ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , UGC CARE Listed (Group -I) Journal Volume 10, Iss 01, 2021

INFLUENCE OF COOLING WATER DISCHARGES FROM KAIGA NUCLEAR POWER PLANT ON AQUATIC ECOLOGY OF THE KADRA RESERVOIR

Dr. Sharmila Soni
Assistant Professor (Guest), Department of Zoology, Bhanupratapdeo Govt PG College, Kanker, 494334, North Baster

Abstract

The alternations induced in the ambient temperature can lead to wide manifestations in species distribution and community structure. In general, elevated water temperature causes changes in species composition, species dominance, standing crop and productivity of biota including phytoplankton communities in any aquatic ecosystem. Thus warm water discharges from power plants into the receiving water bodies may adversely affect aquatic ecology. In the absence of exhaustive data on the response of aquatic organisms and ecosystems in the tropics to elevated temperatures, the only option is to draw inferences, from the experiences in the subtropical and temperate areas. Since, sufficient data on similar line are not available in tropical environment, present paper delineates certain aspects of aquatic ecology of the Kadra reservoir where cooling water is discharged. The study suggests the heated effluents from Kaiga Nuclear Power plant caused changes in Dissolved oxygen and pH of water, heterotrophic bacterial population, sediment biogeochemical cycles related biochemical processes, species composition, species dominance, standing crop and productivity of biota including phytoplankton communities within 500 m from End of Discharge Canal point of Kadra reservoir when two units are running in full capacity.

Introduction

The alternations induced in the ambient temperature can lead to wide manifestations in species distribution and community structure [Countant & Suffern 1979, Manush *et al.* 2004]. In general, elevated water temperature causes changes in species composition, species dominance, standing crop and productivity of biota including phytoplankton communities in any aquatic ecosystem. Towie (2005) reported that in North Sea, UK 15 species of fish had shifted as much as 400 kilometers in to cooler waters and 6 species of fish had moved in to deeper water in their search of cooler living conditions. Thus warm water discharges from power plants into the receiving water bodies may adversely affect aquatic ecology. A small change in temperature above 15^{o}C can cause substantial release of phosphorus because of the exponential increase in conversion rates with increasing temperature [Kaushik 1981]. Increased availability of nutrients can affect many microbiological processes.

In India, all the operating power plants, which employ once-through systems for cooling, are designed for a temperature rise across the condenser of 8-10^{o}C. The Environmental Protection Rules stipulated that the heated water discharged from a power plant to the receiving water should have a temperature not more than 7^{o}C higher than the intake temperature. Power engineers have pointed out that if the rule is implemented indiciously the cooling water requirement of a power plant would increase substantially and major design modifications have also to be incorporated leading to escalation in the unit cost of power.

In the absence of exhaustive data on the response of aquatic organisms and ecosystems in the tropics to elevated temperatures, the only option is to draw inferences, from the experiences in the subtropical and temperate areas. Since, sufficient data on similar line are not available in tropical environment, present paper delineates certain aspects of aquatic ecology of the Kadra reservoir where cooling water is discharged.

Location of Study

Two units of 220 MWe each Pressurized Heavy Water Reactor (PHWR) type nuclear power plants are commissioned in the year 1999 at Kaiga site. The site is located on the left bank of the freshwater Kadra reservoir formed due to construction of a dam on Kali river at about 58 km (by road) east of Karwar in the State of Karnataka. The dam is constructed at about 11 km downstream of the site. While the water spread area of the reservoir at FRL is 37.75 km^2, its dead storage capacity is 179.86 M Cum. The height of the dam above deepest foundation level at overflow section is 48 m. The once through condenser cooling water for the nuclear reactor is drawn at the rate of 1,25,205 m^3/hr from the Kadra reservoir and discharged back to the reservoir through a 1.6 km long open channel.

Methodology

The water samples were collected with the help of a boat from the Kadra reservoir at nine locations (Fig. 1), namely, intake point (1), discharge point (DP: 2), 50 m from DP (3), 100 m from DP (4), 500 m from DP (5), 1000 m from DP (6), 100 m from right side (90^o) of 100 m point (7), 100 m from right side (90^o) of 500 m point (8) and dam site point (12 km from DP: 9) in each month from January 2001 to December 2002 for analyzing various abiotic/biotic parameters pertaining to hydrological and sedimentological aspects which would subsequently help in understanding the water quality and substrate suitability for aquatic organisms. Water samples were collected from three different layers, viz. surface, 3-m depth and bottom of the water column. Different abiotic (dissolved oxygen, pH, turbidity, conductivity, ortho-phosphates, total phosphate, nitrates, sulphate, heavy metals etc., biotic (plankton, chlorophyll-a and primary productivivity) and microbiological (total coliforms, staphylococcus and heterotropic plate count) of water samples were estimated following standard methods (1999). A number of indices have been developed for the assessment of qualities of water & biota, and these have been reviewed by Hellawell (1978), Lagler (1956), Hanes (1980) and Ghosh (1998). In the present study *Shannon Wiener*, *Palmer Pollution*, *Species Evenness, Similarity* and *Habitat* indices were applied to the data, generated from plankton samples of Kadra reservoir.

