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Research Article

A Study on the Physicochemical Properties of the Selected Ponds of Patna Town, Bihar, India

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Abstract: With the progress of the urbanization and industrialization, many types of water pollutants (such as pesticide, heavy metals, detergents, municipal wastes, domestic wastes and fertilizers) were generated. These pollutants were distributed into the environment by the different sources. These pollutants were distributed into the environment by the different sources. In this research paper, physicochemical characteristic of water samples from selected ponds in and around Patna, Bihar has been studied. The parameters observed were Temperature, pH, Electrical conductivity, Calcium, Phosphate, Total Hardness, Alkalinity, Chloride, Dissolved oxygen, Free CO_2 and Nitrate. It can be concluded that the water parameters which were taken for the present study were above the pollution level of surface water which does not satisfy their requirement for the use of various purposes. In this investigation, a brief attempt has been made to study the extent of change in the quality of water in comparison to water quality standards of World Health Organization (WHO).

Keywords: Water pollution, pH, Dissolved oxygen, Alkalinity, Hardness.

1. Introduction

Water covers 70.9% of the earth's surface and is vital for all known forms of life. On earth, 96.5% of the planet's water is found in the oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation. Only 2.5% of the earth's water is fresh, and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater are in rivers, lakes and the atmosphere, and an even smaller amount of the earth's freshwater (0.003%) is contained within biological bodies and manufactured products. In India, very few studies have been made to understand the physicochemical properties of lakes, reservoirs and ponds [1]. Ponds are not only a significant source of water but also provide valuable habitats to the several microbes. Biological oxygen demand, eutrophication, siltation, sedimentation, deterioration in water quality and shrinking of ponds are major problems in India due to various man-made activities. Anthropogenic nutrient enrichment causes serious changes in physical and chemical quality of aquatic water bodies [2]. The excessive amount of nutrients favours the growth of algae and weeds leading to eutrophication in the water bodies [3]. The nutrient enrichment results in diminishing economic, socio as well as recreational values of ponds and rivers [4]. The water bodies get polluted due to the discharge of effluents from the several industries, domestic activities, municipal activities and soil pollution from the nearby polluted areas. These factors result in the deterioration of water quality of the various water bodies.

Most of the cities and towns have developed in and around the bank of the pond because of the multipurpose use of pond water. But, unfortunately, some ponds are being polluted by indiscriminate disposal of sewage and industrial wastes [5]. Pollution of ponds is due to numerous pollutants or contaminants which are given in Table 1. These pollutants when discharged through sewage system poison the biological purification mechanism of ponds and pose

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several pollution problems. It has been drastically affected the living biota of the aquatic system. In Table 2, drinking water standards of the Bureau of Indian Standards (BIS) and World Health Organization is shown.

Table 1. Classification of Different Water Pollutants.

S. No.	Types	Examples
1	**Oxygen demanding wastes**	Human and Animal waste, Decaying vegetation
2	**Organic Wastes**	Detergents, Insecticides, Oils, Aldehydes, Phenolic compounds, Aromatic hydrocarbons
3	**Infectious agents**	Bacteria and Viruses
4	**Plant nutrients**	Nitrates and Phosphates
5	**Suspended materials**	Silt, Stone quarrying works, China clay and Coal particles
6	**Pesticide pollutants**	DDT, Aldrin, Endrin, Lindane and Carbamates
7	**Inorganic Wastes**	Acids, Alkalies, Soluble salts and Polyphosphates

2. Material and Methods

2.1 Study area

Patna is the headquarter of Patna district and the capital city of the state of Bihar. The total geographical area of Patna is 3,202 sq.kms. It is divided into six subdivisions and 23 community development blocks. The district of Patna is very well linked with the other parts of the country through road, rail and air. National Highway No. 31 passes through the district and it lies on the main line of the Eastern Railway, thus making it easier to access other parts of the district and the country. Map of study area is shown in Fig. 1.

The pond is a small water body for various purposes. It may be used for irrigation, bathing, washing of clothes and drinking place for animals. The people of Patna are likely to face a severe water crisis in the coming decades owing to the slow death of its natural water bodies. The groundwater level in different parts of the city has gone down by 15 to 25 feet during the last 30 years, and it is likely to go down deeper with the vanishing water bodies. Till a few decades ago, there were many small ponds and full ditches with aquatic plants all over the city, constituting all important water buffers. But, most of the surface water bodies have either been reduced to dispose of domestic sewage, wastewater and waste disposal dumps or overtaken by human settlements. The present study is an attempt to make an assessment of the change in the physicochemical properties of three selected ponds at Patna, Bihar.

Table 2. Drinking Water Standards of BIS, 1998 and WHO, 1993.

