IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 7 Ver. II (July. 2015), PP 63-72
www.iosrjournals.org

Impact of Effluent Discharge from Thermal Power Station on Status of Fish Species of River Tapi at Bhusawal, District Jalgaon Maharashtra

Sandhya M. Sonawane
JDMVPS Art Science And Commerce College, Jalgaon, Dist. Jalgaon. (M.S.)

Abstract: *The waste water and discharge from Deepnagar power station(DPP) caused various changes in the hydrological features and status of fish species in river Tapi. The upstream and down stream sampling stations were visited twice in every season during march 2013 to 2014. Number of fish were captured from river Tapi from both sampling stations. Fish communities and habitat structures were evaluated under the impact of thermal discharge of DPP and it was composed with that of fish status at Hatnur reservoir. The thermal discharge responsible for alteration in physico-chemical properties of river water. The change in water temperature is one of the significant factor that goes to extreme intolerable level causing decrease in dissolved oxygen level as a secondary effect leading to frequent fish kill events in months of summer season.*

I. Introduction

Thermal electric power plants use the steam-water energy cycle. Heated waters discharged into aquatic environment change physical-chemical properties of water, such as density, viscosity, surface tension, solubility of gases and steam pressure. The influence of heating on aquatic ecosystems is ambiguous, and at different levels of heating it may be both positive and negative. The most important ecological factor is the exclusion of excessive heat dumping exceeding the buffer (compensating) capabilities of the aquatic ecosystem. Thermal loads can cause negative processes in local areas of aquatic environment, such as overgrowth of blue-green algae deteriorating the water quality, changes in the composition of plankton and dynamics of its numbers, disruptions of the structure of fish communities, and microclimatic changes.

Thermal releases are superimposed on chemical discharges (phosphorus and nitrogen compounds, metals, petroleum products and others). It is a combination of thermal releases and chemical contamination leads to local disturbances of ecological equilibrium, such as accelerated eutrophication, changes in the species structure of aquatic ecosystem. As a rule, nuclear and gas power plants prove to be cleaner than coal and fuel-oil TPPs in the extent to which they create chemical contamination of aquatic ecosystems. Among the important factors of the impact on aquatic biota are injuries to aquatic organisms in the water-intake facilities and condensers of the cooling system of power plant, resulting in mass death of plankton and young fish.

Power generating units are mega project, which require not only huge capital investment but also various natural resources like, fossil fuels and water, thus create an immeasurable and everlasting impacts on the environment and generate tremendous stress in the local eco-system in spite of stringent government norms to control and mitigate the damages to the environment by the power plants.

Due to continuous and long lasting emission of SO_2 & NO_2, which are the principal pollutants coal based plants, surrounding structures, buildings, monuments of historic importance & metallic structures too are affected very badly due to corrosive (Acid rain) reactions. Well known example of this is the victimized Tajmahal of Agra which is being deteriorated due to these toxic gases. It is also worth to note that very high amount of carbon dioxide (CO_2) emission (0.9-0.95 kg/kwh) from thermal power plants contribute to global warming leading to climate change.

The water requirement for a coal-based power plant is about 0.005-0.18 m3/kwh. The water requirement can marginally reduced from about 0.18 m3/kWh to 0.15 m3/kwh after the installation of a treatment facility for the ash pond decant. Still the water requirement of 0.15 m3/kwh = 150 Liters per Unit of electricity is very high compared to the domestic requirement of water of a big city. Ash pond decant contains harmful heavy metals like B, As, Hg which have a tendency to leach out over a period. Due to this the ground water gets polluted and becomes unsuitable for domestic use.

The effect of power plants on the socio-economic environment is based on three parameters, viz. Resettlement and Rehabilitation (R & R), effect on local civic amenities and work related hazards to employees of the power plants. The development of civic amenities due to the setting up of any power project is directly proportional to the size of the project. The same has been observed to be the highest for the coal based plants followed by the natural gas based plant and lastly the hydroelectric plant. The coal based plant has the highest number of accidents due to hazardous working conditions.

Depending upon the nature and intensity of utilization of fresh water and thermal effluents, the ecosystem may either reestablish the previous equilibrium or establish a new one, or it may remain in prolonged disequilibrium. In view of the above, periodic observations are necessary to estimate exact response of biotic communities to changing salinity, suspended load and temperature, enabling retaining better quality of river water and associated fish habitat.

Considering the need of hour, the present study is to be undertaken to evaluate the impact of Deepnagar Power Station on hydrobiological features and status of fish species in river Tapi near Bhusawal in Jalgaon District of Maharashtra The possible outcome of the results will be in the form of valuable data related to disappearance of fresh water fishes, if any. It will also help to develop the strategies for conservation of fish species.

