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Assessment of physico-chemical water quality along with phytoplankton and algal biomass on Pratap Sagar pond, Chhatarpur (M.P.), India

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ABSTRACT

The Pratap Sagar pond is one of the biggest eutrophic water body of Chhatarpur city, M.P. Presently this water body was used for domestic and commercial water supply, bathing, washing and recreation purposes. The present study highlights with assessment of physico-chemical water quality along with presence of phytoplankton species and algal biomass on Pratap Sagar pond, Chhatarpur (M.P.). The analysis was assessed during post monsoon, 2011 and pre monsoon, 2012 collected water sample from five different sites of pond. The parameters assessed were temperature, turbidity, pH, total dissolved solids (TDS), total hardness, calcium hardness, magnesium hardness, alkalinity, sulphate, chloride, nitrate, phosphate, dissolved oxygen (DO) and bio-chemical oxygen demand (BOD). The above parameters were analysed by employing standard methods for examination of water and wastewater. The results showed that most of the investigated parameters were found higher with their recommended standard limits prescribed by WHO. Numbers of different phytoplankton species at pond were six and eight at post monsoon, 2012 and pre-monsoon, 2011 respectively. Maximum and minimum algal biomass on pond were found 2042 and 2410 ppm/L at post monsoon, 2011 and pre-monsoon, 2012 respectively.

Key words : *Pratap Sagar pond, Water quality, Turbidity, Alkalinity, BOD, Phytoplankton, Algal biomass*

Introduction

The Pratap Sagar pond is one of the biggest eutrophic waterbodies of Chhatrpur city, M.P. So it is known as "Bada Talab" of the city. This pond is situated in the middle point of city and is surrounded in east by Homeopathy college and district Jail, west by city market, south by Veerangana Awantibai college and north by Naya Maullaha (a ward of city having more Muslim community). The above pond is located in troposheet / Khasra No. 2384. The area and shape of this pond are 5.163 ha and triangle respectively which have reveled as Map (Fig. 1). But presently some part of its area has reduced with illegal capturing of people of area. The history of pond according present generation of former ruler, old's man of the city and information's narrated in governmental record, it was constructed by Maharaja Vishvanath Pratap Singh Joo Dev of that time in the year of 1800 B.C. This pond is attached beside Rani Talaiya pond of the city and height of stairs and catchments area (triangle shaped) of its pond are similar to Rani Talaiya pond indicating the oldest time pond made by former

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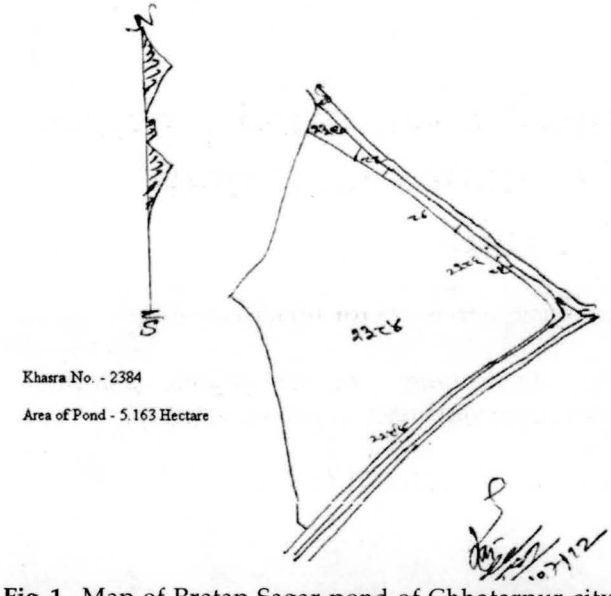

Fig. 1. Map of Pratap Sagar pond of Chhatarpur city (M.P.)

