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Freshwater habitats are the potential source of water for mankind. They are the primary source of water for drinking, agriculture, industrial fisheries, aquaculture, transport, bathing and other purposes.

With growing urbanisation and expanding municipal limits, peripheral aquatic ecosystems come to occupy prime areas of a very high land value. With this, catchment as well as shore line areas of a lake are reclaimed to lay roads, flyovers and gardens. The authorised reclamation thus effectively change the morphometry of a water body. Similarly whenever water line recedes during summer or due to inadequate monsoon, encroachment of lake bed by unauthorised settlers is always a possibility in the prevailing sociopolitical environment.
The word 'ecology' is derived from the Greek 'Oikos', meaning 'house' or 'place to live'. Literally, the meaning of ecology is 'at home'. Odum (1971) defined ecology as the study of the relation of organisms or groups of organisms to their environment or the science of the interrelation between living organisms and their environment. Webster's unabridged dictionary defined ecology as, "the totality or pattern of relations between organisms and their environment". The shortest and the least technical definition of ecology is "Environmental biology".

The study of fresh waters in all their aspects—physical, chemical, geological and biological is termed "Limnology" (Odum, 1971). Welch (1952) stated it as the science dealing with biological productivity of waters together with all the casual influences on the qualitative and quantitative features along with its actual potential aspects. Wetzel (1975) defined limnology as, "Study of the functional relationship and productivity of fresh water biotic environmental factors".

Biological monitoring based on ecology of the flora and fauna has been recognised as an excellent and inexpensive tool for measuring pollution levels in water. Biological data of a particular location not only reflects the conditions existing at the time of monitoring but past conditions as well.

The physico-chemical methods give information about the
type of a substance/pollutant and its concentration, while biological methods indicate their general effect and give clue to the nature and quality of a substance. Hence, by the study of both physico-chemical and biological data, a better understanding of the effects of pollution is obtained and an integrated picture of water body is furnished (Cairns, 1979; Adoni, 1985; Kodarkar and Chandrashekar, 1995; Rao, 1997). Many authors have brought to the light the physico-chemical nature of water from various lakes and reservoirs (Ganpati, 1973; Alexander, 1976; Verma and Datta, 1983; Bhatnagar, 1984; Adoni, 1985; Johri, 1989; Sreenivasan, 1965; 1970; 1974; 1976; Meshram, 1997; Rao, 1997).

Limnological studies on some North Indian lakes and reservoirs were made by Gulati (1984). Bhatnagar (1984) observed that the lake is highly eutrophicated and grossly polluted by continuous inflow of untreated domestic sewage, producing widely, a severe environmental stress for aquatic life.

Agriculture activities are also the major sources of phosphorous and nitrogen to aquatic ecosystems. Atmospheric deposition further contributes as a source of nitrogen. These non point inputs of nutrients are difficult to measure and regulate because they are derived from activities dispersed over wide areas of land and are variable in time due to effects of weather. In an aquatic ecosystems these nutrients cause diverse problems such as toxic algal blooms, loss of oxygen, fish kills, loss of biodiversity and other problems as well. Nutrient enrichment
seriously degrades aquatic ecosystems and impairs the use of water for drinking, industry, agriculture and recreation (Carpenter et al. 1998). In one review article, Carpenter et al. (1998) stated that (1) eutrophication is a widespread problem in rivers, lakes, estuaries, and coastal oceans, caused by over-enrichment with P and N; (2) non point pollution, a major source of P and N to surface waters of the United States, results primarily from agriculture and urban activity, including industry; (3) inputs of P and N to agriculture in the form of fertilizers exceed outputs in produce in the United States and many other nations; (4) nutrient flow to aquatic ecosystems are directly related to animal stocking densities, and under high live stock densities, manure production exceeds the needs of crops to which the manure is applied; (5) excess fertilization and manure production cause a P surplus to accumulate in soil, some of which is transported to aquatic ecosystems; and (6) excess fertilization and manure utilization on agricultural lands create surplus N, which is mobile in many soils and often leaches to downstream aquatic ecosystems, and which can also volatilize to the atmosphere, redepositing elsewhere and eventually reaching aquatic ecosystems. If current practices continue, non point pollution of surface water is virtually certain to increase in the future. Such an outcome is not inevitable, however, a number of technologies in land use practices, and conservation measures are capable of decreasing the flow of nonpoint P and N into surface waters. They were also of the opinion that (1) nonpoint pollution of surface waters with P and N could be reduced by reducing surplus
nutrients flow in agricultural system and processes, reducing agricultural and urban runoff by diverse methods, and reducing N emissions from fossil fuel burning; and (2) eutrophication can be reversed by decreasing input rates of P and N to aquatic ecosystems, but rates of recovery are highly variable among water bodies. Often, the eutrophic state is persistent, and recovery is slow.