Aims And Objectives Of The Study:

- To assess the water quality of the Tapi river at different times, places and seasons.
- To assess impact of discharge of warm water in river Tapi from Deepnagar Power plant (DPP) near Bhusawal in Jalgaon district of Maharashtra.
- To estimate the quantitative use of ash released form DPP.
- To evaluate the local thermal impact on water quality of river Tapi.
- To evaluate the physico-chemical parameters of river Tapi downstream and upstream of DPP.
- To search out relationship between physicochemical parameters with fish species abundance or absence.

Study area:

Bhusawal is a city (21°02′50.56″N 75°47′15.99″E) and a municipal council in Jalgaon district in the state of Maharashtra, India. The thermal power station (TPS), which produces around 12% of the electricity requirement of Maharashtra, is situated in Bhusawal near to Fekari village on the bank of the River Tapi. Bhusawal is also famous for bananas due to rich irrigation system from Tapi river. Special goods trains all over India and especially to the North Area send the bananas of this place. Deepnagar power project (DPP) extension is extended. The new plant capacity consists of two power generators of 500 mW each. Previous plant has capacity of 62+210+210 mW total capacity.

(a) (b)

Figure (1) a) Bhusawal in Jalgaon district of Maharashtra State in India
b) Deepnagar power plant (DPP) near Bhusawal city

II. Materials And Methods

Two sampling stations established along the stretch of Tapi river upstream (US) and downstream (DS) to Deepnagar Power Plant (DPP) for collection of water samples and fish. The study carried out for two years on quarterly basis viz. summer, monsoon, and winter seasons. Water samples were processed for their physico-chemical parameters and prevalence or absence of fish species at both sampling stations was compared. Important physicochemical parameters like Temperature, pH, Transparency, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Alkalinity (TA), Carbonates, Bicarbonates, Chlorides (Cl), Sulphates (SO_4), Total Hardness (TH), Magnesium (Mg), Nitrates (NO_3) and Phosphorus (P) have been investigated according to standard methods given by Kodarkar (2006) and American Public Health Association (APHA, 2008) and results were analyzed statistically as per the procedures in Gurumani (2005).

Sampling stations: Upstream to DPP, the first sampling station was established near Hatnur dam (75^0 90'E, 21^0 12'N) on river Tapi near village Hatnur in Bhusawal tehsil of Jalgaon district in Maharashtra. The height of the Hatnur dam above lowest foundation is 25.5 m (84 ft) while the length is 2,580 m (8,460 ft). The volume content is 3,850 km^3 (920 cu mi), gross storage capacity is 388,000.00 km^3 (93,086.15 cu mi) and having the surface area of 48,160 km^2 (18,590 sq mi). Whereas downstream to DPP, second sampling station was established on the bank of river Tapi near Bhusawal city.

(a) (b)

Figure 2 (a) Satellite image of Hatnur Dam, (b) Photograph of Hatnur dam

Figure 3. Water sampling from river Tapi near Bhusawal city(downstream to DPP).

III. Results Of Comparative Status Of Fish Species In River Tapi At Both Sampling Stations

The upstream and downstream sampling stations were visited twice in every season during March 2013 to June 2014. Number of fish were captured from river Tapi from both sampling stations. The specimens were collected using cast net taking help of local fishermen and preserved in 3% formalin after carefully noting down the color and other external features and brought to the laboratory. Labels indicating serial number, exact locality, date and time of collection were tagged to each specimen. Standard books and keys were used for identification of species (Jayram, 2002; Jhingran, 1982; Talwar and Jhingran, 1991). Similarly personal talks with fishermen communities' also revealed valuable information about the taxonomic status of fish. Western Region Office of Zoological Survey of India, Pune, was cooperated and provided useful information about every fish specimen collected form sampling stations.

The first survey of fish landing in river Tapi was recorded by fishery department in 1958-1961(Karamchnadni and Pisolkar, 1967). Later on, in 1992, the survey was made by Pisolkar, who noted presence of 52 fish species belonging to 30 genera under 14 families from Tapi river from various sampling stations situated in

Madhya Pradesh, Maharashtra and Gujarat. Recently, Lohar and Borse (2003) studied fish landing data in River Tapi from the Hatnur reservoir in Maharashtra to Ukai dam in Gujarat. In the present investigation, in all total 15 fish species belonging to four orders viz, Cypriniformis, Siluriformis, Channiformis and Mastacembeleformes were found during the fish catches made in Hatnur reservoir on Tapi river and their comparative status is evaluated. The Result of this study is given in table 3.