ruler (Gupta et al., 2010). Presently, this water body was used for domestic and commercial water supply, bathing, washing and recreation purposes. Soaps and detergents used for bathing and washing, open deflection by people, cattle wallowing or live stock utility, religious offering as disposed waste materials, etc. activities take place in pond or near by pond and these are very responsible for making the eutrophic water body with enormous density of phytoplankton's. More ever, a major drain of city collecting wastewater including from various sources such as domestic houses, temples, hospitals, institutes, shops, garages, etc. with high nutrients like as nitrogen and phosphate entering the pond is also responsible to make the eutrophic water body (Gupta *et al.*, 2011). The density of plants is biodegradable containing organic substance and decomposed by bacteria to use up as food result in reduce the oxygen level, transparency and depth of water. From the above sources of pollution bearing activities in the pond, it can be said that there are two main causes of eutrophic water body- first-high nutrients input cum high phytoplankton productivity of water body and second- low depth cum low transparency of water body (Patidar, 2009). The above both situations normally deteriorate and deface the pond water quality. Keeping the above situation, the monitoring and analysis of physico-chemical parameters of water to check its water quality, to count different germinated phytoplankton species and measurement of density of algal mass of the pond were performed.

Materials and Methods

Physico-chemical monitoring of pond water was carried out at post-monsoon, 2011 and pre-monsoon, 2012 in day time between 12:00 P.M. to 2:00 PM in order to know water quality status of water body. Water sampling was done as composting method. Two liter water samples for physico-chemical analysis were collected in pre-polyethelene plastic bottles from five different points of the pond. First sample was taken from the east of pond where bathing and washing activities had occurred. Second sample was taken from the deep middle of the pond where water had clean and enjoyed for recreation purpose. Third sample was taken from the west of pond where a major drain of city had entered into the pond. Forth sample was collected from the north of pond where bathing and washing, recreation and religious activities had performed and last sample was collected from the south of pond where open deflection by people and live stock utility had been running. All collected samples were completely mixed for analysis in order to obtain accuracy in results. Physico-chemical parameters under taken of the above study were temperature, turbidity, pH, TDS, total hardness, calcium hardness, magnesium hardness, alkalinity, sulphate, chloride, nitrate, phosphate, DO and BOD. Temperature and DO were analyzed in the sampling point by using a mercury thermometer and winker azide modification titration method respectively. While other remaining parameters were analyzed in the laboratory by using prescribed standard methods for examination of water and wastewater (APHA-AWWA and WEF, 2005) and chemical and biological method for water pollution studies (Trivedy and Goel, 1986). Chemicals and glasswere used in the study were of AR grade and obtained from Qualigen, Hi-Media, E-Merck, etc. and of borosilicate category and obtained from Shott Duran, ASGI, etc. respectively. For collection of germinated phytoplankton species in pond, a plastic bottle with duly filled formalin was used in order to preserve different phytoplankton species. Germinated phytoplankton species were identified some in spot of pond and some in laboratory by using prescribed method of plant taxonomy (Singh and Jain, 1996).

One liter separate water sample in pre-polyethelene plastic bottle was collected from each point of pond and mixed for measurement of produced quantity of algal biomass in its water. Water samples were filtrated through Whatman filter paper No. 40 and before obtaining residue with filter paper, it was initially pre-weighted. After pre-weight, it was dried with residue in hot air oven at 150 °C for two hours or till absorbed of moisture and after that, cooled in air desecrator and then further, finally weighted. Finally, difference between pre-weight and final weight of filter paper gave value of algal biomass. It was calculated from the following formula:

$$\text{Algal biomass (ppm/liter)} = \frac{\text{final weight of filter paper (after drying)} - \text{initial weight of filter paper (without drying)}}{\text{Volume of water sample}} \times 1000$$

Results and Discussion

The results of analysis of physico-chemical quality of pond water of both seasons were mentioned in table 1. The above results were also compared with their recommended standards (Table 1) by WHO, 1994. Average depth of pond in post monsoon, 2011 and pre monsoon, 2012 was 2.2 and 0.8 meter respectively. Names of identified phytoplankton species with their classification were mentioned in table-2. Details discussion of the analysis of physico-chemical parameters are given below:

