

22/01

AN OVERVIEW ON THERMAL POLLUTION WITH SPECIAL REFERENCE TO INDIAN COASTAL WATERS

V. Krishnakumar

Coastal Ocean Space Utilisation Section, National Institute of Oceanography
Dona Paula, Goa

ABSTRACT

The tropical aquatic species live in their upper limits of temperature tolerance in summer. Any addition of heat would have an adverse effect on their well being. The heated effluents from power plants cause tremendous stress on marine life especially in summer. An overview on the adverse effects of heated effluents on coastal environs is presented. As the thermal tolerance data on large variety of marine species along the Indian coastline is sparse, any imposition of a strict guide line for discharge of heated effluents would be difficult at present. Still, from the studies carried out world over and from some laboratory and field investigations, it is suggested that any temperature greater than 35 deg C at the discharge point would be unfavourable for the Indian coastline.

1. INTRODUCTION

In recent days sea is considered as an ultimate dumping place for all the treated and untreated wastes from coastal areas. The coastal marine environment is thus under tremendous stress. We might have no choice but to approach the sea tomorrow for everything, even for food and fresh water. It should not be too late then to solve the coastal pollution problems and to protect the marine biota. Nowadays it has become a scientific practice to calculate the safe levels of toxicants in the effluent discharges. In addition to effluents from industries and domestic wastes from townships, the heated effluents from the increased number of power plants along the coastline pose another kind of pollution in the coastal waters and this aspect is discussed here in brief.

Generally power plants are situated along the coastlines or near the estuaries all over the world for the easy intake of coolant water. These power plants discharge enormous amount of heated water into the receiving bodies causing severe stress on marine life. In tropical countries, especially in summer, the aquatic biota would be living in the upper limits of their tolerance temperature and any addition

of heat would affect them adversely. Even though, in some cases, the marine organisms in the tropical seas can withstand large variations in the temperature in the surrounding waters (eurythermic), the tolerance for lowest and highest limits of temperature range is very critical. Any changes in these temperature limits proves to upset the physiology and at times can be lethal to the resident biota and are studied all over the world and well documented (Naylor, 1965; Krenkel and Parker, 1969; Clark, 1969; Bader et al., 1972; Howells, 1980 etc.). but along the coasts of India, where there are two major power plants and quite a few are planned, this particular problem is hardly studied and data on the thermal tolerance on marine biota is sparse. Eventhough the problem looks like localised, considering the large fluctuations in the temperatures of the coastal waters with seasons, it must definitely have adverse effects on the marine environment.

2. ADVERSE EFFECTS

It has been shown by many researchers all over the world that the use of coastal oceanic waters in the cooling system of power plants leads to the destruction of large number of plankton and larvae of nearshore fishes and invertebrates and thus it has a large impact on adult population in the nearshore areas. The direct and indirect impacts of thermal pollution have been reviewed by Krishnakumar et al (1991) with reference to Indian scenario.

Several investigations have shown that in shallow bays and back-reef areas where water is heated rapidly by the sun, growth of various marine plants and animals is prohibited by high temperatures even in normal conditions. In such environments it is obvious that any discharge of heated water will lead to the expansion of the zone which is inimical to marine

species. In most of the places of outfall, rapid and complete mixing may not occur and one can expect areas with extreme temperature increase which cause drastic ecological changes. The heated effluents are likely to make drastic changes in the inter-tidal communities. The warm species and several others might get reduced or eliminated and sometimes the previously rare or absent species become abundant. These changes in the intertidal zone will become markedly high when there is a 'shoreline discharge' of heated effluents. In waters containing much domestic wastes, long term exposure to even small increases in temperature, will generally increase the algal growth. The growth of blue-green algae may be favoured (favourable temperature 35-40 deg C) over green algae (favourable temperature 30-35 deg C) which results to the damage of the ecosystem because blue-green algae are poorer food source and sometimes release substances toxic to aquatic organisms as well as humans and birds (Pacific Northwest Water Laboratory, 1968). In addition to the shift in the population of the species (desirable ones replaces undesirable ones) species diversity may also continuously drop. In short temperature variations affect physiology, reproductive cycle, digestion rates, respiration rates and many chemical activities of the marine biota as the biological system respond very strongly to the temperature.

