^4 (100 ml)$^{-1}$. The maximum bacterial density was found in the

zone of active degradation, while net algal productivity was observed in the zone of recovery of the river.

150. Hossain, M. M. and Patra, R. W. R. 1989.
A preliminary study on the bacteriological condition of the Karnafully river estuary.
Bangladesh J. Zool. **16(2)**: 111-117.

Presence of coliform and faecal streptococci were observed in the lower stretch of the Karnafully River. Effluents discharged by various drains and channels were found responsible for the contamination. Abundance and density of bacteria varied in different sites of the study area and were found to correlate directly with the volume of waste disposal.

151. Khondker, M., Islam, A. K. M. Nurul and Makhnun, A. D. 1994.
Lemna perpusilla: Screening on habitat limnology.
Bangladesh J. Bot. **23** (in press).

Lemna perpusilla Torrey (a free floating member of duckweed) is usually found to grow in dense mats in slow flowing drains and channels rich in organic pollutants. Three such habitats in Dhaka city were studied whose water quality showed: temperature: 15.0-28.0°C, pH: 6.9-7.8; conductivity: 200-890 μS cm^{-1}, alkalinity: 0.84-7.42 meq l^{-1}; DO: 0-6.45 mg l^{-1}; DO % sat.: 0-79.43%, COD: 2.56 - 22.80 mg l^{-1}; SRS: 2.33-72.45 mg l^{-1}; SRP: 0.10-.94 mg l^{-1}; NO_3-N: 0.04-0.33 mg l^{-1}, chl a: 0-1.17 mg l^{-1} and phaeopigment: 0-0.04 mg l^{-1}. The *Lemna* biomass (dry weight) ranged from 13.2-148.52 g m^{-2}, which showed significant positive correlation with SRS ($P < 0.05$) and negative correlation with temperature ($P < 0.01$) and DO ($P < 0.01$).

152. Khondker, M., Islam, A. K. M. Nurul and Nahar, N. (In press).
Study on the biomass of *Spirodela polyrhiza* and the related limnological factors of some polluted waters.
Proc. 7th Biennl. Bot. Conf., Bangladesh Bot. Soc., Dhaka.

Water temperature showed a negative effect on the biomass of *Spirodela polyrhiza*, but a fall

in the biomass related directly with conductivity (447.15 ± 158.99 μS cm^{-1}), alkalinity (3.58 ± 1.21 meq l^{-1}), silicate (50.58 ± 20.31 mg l^{-1}) and phosphate (1.27 ± 1.18 mg l^{-1}) levels of water in the studied habitats. Maximum biomass of the plant was recorded as 63.79 g m^{-2} as dry weight. The plant tolerated high concentrations of nutrients, ions and an oxygen tension.

153. Hoque, B. A. and Hoque, M. M. 1990.
Faecal pollution of surface-water and diseases in Bangladesh.
In: Environmental Aspects of Surface Water Systems of Bangladesh (Rahman, A. A., Huq, S. and Conway, G. R. eds.) pp. 180-187. Univ. Press Ltd., Dhaka.

Indiscriminate defaecation practices and unsanitary excreta disposal systems were considered as the principal vehicle for the transmission and spread of a wide range of communicable diseases, such as diarrhoea, cholera, typhoid , shigellosis etc. in Bangladesh. Results of several case studies are reviewed and discussed. Recommendations are made to reduce faecal pollution in surface water as well as shallow ground water sources.

154. Islam, A. K. M. Nurul and Islam, M. S. 1993.
Hydrophytes, eutrophication and diseases
In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological Bases for Water Resources Management (Tilzer, M. M. and Khondker, M. eds.) Proc. Int. Symp. Limnol., Botany Dept., Dhaka Univ., Dhaka.

Peak incidences of cholera (in endemic areas) corresponded to blooms of blue-green algae in the natural aquatic environment. Symbiosis between *Vibrio cholerae* and algae might be a possible explanation for this. It has been estimated that surface waters of Bangladesh are contaminated by about 30,000 MT human excreta per day. Many aquatic plant surfaces act as carriers of water borne diseases from one place to another. Carrier plants and the associated disease producing bacteria are tabulated.

