Thermal Pollution Effect on Fishes

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A B S T R A C T

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In our recent environmental awareness, we have coined the phrase "thermal pollution" for extensive thermal changes to natural aquatic environments that are believed to be detrimental to desired fish populations. The key to controlling "thermal pollution" is a firm understanding of how temperature affects fish, and of the circumstances that truly constitute pollution. All other environmental factors, such as light, current, or chemical toxins, act upon fish simultaneously with a temperature regime. With so much of a fish's metabolic activity dependent upon temperature, both immediate and previous, it is little wonder that responses to other environmental factors change with differing temperature. The interactions are seemingly infinite, and the general impression that one obtains is that temperature is masking a clear cut definition of the response pattern to any other environmental parameter. It is clear that temperature is probably the preeminent master factor in the lives of fish. No study of fish in relation to their environment would be meaningful without consideration of thermal relationships. This review can direct the curious to more comprehensive treatises. From a different perspective, there are few environmental modifications that man could make to aquatic systems that would be so assured of causing some ecological change as temperature. Within limits, fish possess effective mechanism for adapting to thermal changes, for such changes are a normal part of their existence. Man must be careful not to exceed these limits, however, if he wishes to preserve a productive commercial and recreational fishery.

Introduction:

Temperature is one of the most important factor and all life processes are accelerated or slowed down by the solubility of gases and salts in water. The volume as well as density of the water depends upon temperature. One of the characteristic properties of water is its high specific heat. By absorbing and releasing heat slowly, water serves as an excellent medium for heat exchange. Hence water has been used for many heating and cooling purposes. The major use of water as a coolant is in the electric power industry. The steam electric generating unit receives exhaust steam from the turbine, which is subsequently cooled to condense it to water. The cooling of exhaust steam requires large quantities of cooling water, which is drawn from a river or estuary adjacent to the electric power plant and made to circulate through the unit condenser. When water is finally discharged to the stream, its temperature is generally 10-16oC higher than the initial temperature, thus causing a progressive warming of the water body,

The discharge of waste heat into natural waters is termed as thermal pollution and is one of the prominent causes of environmental damage. This article describes the catastrophic effects of thermal pollution on the population of fish, followed by a synopsis on how thermal loading, if unavoidable, may be put to beneficial uses.

A good amount of information is available on how temperature affects the life processes of fish. Most of the effects stem from the impact of temperature on the rate of metabolism, which is speeded up by heat in accordance with the vant Hoff's principle that rate of chemical reaction increases with rising temperature. In general, the metabolic rate doubles with each increase of 100C.

Effect on Fish:

All organisms have temperature limits to their survival ability, but for most, acclimation is possible to some extent if the temperature change is gradual. The sudden change in temperature, however, is generally lethal. Hence a rapid change in temperature or the sudden transference of fish to warm water, may result in death at a temperature well below that regarded as lethal for the species.

Temperature also affects the longevity of fish. High temperature may lead to a short but exhaustive spell of rapid growth, Daphnia can live for 108 days at 80C, but its life span at 280C is only 29 days. The water flea Moina has a life span of 14 and 5 days at 130C and 330C respectively.

An increase in temperature causes not only disappearance of dissolved oxygen, due to the lower solubility of oxygen at higher temperatures, but also an increase in the rate of respiration of fish. The oxygen consumption for most fish increases four fold as the temperature of water is raised to the maximum at which they could survive. At higher temperatures, the hemoglobin of fish's blood has a reduced affinity for oxygen and therefore becomes less efficient in delivering oxygen to the tissues. The combination of increased need for oxygen and reduced efficiency in obtaining it at higher temperatures can put severe stress even on fish that are normally capable of living in a limited supply of oxygen.

Temperature profoundly affects the reproduction of aquatic animals. An increase in temperature induces seasonal development of gonads and triggers females to deposit their eggs. A rise in temperature also reduces the time taken by a fish's egg to hatch. In general, the fish tend to raise their swimming speed and show more spontaneous movement as the temperature rises. The decrease in speed at higher temperatures affect their ability to feed. They slow down in pursuing minnows and at still higher temperatures are almost incapable of catching minnows.

The temperature of water has a pronounced effect on the assimilation of food in fish. It has been established that digestion is fast at higher temperatures. Tracer experiments with young carp, in which food was labeled with colour, revealed that at 10oC, the food took 18 h to pass through the alimentary canal, while at 26oC it took only 4-

5 h. Since at higher temperatures, the metabolic activity of the fish increases, a substantial portion of the food intake in warm waters is utilized for merely maintaining the body functions.

Temperature differences during growth and development have induced morphological changes in aquatic organisms. Whitefish subjected to thermal pollution showed agape jaws, eye abnormalities and twining. Above 300C the incidence of spinal deformation is high. The toxicity due to insecticides, detergents, paper mill effluents and other chemicals increases with rise in temperature.

Beneficial Uses:

It is becoming increasingly evident that we cannot continue to inject waste heat into water without causing serious environmental problems. Two mechanical means are employed for abatement of thermal pollution. These are the wet cooling towers and the dry cooling towers. In the wet cooling method, hot water is sprayed over baffles in huge hyperbola shaped tower. Cool air rising through the tower carries waste heat and the cooled water is either discharged into the stream or recycled. Two problems are associated with the wet tower technique. Firstly, a substantial amount of water is lost through evaporation. This not only vitiates the benefit of recycling, but also concentrates whatever pollutants the effluent may contain. Secondly, in cooler regions, there is extensive fog formation in the vicinity of the wet cooling tower, causing damage to vegetation.

In a dry cooling tower the heated effluent is contained in a system of pipes. Air is passed over the pipes by a large fan facilitating heat exchange by radiation and convection. Water loss and fog formation are controlled by this method, but installation and maintenance costs are much higher as compared to those of a wet cooling tower.

Since both the abatement techniques suffer from one or more drawbacks, it is desirable to take advantage of some positive aspects of thermal loading. Warm water outfalls in winter attract fish because they extend often prevents adequate oxygenation of the water beneath. The artificial rearing of catfish in winter is carried out in cages exposed to thermal loading.

Conclusion :

By combining waste water from a power plant and effluents from a sewage treatment plant, the heat and nutrients, considered a nuisance in most environments can be put to good use. But supplying heat-tolerant algae as primary producers and introducing warm-water fish to harvest the algae, water would have time to cool, have its nutrient content sharply reduced, and its algae harvested in the form of useful protein, before being returned to the natural environment. It has been established that growth of some crops is accelerated by irrigation with warm water. Hence heated water may be put to good use by applying it to such crops. Frost protection can also be achieved by spraying fruit trees with warm water. Waste heat is also being used in desalination plants to aid in the evaporation process.

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