Temperature is one of the important parameter for various physico-chemical and biological reactions. All physico-chemical and biological reactions change with their increase and decrease of temperature. Solubility of gases in water, growth of algae by nutrient input, organic decomposition etc. reactions are temperature dependent. An ideal value of temperature to be performed the above reactions should be from 20 to 25 °C. In this study, temperature was found 30 and 38 in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively. Both above values of temperature were higher than that of their ideal values.

pH is a measurement of hydrogen ion concentration and it is also defined as negative log of hydrogen ion concentration. It is a highly significant characteristic of water as it affects equilibrium among most chemical species, effectiveness of coagulation, potential of water to be corrosive & scaling nature and other characteristics of water. It is also universally used to express the intensity of a solution whether the acid or alkaline form. Values of pH were found 8.6 and 9.0 during post-monsoon, 2011 and pre-monsoon, 2012 periods respectively (Table 1). Both values indicated to alkaline nature of water and found higher than their permissible limit as per their prescribed standard (Table 1). Higher values were noticed due to be algae rich water where algae's use the carbon dioxide in their photosynthesis activity. Thus, removal of free carbon dioxide is responsible to make for high pH condition. More ever, much quantity of use of soaps and detergents containing elements of bicarbonate and phosphate might be responsible to enhance the pH of pond water.

Turbidity in water takes place due to clay, phytoplankton's with organic decay materials, silt, various offering goods by the people, etc. Its value was found 20.5 and 25.0 NTU in pre-monsoon, 2012 and post-monsoon, 2011 periods respectively. The above values of turbidity were more than their permissible limits (Table 1). Higher values of turbidity might have recorded on account of more offered suspended religious goods, bathing & washing activities by the people at pond. Also inorganic nutrients such as nitrogen and phosphorus presenting in wastewater stimulate algal growth in water result in pond contributes more turbidity.

Total dissolved solids (TDS) are known as ionic constitution of water. TDS value was found 680 and 722 mg/L in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively. Both values of TDS were higher than their prescribed standards as per WHO (Table 1). The high concentration of TDS might be come released wastewater from households of city drainage, used detergents and soaps, religious offering, etc.

Hardness as $CaCO_3$ in water is caused by divalent metallic cations mostly occurring by calcium and magnesium. These cations are capable to react with soaps and detergents to form precipitate. The values of hardness in pond were recorded 312 and 334 mg/L at post-monsoon, 2011 and pre-monsoon, 2012 duration respectively. The Swayer (1967) classified the water on the basis of the hardness in four categories as soft, moderate, hard and very hard. If the hardness is less than 50 mg/L, the water will be soft. If the hardness is from 50 to 100 mg/L, the water will be moderate soft. If the hardness is from 101 to 200 mg/L, the water will be slightly hard. If the hardness is above 200 mg/L, the water will be hard water. Both values were found more than their rec-

ommended limit of 300 mg/L and showed the hard category of water (Table 1). Hardness of pond water might be due to addition of lime (calcium hydroxide) to eliminate carbon dioxide and to maintain oxygen level result in removal of odour problem of the pond .

Calcium and magnesium hardness as $CaCO_3$ is caused by total hardness. The values of calcium hardness of pond water were recorded 208 and 222 mg/L at post-monsoon, 2011 and pre-monsoon, 2012 periods respectively while magnesium hardness values were recorded 104 and 112 mg/L at post-monsoon, 2011 and pre-monsoon, 2012 periods respectively (Table 1). Generally, calcium and magnesium hardness represent the free calcium and magnesium ions. These ions can be calculated as by dividing 2.5 and 4.12 factors from calcium and magnesium hardness values respectively. The low values of calcium and magnesium may be harmful for normal plant growth and biological process of fish such as blood clotting, bone and scale formation, other metabolic reactions, etc. (William and Durborow, 2002). But, value of calcium hardness was higher than that of magnesium hardness value because lime entered to the pond in order to remove CO_2 which was an additional source of calcium.