The primary productivity is one of the most important sources of energy input in freshwater ecosystem. This productivity is greatly dependent on the nutrient status of the aquatic body in relation with other physico-chemical parameters. The processes that contribute to primary productivity exhibit complex environmental relationships, where radiant energy is converted to chemical energy with the help of other physico-chemical parameters by the autotrophs through photosynthesis. Thus measurement of the amount and rate of energy fixation is based on the evolution of photosynthetic oxygen.

Herbivorous zooplankton occupies the key position in the food chain of lakes determining its type (grazing or detrital). Therefore, interactions between zoo and phytoplankton are acental topic in plankton ecology. Zooplanktons are the microscopic free swimming animalcule components of an aquatic ecosystem which are primary consumers of phytoplanktons. Zooplanktons provide the main food item of fishes, and can be used as an indicators of the trophic phase of water body (Mathew, 1975; Verma and Datta Munshi, 1987).
Zooplanktons play an integral role in transferring energy to the consumers, hence they form the next higher trophic level in the energy flow after phytoplanktons. Therefore, in view of importance in studies related to their distribution, ecological requirement and mode of reproduction, zooplanktons have attracted the attention of several workers throughout the world.

The density and diversity of the zooplanktons in reservoirs are controlled by several physico-chemical factors of water. The pattern of algal distribution and its density is the main biological factor affecting the density and diversity of the zooplanktons. Temperature, dissolved oxygen (DO) and organic matter are the important factors which control the growth of zooplankton (Hanazato and Yasuno, 1985; Bhati and Rana, 1987; Takamura et al.; 1989). Several researchers have used the different zooplankton groups to evaluate the trophic status and pollution potential of the freshwater bodies all over the world. Zooplanktons are also used as biological indicators of eutrophication.

Changes in both zooplankton community structure and zooplanktivorous predators often accompany the anthropogenic acidification of lakes (Williamson et al., 1999).

Rotifers are especially suited for an analysis of habitat relations because this group contains such a high number of species, inhabiting diverse environments (Pejler, 1995). Furthermore, rotifers are
to a large extent cosmopolitan, implying that ecological barriers, rather than geographical, are decisive of their distribution.

Phytoplankton plays a very important role in regulating the dynamics of the aquatic food web and become a driving force in shaping the community structure of zooplankton (Xie et al., 1998).

Reaves and Crotiny-Hartman (1994) have explained the wetlands and their importance as below:

Wetland Biology typically is hydrologically driven. The hydrology of created and restored wetlands frequently differs from that of natural systems, and the resulting floral and faunal composition of the wetland may also differ. In general, restored wetlands are more similar to natural wetlands than are created wetlands, and the biota of restored wetlands will more closely resemble that of natural wetlands. Created wetlands vary greatly from natural wetlands in both the hydroperiod and the quality of the water moving through them. Consequently, created wetlands are often biologically quite distinct from natural wetlands. Substantial efforts to restore wetlands throughout the United States have been taking place since the mid 1980s. The goals of wetlands restoration are to 1) improve water quality 2) control storm water, and 3) provide habitat for a variety of plants and animals. Numerous species of plants and animals, including many endangered or threatened species, are dependent upon wetland habitats. Following restoration of
the hydrologic regime, native aquatic plants return to restored wetlands within one year. As the water regime and plants cover become established, the wetlands are colonized by a variety of animals, including aquatic invertebrates. Use of the wetland system by wildlife is directly related to the size of the wetland, but distance between wetlands may affect the occurrence of taxa that have restricted dispersal ability. Unlike most natural wetlands artificially created wetlands may have constant water regime that can influence the floral composition of the system. Wetland plants that need periods of draw down are often eliminated with time. The biology of wetlands created for wastewater treatment is also greatly influenced by influent water quality. Wastewater often contains high levels of organic and ions that stress both the plants and the animals. If the system is used for the primary or secondary treatment of wastewater, the invertebrate assemblage will shift to pollution tolerant species. Even created wetlands utilized for tertiary wastewater treatment may be subjected to water of lower quality than natural wetlands, and they may experience a lesser shift toward pollution-tolerant species. However, increased nutrient inputs can lead to great productivity in wastewater treatment wetlands than is found in comparable natural wetlands. Wildlife and avian use of constructed wetlands are directly related to the size of the facility. Large systems attract a greater diversity of birds. These treatment systems may provide major bird-watching areas for the people they serve.

