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Comparative studies on seasonal fluctuation in physico-chemical properties of water on biotic community of two sewage-fed fish ponds of Madhubani

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Abstract
Water intended for human consumption should be "safe" and "wholesome" i.e. free from pathogenic agent and harmful chemicals, pleasant to taste and usable for domestic purpose. The study area selected was Gangasagar pond and Raj Pond of Madhubani, Bihar. The physico-chemical parameters like temperature, pH, DO, total hardness, total alkalinity and turbidity were studied to analyse the water quality of the ponds. Water supports life on earth and around which the entire fabric of life is woven. The requirement of water in all lives, from micro-organism to man, is a serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization (Singh *et al*., 2002). Generally speaking, water pollution is a state of deviation from pure condition, whereby its normal functioning and properties are affected. Aggravated environmental problems often reflect the misuse or misunderstanding of technology. The pollution of this ponds are a matter of great concern, since it has reached an alarming level due to inflow of large volume sewage and solid wastes.

Keywords: Water, Quality, Physico-Chemical, Urbanization and sewage.

Introduction
Water is one of the most important of all natural resources known on earth. It is important to all living organisms, ecological systems, human health, food production and economic development. The safety of drinking water is important for the health. The safety of drinking water is affected by various contaminants which included chemical and microbiological. Such contaminants cause serious health problems. Due to these contaminants quality of drinking water becomes poor. Sometimes such poor quality water causes many diseases in the humans, so that quality of water must be tested for both the chemical as well as for the microbial contaminants. Water intended for human consumption should be "safe" and "wholesome" i.e. free from pathogenic agent and harmful chemicals, pleasant to taste and usable for domestic purpose. The study area selected was Gangasagar pond and Raj Pond of Madhubani, Bihar. The physico-chemical parameters like temperature, pH, DO, total hardness, total alkalinity and turbidity were studied to analyse the water quality of the ponds. Water supports life on earth and around which the entire fabric of life is woven. The requirement of water in all lives, from micro-organism to man, is a serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization (Singh *et al*., 2002). Generally speaking, water pollution is a state of deviation from pure condition, whereby its normal functioning and properties are affected. Aggravated environmental problems often reflect the misuse or misunderstanding of technology. The pollution of this ponds are a matter of great concern, since it has reached an alarming level due to inflow of large volume sewage and solid wastes.
Ponds are very productive ecosystems, which help in the regulation of biological cycles, maintenance of water quality, nutrient movement and support for food chains. Ponds are areas where water is the primary factor controlling the environment and the associated plant and animal life. Ponds are important components of watersheds and provide many valuable functions to the environment and to society.

Now Ponds are shrinking rapidly because of urbanization and industrialization. The physical and chemical characters of the Ponds water can be used to assess the ecological nature of the Ponds. Several studies have been conducted to understand the physical and chemical properties of lakes, wetland and reservoir (Rajas Kara *et al.,* 2005). In such studies the characteristics of water bodies were taken into consideration with reference to physical, and chemical properties. It is a wellestablished fact that domestic sewage and industrial effluent discharges result in changes of water quality and eutrophication. The other important sources of water pollution include mass bathing, rural waste matter, agricultural runoff and solid waste disposal. In view of this an attempt was made to analyze the physico- chemical parameters of the two ponds viz., Gangasagar and Raj ponds of Madhubani. An assessment of Gangasagar pond water and its suitability for public domestic use and pisiculture was thought to be essential in present endeavor. Most of the Physico- chemical conditions of Gangasagar pond described above exhibits some basic characteristics, which favors a successful in using the water for washing the cloths, bathing and also fish culture practice. Favorable range of temperature, alkaline pH and high values of DO are indicative of the productive and usable nature of Gangasagar pond.The comparison of water quality of Gangasagar pond with limits laid down by fresh water quality criteria for public use i e. fisheries practices, bathing, washing cloths and animals etc.However, very high level of phosphate and alkalinity was recorded which needs to be managed to reach permissible limits. Hence corrective measures have to be taken either preventing sewage release into the swamp or its proper treatment before release could improve condition so that full potential of lake could be utilized.