155. Islam, A. K. M. Nurul and Khatun, M. 1986.
Preliminary studies on the phytoplankton of polluted waters.
Sci. Res. **3(2)**: 94-109.

The studied ponds located in and around Dhaka University campus were polluted by domestic, hospital and industrial (small type) waste products. Water quality characteristics of some of the ponds were: dissolved phosphorus: 43.8 ppm, nitrate: 5 ppm, pH: 7.5-8.5 and water temperature 28-34°C. Such heavily polluted ponds supported luxuriant growth of blooms' of blue-green algae, bacteria etc. Systematic account of the recorded phytoplankton species and their illustrations were furnished.

156. Islam, A. K. M. Nurul, Khondker, M. and Haque, S. 1991.
Euglenoid algae of four polluted ponds in and around Dhaka city.

Phytoplankton populations in four organically enriched polluted ponds were investigated. A total of 28 species of *Euglena*, 9 species of *Phacus* and one species each of *Astasia*, *Petalomonas*, *Eutreptia* and *Strombomonas* were recorded. Systematic illustrated descriptions of the species were presented.

157. Islam, A. K. M. Nurul and Nahar, L. 1967.
Preliminary studies on the phytoplankton of polluted waters.
Sci. Res. **4(2&3)**: 141-149.

The paper dealt with planktonic blue-green algae found in six ponds polluted by domestic and hospital wastes which caused the formation of 'algal blooms'. A total of 41 species belonging to 13 genera of blue-green algae was described and illustrated.

158. Jewson, D. H., Khondker, M., Rahman, M. H. and Lowry, S. (In press).
Auxosporulation of the freshwater diatom *Aulacoseira herzogii* in Lake Banani, Bangladesh.
Diatom Research.

Auxospores of a rarely reported diatom species *Aulacoseira herzogii* (Lemm.) Simonsen were found in Lake Banani (Dhaka, Bangladesh) during the monsoon season in September 1992. In the following weeks, the population declined and the shallow, eutrophic lake became overgrown by a floating canopy of water hyacinth (*Eichhornia crassipes*). During this period water quality characteristics of the lake were: temperature: 28.5-31.5°C, Secchi: 33-59 cm, pH:7.0-8.1, conductivity:239-362 μS cm^{-1}, Sodium: 17-43 mg l^{-1}, DO: 0.7-9.5 mg l^{-1}, BOD:

5.5-15.7, chl a: 49-209 μg l^{-1}, phaeopigment: 22-40 μg l^{-1}, silicate: 9-41 mg l^{-1}, nitrate: 14-57 μg l^{-1} and phosphate: 156-592 μg l^{-1}. The lake is strongly polluted by domestic wastes. The northern part of the lake received high amounts of organic material. In other places around the lake, there was localised pollution from laundering of clothes and cleaning of slaughtered animals.

159. Karim, M. A. and Islam, A. K. M. Nurul. 1976.
Eutrophication of the surface water of some lakes studied at Dacca (Bangladesh). Proc. Int. Symp. on Eutrophication and Rehabilitation of surface waters. Karl-Marx-Stadt, G. D. R. pp. 200-207.

Factors affecting the process of eutrophication in natural and artificial water bodies of Bangladesh were summarized. Comparative accounts of plankton studies in two lakes (Ramna and Dhanmondi lake) were reviewed.

160. Khan, M. R., Bashar, M. A., Rahman, S. M. and Shaha, U.K. 1986.
A microbiological study of sewage samples collected from Dhaka metropolitan city and its suburban areas.
Dhaka Univ. Stud. Pt. E. **1**(1): 41-44.