3. LABORATORY STUDIES

Experiments were conducted in the laboratory (NIO, 1990) with some representing resident biota of a marine environment close to a proposed nuclear power plant along the west coast of India. Eventhough the exact field conditions could not be generated in the laboratory for the extreme complications in oxygen absorbing/emitting mechanisms and for several other reasons, temperature tolerance of some species could be studied to some extent. The test animals were acclimatised in a control tank in the laboratory at 25 to 26 deg C and then exposed to 40 deg C for 4 days. Eventhough no mortalities were observed for this period,

physiological changes were quite significant. At 30 deg C, animals lost their pigmentation and their movements become highly sluggish. When they were transferred to a tank at normal room temperature, within a few hours they were found to have regained their activity and pigments also reappeared after 3 to 4 hours. Bioassay studies showed that slight changes in the ambient temperature immediately upsets the behaviour and physiology of the biota and thus the heated effluents from power plant can be lethal to the resident biota.

Further studies along this part of Indian coast showed that any change in the temperature is likely to affect the primary productivity, phytoplankton bloom, fish larvae, functional physiology and the reproduction of the biota. It is suggested that long term monitoring and experimental studies have to be carried out to suggest remedial measures for maintaining ecological balance in these marine environs (NIO, 1990).

4. CHANGES IN PROPERTIES OF SEA WATER AND AFTER EFFECTS

Higher temperatures affect the physical and chemical properties of water. A rise of 10 deg in temperature reduces the solubility of Oxygen by 20%. It is well proved that the variations in Dissolved Oxygen (DO) is affecting the coastal environs more adversely than the temperature variations directly. The variations of Do with temperature is well studied by Zanoni (1967). The heated effluent plume forms a thick layer over the coastal ocean reducing the rate of exchange of oxygen from air to water. As the oxygen producing green plants are reduced by the discharges, the DO content in sea water would further deplete to make the problem worse. The rate of oxygen usage and the rate of all metabolic activities increase with an increase value is achieved. Increase in temperature beyond this point may result in denaturing of enzymes and in the actual destruction of some of the micro organisms.

The density and viscosity decreases and vapour pressure (evaporation rate) increases as the temperature increases. Also the

Table 1. Variation of different sea water parameters with temperature (after Hodges, 1973)

| Temperature (deg C) | Density (g/cu cm) | Viscosity (centipoise) | Vapour pressure (mm of Hg) | D O (mg/l) |
|---------------------|-------------------|------------------------|----------------------------|------------|
| 0 | 0.99987 | 1.7921 | 4.58 | 14.6 |
| 5 | 0.99999 | 1.5188 | 6.54 | 12.8 |
| 10 | 0.99973 | 1.3077 | 9.21 | 11.3 |
| 15 | 0.99913 | 1.1404 | 12.80 | 10.2 |
| 20 | 0.99823 | 1.0050 | 17.50 | 9.2 |
| 25 | 0.99707 | 0.8937 | 23.80 | 8.4 |
| 30 | 0.99567 | 0.8007 | 31.80 | 7.6 |
| 35 | 0.99406 | 0.7225 | 42.20 | 7.1 |
| 40 | 0.99224 | 0.6560 | 55.30 | 6.6 |

solubility of the sea water decreases. Table 1 shows the changes in properties of sea water with variations in temperature and also the amount of DO when the water is saturated with oxygen. These properties have important effects on aquatic life. The decrease in viscosity and density causes the settling speed of suspended particles which affects the aquatic food supplies. The lowered solubility of oxygen in water is of great importance since fish requires atleast 5 mg/l (7 mg/l in spawning areas) for well being. From Table 1 it is clear that above 35 deg C the DO content may be dangerously low even if the water is saturated with oxygen, which is not generally the case. Since higher temperature favours bacterial growth and increase the rate of physiological processes, the decomposition of organic and other oxygen demanding wastes will be speeded up, increasing the rate of oxygen depletion and further aggravating the DO problem (Hodges, 1973).

The heated effluent is usually super saturated with nitrogen gas and excess nitrogen taken into a fish's blood tends to bubble out leading first to disequilibrium and ultimately death (Gas bubble disease).

Tidal mixing may cause the heated water to drop temperature to some extent. When the tidal currents are significantly large (for ex-

ample, northern coasts of India), the heated effluents will be carried to great distances and probably all the water column may get affected. A drift carrying the heated effluents off to the sea is more favourable than a residual current flowing parallel to the coast, eventhough it be stronger.

Along the Indian coasts, the water temperature generally varies with seasons (sometimes the variations are as high as 10 deg C). This along with the natural fluctuations occurring are reflected in the growth and numbers of aquatic organisms and above all have a major control over the total marine environment. Continuous heated effluent discharge to these coastal waters thus causes a mitigation in the thermal differences between summer and winter, resulting in fading of the natural seasonal cyclic changes in the species composition and density.