The alkalinity of water is measurement of its capacity to neutralize acid. It generally occurs in water as $CaCO_3$ due to presence of carbonate and bicarbonate anions. Besides salt of weak acid, strong or weak base, few organic acid, phosphate, hydroxide and silicate also contribute the alkalinity. It was found 220 and 242 mg/L in post-monsoon, 2011 and pre-monsoon, 2012 duration respectively (Table 1). Both values were higher with their permissible limits i.e. 200 mg/L. Higher concentration of alkalinity was recorded on account of algae rich water consequently water may contain appreciable amount of carbonate and bicarbonate, hydroxyl alkalinity due to release free CO_2 by decomposition of biodegradable organic matter. It can be explained by some reactions which are as follow:

$$\text{Decay organic matters} + O_2 = CO_2 \quad \ldots (1)$$

$$CO_2 + H_2O = H_2CO_3 \quad \ldots (2)$$

$$H_2CO_3 = H^+ + HCO_3 \quad \ldots (3)$$

$$2HCO_3^- = CO_3^{--} + H_2O + CO_2 \quad \ldots (4)$$

$$CO_3^{--} + H_2O = 2OH^- + CO_2 \quad \ldots (5)$$

Bicarbonate ion is also released by the soaps and sediments of the pond water. High alkalinity of pond water hints about its role in increasing trend of eutrophication.

Chloride has anionic nature. It is not utilized by the plants for their growth. It supports an indicator of pollution which comes from leaching of organic waste of live stock and human excreta, etc. Its presence in large amount is regarded as an indication of

Table 1. Results of the physico-chemical water quality of Pratap Sagar pond, Chhatarpur matching with prescribed standard

Parameters/ Seasons	Post-monsoon, 2011	Pre-monsoon, 2012	Standard criteria for drinking water quality WHO,1994
Temperature (^{0}C)	30.0	38.0	25
pH	8.6	9.0	7.0-8.5
Turbidity(NTU)	25	20.5	5.0
TDS (mg/L)	680	722	500
Total hardness as $CaCO_3$ (mg/L)	312	334	300
Ca^{++} hardness as $CaCO_3$ (mg/L)	208	222	75
Mg^{++} hardness as $CaCO_3$ (mg/L)	104	112	30
Alkalinity as $CaCO_3$ (mg/L)	220	242	200
Chloride (mg/L)	160	185	250
Sulphate (mg/L)	48	65	200
Nitrate (mg/L)	12	20	45
Phosphate (mg/L)	2.6	4.0	0.1
DO (mg/L)	6.8	7.7	4-6
BOD (mg/L)	25	45	6.0
Algal biomass ppm/liter	2042	2410	-
Total algal biomass (ton)	232.8	99.5	-

Table 2. Common and botanical names of different plant species in Pratap Sagar pond at post-2011 and pre-monsoon, 2012

S. No.	Aquatic plants	Botanical names of plant species & their classification	Presented plant species	
			Post-monsoon, 2011	Pre-monsoon, 2012
1	Water spinach	*Ipomoea aquatica* Kingdom: Plantae (unranked): Angiosperms (unranked): Eudicots (unranked):Asterids Order: Solanales Family: Convolvulaceae Genus: Ipomoea Species: aquatica	Yes	Yes
2	Banana lily	*Nymphoides aquatic* Kingdom: Plantae Division: Magnoliophyta Class: Magnoliopsida Order: Asterales Family: Menyanthaceae Genus: *Nymphoides* Species: *aquatica*	No	Yes
3	Water lettuce	*Pistia stratiotes* Kingdom: Plantae (unranked): Angiosperms (unranked): Monocots Order: Alismatales Family: Araceae Genus: *Pistia* Species: *stratiotes*	No	Yes
4	Filamentous green alga	Oedogonium Kingdom: Protista Division: Chlorophyta Class: Chlorophyceae Order: Oedogoniales Genus: *Oedogonium*	Yes	Yes
5	Rolling alga	Volvox Kingdom: Plantae Phylum: Chlorophyta Class: Chlorophyceae Order: Volvocales Family: Volvocaceae Genus: *Volvox*	Yes	Yes
6	Water hyacinth	*Eichhornia crassipes* Kingdom: Plantae(unranked): Angiosperms(unranked): Monocots(unranked): Commelinids Order: Commelinales Family: Pontederiaceae Genus: *Eichhornia* Species: *crassipes*	Yes	Yes
7	Filamentous green alga	*Spirogyra* Domain: Eukaryote (unranked):Archaeplastida Kingdom: Protista (unranked): Streptophyta Phylum: Chlorophyta Class: Zygnematophyceae Order: Zygnematales Family: Zygnemataceae Genus: *Spirogyra*	Yes	Yes
8	Filamentous green alga	*Draparnaldiopsis indica* Domain: Eukaryota Kingdom: Plantae Division: Chlorophyta Class: Chlorophyceae Order: Chaetophorales Family: Chaetophoracea Genus:*Draparnaldiopsis*	Yes	Yes