Table 3. Comparative abundance of individual fish species in river Tapi at upstream and downstream of Deepnagar Power plant during toe years of study

Common Name/ Variety	**Order**	**Scientific Name**	Sampling stations	
			US	**DS**
Major carps (4 species)	Cypriniformis	Labeo rohita (Ham.)	+ + +	+ +
		Catla catla (Ham.)	+ + +	+ +
		Cyprinus carpeo (Linn.)	+ + +	+ +
		Cirrhinus marigala (Ham.)	+	NF
Minor carps (4 species)	Cypriniformis	Labeo calbasu (Ham.)	+	NF
		Labeo bata (Ham.)	+	NF
		Labeo fimbriatus (Bloch.)	–	NF
Cat Fishes (6 species)	Siluriformis	Clarius batrachus (Linn.)	+ +	+
		Ompak bimaculatus (Bloch.)	+ +	+
		Wallago attu (Schn.)	+ +	+
Murrels (2 species)	Channiformis	Channa punctatus (Bloch.)	+ +	+
		Channa striatus (Bloch.)	+	NF
Trash Fishes (3 species)	Cypriniformis	Amblypharyngodon mola (Ham.)	+	+
		Puntius sophore (Ham.)	+ +	NF
	Mastacembeleformes	Mestacembelus armatus (Lacepede.)	+ +	NF

+++ Most abundant, ++ Abundant, + Less abundant,
NF = Not found in fish catches during study period.

Fish communities and habitat structures were evaluated under the impact of thermal discharge of DPP and it was compared with that of fish status at Hatnur reservoir. Fish communities exhibited significant differences between the upstream and downstream sampling stations, near Bhusawal city the sampling site downstream to DPP, showed a significant decrease in fish species richness and diversity, as well as a decrease in benthic cover. In Hatnur reservoir, 15 fish species were described, andthe average water temperature was 28.8 ± 0.5 °C, compared with 8 species at sampling site downstream to DPP with average water temperature 35.96 ± 0.7 °C.

Plate No.1

1. **Labeo rohita** (Ham–Buch)

2. Catla catla (Ham-Buch)

3. Cyprinus carpio (Linn)

Plate No. 2

4. Cirrhinus mrigala (Ham-Buch)

5. Labeo calbasu (Ham.

6. **Labeo bata** (Ham.)

Plate No. 3

7. **Labeo fimbriatus** (Bloch.)

8. **Clarius batrachus** (Linn.)

9. **Ompak bimaculatus** (Bloch.)

Plate No. 4

10. **Wallago attu** (Bloch and Schneider)

11. **Channa punctatus** (Bloch.)

12. **Channa striatus** (Bloch.)

Plate No. 5

13. **Amblypharyngodon mola** (Ham.)

14. **Puntius sophore** (Ham.)

15. **Mestacembelus armatus** (Lacepede)

The observed data revealed that thermal pollution alters influences fish assemblages by altering composition and decreasing richness since Cirrhinus marigala (Ham.), Labeo calbasu (Ham.), Labeo bata (Ham.), Labeo fimbriatus (Bloch.), Channa striatus (Bloch.), Puntius sophore (Ham.) and Mestacembelus armatus (Lacepede.) fish species could not find in the fish catches mad at downstream to DPP. Thus there were only 8 fish species found in river water due to thermal discharge as compared to 15 fish species inhabiting in Hatnur reservoir upstream to DPP. Disappearance of above-mentioned fish species from river Tapi near Bhusawal city might be attributed to increased water temperature due to thermal discharge from Deepnagar Power plant. It was found in the present investigation that Deepnagar Power Plant usually discharge 20000 m^3 day^{-1} of heated effluent in the Tapi river, leading to adverse impacts on prevailing hydrological and biological features of riverine ecosystem.

Thermal discharge might be resulted into the disturbance in physicochemical constituents of water body, affecting species composition including zooplankton and macrofauna such as fish. The temperature change in water affects spawning period of benthic macrofauna. Benthic organisms being sedentary animals associated with sediment bed provide an understanding of integrated effects of stress, and hence serve as good bio-indicators of early warning of potential damage (Hoffmeyer et al., 2005).

IV. Fish Kill In River Tapi Near Bhusawal City-Downstream To Deepnagar Power Plant

Fish kills are often the first visible signs of environmental stress and are usually investigated as a matter of urgency by environmental agencies to determine the cause of the kill. Many fish species have a relatively low tolerance of variations in environmental conditions and their death is often a potent indicator of problems in their environment that may be affecting other animals and plants and may have a direct impact on other uses of the water such as for drinking water production. Pollution events may affect fish species and fish age classes in different ways. If it is a cold-related fish kill, juvenile fish or species that are not cold-tolerant may be selectively affected. If toxicity is the cause, species are more generally affected and the event may include amphibians and shellfish as well. A reduction in dissolved oxygen may affect larger specimens more than smaller fish as these may be able to access oxygen richer water at the surface, at least for a short time. A fish kill can occur with rapid fluctuations in temperature or sustained high temperatures. Generally, cooler water has the potential to hold more oxygen, so a period of sustained high temperatures can lead to decreased

Dissolved oxygen in a body of water. An August, 2010, fish kill in Delaware Bay was attributed to low oxygen as a result of high temperatures (NJ News, 2010). Chlorine used in coastal power plants as antifouling agents of condenser tubes affect non target organisms (Fox and Moyer, 1975; Hall et al., 1979). Numerous fish and macro-invertebrates get impinge on intake water screening devices of power plants, culminating in sizable mortalities (Schubel et al., 1977).

