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Environmental case study of Water Quality and Climate Change resulting a mass Mortality of Fish at Taj Boudi of Bijapur

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Abstract: *Water itself is an environment supporting a large number of organisms- a mosaic of flora and fauna highly affected by increased population and urbanization.*
An incidence of large scale mortality of fish in Bijapur (Karnataka) on 20th to 23rd Dec.2010 was reported in the local news paper and it was a major concern in the Bijapur city. Thousands of fish died in the historic Taj Boudi, the largest well built by Adil Shahis and it is a lotic calm water body. The dead fishes were identified as ***Tilapia mossambica****, commonly called as* ***Chilla pilli/Gilabi*** *in local language (poor commercial value). An intensive study of the water quality of Taj Boudi was carried out. These studies reveal that the mass mortality of fish in Taj Boudi is due to sudden fall in temperature of the water, depletion of dissolved oxygen, elevated BOD, high level of molecular ammonia and eutrophication due to the enrichment of water with Phosphorous and Nitrogen in the form of PO_4 and NO_3. Another rare phenomenon of Inverse thermal stratification was also observed in the previous study of Taj Boudi water and it may also have added to the mass mortality of fish.*
Key words: *Eutrophication, Inverse thermal stratification, Mass mortality, Taj Boudi, Tilapia mossambica.,*

I. Introduction

Clear ponds and reed often lie in lush green meadows extending to the fringe of forests. In spring and summer the ponds are covered with blanket or flowering plants. Everywhere there is life and brisk activity. The inter relationships within nature's household of the landscape are indeed complex and dependent on each other. Water and landscape are mutually dependent. The link being closer and more versatile. Any change in the water quality necessarily influences the whole of surrounding environment. Hence to maintain a well defined environment, the ecology of an ecosystem should not be disturbed. Thus water is an unique universal solvent and takes the priority. Fresh waters are getting highly polluted due to the impact on the environmental factors of the biotic component of water especially in the depth profile.

As reported by Captain Sykes, a visitor to Bijapur in 1819, Adil Shahi kings have built a large number of wells (more than thousand) both with steps and without steps for the water supply, recreation, and archeological wonder. Many of these wells were named after their queens. Taj Boudi is the largest well in Bijapur measuring 67mts in square and about 27 mts in depth (Figure 2). It is named after Taj Sultana, the queen of Ibrahim Adil Shah II. Formerly the water of this well used for the drinking and for the irrigation of nearby agricultural lands. Till recently it was used for swimming but at present the well water is used for dumping of idols of lord Ganesh and other deities and washing clothes. At present it is surrounded by colonial residential houses all around, which seep their waste water through the inlets to TajBoudi. This is how the defiling of the natural environment by the waste unwanted pollutants takes place. This in constant method is creating and environmental pollution – a threat to the future sustainable life in the well and the surrounding. Thus the eutrophication of water of Taj Boudi is occurring. In simplest sense it means pollution water or enrichment of nutrients is taking place and resulting degradation of its quality (5). The water has become very dirty due to negligence of the local authority and local residents. Theoretically it would be impossible to keep all contaminants out of all water everywhere; even without human influences contamination of bodies of water has always occurred and will continue to occur. For example, we need only think of the compounds which can be formed in lakes under certain conditions, such as hydrogen sulphide (H_2S), which causes most of the organisms within the affected zone to die off, or at the very least causing oxidophilic organisms to avoid such polluted aquatic environments. If there is excessive introduction of allochthonous organic matter and/or in-situ production of organic substances, hydrogen sulfide is formed, for instance on the bottom of lakes, when the oxygen content is no longer sufficient for mineralization of organic materials by aerobic processes.

An instance of mass mortality of fish in Taj Boudi was reported. A large number of fish were killed between 20th to 23rd December, 2010. It was of major concern to the people of Bijapur and also the government authority. The dead fish were identified as Tilapia mosambica (6), commonly called as Chilla pilli or Gilabi.

These fish exist in specific lotic water body and they can tolerate water temperature between 16 to 35^{O} C. to know the cause of fish mortality the present study was carried out.

1.1 Taj Boudi

It is the largest well in Bijapur measuring 67 mts. in square and about 27 mts. in depth. It is named after Taj Sultana, queen of Ibrahim Adil Shah II. Formerly the water of this well was used for the drinking purpose and also for the irrigation of nearby farms. Till recently it was used for swimming, but at present, due to the negligence and dumping of wastes, idols of Ganesh and other gods, water has become very dirty, highly polluted and is used for washing of the clothes. Its ecosystem also exhibits its own microbes, flora and fauna. Common weed fish like Tilapia mosambica are luxuriantly observed in these deep well water.