pollution by the organic substances. Value of chloride was found 160 and 185 in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively. Both values of chloride were found higher than that of their permissible limits i.e. 250 mg/L (Table 1). Sufficient concentration of chloride was noticed due to regular entering of community drainage in pond water. Open deflection by people towards the out side of pond while excreta of livestock animal towards the inside of pond are more chances to enhance the chloride level in pond.

Hyper concentration of sulphate in water creates two types of problems i.e. odour and swear corrosion. Sulphate value was observed 48 and 65 mg/L in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively (Table 1). Sulphate is main constitution of soap and detergent due to having biocides property. It has reached in pond through more use of soaps and detergents by people during their bathing and washing activities. Both values were found within permissible limits (Table 1).

Presence of nitrates and phosphate is an indication of severe eutrophication problem in a surface water body. Value of nitrate in the pond water was 12.0 and 20.0 mg/L, while phosphate in water was 2.6 and 4.0 mg/L in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively (Table 1). Nitrate might have reached in pond from excreta of animal through cattle wallowing, open deflection by people, during rain, atmosphere nitrogen fixation by the autotrophic plants, while phosphate might have come due to use of soaps and detergents by the surrounding population. Nitrate showed lesser than its permissible limit but phosphate was found beyond its permissible limit which was a cause of eutrophic water body.

Dissolved oxygen (DO) is an important parameter to cheek the water quality status and productivity of flora and fauna of pond water. It is used by aquatic organism as a respiratory gas to complete ttheir oxidation reactions (Sunder *et al.*, 2007). Value of DO was observed 6.8 and 7.7 in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively. Better value of DO from limitation of minimum desirable limit was found due to be algae rich water.

Extent of BOD was found 25 and 45 mg/L in post-monsoon, 2011 and pre-monsoon, 2012 periods respectively (Table 1). High values of BOD were owing to more organic waste load to the pond obtained from the surrounding through various human activities like as bathing, washing, domestic sewage, excreta of livestock, etc. Household solid waste dumping at the banks of pond, etc. may also be cause to rise BOD value at the pond.

Plant species: More productivity of phytoplankton in water body is found owing to be more input of nutrients especially nitrates and phosphates consequently water body is converted into eutrophic water body. Numbers of different plant species at pond were six and eight at post monsoon, 2012 and pre-monsoon, 2011 respectively. Mostly, plant species in pond during the study period were Water spinach, Banana lily, Water lettuce, Water hyacinth, Filamentous green alga, Rolling alga, etc. (Table-2). Eutrophic water bodies produce more algal biomass due to be decay of above algal plants than other water bodies, if except other anthropogenic activities such as dumping of solid waste, washing bathing and mass bathing religious goods, etc, which are not directly performed in water body. Produced biomass of algal decay plants that correlates with total suspended solids and turbidity of water. In this study, maximum and minimum algal biomass of pond were found 2042 and 2410 ppm/liter at post-monsoon, 2011 and pre-monsoon, 2012 respectively (Table 1). Based on area of pond i.e. 5.163 hectare and average depth of the pond of both seasons, the total volume of water in pond was $1.14.X\ 10^8$ and $4.13\ X\ 10^7$ at post-monsoon, 2011 and pre monsoon, 2012 respectively. Thus, the total biomass of pond was 232.8 and 99.5 ton at post-monsoon, 2011 and pre monsoon, 2012 respectively.