The perennial "Gangasagar Pond situated at near bus stand Madhubani was selected for present study. Gangasagar pond is surrounded by bus stand, Kali Temple and Vivekanand Colony on the North bank and by densely populated human colonies with bathing site on its west margin. Continued water supply is ensured by two large drains, one coming from the railway station compound and the other carrying sewage water from the south side of the pond. Except these two large drains many small drains carry sewage to it from residential houses, dairies, hotels and a manufacturing factory apart from run off and flood water during rains. It receives the garbage and household refuses in a very large quantity everyday and is infested heavily with microphytic and macrophytic vegetation. Detergents, cattle wedding, sewage and household water enriches its water with organic matter and nutrients which cause eutrofication and odorification of the pond resulting in fish mortality and unpleasant smell specially during summer.

The perennial "Raj Pond situated at near Police Line Madhubani was selected for present study. Raj pond is surrounded by Police line, Kali Temple and Muslim Colony on the East bank. Continued water supply is ensured by two large drains, and the other carrying sewage water from the south side of the pond. Except these two large drains many small drains carry sewage to it from residential houses, dairies, hotels and a manufacturing factory apart from run off and flood water during rains. It receives the garbage and household refuses in a very large quantity everyday and is infested heavily with microphytic and macrophytic vegetation. Detergents, cattle wedding, sewage and household water enriches its water with organic matter and nutrients which cause eutrofication and odorification of the pond resulting in fish mortality and unpleasant smell specially during summer.

Madhubani District is one of the thirty-eight district of Bihar State Situated on°26.3483^0N and 86.0712^0E India, and Madhubani town is the administrative headquarters of this district. Madhubani district is a part ofDarbhanga Division. The district occupies an area of 3501 km² and has a population of 3,570,651. This is the centre of Mithila, a region where the main language is Maithili.

Water quality

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in ponds are two factors of primary importance for successful pond cultural operations. To keep the aquatic habitat favourable for existence, physical and chemical factors like temperature, turbidity, colour, odour, pH, dissolved gases like oxygen, carbon dioxide and also reducing gases hydrogen sulphide, methane working lethal on fish life, will excercise their influence individually or synergetically, while the nutrient status of water and soil play the most important role in governing the production of plankton organisms or primary production in fish ponds. Rating of fish ponds on the basis of these factors is a difficult problem because of the complexities influencing and governing these factors and also for the fact that it is not possible to study the effect of any individual factor under uniform optimal conditions. Nevertheless from a study of a large number of ponds under diverse physical and chemical conditions it is possible to arrive at some broad generalisation which can be gainfully used by fish farmers. It may be remembered also that different fishes behave differently as to the suitabihty of environmental condition and food habit. As the major carps, catla *{Catla catla),* rohu *(Labeo rohita)* and mrigal *(Cirrhina mrigala)* are the widely cultivated fast-growing fishes in Bihar these have been always used as standards except when otherwise mentioned. The major water quality parameters considered for the examination in this study are pH, Odour, Colour, Taste, Temperature, Turbidity, Total Dissolved Solids (TDS), Dissolved oxygen (DO), Dissolved carbon dioxide, Metals and Metalloids, Total Hardness, Alkalinity.

Review of literature

Review of related literature provides an opportunity of gaining insight into the method, measures, subject and approaches employed by the other researchers. A careful review of research, journals, books, and other sources of information about the problem to be investigated is one of the important steps in the planning of any studied.