II. Materials And Method

The collection of water samples were made once in a month at fixed spots from October to September for normal analysis of water samples with physic-chemical, Biochemical and phytoplankton parameters. The collection of samples was made between 8.30 am to 9.30 am. Temperature was noted on the field and winklerisation was done on the spot. Other factors were analysed immediately in the laboratory on the same day without much lapse of time. The collection of samples at depth were done by using Van Dorn water sampler. All the parameters for our research were analysed by the standard methods, 1980 and NEERI, 1988 manual. Surface water samples were collected for the microbial study in sterilized containers and given to the department of Microbiology, BLDE Medical College for the E-coli test.

A rare case of mass mortality of the fish was observed in the winter during 20^{th} to 24^{th} of December , 2010 at Taj Boudi. Bijapur city extends between 16°49' to 16°50 North latitude and 75°42' to 75°44' East latitude. The historic well-Taj Boudi ages nearly about 387 years old. The collection of the water samples were made on 20^{th} , 21^{st}, 22^{nd} and 24^{th} December, 2010 at surface, 10 ft, 20 ft and 30 ft depth (Table I) between 8-30 am to 9-30 am. Temperature was noted on the field and winklerisation was done on the spot. Other factors were analyzed immediately in the laboratory on the same day without much lapse of time. The collection of samples at depth were done by using Van Dorn water sampler. The physico-chemical parameters were analyzed by the standard methods1980, and NEERI,1988 (2). The dead fish were collected and sent to Dr. M.David, department of Zoology, Karnatak University, Dharwad (Karnatak) for its detailed study and the reason for the mortality.

III. Results And Discussion

3.1 Water Temperature

Water temperature range throughout the study at Taj Boudi exhibited clear thermal stratification in summer and winter. There was a rare phenomenon observed of inverse thermal stratification in which the temperature of the deeper strata were higher than the upper layers. Both the studies of the water body experienced the higher temperature. But in winter there was fall and severe cold which affects sudden increase and decrease in the temperature of the aquatic system. The reason may be due to the warming up of the rocky beds and cooling of the water.

3.2 Taj Boudi- Temperature

Temperature maxima were observed in the month of June and July at the surface. Heavy rains were recorded in these months and that may be the cause for the rise in the temperature at the surface. December and January were cold with minimum temperature at the surface. A fluctuation of 6 to 8^{o} C was noted in the surface. Such low amplitude of thermal variation throughout the study is indicative of the tropical status of the water body (1 & 2). Water temperature decreased from surface to 9 mts depth. An exceptional inverse thermal stratification has been attained in the months of December and January, the temperature has increased with the increase of the depth (8,9 & 10). This may be attributed to the formation of some chemical stratification where the increase in density due to the rise in temperature is not sufficient to overcome the increase due to the dissolved concentration (11). Thus in Taj Boudi a phenomenon of inverse thermal stratification is observed.

3.3 Temperature effect on the common fauna that is fish in Taj Boudi :

Fish are poikilothermic animals that are their body temperature is the same as, or 0.5 to 1^{o}C above or below the temperature of the water in which they live. The metabolic rate of fish is closely correlated to the water temperature: Higher the water temperature, the greater the metabolism. At low temperature fish become less active and consume less food. Water temperature also has a great influence on the initiation and course of a number of fish diseases. The immune system of the majority of fish species has an optimum performance at water temperatures of about 15^{o}C. Whereas in the recent incidence environmental and water temperature was drastically reduced below the optimum temperature for fish survival and may be the possible factor for fish death (7). The authors have conducted a detailed study on the waters of Taj Boudi between 2009 and 2010. They

have carried out the physico-chemical, biochemical, phytoplanktonic and bacteriological study at surface, 3mts, 6mts and 9 mts depth. Taj Boudi exhibits clear thermal stratification in summer and winter (9). There was a rare phenomenon of inverse thermal stratification in which the temperature at deeper strata showed higher temperature than the upper layers (10,11,12,13). During the present study temperature reading between 20th to 23rd was 7^{o} C to 5^{o}C at surface waters. An inverse thermal stratification which was observed in the earlier study probably has been observed in the present study in the month of December. The temperature has increased in the depth from 7^{o} C , 8^{o} C, 11^{o}C and 12^{o}C respectively at surface, 3 mts, 6 mts and 9 mts (Table I). The fish –Tilapia mosambica commonly existing at surface waters, surviving within the temperature limitation of 16 to 35^{o}C have tried to move from the cold surface water towards the lower strata which are much warmer. As they move towards the deeper strata the fish death must have taken place by asphyxiation (Figure 1) due to the depletion in oxygen and, increased biological oxygen demand.