Temperature and pH of the sewage samples varied from 18-33°C and 6.8-8.4 respectively. Pollution indicating parameters at their maximum concentrations from the sewage samples (in underground drains, sedimentation tanks and final effluents) were: suspended solids: 20250 mg l^{-1}, ammonia: 1357 mg l^{-1}, and BOD: 412 mg l^{-1}. The highest number of cysts of *Ascaris* sp., *Trichuris* sp. and *Ancyclosoma* sp. was found to be 10233, 900 and 3400 (100 ml)$^{-1}$ respectively. Maximum count of bacteria were: coliform 3.05 x 10^7 and faecal coliform: 3.35 x 10^7 l^{-1}. The results indicated that local sewage treatment and disposal systems were inadequate.

161. Khan, M. R., Rahman, M. and Huq, A. 1978.
Presence of faecal coliform bacteria in tap water of different localities of Dacca metropolitan city.
Bangladesh J. Bot. **7**(2): 40-45.

Faecal coliform bacteria were isolated from nineteen out of forty two tap water samples collected from the different localities of Dacca metropolitan city. Eight samples had reasonably high numbers (13-1232 (100 ml)$^{-1}$). One sample was found to contain pathogenic form.

162. Khondker, M., Islam, A. K. M. Nurul, Begum, Z. N. T. and Hauqe, S. 1990. Limnological studies of four polluted ponds in and around Dhaka city with reference to indicator species.
Bangladesh J. Bot. **19(1)**: 51-63.

Four selected ponds having various grades of pollution (mainly of domestic origin) and age were studied. The ponds were slightly acidic to alkaline (pH: 6.1-7.6), but showed a wide range of variation in conductivity (75-100 μS cm^{-1}). DO levels varied markedly, from anoxic to a supersaturated concentration of 17.77 mg l^{-1}. Bicarbonate alkalinity and CO_2 concentration varied from 0.004 to 1.9 meq l^{-1} and 0.123 to 3.19 mg l^{-1}, respectively. Euglenoid algae were higher in organically enriched ponds.

163. Morshed, M. G., Aziz, K. M. S., Islam, M. S. and Khan, M. R. 1985. Presence of coliform bacteria and their relative abundance in three sampling stations on Buriganga river.
Bangladesh J. Microbiol. **2(1&2)**: 6-10.

Seasonal variations in the quantitative distribution of coliform bacteria in the Buriganga River were studied. The total coliform count varied from 0.8 x 10^4 - 16 x 10^4 (100 ml)$^{-1}$ and faecal coliform from 0.35 x 10^4 - 50 x 10^4 (100 ml)$^{-1}$. Both counts were highest in the dry season and lowest in the rainy season. The average total and faecal coliform counts in all three stations were several folds higher than the permissible range for drinking and recreational water.

164. Morshed, M. G., Sayeed, S., Parveen, S., Ahmed, A. U. and Hossain, N. 1989. Coliform bacteria during peak period in Dhaka city. A case study.
Bangladesh J. Life Sci. **2**: 41-45.

During the heavy flood of 1988 when about 70% of the country was inundated, 28 locations in Dhaka city were sampled for the presence of coliform bacteria. The counts of faecal coliform ranged from 1 x 10^5 - 180 x 10^5 c Fu (colony forming unit) (100 ml)$^{-1}$. The counts were 2 to 3 times higher than previous results. In the Kalyanpur area the counts of faecal coliform ranged from 0.2 x 10^5 - 350 x 10^5 c Fu (100 ml)$^{-1}$. *Vibrio* sp. was present in all sampling sites.

165. Patra, R. W. R. and Mohsin, N. A. 1979.
Studies on coliform bacteria as an indicator of pollution in the Chaktai Khal, Chittagong, Bangladesh.
Bangladesh J. Zool. **7(2)**: 125-129.

A survey of Chaktai *Khal*, Chittagong which received pollutants from different parts of the city showed the presence of *Escherichia coli* in abundance which confirmed that its water was polluted.

166. Rahim, Z., Aziz, K. M. S. and Islam, M. S. 1985.
Current environmental pollution by human faecal contamination.
Proc. SAARC Seminar on protecting the environment, Dhaka.