Jayabhaye UM *et al.,* (2008) [1] The physico-chemical parameters of a small lake Sawana, in Hingoli, Maharahstra, shows seasonal changes in physico-chemical parameters such as water temperature, water transparency, pH, Dissolved oxygen, Total dissolved solids, Total hardness, Calcium, Magnesium, Chlorides, Phosphates and Nitrates were analyzed twice in a month for a a period of two years during 2005-06 and 2006-07. All the parameters were within the acceptable limits. The results specify that the reservoir is not polluted and water can be used for irrigation and pisciculture.

Kamble SM *et al.,* (2009) [2] The physico-chemical parameters of Ruti dam water, was analysed during

September 2008 to August 2009. The various physico-chemical parameters such as atmospheric temperature, water temperature, pH, Transparency, Turbidity, DO, C02, BOD, total dissolved solids, alkalinity and hardness of water. The results revealed that there was significant seasonal variation in some Physio-chemical parameters and most of the parameters were in the normal range and indicated better quality of dam water.

Devi and Sharma (2007) [3] worked on physico-chemical analysis of the water samples in the freshwater.ponds of Manipur and found the nature of water was acidic to slightly alkaline and maximum depths of water as well as maximum turbidity index values during rainy season. Ecological status of Chitrapuzha river was documented and observed that the river severely impoverished in terms of species composition and density and the population density of plankton, nekton and benthos were low due to existing stress condition.

Begum *et al.* (2006) [4] there were variations in physico-chemical concentrations during rainy season and except turbidity all other physicochemical parameters of water found within the permissible limits in the reservoir at Davangere city, Karnataka (India).

Material and Methods

The present study was carried out for two different ponds located in Madhubani Town. In the present study the sampling was done during morning hours and all water samples were collected in the polyethylene bottles. For lake water sample collection the closed bottle was dipped in the ponds at the depth of 0.7 to 0.9 m, and then a bottle was opened inside and was closed again to bring it out at the surface. Water sample was collected from two different ponds of Madhubani Town. From the time of sample collection and to the time of actual analysis, many physical and chemical reactions would change the quality of water sample therefore to minimize this change the sample were preserved soon after the collection. The water samples were preserved by adding chemical preservatives and by lowering the temperature. The water temperature, Odour, Taste, TDS were analyzed immediately on the spot after the collection, Whereas the analyses of remaining parameters were done in the laboratory. The study was carried for a period of four month (january 2015 to April 2015).The collected water samples were brought to the laboratory and relevant analysis was performed. pH was determined using pH meter, and similarly turbidity is measured by Turbidity meter. Alkalinity, Chloride, Calcium, Magnesium, Total Hardness, Dissolved oxygen, Dissolved carbon dioxide, Barium, Copper, Sulphate was determined by standard methods (APHA, 2005).

Results and discussion

The average values and standard deviation of the two ponds are represented in Table. The water temperature in Gangasagar pond is 24.39±2.68oC and 27.48±3.63oC in Raj Pond respectively. The pH of the Gangasagar and Raj ponds was alkaline and it ranges from 7.80±0.46 and 7.53±0.41 the pH range. Total hardness depends on the amounts of calcium and magnesium present in the water. In the present study it ranged between 186.25±54.52 mg/L and 119.75±65.23 in Gangasagar pond and Raj Pond respectively. Dissolved oxygen (DO) is one of the important factor in the water body. The main source of DO in water is the atmosphere and by the photosynthetic activity of aquatic plants. Atmospheric oxygen enters the aquatic system by direct diffusion at the surface water agitation. Dissolved oxygen varied between 5.21±1.99 mg/L and 4.53±1.78 mg/L in Gangasagar and Raj ponds indicating the good water quality and is supported by Sahu et al., (2000). Free carbon dioxide ranged from 5.21±1.99 mg/L Gangasagar pond and 4.53±1.78 mg/L in Raj pond. Free carbon dioxide exhibited a prominent inverse relationship with the amount of DO and increase in one of these parameters lead to the decrease of others and vice versa. These relationships may be governed by reduction in the autochthonous oxygen supply, decomposition of aquatic vegetation, continuous use in respiration by the flora and fauna and to some extent by the mixing of water. In the present investigation the maximum concentration of magnesium 33.25±10.08 mg/L was recorded in Gangasagar pond and minimum concentration of magnesium 18.38±7.47 mg/L was recorded in Raj pond. The higher calcium content of the water is an indication of pollution and eutrophication of wetland. In Gangasagar pond and Raj pond the range of calcium observed was 38.38±10.96 and 20.53±7.66 mg/L. Nevertheless, acidity contents were in ranges of 11.08±4.06 and 12.86±4.13 mg/L respectively. Nitrate and phosphate contents reported in Gangasagar pond and Raj pond were in the range of 0.11±0.10 and 0.20±0.24 mg/L and 0.12±0.08 mg/L and 0.20±0.24 mg/L respectively. Sulphates are in the permissible limit (250) ranges from 112.33±42.38 in Gangasagar pond and 128.42±43.93 in Raj pond. The variation in concentration of inorganic salts was observed to be maximum because of seasonal variation in environmental factors. The study assessed the evolution of water quality in Gangasagar pond and Raj pond comparative study of both ponds were carried out by taking certain important parameters. The present investigation reveals that as the season changes there is a fluctuation in the physico-chemical characters of the water this will be due to in flow and change in the temperature as season changes.