Impact of temperature individually (26, 31, 33, 36^{o}C and above) and in combination with chlorine (10, 5, 2, 1, 0.5, 0.25, 0.125 ppm and below) on select plankton, isolated from Kadra reservoir water samples and were cultured in their respective/ developed media, was assessed in the laboratory.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 01, 2021

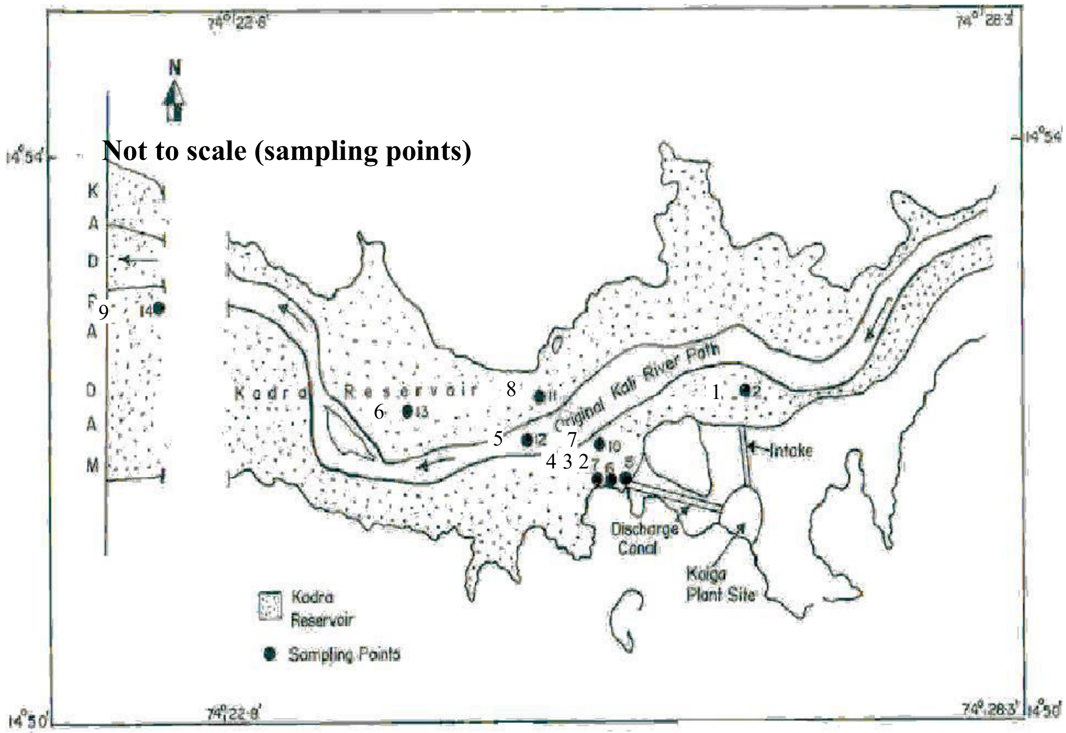

Fig. 1: Map indicating sampling points at Kadra reservoir

Result and discussion

Abiotic characteristics

Water temperature is one the most important abiotic parameters controlling the survival and propagation of living components of an aquatic medium. DO was always found to be more in surface followed by middle and bottom waters during the study period. Near discharge point areas where waters had comparatively higher temperature, DO levels were observed to be marginally decreased till 100 m from right side (90°) of 100 m point. pH values of surface and 3 m depth waters were always lower irrespective of season around discharge point area. Nutrient load, in terms of phosphate, orthophosphate and nitrate, was maximum during monsoon and summer seasons as compared to winter season. However, conductivity was not found to be correlated with temperature irrespective of seasons. Total hardness, suspended solid, alkalinity and TDS did not show much difference in different seasons. Levels of heavy metals were found within the permissible limits of drinking water standard as specified in Bureau of Indian Standards-10500 – 1991.It may be assumed that heavy metals were not in alarming state in the reservoir. Although chlorine is normally applied to prevent biological fouling in pipes and culverts of the power station cooling systems, it could not be detected at discharge point. Apparently, enhanced water temperature, due to discharge of cooling water in the reservoir did not cause remarkable adverse impact on abiotic characteristics beyond 100 m from the discharge point (DP) of the Kadra reservoir water.