Faecal coliform (FC) and faecal streptococci (FS) were isolated from water samples of the Buriganga River and a pond in Dhaka for a period of 15 months from June to August. In the river FC and FS counts ranged from 1.3 x 10^4 - 310 x 10^4 and 2.7 x 10^3 - 3.1 x 10^3 (100 ml)$^{-1}$ respectively. In pond water FC counts varied from 8 x 10^2 - 620 x 10^2 (100 ml)$^{-1}$. The ratio of FC to FS was always >4 which indicated faecal pollution and that the water was unsuitable for human use (for swimming, bathing, washing etc.).

167. W P C P. 1975.
Pollution study of Dhanmondi lake.
In: Year book, Water Pollution Control Project, Water Pollution Control Board, Govt. of Bangladesh Dacca, pp. 505.

Dhanmondi Lake, Dhaka was used as a depository for domestic and market wastes from New

Market, Kalabagan, Dhanmondi Residential Area, Peelkhana and Hazaribagh areas. Qualitative estimates of character and amount of wastes were made. Point sources of pollution were identified and mapped. Several water quality parameters varied as follows: water temperature: 24.7-31.7°C, pH: 5.83-8.5, DO: 0.1-10.5 mg l^{-1}, Cl: 15-50 mg l^{-1}, total alkalinity: 51-152 mg l^{-1}, BOD: 4.3 - 60.0 mg l^{-1}, Coliform: 9-900 $(100\ ml)^{-1}$, TS: 144-336 mg l^{-1}, TDS: 137-308 mg l^{-1}, SS: 0-66 mg l^{-1}, TVS: 71-663 mg l^{-1}, TDVS: 80-166 mg l^{-1}; and conductivity: 160-400 m mhos cm^{-1}.

2.3.4 Agro-chemical pollution

168. Begum, Z. N. T. and Islam, M. M. S. 1993.
Study on the effect of Basudin and Furadan on *Nostoc commune* Voucher and *Calothrix marchica* Lemm.
In: Hypertrophic and Polluted Freshwater Ecosystems: Ecological Bases for Water Resource Management (Tilzer, M. M. and Khondker, M. eds.). Proc. Int. Symp. Limnol., Botany Dept., Dhaka Univ., Dhaka.

Two most commonly used insecticides namely, Basudin and Furadan have been tested on nitrogen fixing blue-green algae at various concentrations. Recommended dose (for field 4, 7.5 mg l^{-1}) of Furadan showed inhibitory effects on the growth and N_2-fixation of both the algae. In contrast Basudin did not generally affect these activities in both organisms.

169. Safiullah, S. and Huq, S. 1986.
Environmental studies in Bangladesh - a perspective for the less developed countries.
The Science of the total Environment **55**: 165-173.

Between 1970 and 1974 the use of urea, potash, phosphate and all types of pesticides increased in the order of 14, 7, 10 and 44 fold, respectively. It is assumed that excessive leaching of fertilizers poured unacceptable concentration of nutrients in many oxbow lakes of the country. These water bodies contributed 30% of the total fish production which has dwindled to less than 10%. Depletion of useful bacterial microflora and earthworms in the soil might have occurred due to extensive use of chemical fertilizers and pesticides

(malathion, parathion etc.). Possible contamination of ground water by nitrate through leaching has been suspected. NO_3-N level at Chalan *beel* area was found 27 mg l^{-1} (safe level is 11 mg l^{-1}, WHO). Non-degradable polychlorinated hydrocarbons like DDT, aldrin, dieldrin etc. might be incorporated into food chains and persist for a long time.

170. Safiullah, S. and Mofizuddin, M. 1988.
Biogeochemical parameters in river waters in the industrial belts of Bangladesh. *In*: Monitoring of environmental systems of chemical fertilizers in Bangladesh (Haider, S. Z. ed.) pp. 69-82. Bose Cent. Adv. Stud. Res., Dhaka Univ., Dhaka.

In Bangladesh urea is produced by using valuable natural gas. Urea is highly soluble in water. So, under the conditions of irrigation or during monsoon floods about 40% of the applied urea is washed away into the aquatic ecosystems. This incurs a loss of about 5 billion taka and might cause numerous pollution problems. Excessive input of nitrogenous compounds produces water blooms subsequently leading to eutrophication. Nitrate has some carcinogenic effect on higher animals. Phosphate fertilizer if discharged in excessive amounts might also cause similar pollution effects. The excessive use of various pesticides such as dieldrin, malathion etc. might cause serious health problems for humans.