Table 1: Average values of physicochemical parameters of the water of two ponds

Parameters	Gangasagar pond	Raj Pond
AT	26.44±2.99	27.48±3.63
WT	24.39±2.68	25.44±3.25
pH	7.80±0.46	7.53±0.41
TUR	44.21±20.10	34.86±16.50
Cl	29.61±15.09	94.00±48.51
TH	186.25±54.52	119.75±65.23
Ca	38.38±10.96	20.53±7.66
ALK	181.58±46.25	148.00±65.24
Aci	11.08±4.06	12.86±4.13
No3	0.11±0.10	0.20±0.20
DO	5.21±1.99	4.53±1.78
BOD	3.47±2.17	4.17±2.99
CO2	1.53±0.92	1.45±0.44

Of the physical factors, heat and light are essential in all waters for photosynthetic activity, which in turn is basic to productivity. Water temperature generally depends upon climate, sunlight and depth. To get an idea about the diurnal and seasonal variations of thermal conditions in fish ponds, data in two fish ponds of Madhubani were collected. Temperature in a fish pond is generally minimum during the early hours of morning and reaches a maximum value in the afternoon, showing a range of variation of about 7^0C. It has, been found that the wide fluctuation in temperature in a

summer day does not have any direct adverse effect on the fish. But in ponds with high organic content in bottom mud, sometimes large-scale mortality takes place in summer months in early morning especially if the surface water is suddenly cooled by a shower of rain or a cold wind. This happens due to the overturn of thermally stratified layers so that bottom layer with reducing gases distributes itself throughout the volume of water and even the relatively oxygen rich surface layer of water suffers oxygen depletion.