Soil erosion due to construction activities in the catchemnt
generates a lot of silt which along with the surface runoff ultimately ends up into lakes. Similarly, traditional festivals like Ganesh and Durga Puja conclude by immersion of massive idols made of clay, plaster of paris etc. in the lakes. Apart from addition of tons of silt, other things like paints, pigments, wooden and iron frames etc. also get into the water bodies.

Eutrophication is a global phenomenon associated with nutrient enrichment of aquatic ecosystems. In natural course it is slow process of lake ageing which ultimately leads to succession. However, man is responsible for accelerating the process many folds endangering the very survival of water bodies all over the world.

The nutrients responsible for eutrophication are Nitrates (NO$_3^-$) and Phosphates (PO$_4^{3-}$). The main sources of nitrates are untreated domestic sewage and effluents from food, drug and pharmaceutical industries. The limiting nutrient, phosphorus in the form of orthophosphate or soluble reactive phosphate (SRP) is mainly contributed by sewage, detergents and effluents from fertilizer and chemical industries. Finally, apart from the two basic factors, sulphates, chlorides and silicates also contribute to the process of eutrophication.

On the basis of nutrient level the aquatic ecosystems are classified into Oligotrophic (nutrient poor), Mesotrophic (fairly high) and Eutrophic (nutrient enriched).

In terms of volume and impact a single factor affecting the
trophic status of water bodies is domestic sewage. In developing countries sewage pollution from rapid urbanisation is a major environmental issue today. The lack of proper sewage treatment and disposal are the two factors responsible for gross pollution of ecosystems, particularly in urban environment.

Nutrient enrichment directly affects the water quality and leads to a number of consequences indicative of imbalance in the ecosystem.

The first and most visible symptom of nutrient enrichment is prolific growth of algal communities (primary producers) producing mono or polyspecific blooms. Normally a small number of taxonomic groups are well adapted to heavy pollution loading and consequent alterations in the physico-chemical conditions and biogeochemical and energy cycles in an ecosystem. The main groups of hypertrophic phytoplankton are Cyanobacteria, Chlorophyceae, Cryptophyceae, and Euglenophyceae. Comparatively diatoms attain biomass lower than the preceding groups. Other groups like desmids occur in an oligotrophic system. Dianoflagellates, Chrysophyceae and Xanthophyceae are either absent or present in very low number in hypertrophic lakes.

Four distinct patterns of seasonal succession on the basis of dominating phytoplankton have been identified in hypertrophic ecosystems. Level of DOM and planktonic sensitivity to ammonia is the main basis for this classification:
Type I: Cyanobacteria dominated succession.

Type II: Short episodes of green algae and diatoms with blue green dominating all the year.

Type III: Cyanobacteria dominate in summer while green algae rest of the year.

Type IV: Flagellates and some chlorococcales population dominate (tolerant to DO and Ammonia).

Among different species associated with eutrophication bluegreens have attracted most of the attention of researchers due to their environmental toxicology. Three quite separate toxins are identified from blue greens which are neurotoxins (alkaloids, potent neuromuscular blocking agents), Hepatotoxins (peptides inducing weakness, vomiting, diarrhoea, circulatory shock and acute liver damage), and Lipopolysaccharides (skin irritation).

Blue green algal blooming is a global phenomenon and a lot of efforts at theoretical and practical levels are going on the evolving effective strategies for its control. Environmentally, the algal blooms are highly detrimental to ecosystem; they adversely affect water quality, disrupt nutrient and energy cycles, alter trophic states, reduce biodiversity and are responsible for fish kills. Thus, water forming algal blooms is totally useless for aquaculture, and use in domestic, industrial and
irrigation sectors. Theoretically algal blooms can be controlled by targeting the measures at life histories, environmental requirements and ecological responses of the problematic species.