IV. Physicochemical Parameters

4.1 Hydrogen ion concentration.

pH of the water of Taj Boudi is on alkaline side. Taj Boudi indicate the pH was controlled by carbonate and bicarbonate systems. Free CO2 did not limit the pH. This may be due to the large inputs of the soaps and detergents. The optimal pH range for fish is from 6.5 to 8.5. Alkaline pH values above 9.0 and acidic below 5.0 can damage fish. As a defense mechanism against the effect of a low or high water pH, fish can produce an increased amount of mucus on the skin and on the inner side of the gill covers. Extremely high or low pH values cause damage to fish tissues, especially the gills and haemorrhages may occur in the gills and on the lower part of the body. An excess amount of mucus often containing blood was seen in post mortem examination of the skin and gills. However the pH of the water sample was recorded 8.3 (Table II). Although fluctuations do persist, since the carbon dioxide and total alkalinity were found to be above the optimum range it may also be the cause of fish kill.

4.2 Carbondioxide:

The primary sources of carbon dioxide are derived from respiration by fish and the microscopic plants and animals that comprise the fish aquatic biota. Decomposition of organic matter is also a major source of carbon dioxide in fish ponds. In addition there is some evidence to suggest that the toxicity of carbon dioxide is enhanced by low dissolved oxygen concentrations. Fish are able to rid themselves of carbon dioxide through the gills in response to a difference in carbon dioxide concentration between fish blood and the surrounding water. If environmental carbon dioxide concentrations are high, the fish will have difficulty reducing internal carbon dioxide concentration, resulting in accumulation in fish blood. This accumulation inhibits the ability of hemoglobin, the oxygen carrying molecule in fish blood, to bind oxygen and may cause the fish to feel stress, suffocation leading to death. Carbon dioxide levels of below 10 mg/l are thought to be well tolerated by fish although sensitivity to the gas varies between species. The level of carbon dioxide in the water varies with the respiratory and photosynthetic activity of animals and plants in incoming water, the level of decomposition of organic material in that water (a very significant contributor to CO_2 levels in some nutrient rich waters), and the respiration of the fish themselves. CO_2 can build up to significantly high levels in systems with large numbers of fish and relatively slow water turnover. The effect of increased CO_2 in water is to reduce the rate at which CO_2 from the fish's own metabolism can be released from the blood through the gills, thus the CO_2 in the blood also increases – this is known as *hypercapnia* (the physiology of the fish can counteract the effect by balancing the acidosis with an exchange of ions such as increasing the uptake of bicarbonate and losing hydrogen and phosphate ions and little harm is done. In the long term this balancing act can have a more profound effect on the health of the fish)- resulting in drop in the blood pH, an acidosis. At the same time the oxygen – carrying ability of the hemoglobin in the blood is reduced. The fish mortality at Adil Shah well incident the water analysis of CO_2 in the water recorded 19.8 mg/l, whereas the tilapia fish can tolerate maximum critical level of CO_2 0-16 mg/l (Table II). So the high level of CO_2 content may be also the reason for the fish mortality**.**

4.3 Dissolved Oxygen:

Dissolved oxygen concentration was not dependent on water temperature in Taj Boudi. It exhibited very low concentration of DO. This may be due to stratified nature.

Oxygen in water dissolves by diffusion from the surrounding air. Fish and aquatic animals cannot split oxygen from water of other oxygen containing compounds. Only green plants and some bacteria can do that through photosynthesis and similar processes. Virtually all the oxygen we breathe is manufactured by green plants.

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life (8). Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The

lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. Dissolved oxygen content in the Taj Boudi well was below detectable limit. Though fishes live in water, they are strict aerobes, obtaining sufficient oxygen is greater problem for fishes than for air breathers for two reasons: First, oxygen has a low solubility in water, constituting only about 0.5% compared with approximately 21% in air. second, the diffusion of oxygen is many thousands or times slower in water than in air. If the fishes or the water remained still, oxygen in the vicinity of the exchange surfaces would not be renewed by diffusion fast enough to sustain the animal.