The more significant effect of higher temperature is the increased rate of bio-chemical activity of the microbiota so that the release of nutrients by decomposition of organic matter at bottom is more at higher temperature with consequent increase in the nutrient status of water. It is also a common experience in the tropics that the growth rate of fish is much higher in summer than in winter. The temperature data of Gangasagar pond showed that the temperature remained below 25^0C in January and December; for the months of February, March, October and November it generally fluctuated between 25^0C and $5O^0$C; and for the rest of the year it was between $5O^0$C and 40^0C. The maximum temperature of 40^0C was recorded in May and the minimum of 20.8°C in January. Thus it is found that for about 8 months in the year the temperature remains between 30^0C and 40^0C which may be responsible for high productivity in waters. Apart from these, temperature plays a very important role in some physiological processes like release of stimulii for breeding mechanisms in fish, both under natural and artificial conditions (Chaudhuri, 1964), Light is another physical factor of importance. As the primary production or synthesis of carbohydrates is a photo-chemical process energised by light, availability of light energy to a fish pond greatly influences its productivity. Penetration of light to water phase is determined by turbidity which is measured optically and represents the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the decomposition of organic matter. According to Smith (1934) excessive turbidity has a pronoxmced effect in confining daily heat gains to the surface layer of water. In general all fish ponds attain the highest turbidity during rains in July and August due to turbid rain water entering the pond. This, however, represents a temporary phase, turbidity assuming its normal value in October-November during the pre-winter period. In the ponds studied it is generally found that turbidity varies between 10 and 15 ppm. While highly turbid waters are undesirable for fish ponds, productive ponds are generally found to have slightly turbid water. Probably an exchange process between the adsorbed nutrients on the surface of the clay particles and soluble nutrients in water help to maintain higher nutrient concentration in water. Among the physico-chemical factors influencing aquatic productivity, pH, alkalinity, dissolved gases like oxygen and carbon dioxide and dissolved inorganic nutrients like nitrogen and phosphorus are considered to be important. The procedure generally adopted (Upadhyaya, 1964) is to determine these factors for a large number of productive, improductive and moderately productive ponds and indicate the range and average for the individual constituents.

Hydrogen-ion concentration (pH)

According to Roule (1930) the largest fish crops are usually produced in water which is just on the alkaline side of neutrality between pH 7.0 and 8.0 The limit above or below which pH has a harmful effect is given by Ohle (1938) as 4.8 and 10.8. In the present study it was observed that excepting the ponds in the acid soil zones of Raj Pond which had a pH below 7.0 and Gangasagar pond in alkaline soil showing water pH above 8. This is generally the normal range of pH in freshwater ponds unless contaminated by acidic or alkaline wastes.

Alkalinity, carbonate, bicarbonate and free carbon dioxide

Alkalinity or acid-combining capacity of natural freshwater ponds is generally caused by carbonates, and bicarbonates of calcium and magnesium, calcium forming the major constituent. These along with dissolved carbon dioxide in water form an equilibrium system which is of primary importance in the ecology of the environment.

In general calcareous water with alkalinities of more than 50 ppm are most productive offish, waters with an alkalinity of less than 10 ppm rarely produce large crops, water intermediate between these two groups may produce useful results (Ohle, 1938). Moyle (1946), from a study of a large number of lakes and ponds in Minnesota, gives the range of total alkalinity as 0.0 - 20.0 for low production, 20.0 - 40.0 for low to medium and 40.0 - 90.0 for medium to high production. Both two ponds above 90.0 ppm of total alkalinity have been found to be productive. In the present study it was found that an alkalinity below 20 ppm was definitely indicative of low production. This shows that above 20 ppm total alkalinity cannot work as a limiting factor. Its influence is probably obscured by other more important limiting factors such as dissolved phosphorus and nitrogen.

Dissolved oxygen

Among the chemical substances in natural waters, oxygen is probably one of primary importance both as a regulator of metabolic processes of plant and animal community and as an indicator of water condition. Hutchinson (1957) has aptly remarked that a series of oxygen determinations along with a knowledge of turbidity and colour of water could provide more information about the nature of water than any other chemical data. In the present study it was noticed that dissolved oxygen ranged from a minimum value of 5.4 ppm to a maximum value of 10.8 ppm. This represents near about the mean value for the day. It may be noted, however, that in ponds with a thick dispersion of phytoplankton or with a dense growth of submerged aquatic plants dissolved oxygen attains a minimum value in the early morning hours often times less than 5.0 ppm, and sometimes even less than 4.0 ppm. Though under this extreme condition, associated with other detrimental factors, this low concentration of dissolved oxygen may cause large-scale mortality of fish, generally it is found that the effect of this low oxygen alone does not cause any adverse consequence except that the fish suffer from slight distress during this period and congregate near the surface for respiration. Thus it may be said that normally the mean oxygen concentration in a pond does not show a value less than 5.0 ppm. In the range 3.0-5.0 ppm ponds are unproductive. For average or good production, ponds should have dissolved oxygen concentration above 5.0 ppm. It may be incidentally mentioned that very high concentration of dissolved oxygen leading to a state of supersaturation

sometimes becomes lethal to fish fry during the rearing of spawn in nursery ponds.

