Biological Aspects of Water Pollution and Water Supply Problems

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Sanitary biology is the science having to do with the relationships of aquatic organisms to water supply, water pollution, and waste disposal problems. Although the fields overlap, it is distinct from sanitary bacteriology in that it generally deals with organisms higher than the bacteria. It is concerned with the influence of the environment on the organisms, such as the effects of pollution on fish, and with the influence of the organisms on the environment, such as the effects of algae on water supplies.

The relationship of algae to water supply and waste disposal processes is one of the most important phases of sanitary biology. Algae frequently create nuisances in water supplies, the most serious of which is probably their effect on the palatability of the water. Increased use of water in a river basin may be accompanied by the development of algal problems. The river may be enriched by the discharge of nutrients in the form of domestic sewage or other organic wastes from the cities and industries along its banks. Increased irrigation and other agricultural drainage may be a further source of nutrients, making the environment more favourable for the growth of plankton populations. The impounding of reservoirs creates areas with the slow current favourable to plankton; if silt turbidity is present, the slower current allows this to settle and there is greater light penetration for photosynthesis. As the plankton populations build up, they in turn can affect the environment, making the water unpalatable or difficult to treat for water supply purposes. Some of these changes may be taking place on the Waikato River, where taste and odour problems in water supplies have been associated with plankton blooms in the reservoirs impounded in recent years.

These taste and odour problems can be extremely difficult to deal with. In some cases a limnological survey may reveal areas from which satisfactory water can be drawn. For example, if a thermocline is present, it may provide a source of water below the photosynthetic zone, yet above the zone of decomposition. Algicides can be used where it is economically feasible. Research on the development of specific algicides may enable more effective algal control. Frequently the nuisance may be caused by a specific organism or group of organisms in the plankton; if the objectionable species can be killed and the harmless ones left to take their place, there is less chance of a recurrence than if the total plankton is destroyed. Total destruction leaves a gap in the environment which may be filled by the nuisance species again as soon as the toxicity is dissipated. In bodies of waters such as large rivers, where only a small proportion of the water is used, treatment with algicides is uneconomical. Research is now in progress to attempt to identify the complex organic compounds causing tastes and odours and to devise means of treating them in water plants to render the water palatable.

Oxidation ponds are coming into wider use as a means for the disposal of wastes, both overseas and in New Zealand. Organic wastes are discharged to these ponds and decomposed by a combination of algal and bacterial activity. The organic matter is oxidised by the bacteria utilising oxygen produced by algal photosynthesis. The resulting inorganic nutrients are, in turn, stimulants to algal growth. An understanding of the role of algae in this process is important in the design and operation of ponds which will maintain the most favourable oxygen balance. If suitable harvesting methods can be devised, the algae could provide an important source of food in the future.

Studies of the effects of pollution on fisheries have involved the determination of the resistance of fish to various toxic wastes. In addition, the toxic constituents of many of the more complex wastes cannot be measured physically or chemically, and routine bioassay procedures rather than chemical tests may be necessary to regulate discharge from some industries. The avoidance reaction of fish to various pollutants is being studied and this is giving information as to whether fish can detect and avoid localized pollution. This could be of importance, for example, where spawning runs can encounter localized zones of pollution near the mouths of rivers. Physiological requirements such as dissolved oxygen and pH range have been determined for many species. As in the case of toxicity data, most of this information has been determined experimentally. A closer understanding of the relationship of experimental results to actual field conditions is necessary before the information can be applied successfully. In some cases, certain environmental conditions have been duplicated in the laboratory, as nearly as possible. For example, the effect of current velocity on the oxygen requirements of fish and other aquatic organisms is being studied by making the test animals maintain themselves in an artificial current. Artificial streams in which the various conditions associated with pollution can be controlled, afford another method for more closely observing and interpreting the effects of pollution. Development of continuous dissolved oxygen recorders should enable better field observation of the effects of this important factor.

A technique being applied in New Zealand is the use of the invertebrate fauna to evaluate the effects of stream pollution. Pollution by organic wastes is widespread in New Zealand, from sources such as freezing works, dairy factories, domestic sewage, and barnyard drainage. Wastes from all these different sources have much the same effect on the receiving stream. Bacterial oxidation of the wastes takes place and this removes dissolved oxygen from the water. If the oxygen demand of the wastes is great, and the dilution is small, septic conditions may be created. Re-oxygenation occurs through atmospheric and tributary re-aeration and photosynthesis, and ultimately the oxygen demand is satisfied, recovery takes place, and the stream returns to a healthy condition. The fertilizing effect of the organic material frequently stimulates algal growths, which can aid in the self-purification process by supplying oxygen, as they do in oxidation ponds.

These effects cause corresponding changes in the bottom fauna of the stream. Species requiring high concentrations of dissolved oxygen, or sensitive to toxic conditions associated with organic pollution, disappear, while the more tolerant species become abundant because of the concentrations of nutrients available. Thus an estimate of the extent and severity of the pollution can be made by sampling the bottom fauna. The more usual chemical sampling gives accurate data, but it must be done during the period of critical conditions to give a useful picture of the extent of the pollution. As these critical periods may be short or intermittent, this is frequently not feasible. The biological method has the advantage that the bottom fauna reflect past pollutional conditions, and evaluations of pollution can be made at other than critical periods. It is difficult to relate closely the biological data with chemical conditions because a number of variables could be responsible for the changes in the fauna; oxygen depletion, sulphide or ammonia toxicity, or physical effects such as the blanketing of the substrate by periphyton growths or siltation. As with the fisheries aspects already discussed, more exact information will probably depend upon the correlation of ecological and experimental studies.