The aquatic ecosystem comprises of two kinds of bacteria: aerobic bacteria which require oxygen and anaerobic bacteria which do not need oxygen to exist, indeed many are obligate anaerobes that cannot tolerate oxygen. Anaerobic bacteria are common in water bodies and in sediments as they are in the piles of garbage and manure.

4.4 Biological Oxygen Demand:

Biological oxygen demand is the amount of dissolved oxygen needed to oxidize organic materials to carbon dioxide and water at a particular temperature and pressure. If there is a large quantity of organic waste, there will be a lot bacteria working to decompose this waste. The greater the polluted organic waste, the higher the BOD. Thus in the present study BOD level of the Taj Boudi water is found to be 380 mg/l (Table II), which is very highly lethal to fish.

4.5 Eutrophication:

Eutrophication is a natural process taking place in water. The process is characterized by a development towards an environment rich in nutrients and a proliferous plant production. Man made activities cause excessive discharge of nutrients, especially phosphorous (P) and Nitrogen (N) in the form of PO_4 and NO_3. The changes in the critical water chemistry, accumulation of excess of carbon compounds leads to eutrophication and death of fish. Visual effects of eutrophication include muddles and discolored water, excessive algae which were observed in the present water sample (Figure 3).

4.6 Ammonia :

Ammonia pollution of water courses, ponds and lakes may be of organic origin (the reduction of nitrates and nitrites by bacteria in anoxic waters). In water or in biological fluids, ammonia is present in a molecular form (NH_3) and in the form of ammonium ion (NH_4^+). The ratio between these two forms depends on the pH and temperature of the water. The cell walls of the organisms are comparatively impermeable to the ammonia ion (NH_4+), but molecular ammonia (NH_3) can readily diffuse across the tissue barriers where a concentration gradient exists and is therefore the potentially toxic form to fish. Also under normal conditions there is an acid-base balance at the water –tissue interface. If this balance is altered, the side on which the pH is lower will attract additional molecular ammonia. This explains how molecular ammonia passes from water through the epithelium of the gills to the blood and also how it passes from the blood to the tissues. The ammonia has a particular toxic effect on the brain; that is why nervous symptoms are so pronounced in cases of ammonia toxicity to fish. The maximum admissible ammonia concentration is 0.05 mg/l, where as the ammonia level in the Taj boudi water is 2.71 mg/l (Table II), which is lethal to fish.

A related incidence of fish mortality in Bangalore had occurred in June-July 1995 in the Sankey lake and Lalbagh Lake (3). Recently dead fish floating on the surface of the Devera Bislahalli Lake near Marathalli Ring road, Bangalore was also noticed on 24th Nov. 2010. Such incidents were reported in other states as Maharashtra (Mumbai; 26.10.2010), Uttar Pradesh (Lucknow; 16.11.2010). These episodes have been reconciled with organic pollutants discharged into the aquatic ecosystem.

V. Phytoplankton

The study of phytoplankton ecology contributes to an understanding of the basic nature and general economy of the fresh water body. Generally a lake or a water body is considered as an ecological complex of a very high order and defined as ecosystem consisting of biotopes and biocoenosis. The phytoplankton coexists in a community balanced by the flora, bacteria and fauna. In the present study, the desmids, chlorococcales, bacillariophyceae and cyanophyceae recorded peculiar adaptability. The diatoms are predominant and resistant in the organically rich water.

VI. Biochemical And Bacteriological Studies

The bacterioplankton population was studied with more importance to the count of Escherichia coli (E-coli) as indicator bacteria. In Taj boudi E-coli count was at an average of 1359 per 100 ml. The source of biocdhemical substances like glucose, protein, urea, uric acid and creatinine act as substrate for the bacterial growth.

The bacterioplankton and phytoplankton population were studied in relation with temperature, oxygen, dissolved organic matter and pH. Other substances like the biochemical compounds were also correlated.

Thus the dominancy of E-coli in open wells with phytoplankton and the weed fish Tilapia mosambica interacting with the physico chemical and biochemical parameters is further controlled by the climatic conditions like temperature in winter and depletion of oxygen at the different strata of deep water body is the existing evidence of multiplex ecosystem.

On the whole there is a natural and beautiful symmetry expressed in the biological science between the seasonal changes and the living organisms. Minute variations result in the major disturbances of the flora and fauna. Thus the entire beauty of ecosystem goes into a misevent.