Biotic Characteristics

Phytoplankton

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper **© 2012 IJFANS. All Rights Reserved**, UGC CARE Listed (Group -I) Journal Volume 10, Iss 01, 2021

During the study period, 54 genera of phytoplankton were identified from water samples of Kadra reservoir. Four major groups, viz. bacillariophyceae, cyanophyceae, chlorophyceae and pyrohphyceae were recorded. Counts were higher at surface waters as compared to middle and bottom layers in all the seasons. Phytoplankton counts were gradually increased in straight line starting from DP in all the seasons of surface and middle waters, whereas in the bottom waters the same pattern was not found. Beyond discharge point, phytoplankton populations were increased gradually and were restored to nearly 90 and 100 percent of normal (intake) levels at a distance of 500m and 1km respectively from the DP. Chlorophyll-a values of bottom waters were always found to be less compared to surface and middle waters at all sampling points throughout the study period. The chlorophyll-a values were found to be increased from DP towards dam site, however, the rate of carbon fixation by algae was found to be low upto 500 m as compared to intake point [Zargar & Ghosh, 2005_a). Shannon Wiener diversity values were gradually higher in winter and summer seasons as compared to monsoon seasons. Palmer Pollution Index (PPI) value of zero supports the oligotrophic nature of the lake water throughout the study period. Species evenness index values indicate that distribution of phytoplankton genera was most uneven at 500 m from DP as compared to DP, where the genera were most evenly distributed. Similarity index values denote that availability of similar types of genera amongst certain points like intake & DP, DP & 100 m etc. were poor in all the seasons. The decrease in Sorenson's similarity index between these stations in this study indicated less faunal overlap and predictability of community composition. Habitat index values revealed marginal change of rankings of phytoplankton amongst zone 1 (within 500 m from discharge point) and zone 2 (beyond 500 m from discharge point) (Zargar & Ghosh, 2006).

Zooplankton

Four major groups of zooplankton, viz. copepoda, rotifera, cladocera and diptera were found in Kadra reservoir. The copepoda was represented by *Cyclops* sp., *Diaptomus* sp., and Nauplius larvae, while cladocerans were represented by *Bosmina longirostris*, *Bosminopsis dietersi* and *Ceriodaphnia reticulata*. Among rotifers, a total of 15 genera were found, of which Brachionus was represented by six species, viz. *B. calyciflorus*, *B. angularis*, *B. caudatus*, *B. havanaensis*, *B. rubens* and *B. quadricauda*. Peaks of the zooplankton were found in winter and monsoon seasons, which might be considered as favourable seasons for zooplankton growth. As the discharged water gets mixed with the bulk reservoir water, the temperature falls gradually. Zooplankton populations were increased gradually and were restored to over 80 percent of the intake values beyond a distance of 500 m from the discharge point. Biomass of zooplankton was gradually increased as temperature fell down in straight line from DP. Shannon Wiener Index (SWI) values were varying from 1.80 to 2.64 indicated semi-productive nature of Kadra reservoir water. Evenly distribution of species, as indicated by Species Evenness Index (SEI) values, was found to be higher in monsoon-2001 at 100 m from DP where temperature was 33.5ºC, whereas minimum was recorded in winter-2001 at DP where temperature was 31.5ºC. In general, similarity index values between intake and the points close to DP were comparatively less as compared to those of other stations during different seasons. Habitat index values indicated that Nauplius larvae, *Ceriodaphnia reticulata* and *Cyclops* sp. were most favourable

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 01, 2021

zooplankters at intake, DP and 100 m from DP point respectively; while 500 m from DP point and beyond areas were preferred mostly by *Bosminopsis dietersi*, followed by *Cyclops* sp., Nauplius larvae etc.

Microbiological

The development, growth and sustenance of microbes in water or sediment depends upon the different abiotic factors like temperature, oxygen, pH, and organic matter. Usually the microbes prefer a pH range of 6.5 to 7.5. Total coliforms being present maximally in the mixing zone (within 500 m from discharge point) showed negative impact of elevated water temperature. Fecal *Streptococci* and *Staphylococci* sp. did not show any correlation with temperature. Heterotrophic bacteria of water and sediment showed negative correlation with temperature, their number is reduced by one to order of magnitude at End of discharge canal and mixing zone. Temperature showed a positive correlation with carbon utilization rate and negative correlation with volatile solids from mixing zone. Nitrification and Denitrification rate did not show any correlation with temperature. Acid and Alkaline phosphatase enzyme activities showed a positive correlation with temperature at sediment of mixing zone.

