APPENDIX

EXAMINATION OF SOME ENVIRONMENTAL FACTORS FOR THE CAUSE OF A SUMMER FISH-KILL IN A TANK NEAR ALLAHABAD
CASES of fishkill in ponds, tanks, lakes and reservoirs have been recorded from time to time by a number of fishery workers in India. These kills are attributed to various factors: decaying filamentous algae bloom, mechanical injury, choking of gill filaments, excessive alkaline condition and certain meteorological factors like, calm, windless or cloudy day. In the present communication an attempt has been made to examine the environmental factors resulting in a massive summer fishkill in a tank near Allahabad.

The estimation of NH₂-N, NO₃-N, PO₄-P, Fe, Free CO₂ and DO (dissolved oxygen) was done using direct Nesslerization method, phenol-dissulphonic acid method, ammonium chloride method, Potassium thiocyanate method, Phenolphthalein method and unmodified Winkler's method respectively. The plankton samples were collected using a net of truncated cone shape with an upper diameter of 30 cm. The net is made of nylon net having 173 meshes linear inch. 50 l of water was collected from each of the 4 banks made into 200 l and was sieved through the above net forming a single sample.

The tank in question is about 1 ha in area and is located at Jari, about 30 km from Allahabad. At full tank level in August 1976 it recorded a depth of 3-5 metres. The water level started receding subsequently largely due to evaporation and it was barely 0-66 metre on 26th April 1977 when the massive fishkill took place. The dead fish included major carps, minor carps, cup minnows and eel-tails. The fingerlings of Cirrhinus mrigala, Labeo rohita, Catla catla and L. bata, kept in floating cages for experimental rearing, also suffered a large scale mortality.

In April, the tank witnessed a massive myxophyceae bloom, a feature not altogether uncommon in lentic waters in India. The blue-green algae in the present case was made of Chroococcaceae (Microcystis, Merismopedia), Rivulariaceae (Calothrix, Gleotrichia) Nostocaceae (Anabaena, Nostoc) and Oscillatoriaceae (Oscillatoria, Spirulina, Phormidium). Among them only Anabaena and Microcystis formed dominant blooms in April. Anabaena which formed only 3,625 units/litre in February rose to 16,250 µ/l in March reaching a peak of 1,07,708 µ/l in April. Microcystis contributed 2,750 µ/l in February, 1872 µ/l in March and 14,167 µ/l in April. The blue-green algae in total formed during the above period 15,000 µ/l in February, 22,550 µ/l in March and 1,29,584 µ/l in April, showing thereby a sudden increase in numbers per litre from March to April. Bacillariaceae (Synedra, Navicula, Nitzschia, Melosira), Chlorophyceae (Scenedesmus, Ankistrodesmus, Microra, Characiun, Pedistrium, Gomphus) and Desmidieaceae (Clasteria, Microstata, Staurostrum) were also present in the phytoplankton during the above period but their numbers were insignificant: 1550 µ/l in February; 867 µ/l in March; and 2718 µ/l in April. The zooplankton during the above period was largely made of rotifers (Keratella, Brachionus, Asplanchna, Filina) and copepods ( Cyclops, nauplii). The flagellates were represented by Pleodorina, Volvox and Phacus. The abundance of zooplankters during the above period was, in terms of organisms/litre, 1,500 in February, 27,584 in March and 10,325 in April. It is obvious from the foregoing that there is a drop in zooplankton abundance in April as phytoplankton especially blue-green algae rose to a high peak.

The PO₄-P is known to trigger off algal blooms of myxophyceae. The PO₄-P content of water in April was of a high order (0-5 ppm) whereas it was only in traces in February. The enhanced phosphorus appears to have come from the marginal sediment and increased rate of organic decomposition in the shallower mud. Because of the shallowness, the entire tank bottom deposit becomes available in summer as a source of nutrients. This is also reflected by the increased NH₃-N content of the water (3-2 ppm). More phosphate was liberated then seemingly assimilated by the Myxophyceae bloom. It is for this reason obviously that PO₄-P remained high level in April even when the algal blooms were also at their peaks. The analysls of tank soil collected in April 1977 was also marked by high ferric iron content (7-60 gm/100 gm soil). The physico-chemical features of the tank on April 20 is shown below. The observations were taken at about 11 A.M.

<table>
<thead>
<tr>
<th>Air Temp. °C</th>
<th>Water Temp. °C</th>
<th>pH</th>
<th>NH₄-N (ppm)</th>
<th>NO₃-N (ppm)</th>
<th>PO₄-P (ppm)</th>
<th>Fe (Total) (ppm)</th>
<th>Free CO₂ ppm</th>
<th>D.O. (% saturation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.0</td>
<td>27.1</td>
<td>8.8</td>
<td>3.2</td>
<td>0.45</td>
<td>0.50</td>
<td>4.5</td>
<td>Nil</td>
<td>9.2</td>
</tr>
</tbody>
</table>
Studies on diurnal variation of physico-chemical features in respect of water temperature, pH, DO, and \( \text{CO}_2 \) carried out at 3 hourly intervals in the same tank on 16/17 April 1977 (4 days earlier to the day of mass fishkill) further provide a glimpse of the metabolic processes of the ecosystem.

<table>
<thead>
<tr>
<th>Factors</th>
<th>06 hrs.</th>
<th>09 hrs.</th>
<th>12 hrs.</th>
<th>15 hrs.</th>
<th>18 hrs.</th>
<th>21 hrs.</th>
<th>00 hrs.</th>
<th>03 hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8-6</td>
<td>9-2</td>
<td>9-4</td>
<td>9-6</td>
<td>9-2</td>
<td>9-0</td>
<td>8-6</td>
<td></td>
</tr>
<tr>
<td>D.O. ppm</td>
<td>0-8</td>
<td>6-8</td>
<td>9-2</td>
<td>12-2</td>
<td>7-6</td>
<td>4-4</td>
<td>2-4</td>
<td>1-4</td>
</tr>
<tr>
<td>( \text{CO}_2 ) (ppm)</td>
<td>6-0</td>
<td>12-0</td>
<td>16-0</td>
<td>18-8</td>
<td>16-2</td>
<td>14-0</td>
<td>8-0</td>
<td>6-0</td>
</tr>
</tbody>
</table>

The ecosystem was marked both by high values of D.O. between 12 hrs. and 15 hr. indicative of high rate of photosynthesis and low values of D.O. between mid night and 06 hr. indicative of the impact of respiration of biota including nekton and bacteria. The high pH in the range 8-6-9-6 and presence of carbonates in the range 6-0-18-8 ppm led to the absence of free \( \text{CO}_2 \) at any point of time during the course of day and night.

The large scale fishkill in April appears to be due to a number of factors. The fish were alternatively under great physiological stress both from high and low oxygen tension. It is known that D.O. at 3 ppm or less, free ammonia in concentrations over 2-5 mg/l in neutral or alkaline waters and ferric iron in the range 4-4-6-0 ppm are all hazardous and even lethal to freshwater fishes. In the present case the D.O. dipped as low as 0-8 ppm (going by observation on 17th April and is taken as same or even less on April 20) and free ammonia and ferric iron rose as high as 3-2 mg/l and 4-5 ppm respectively. All these factors individually or cumulatively are potentially capable of causing large scale mortality in fishes. A calm and windless day appears to have provided the final trigger for a mass fishkill on April 20, 1977. Many of the blue-green algae are also known to be toxic but whether it is also one of the factors in the present case is difficult to conclude from the present study.

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