VII. Tilapia Mosambica- The Fishes

The common weed fish in Taj Boudi water is identified as Tilapia mosambica – commonly called as chilla pilli of gilabi in the local language- a proliferic breeder inhabitant in stagnant water. They are exotic with poor commercial and edible importance. The fishes are poikilothermic that is there body temperature is same as or 0.5 to 1.0^{o} C above or below the temperature of the water in which they live. At low temperature fishes become less active and consume less food resulting the mass mortality along with oxygen depletion. They are strictly aerobes. This is the cause for their massive kill.

VIII. Conclusion

On the whole the above study clearly indicate the cause of mass mortality of fish in Taj Boudi were due to low temperature of the water body, inverse Thermal Statification, fish must have moved to the deeper water layers for higher temperature and due to depletion in DO must have been killed, sudden depletion of dissolved oxygen, high Biological Oxygen Demand and higher concentration of molecular ammonia. Bijapur in general experiences a very low temperature in the months of December and January, and the temperature at lower layers slightly increases due to inverse thermal stratification. Hence fish move towards deeper strata for the warmth and due to depletion of dissolved oxygen get choked and might get killed. Regular monitoring of water quality management for physicochemical parameters for zooplankton, anaerobic bacteria particularly of sulphate reducing bacteria, hydrogen sulphide concentration as indicators of pollution may uncover factors regulating fish population in water bodies. This remedy is to be taken by the district authority to avoid calamity of the fauna of Taj Boudi ecosystem saving the flora, the fauna- fish and the water which is a natural heritage.

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Tables And Figures

Table I Average values of Water temperature.

Surface	3 mts depth	6 mts depth	9 mts depth
7.0	8.0	9.0	9.5

Table II. Results of Physicochemical parameters at surface and various depths and average values

Parameter	pH	CO2 Mg/l	D.O Mg/l	Org. Nitrogen Mg/l	Phosph-Orous Mg/l	Free NH3 Mg/l	BOD Mg/l	NO3 Nitrate Mg/l
Surface	8.2	20.0	-	5.03	7.02	2.72	380.0	4.60
3 mts	8.3	19.8	-	5.01	7.06	2.69	375.0	4.62
6 mts	8.3	19.8	-	5.02	7.08	2.73	380.0	4.64
9 mts	8.4	19.6	-	5.02	7.04	2.70	385.0	4.68
Average	8.3	19.8	N.D	5.02	7.05	2.71	380.0	4.64

Figure 1. Dead fish *Tilapia mossambica* (chilla pilli) found in Taj Boudi.

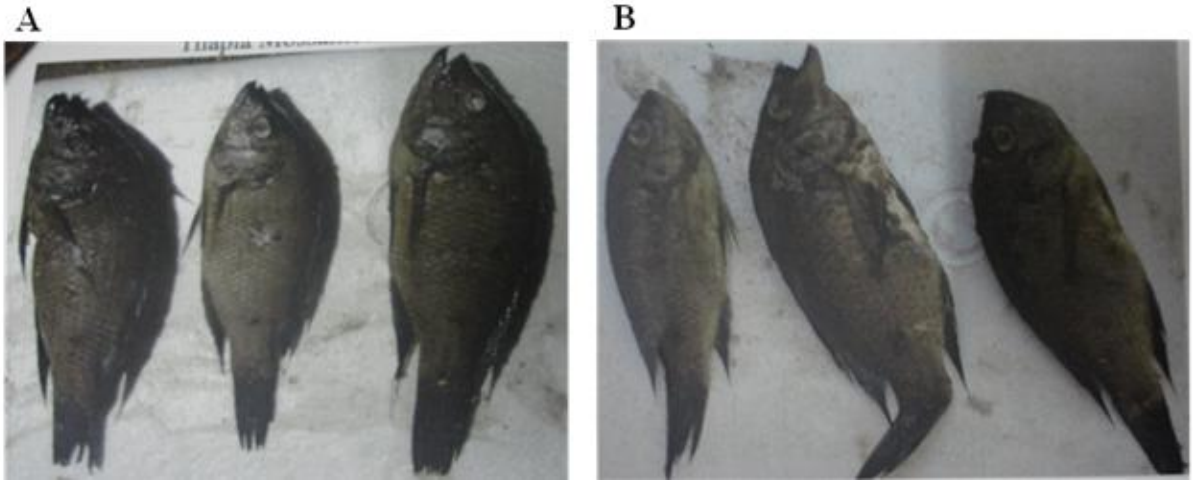

Figure 2. Satellite view of Taj Boudi.

Figure 3. Algal bloom and fish kill in Taj Boudi.