Dissolved nitrogen and phosphorus

Of the dissolved nutrients, nitrogen and phosphorus have been widely studied and their role and importance in aquatic productivity is well recognised. As a constituent of protein, nitrogen occupies a highly important place in aquatic eco-system. Chu (1943) concluded from the results of laboratory experiments that nitrogen and phosphorus naturally occur in quantities far below the upper limit for optimal growth of plankton and often do not reach lower optimal concentrations, the optimal limit of nitrogen being given by him as 0.3 to 1.3; these, however, may not be applicable to natural conditions. The percentages of productive ponds in these respective ranges were showing that dissolved nitrogen 0.2 ppm does not indicate a productive condition. Ecologically phosphorus is often considered as the most critical single element in the maintenance of aquatic productivity. Moyle (1946), from a study of a large number of ponds, gave the phosphorus fertility range as (1) 0.00-0.02 ppm low (2) 0.02-0.05 ppm fair (3) 0.05-0.10 ppm good (4) 0.10-0.20 ppm very good (5) above 0.20 ppm excessive. In present study, it was found good production of fish in the ponds having phosphorus concentration 0.02-0.05 ppm, while for the other ranges all ponds were found to be almost equally productive.

Eutrophication is accelerated as a result of human activities near or in a body of water that generates residential wastes, untreated or partially treated sewage, agricultural runoff, urban pollutants, and so forth. Sewage or residential waste, consisting largely of phosphate-containing detergents, is a major source of nutrients in bodies of water. The flow of nutrients in the water may overstimulate the growth of algae. This creates conditions that interfere with the recreational use of ponds and adversely affect the diversity of indigenous fish, plant and animal populations. The concept of nutrient overloading has a great impact on all subsequent eutrophication research and ponds management. It is fair to state that nitrates and phosphates are probably the key nutrients in controlling aquatic plant growth.

The nitrate and phosphate are two important constituents that immensely help in the growth of the plants where they present. If they are present in ponds they are excessively promote the growth of aquatic weeds and polluting our aquatic resources. International studies on the nitrates and phosphates in the surface waters of various bodies of water have expressed their concern and drawn the attention of scientists around the globe. These constituents are immensely help in the growth of the macrophytes like water hyacinth (Eichhornia crassipes) which is the most troublesome aquatic weed in the world. The major sources of nitrate in ponds are from the catchment area by rainfall, sewage effluents, agro waste, suspended organic matter when algae and other suspended micro-organisms die and settle down to the bottom. They carry their nitrogen and phosphorous with them, during decomposition. This nitrogen is released and becomes available for subsequent growth of aquatic biota (Singh and Mahajan, 1987). Presence of nitrate in water indicates the final stage of mineralization (Nema *et al*., 1984). Phosphorous is present in many forms among them orthophosphate plays important role in the aquatic ecosystem. Orthophosphate is the soluble reactive phosphorous which is also termed as inorganic phosphate. It plays a dynamic role in aquatic ecosystem which is taken up widely by phytoplankton (Goldman, 1965).

Conclusion

The result obtained during study was compared with ISI standards. Potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm. Habited water is generally used by animals & birds & aquatic life. The disturbance in this biological system & ecological system may affect health of animals & birds & aquatic life. After physicochemical analysis we found that the sample of Potable water and Habited water are free from pollution & ecologically balanced. The present study reveales that the assessment of water quality deterioration is due to various reasons. Better water quality was found in winter season than summer. Extent of pollution that has occurred due to urbanization, anthropogenic activities; increased human interventions in the water bodies have been ascertained.

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