Laboratory studies

Laboratory studies revealed that the growth of the select phytoplankton, viz. *Chlorella vulgaris*, *Scenedesmus quadricauda* and *Chroococcus prescotii* was not affected at 36ºC.However, 0.25 ppm of chlorine adversely affected the growth at 36ºC [Zargar & Ghosh, article in press]. The survival of the zooplankton was not affected at 0.06 ppm of chlorinated water irrespective of selected temperatures [Zargar and Ghosh, 2005_{b}]. During laboratory studies, it was recorded that growth of zooplankton was affected at 33ºC though 14.8 KD stress protein was expressed only at 36ºC. On the other hand, phytoplankton growth was retarded at a temperature above 36ºC and HSP 70 was detected at 40ºC [Zargar *et al.* $2006_{a,b}$]. Since growth of zooplankton was comparable to control at 31ºC, maximum allowable temperature limit (MATL) to all kinds of plankton might be in between 31 and 33ºC. Further, population of plankton in Kadra reservoir, at a distance beyond 500 m from discharge point, was comparable to upstream (intake) water. The area upto 500 m from discharge point (average surface temperature; 31.8 to 34.2ºC) may be treated as mixing zone. Investigation revealed that the average temperature of the water beyond this zone varied between 29.4 and 31.6ºC, which satisfy the laboratory determined MATL.

Conclusion

From the observations it may be concluded that the heated effluents from Kaiga Nuclear Power plant caused changes in Dissolved oxygen and pH of water, heterotrophic bacterial population, sediment biogeochemical cycles related biochemical processes, species composition, species dominance, standing crop and productivity of biota including phytoplankton communities within 500 m from End of Discharge Canal point of Kadra reservoir when two units are running in full capacity.

Acknowledgements

The authors are grateful to the Director NEERI, Nagpur for infrastructure facilities, to Dr. T. Chakrabarti, NEERI, Nagpur and to Dr. S.K. Apte, BARC, Mumbai for helpful suggestions during the investigation. We acknowledge the financial support from Board of Research in Nuclear Sciences (BRNS sanction No.99/36/23/BRNS/1869), Department of Atomic Energy, Government of India.

References

Coutant, C.C. & Suffern, J.S. (1979) Temperature influences on growth of aquatic organisms. In: Lee S.S., Sengupta, (eds) Waste heat management and utilization. Hemisphere Publ. Corp., Washington, D C, pp 113-124

Ghosh, T.K. (1998) Application of different indices for assessment of aquatic biota in EIA studies In: Ecology of Polluted Waters and Toxicology (Ed: K.D. Mishra). Technoscience Publications, Jaipur, India, pp. 1-18

Hanes, T. (1980) Vegetation and wildlife impact analysis In: Environmental Impact Analysis Handbook (Eds: J.G. Rrau and D.C. Wooten). McGraw-Hill Book Comp., New York, pp.7.1-7.59

Hellawell, J.M. (1980) Biological surveillance of rivers. Water Research Centre, Medmenham.

Kaushik, N. K. (1981) Water Pollution and Management Reviews. (Varshney, C. K. C. ed.). South Asian Publishers Pvt. Ltd., New Delhi.

Lagler, K.F. (1956) Freshwater fishery biology. WMC Brown Co., Dubuque, Iowa .

Manush, S.M., Pal, A.K., Chatterjee, N., Das, T. & Mukherjee, S.C. (2004) Thermal tolerance and oxygen consumption of Macrobrachium rosenbergii acclimated to three temperatures. J. Therm. Biol. 29: 15-19

Standard methods for the examination of water and wastewater (1999). 20th edition, APHA, AWWA and WPCF, Washington, D.C.

Towie N (2005) Fish get hooked on cooler towers. http://www.bioedonline.org/news

Zargar, S. & Ghosh, T. K. (2005_a) Impact of cooling water discharges from Kaiga Nuclear Power Plant on chlorophyll-a and primary productivity of the Kadra reservoir. *J. of Inland Fisheries Society of India* 37 (1), 1-8

Zargar, S. & Ghosh, T. K. (2005_b) Thermal and biocidal (chlorine) effects on freshwater zooplankton. *J. of Aquatic Biology* 20 (1), 91-95

Zargar, S. & Ghosh, T. K. (2006) Influence of cooling water discharges from Kaiga Nuclear Power Plant on selected indices applied to plankton population of Kadra Reservoir. *J. of Environmental Biology* 27 (1/2),191-198

Zargar, S. & Ghosh, T. K. Thermal and biocidal (chlorine) effects on select freshwater plankton.. *Achieves of Environmental Contamination and Toxicity*. (article in press)

ISSN PRINT 2319 1775 Online 2320 7876

Zargar, S., Krishnamurthi, K., Sarvanadevi, S., Ghosh, T. K. & Chakrabarti, T. (2006_a) Temperature induced stress on growth and expression of hsp in freshwater alga *Scenedesmus quadricauda*. *Biomedical and Environmental Sciences* 19 (6).

Zargar, S., Krishnamurthi, K., Sarvanadevi, S., Ghosh,T. K. & Chakrabarti, T. (2006_b) Growth response and heat shock protein (hsp) expression in *Chlorella vulgaris* exposure to elevated temperatures. *Asian Fisheries Science* 19 (1/2): 69-74