Conclusions

The above finding indicated that quality of pond was not satisfactory for area people. Due to high unmanaged and unwanted activities of the surrounding population, water quality of pond is being polluted continuously. Inputs of nutrients through wastewater of city entering the pond might increase many time nutrients load than their prescribed limit in future time. They will be responsible for low depth, aesthetic and odour problems, etc. of pond water. This information will be shared with people of the area and prescribed regulatory water management agencies i.e. Public Health Engineering Department (P.H.E.), Municipal authority (M.A.), State Pollution Control Board (SPCB), Central Pollution Control Board (CPCB), Ministry of Environment and Forest (MOEF), etc. for aforesaid remedial mea-

sures to improve the water quality of pond. On the basis of above finding of the present study, the following recommendations may be considered for conservation and management of the pond water and to improve sanitary quality of the water so that this water may be used for municipal supply.

1. The washing activity on the pond should be prohibited while bashing activity should be controlled with limitation.
2. Paddle and rowing boats may be allowed for aeration as it increases the oxygen level and decreases the BOD load.
3. Biological control method may be very useful method for removal of organic matter i.e. macrophytes algae etc, from the pond. Fisheries may be used as biological control method for removal of organic load because fishes easily use the phytoplankton, algae, etc. to feed their food. Thus, excess amount of organic matter obtained from vegetable origin can be controlled.
4. The de-weeding after per week may be done to reduce the nutrients load and to eliminate biomass. Eliminate biomass can be used either for composting or for feeding the domestic animals.
5. The algal mass may also be weighted pre and post monsoon after de-weeding in order to take average production of biomass on per year.
6. The rate of eutrophication in the pond due to caused by input of excessive amount of nutrients released from domestic wastewater, solid waste, agriculture residues, human and animal excreta, used soaps and detergents etc. should be decreased either by effective recycling nutrients or by diverting the above activities towards to other side of the pond.

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References

APHA, AWWA & WEF. 2005. *Standard Methods for Examination of Water and Wastewaters, 21th edn.* American Public Health Association, Washington, USA.

Gupta, A., Tripathi, D.K., Sengar, S.S. and Gupta, G.S. 2011. Monitoring of algal evaluation and eutrophication in various surface water bodies of Chitrakoot region. *Indian J. of Environmental Protection.* 31(1) : 217-223.

Gupta, L.N., Parihar, J.S. and Gupta, G.S. 2010. Physico-chemical characterization of Rani Taliaya (pond), Chhatarpur. *Indian J. Environmental Protection.* 30 (10): 848-852.

Patidar, S.K. 2009. Problems and prospects of eutrophication control. *Indian Association for Environmental Management.* 36 (1): 47-51.

Sawyer, C.N. and Mc Carty, P.L. 1967. *Chemistry for Sanitary Engineers (2nd edn).* Mc Graw Hill, Newyerk.

Singh, B. and Jain, B.K. 1996. *Taxonomy of Angiosperm.* Rastogi Publication, Meerut.

Sunder, K.M.S., Banakar, A.B., Manjappa, S. and Puttaiah, E.T. 2007. Aqua-chemistry of Gopala Swamy pond in Chitradurga, Karnataka. *Indian J. of Environmental Protection.* 27(5): 420-424.

Trivedy, R.K. and Goel, P.K. 1986. *Chemical and Biological Method for Water Pollution Studies.* Environmental Publication, Karad (M.H.).

WHO 1994. *Guidelines for Drinking Water Quality Recommendation.* World Health Organisation, Geneva. 1: 1-130.

William, A.W. and Durborow, R.M. 1992. Interaction of pH, carbon dioxide, alkalinity and hardness in fish pond. *SRAC Publication.* Kentucky State University, U.K.: 464.