EFFECT OF ORGANIC MANURES ON THE OXYGEN BUDGET IN FISH PONDS.

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The dangers of manuring water with heavy doses of sewage and other organic materials are not unknown to pisciculturists. A typical instance of large scale fish mortality due to over application of organic manure was witnessed by us recently in the Hanakhali sewage-irrigated fishery near Calcutta. This provided an opportunity for studying the effects of organic fertilisers on fish productivity in general and the attendant physico-chemical aspects related to sewage fisheries. While the results of this investigation will form the subject of a separate communication by Mr. S. P. Basu, the main object in presenting this paper is to point out some of the fundamental aspects of the question about which we have meagre data and to emphasise the need for more experimental work, taking into account the recent advances in our knowledge in the field of water sanitation.

Oxygen is important for all life and the resources of oxygen in the aquatic environment are indeed very limited. This condition often becomes a critical factor in tropical ponds because of the low rate of re-aeration and large consumption of oxygen required for biochemical oxidation. Application of organic fertilisers to fish ponds should, therefore, be done with due regard to this consideration. Injudicious application of organic fertiliser to water will lead to hazardous oxygen condition often leading to large scale mortality of fishes.

The chief source of dissolved oxygen in the aquatic environment is the atmosphere and the rate of oxygenation of any body of water is dependent on the nature of its source and the temperature. Rapid circulation of water taking place in tropical ponds and lakes helps the process of re-aeration considerably. When there is good sunlight, the plant life in water also contributes towards its oxygen resources. The oxygen thus made available in the body of water is made use of by the organisms for respiration. A considerable portion of the dissolved oxygen is also utilised for the biochemical oxidation of the organic materials present in the body of water as well as in the bottom sediments. A satisfactory balancing of the income and expenditure of oxygen within the water environment is essential for the sustenance of healthy fish life. Even under the most unfavourable weather conditions the oxygen concentration should not fall below 3 parts per million of oxygen, the minimum required for healthy fish life (U.S. Pub. Health Report, 1943). An understanding of the oxygen transactions taking place inside the water body to which various organic fertilisers are added is, therefore, fundamental in standardising fertiliser practices.

The nature of the oxygen transactions taking place in a pond fertilised with organic manures can best be discussed by considering a specific instance of a small pond fertilised with sewage. If the pond is to sustain healthy fish life, the application of sewage should be limited to a dose such that the concentration of oxygen in the pond water does not fall below 3 p.p.m. (2·14 c.c. per litre). Let us now consider a small pond 200 feet by 100 feet with an average depth of 5 feet of water. At 85 per cent saturation level, the water in the pond will hold 42 lbs. of oxygen at a temperature of 25°C. The re-aeration constant of this pond may be assumed to have a value of 0·05 per day at 25°C. (Streeter, 1926). Under these conditions it can be shown that re-aeration will provide 23 lbs. of oxygen to the pond water every day. The total amount of oxygen available in the pond will, therefore, be of the order of $42+23 = 65$ lbs. Leaving 3 p.p.m. (19 lbs.) of oxygen in the pond water, we have $65-19 = 46$ lbs. of oxygen available for biochemical oxidation of the organic manure. The application of sewage to the pond should be limited to this oxygen consumption in a single day.

The rate at which oxygen is consumed for biochemical oxidation of sewage and other organic manure follows what the chemist calls the unimolecular law (Theriault, 1926). This law states that the amount of oxygen used up during any period is proportional to the concentration of organic matter at the beginning of the period. The biochemical oxygen consumption rate of sewage in the pond environment is of the order of 0·125 per day and this represents 25 per cent of biochemical oxygen consumption in the course of each day. It has been shown that the maximum oxygen available in a single day that can be used up for biochemical oxidation of organic matter is 46 lbs. From the above it would be apparent that $46 \times \frac{100}{25} = 184$ lbs. of sewage as B.O.D. can be safely applied to the pond. If this amount of sewage is added to pond, the oxygen consumption in the pond will be as follows:—

1st day	46 lbs.	4th day	25 lbs.
2nd day	36 ,,	5th day	18 ,,
3rd day	29 ,,	10th day	5·7 ,,
		20th day	0·7 ,,

After 20 days, a second dose of sewage may be applied and the operation repeated periodically without any deterioration in the oxygen status of the pond.

Knowing the biochemical oxygen consumption rate of the organic manure and the re-aeration constant of the body of water, it is possible, therefore, to figure out the dose of organic manure that can be safely applied to the pond. Temperature and other atmospheric conditions do affect the rate at which these oxygen transactions take place. But the value of the rate constants can be corrected to include these affects and the dosage of manure can be determined for the actual conditions obtaining in the pond.

Part of the organic manure settles in the bottom of the pond. The bottom sediments will also demand the oxygen resources in the water for their decomposition. However, the rate of biochemical oxidation of the organic matter in the pond bed is very low, being of the order of ·005 per day and if the bed is not vigorously disturbed the demands made by the bottom sediments are not very considerable.

Some data are available in literature on the re-aeration constants of different bodies of water (Phelps, 1948). They are as follows:—Small ponds ·05 to 0·1 per day, sluggish streams 0·1 to 0·2 per day, normal streams of low velocity 0·2 to 0·3 per day and swift streams 0·3 to 0·5 per day. The rate constant for biochemical oxygen consumption of sewage in the aquatic environment is known, but a similar data on other organic fertilisers are not available.

Photosynthetic activity of plants, under certain conditions, will add considerable amounts of oxygen to the pond. This is somewhat undependable. An appraisal of the oxygen assets contributed by them is not possible because we have few quantitative data on the oxygen donating power of the green plants growing in water. Too much growth of algae or other green plants is not desirable as they will use up considerable amounts of oxygen from the water during the night and cloudy part of the days. More experimental data on this aspect of the problem is necessary before we can intelligently use algae and green plants as an aid in maintaining the oxygen balance in fish ponds.

Application of organic manures to fish ponds affects the oxygen balance in the pond environment. If manuring practices are to be rationalized on the basis of the oxygen requirements, there is need for more specific data on (i) rate of biochemical oxygen consumption of different types of organic manures, such as cow dung, sheep manure, oil cakes, etc., which are commonly used in fish farming and (ii) oxygen donating power of different types of plant associations met with in fresh waters.

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