171. FAP 17. 1993.
Investigation of pesticide residue levels in floodplain fish in Bangladesh.
Interim Report Annex B, FAP 17.
Fisheries Studies and Pilot Project. pp. 1-13.

Four species of fishes (*Channa punctatus, Mastacembalus armatus, Lepidocephalus guntea* and *Mystus tengra*) were selected for pesticide residue analysis. The fishes were collected from four *beels* located in the Tangail Compartmentalisation Pilot Project area in May 1992. Levels of pesticide residues such as DDT, Dieldrin, Endosulfan and organophosphorus were determined. The results revealed the presence of low concentrations of organochlorine pesticide residues in fish tissue which were not considered harmful to human consumers. The paper includes several useful recommendations on pesticide aspects.

2.4 Ground Water Quality

172. B A F R U. 1990.
A survey of fish farm water quality in Bangladesh.
Univ. of Stirling, Stirling, Scotland, pp.82.

A survey of the quality on hatchery supply water was carried out in Bangladesh. Average values of deep tubewell (100 m depth) water quality from different parts of Bangladesh were: temperature: 26.7°C, conductivity: 521 μS cm^{-1}, TDS: 261 mg l^{-1}, pH: 7.0, CO_2: 104 mg l^{-1}, total hardness: 188 mgl^{-1}, total alkalinity: 180 mg l^{-1} (as $CaCO_3$); orthophosphate: 0.23 mg l^{-1}, total iron: 2.42 mg l^{-1} and aluminium: 0.03 mg l^{-1}. Water quality characteristics in shallow tubewells (10-30 m depth) were (mean values): temperature: 26.7°C, conductivity: 433 μS cm^{-1}, TDS: 216 mg l^{-1}, pH: 7.0, CO_2: 57 mg l^{-1}, total hardness (as $CaCO_3$): 145 mg l^{-1}, total alkalinity (as $CaCO_3$): 135 mg l^{-1}, orthophosphate: 0.97 mg l^{-1}, total iron: 8.93 mg l^{-1} and aluminium: 0.17 mg l^{-1}. Hand pump (< 10 m depth) water showed average values of different parameters such as temperature: 27.0°C, conductivity: 510 μS cm^{-1}, TDS: 255 mg l^{-1}, pH: 6.8, CO_2: 75 mg l^{-1}, total hardness (as $CaCO_3$): 143 mg l^{-1}, total alkalinity (as $CaCO_3$): 114 mg l^{-1}, orthophosphate: 0.22 mg l^{-1}, total iron: 4.77 mg l^{-1} and aluminium: 0.01 mg l^{-1}. Most commonly reported water quality problem associated with tubewell water in Bangladesh is a high concentration of iron. There is increased mortalities at hatcheries where the tubewell water quality is greater then 1 mg l^{-1} of iron.

173. Basher, S. H. M. A. and Reazuddin, M. 1991.
International Union for Conservation of Natural Resources - The World Conservation Union. Towards sustainable Development: Issues of Environmental Pollution in Bangladesh.
Ministry of Environment and Forest and National Conservation Strategy Secretariat, BARC, Dhaka.

Bangladesh Water Development Board surveyed 136 wells throughout the country. Nitrate in excess of 0.5 mg l^{-1} was detected in 30 wells out of 136 and a total of 10 wells contained nitrates exceeding 20 mg l^{-1}. Almost all the higher concentrations are located in Dinajpur. Most of the shallow wells contained concentrations of 20 mg l^{-1}. The permissible level is 7 mg l^{-1}.

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174. B C A S. 1989.
Environmental aspects of agricultural Development and surface water systems of Bangladesh: An interim report.
Bangladesh Centre for Advanced Studies. Dhaka.