One of the basic approaches in controlling blooms is prevention and control of nutrient loading from point sources. Particularly available phosphorus acts as a limiting factor at level less than 10 µg/L for the growth of blue green species like Microcystis. In the case of lakes in urban environments, nutrient loading is mainly from domestic sewage. Even sediments of eutrophic reservoirs are rich in two key nutrients, nitrogen and phosphorus. Thus, recovery of water quality is extremely slow process in such cases. Nevertheless, nutrient level of standing water can effectively be reduced by periodically harvesting the algal and macrophytic biomass (Kodarkar et al, 1991).

Among other approaches one of the most discussed is biomanipulation of trophic pathways. Other remedial measures include basic engineering solutions like removal of sediment, treatment of affluents and effluents draining of lake water, under different stages of trial.

Inorganic (Copper sulphate) and organic (diquat type) compounds are also extensively used for the control of algae. Unfortunately these substances are not exclusively algicides and have general toxicity. Biological control through certain viruses, parasitic fungi and herbivorous ciliates is quite promising; however, biotechnology for
their precise application is yet to be fully developed.

Aquatic weeds referred to as macrophytes constitute an important component of an aquatic ecosystem. Their diversity and biomass influence primary productivity and complexities of trophic states (Singh, 1991; Verghese, 1992). The weeds also provide habitats for extensive development of periphyton.

The diversity of aquatic weeds reflect limnological status of an ecosystem. Some weed species are bioindicators of aquatic pollution (Varshney, 1981; Ambasht, 1981).

Eutrophic water bodies with growth of macrophytes provide ideal sites for the breeding of vectors like mosquitoes, snails and crustaceans responsible for the spread of a wide variety of vector borne diseases like malaria, filaria, kala azar and schistosomiasis.

In a highly polluted aquatic ecosystem characterised by low DO and high BOD, set in microbial processes producing foul smelling gasses like Methane, Hydrogen sulphide and Ammonia. An ecosystem polluted by domestic sewage receives sulphur in the form of organic substances like proteins and amino acids and inorganic sulphates. In prevailing anaerobic conditions they are reduced to foul smelling volatile gas, hydrogen sulphide \((H_2S)\) by bacteria.

In addition to \(H_2S\), methane is produced by bacterial
anaerobic metabolism which decomposes substances like cellulose, starch, proteins, fats, alcohol etc.

Normally well balanced ecosystem maintains fairly constant biogeochemical and energy cycles, trophic states and biodiversity. However, imbalance as a result of pollution once sets in, sensitive species are replaced by more tolerant, fast breeding and hardy ones. Biodiversity is markedly reduced and succession sets in. Fishes occupy high position in the food chain and their mass mortality is indicator of ecological imbalance and environmental degradation.

On the basis of number of dead specimens in a specific unit area the fish kills are classified into minor (1 to 100) 1 to 2 kms stretch of a stream, moderate (100 to 1000) and major 1000 dead or dying fish of many species upto 16 km length of a stream (APHA 1992).

Extensive work done to unravel the mystery of fish kills clearly indicates that a number of long acting and immediate factors are responsible for this phenomenon. Number of workers have described factors like sudden change of the temperature and consequent thermal shock, total anaerobia and resultant asphyxiation, clogging of gills and build up of pesticides and highly poisonous chemicals like phenols, heavy metals and ammonia as other reasons for the fish kills. The work on trace metal movement in food chain and web and their bioaccumulation and bioconcentration clearly points out to the possibility of trace metal
role in enhanced physiological susceptibility of fishes to sudden changes in physicochemical environment due to pollution (Manjula Devi, 1988).

Thus, due to a variety of complex factors the very existence of aquatic ecosystems in the urban environment is in question. In general, the factors responsible for degradation are gross pollution, siltation, and encroachment and reclamation. Unfortunately, the costs of ecological benefits are seldom understood and appreciated by administrators and policy makers in particular and common man in general.

Lake Chhatri is one such lake which is facing the danger of eutrophication due to increasing population of Amravati city, the increased human activities, development of weeds and industrialization. The present study was proposed to investigate the cumulative and detrimental effects of the inflow of industrial waste on the water quality of Chhatri Lake.

However, morphometric and physico-chemical features along with biological aspects have also been taken into account to evaluate limnological status to monitor the water quality of lake.

The investigations were carried out by considering the following points:

1. Morphometric study of the lake Chhatri.


4. Monthly qualitative broad analysis of phytoplankton and weeds in lake Chhatri.

5. Productivity of lake Chhatri.