A massive (hundreds of thousands) fish kill at the mouth of the Mississippi River in Louisiana, September, 2010, was attributed to a combination of high temperatures and low tide. Such kills are known to happen in this region in late summer and early fall, but this one was unusually large (US News, 2010). A short period of hot weather can increase temperatures in the surface layer of water, as the warmer water tends to stay near the surface and be further heated by the air. In this case, the top warmer layer may have more oxygen than the lower, cooler layers because it has constant access to atmospheric oxygen. If a heavy wind or cold rain then occurs (usually during the autumn but sometimes in summer), the layers can mix. If the volume of low oxygen water is much greater than the volume in the warm surface layer, this mixing can reduce oxygen levels throughout the water column and lead to fish kill.

Fish kills can also result from a dramatic or prolonged drop in air (and thus, water) temperature. This kind of fish kill is selective – usually the dead fish are species that cannot tolerate cold. This has been observed in cases where a fish native to a more tropical region has been introduced to cooler waters, such as the introduction of the tilapia to bodies of water in Florida. Native to Africa's Nile River, the tilapia stop feeding when water temperatures drop below 60 °F (16 °C) and die when it reaches 45 °F (7 °C). Thus, tilapia that have survived and successfully reproduced in Florida are occasionally killed by a winter cold front (UNIFL, 2003).In January, 2011, a selective fish kill affecting an estimated 2 million juvenile spot fish was attributed to a combination of cold stress and overpopulation after a particularly large spawn (CNN story, 2011)

Similar observations related to frequent mass killing of fish in river Tapi near Bhusawal city downstream to Deepnagar power plant were noted during months of summer in two years of study (Figure 4). The local news papers raised the issue and bring it to notice of authorities of Deepnagar Power Plant. But no one taken serious measures to curb this problem in which thousands of fish died due to thermal discharge from Deepnagar Power Plant.

Figure 4. Fish kill in river Tapi at sampling station downstream to Deepnagar Power plant

It was generally apparent from discussions that there was a growing need for continued research and studies on effects of thermal discharges on biota in order to provide more data which would be of value in developing criteria for the development of standards for thermal release, and also as an aid to siting thermal or nuclear power stations. The question of having criteria or standards has come about because at some power stations under observation environmental effects from thermal releases have been observed. Some of these have been clearly detrimental; others have probably been beneficial, and in a large number of cases they are very uncertain. Since there are probabilities of having detrimental effects, some limits ought to be established so that planners don't go too far beyond what could either be beneficial, inconsequential or detrimental. The real questions are what kind of criteria should one adopt? How detailed should the criteria be? Where should the criteria be applied? While debating these issues power plants are going to be built - they have to be built - and we have the real danger of formulating technically poor criteria too soon, or the danger of coming up with very excellent criteria too late. Varied views were expressed on the distinction between criteria and standards. On the one hand it was suggested that criteria were socially desirable objectives, whereas standards were obtainable objectives. Alternatively, and a more readily acceptable distinction, is that criteria are the scientific data on which one can base recommendations for the particular standards that may be necessary.

V. Conclusion

In general, water and air temperature data is sufficient to reveal possible changes in mean water temperatures and summery extreme temperatures and to prove a correlation between air and water temperatures. Positive trends of water temperatures of river Tapi were identified in summer months. The thermal discharge from DPP is responsible for alteration in physico-chemical properties of river water. The change in water temperature is one of the significant factor that goes to extreme intolerable level causing decrease in dissolved oxygen level as a secondary effect leading to frequent fish kill events in months of summer season. Decrease in fish richness from the point of species diversity and mass mortality of fish due to upper lethal thermal discharge from DPP is the matter of serious concerned which is to resolved soon to protect the diversity of fish of the river Tapi and protect the riverine ecosystem. Release of hot water from cooling towers and ash from DPP directly in to Tapi river are notorious anthropogenic activities that must be prevented or there must an corrective measure including implementation of new technology making operational changes to minimize the thermal load and to maximize the restoration of aquatic fauna inhabiting in River Tapi. DPP should have improved ecological monitoring system for dealing the most serious ecological effects of steam-electric power generators on air, water and soil in its vicinity. Astringent action plan is essential to generation an electricity on one hand and on the other hand to conserve the ecosystem.

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