Results of chemical analyses of ground water samples from Dhaka city are tabulated. The depth of sunk tubewells varied from 46-143 m. Water quality parameters varied as follows: pH: 6.5-10.0; TDS: 152.4-591.0 ppm; Fe:0-5.8 ppm, chloride: 6.5-172.0 ppm, sulphate: 0-52.67 ppm and bi-carbonate: 65.0-152.2 ppm.

175. Billah, M., Hadi, D. A., Khan, A. H., Chowdhury, C. R. and Hoque, S. M. 1989.
Fluoride level of some drinking water supplies in Dhaka city.
Nuclear Sc. Appl. **1(1)**: 27-31.

The fluoride content in the drinking water of Dhaka city ranged from 0.02-0.68 ppm which is lower than the recommended level (1 ppm).

176. Dray, M. 1983.
Contribution of isotope techniques in the determination of the relationship between surface water/ground water in Bangladesh (Ganges and Brahmaputra areas).
In: River Basin Development (Munir Zaman, ed.) pp. 158-170. Tycooly Int.

Ground water quality in the Ganges and Gorai river areas were found as: dug wells, TDS: 1200 ppm, conductivity: 1000 μS cm^{-1} and the drilled wells, TDS: 500 ppm and conductivity: 500 μS cm^{-1}. The pH measured in the field was close to neutrality for the wells and alkaline for the rivers. The temperature was around 27°C. High levels of nitrate, upto 100 ppm, potassium, 35 ppm and sodium 75 ppm were recorded in the dug wells. In the ground water circle of Dinajpur, Rangpur and Bogra drilled well waters were ironically less rich, TDS: 400 ppm, bicarbonate type with Na as major cation. The temperature of the well waters varied between 20.5-27.0°C.

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177. Habib, M. A. B., Khan, L. R., Alam, M. J. and Begum, M. 1988.
Effect of groundwater on the chemical properties of nursery pond water.
Bangladesh J. Water Resource Research **9(1)**:

Chemical properties of ground water did not affect significantly the water quality of nursery ponds. Several other correlations were established between different water quality parameters of ground water and nursery pond waters.

178. Jones, P. H. 1985.
Geology and ground water resources of Bangladesh.
Report to the World Bank, South Asia Region.

Except the coastal area of Sundarbans, water of Aquifer No. 1 can be classified as fresh and potable (after WHO standards). Treatment for the lowering of hardness is however, recommended to meet the public health requirement so that Fe content does not exceed 0.3 mg l^{-1}. The chloride content exceeds the recommended maximum 130 mg l^{-1}. However, the water is suitable for irrigation except in the coastal region.

179. Khan, L. R., Talukder, S. U. and Biswas, M. R. 1977.
The water quality of ground water in Dinajpur district for irrigation use.
Bangladesh J. Agrl. Sci. **4(2)**: 225-234.

Irrigating ground water in the area was found to contain low salinity. Water quality parameters varied as follows: pH: 7.0-8.5, Ca^{2+}: 0.004-2.1 ppm, Mg^{2+}: 9.68-40.84 ppm, Na^{+}: 6.51-50.16 ppm and K^{+}: 0.078-1.53 ppm. Soluble sodium percentage and sodium ration varied 11.75-71.90 and 0.28-3.36, respectively. Conductivity ranged between 52.5 and 425 $\mu S\ cm^{-1}$. Residual alkalinity and iron were satisfactory.

180. Maroof, F. B. A., Hadi, D. A., Khan, A. H. and Chowdhury, A. H. 1986.
Cadmium and zinc concentrations in drinking water supplies of Dhaka city.
The Science of Total Environment **53**: 233-288.

The concentration of cadmium in supply water and tubewell water ranged from 1.03-1.58

ppb and 171-2.24 ppb, respectively. Corresponding zinc content ranged from 0.013-0.37 ppm, which is higher than the maximum level (50 ppb). Excess accumulation of zinc was considered harmful.

181. Talukder, A. K. M. H., Khondker, M. and Anam, K. K. 1993.
Water quality: in the environmental perspective of north western region of Bangladesh.
Bangladesh J. Sci. Res. **11(2)**: (in press).