5. SUGGESTIONS

Adequate and proper coastal oceanographic investigations should be carried out (Krishnakumar et al., 1992) for siting a power plant to avoid any possible stresses on the marine environment. Mathematical modelling of heated effluents help in studying the localised characteristics of a thermal plume and this could save time and cost of tedious in situ measurements to some extent. Power plants may not be lo-

cated in estuarine areas as these areas are breeding and nursery grounds for many aquatic species. Deterioration of estuarine water quality would increase the stress immensely in addition to the stress naturally imposed (due to the large variations in DO, temperature, salinity etc.) on estuarine organisms. Power plants are required to discharge at a point where mixing/dispersion is very effective and rapid. A properly designed and located multiport diffuser system at the end of a sea outfall provides an efficient method for maximising initial dilutions and achieving the regulatory requirements. Use of cooling towers, cooling ponds, etc. may also be required by the power plants. The temperature tolerance data and other valuable informations on the marine biota along the Indian coastal waters are not adequate to draw a strict guideline on the thermal effluent discharges. Still it is obvious from the various studies world over and from some field and laboratory experiments, any discharge temperature above 35 deg C is not desirable for the Indian coastal waters, that too, if proper initial dilution is guaranteed. In short, the effluent discharges to coastal waters may be in such a way that the water temperature of the receiving water shall not be increased so as to cause any damage or harm to the aquatic life or vegetation or interfere with any beneficial use assigned to such waters.

REFERENCES

- Naylor E (1965) Effects of heated effluents upon marine and estuarine organisms, *Adv. Marine Biology*, 3, pp 63-103.
- Krenkel P A and F L Parker (eds) (1969) *Biological Aspects of Thermal Pollution*, Nashville, Tenn.: Vanderbilt University Press
- Clark J R (1969) Thermal Pollution and Aquatic Life, *Scientific American*, 220 (3), pp 18-27.
- Bader R G, M A Roessler and A Thorhaug (1972) in *Marine Pollution and Sea Life*; Mario Ruivo (ed) Fishing News (Books) Ltd., England.
- Howells H G (1980) The effects of power station operation on the marine environment, *Seminari Intunationali Sull 'Inguinarments Marino*, N Della Goce (ed) 16, Maggio-27, Gugus Geneva.
- Krishnakumar V, J S Sastry and G Narayana Swamy (1991) Implication of thermal discharges into the sea - A

review, *Indian Journal of Environmental Protection*, 2 (7), pp 525-527.

Pacific Northwest Water Laboratory (1968) *Industrial Waste Guide on Thermal Pollution*, Corvallis, Ore.: Federal Water Pollution control Administration.

N I O (1990) Report on Ecobiological characterisation of the environs of the Nuclear Power Station site at Jaitapur (Dist. Sindhudurg, Maharashtra State) & Bioassay tests for tolerance and lethal limits of thermal effluents on Biota & Environment, Tech. Report No. NIO/SP-4/90, p 32.

Hodges L (1973) in *Environmental Pollution - A survey emphasising physical and chemical principles*, Holt, Rinehart and Winston Inc (New York), p 370.

Krishnakumar V, G Narayana Swamy and J S Sastry (1992) Significance of oceanographic field investigations for siting coastal thermal and nuclear power plants, *Irrigation & Power Journal*, Vol 49, No.2, pp 129-135.

HOME STOVE USES FREE FUEL

A stove adapted by the International Rice Research Institute (IRRI) in the Phillipines from a Vietnamese design not only cooks rice more quickly, but is also eco friendly and uses virtually free fuel. Called the Ipa Qalan it uses rice hull waste which is produced when rice is milled.

The stove requires 1.5 kg of rice hull for one-hour of cooking. A litre of water boils within five minutes. The stove is easy to fire, has a low smoke level, and requires minimal attention. The design is simple, and it can be constructed economically with recycled oil drums, biscuit cans and used sheet metal, using only a tin-cutter, a hammer, and a four inch nail.

IRRI engineers have calculated that a house-hold of 5 or 6 people could save at least two tonnes of wood each year or about one hectare of a forest where trees are harvested for fuel with the new stove. Rice hull disposal is often a problem for it has few uses in most rice producing areas.

With the Ipa-Qalan, 7 grammes of a newspaper, is sufficient to start the stove. After five minutes, the combustion chamber of the stove is hot enough to ignite pieces of coconut shells within 30 seconds of introduction into the stove. Rice straw may also be used but it tends to generate excessive fly ash.

Source : The Hindu 3-08-94