Ground water quality (shallow and deep tubewell) from Gaibandha region of Bangladesh showed the following variation for different parameters: temperature: 24.5-26.0°C; pH: 6.5-6.7, NH_3-N: 0.2-1.6 mg l^{-1}, Cl^-: 4.0-14.0 mg l^{-1}, Fe: 1.2-5.8 mg l^{-1}, DO: 0.3-2.0 mg l^{-1}, DO% sat: 4-25, BOD_5: 2.5-40.0 mg l^{-1}, COD: 18.0 - 40.0 mg l^{-1} and total coliform: 80-120 (100 ml)$^{-1}$. In the north west region (some districts of Rajshahi division), samples from drinking water and shallow-tubewells showed the following quality: temperature: 25.2-26.9°C, pH: 6.7-7.2, NH_3-N: 0.4-2.0 mg l^{-1}, Cl^-: 13.0-38 mg l^{-1}, $SO4^{2-}$: 8.5-41.5 mg l^{-1}, Fe: 0.9-2.1 mg l^{-1}, DO: 1.9-2.6 mg l^{-1}, DO% sat: 23-33, BOD_5: 7.5-12.1 mg l^{-1}, COD: 22.0-55.0 mg l^{-1} and total coliform: 34-100 (100 ml)$^{-1}$. Ground waters do not meet the standards of drinking water quality set forth by WHO. Non-technical sinking of some tubewells might be responsible for this.

182. U N I C E F. 1989.
Water sanitation and hygiene.
In: An analysis of the situation of children in Bangladesh (a report).

In Bangladesh about 15% of the total rainfall percolates and recharges the water table. The ground water table rarely exceeds 15 m. The groundwater reservoir consists of an upper silty clay layer over a zone of very fine sands of about 20 m in thickness. It has been estimated that over 70% of tubewell water have iron concentrations >1 mg l^{-1}. About 15 million people of the country consume water having an iron content >5 mg l^{-1}.

183. C I R D A P. 1987.

The impact of Flood Control, Drainage and Irrigation (FCDI) Projects in Bangladesh: Benchmark survey and initiation of monitoring the evaluation system (MES).

Centre for Integrated Rural Development for Asia and the Pacific (CIRDAP), Dhaka.

The contents of nitrite and sodium chloride in the water of studied villages were lower than the values recommended by the Bangladesh Water Quality Standards (1-5 ppm). However, the iron content of the average ditch in the Damodari village was found as high as 35 mg l^{-1}. Except the village Damodari, tubewell waters from all other villages showed higher iron content. Total hardness and acidity were all within the limits of Bangladesh standards. However, the colour and bacteriological levels did not satisfy the recommended ranges. DO values of floodplain and river water exceeded 10 mg l^{-1}.

184. FAP 3. 1992.

North Central Region Study. Preliminary supporting Report V. Ecological assessment.

Consortium: BECOM, Compagine Nationale du Rhone Eurocon.

Limited studies of the water quality from the project area were made. Some places showed high pH, DO was generally good and BOD was within the allowed range of 8 mg l^{-1}. COD of some samples at Hazaribagh exceeded the permissible standards. Industrial pollution was extensive in the Lakhya, Dhaleswari and Meghna rivers. Total suspended solids increased gradually in the Brahmaputra River. Bacterial counts varied from 10^6-10^7 $(100\ ml)^{-1}$ and therefore, did not fulfil the maximum limit (5×10^3 $(100\ ml)^{-1}$). Pathogenic bacteria was however, absent. Proper national monitoring for water quality criteria in different water bodies of the area was recommended.

185. FAP 6. (North East Region).
Water pollution.

Pollution from industrial sources in the Surma and Kushiyara rivers produced a negative impact on fisheries. Fishermen believed that the Fenchuganj fertilizer factory reduced the fish catches in the area. Similar criticism was made about the cement factory and paper and pulp mills at Chattak which pollute the Surma River. Local people refuse to eat fish from the Surma River because of their bad teste and smell caused by contamination of the fish flesh. The fishes are marketed elsewhere in the country. Urgent action is needed to install a treatment plant.

3 INDEXES