S. No	Parameters	Units	BIS, 1998		WHO, 1993		Methods
1	**pH**	-	6.5	*9.2*	6.5	8.5	Electrometric
2	**EC**	(μS/cm)	-	-	-	-	Electrometric
3	**TDS**	mg/l	*500*	*1000*	300	600	Electrometric
4	**TSS**	mg/l	-	-	-	-	Electrometric
5	**Total Hardness**	mg/l	*300*	*600*	-	-	Titration *(EDTA method)*
6	**Alkalinity**	mg/l	*200*	*600*	-	-	Titration
7	**Chloride**	mg/l	*250*	*1000*	200	600	Titration
8	**Dissolved Oxygen**	mg/l	-	-	-	-	Winkler method
9	**Free CO_2**	mg/l	-	-	-	-	Titration
10	**Nitrate**	mg/l	-	-	-	-	Titration

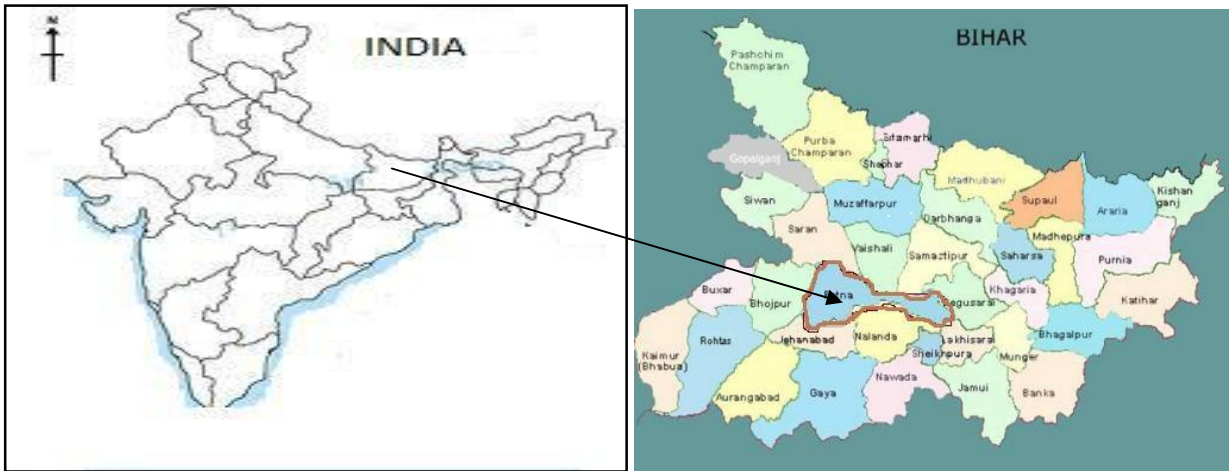

Fig. 1. Map of Study Area.

2.2 Collection of water samples

Water sample of ponds was collected in high grade plastic bottles of one litre capacity rinsed with distilled water, and before collection of water samples, they were rinsed thrice with sample water. The water samples were collected from the surface near the margins of the pond between 10 am to 11.30 am. After addition of appropriate preservatives like magnesium sulphate, alkali iodide and sulphuric acid at the sampling sites. The collected water samples were transferred to a water testing laboratory, for analysis of various physicochemical parameters. In Patna, three ponds were selected such as Phulwarisharif pond (denoted as P_1), a Secretariat pond (S_2) & Adalatganj pond (A_3) in the present investigation. The general description of the pond is not mentioned in this paper.

2.3 Methodology

The guidelines given by [6] & [7] were followed for water sampling. The Dissolved oxygen (DO) was fixed at selected site and above mentioned [6] & [7] methods were adopted for the analysis of pond water samples. Some selected parameters were analyzed within 36 hours. The reagents used for the analysis were AR grade and double distilled water was used for the preparation of the solution. The standard analytical method is given in Table 3.

3. Result and Discussion

The results of the physicochemical analysis of different sampling sites are presented in Table 4.

3.1 pH

pH is defined as a negative decimal logarithm of the hydrogen ion activity in a solution. pH is commonly measured by means of a glass electrode connected to a Milli voltmeter with very high input impedance, which measures the potential difference or electromotive force (E), between an electrode sensitive to the hydrogen ion activity and a reference electrode, such as a calomel electrode or a silver chloride electrode. Water that has been exposed to air is mildly acidic. This may be due to water absorbs carbon dioxide from the air, which is then slowly converted into carbonic acid, which dissociates to liberate hydrogen ions:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

pH of water samples ranged from a minimum of 7.4 to 8.08, 6.1 to 7.9 and 6.2 to 6.8 at site P_1, S_2, and A_3 pond respectively. The obtained results indicate that the water of A_3 pond is slightly acidic which can be due to accumulated organic matters and decomposition of vegetation which on biological oxidation gives up CO_2 which ultimately reduces the pH. The use of such pond water is unsuitable for drinking purposes.

Table 3. Standard Analytical Methods of Water Samples.

S. No.	Parameters	Unit	Methods
1	**pH**	-	Electrometric
2	**Electrical Conductivity (EC)**	(μS/cm)	Electrometric
3	**Calcium**	mg/l	EDTA method
4	**Phosphate**	mg/l	Colorimetric method
5	**Total Dissolved Solids (TDS)**	mg/l	Electrometric
6	**Total Suspended Solids (TSS)**	mg/l	Electrometric
7	**Total Hardness (TH)**	mg/l	Titration *(EDTA method)*
8	**Alkalinity**	mg/l	Titration
9	**Chloride**	mg/l	Titration
10	**Dissolved Oxygen (DO)**	mg/l	Winkler method
11	**Free CO_2**	mg/l	Titration
12	**Nitrate**	mg/l	Titration

Table 4. Physicochemical characteristics of water sample of ponds, Patna.

S. No.	Parameters	WHO Standard, 1984	Phulwarisharif pond (P_1)	Secretariat pond (S_2)	Adalatganj pond (A_3)
			Ranges (Summer - Winter)	Ranges (Summer - Winter)	Ranges (Summer - Winter)
1	**pH**	7.0 -8.5	7.4 - 8.0	6.1 - 7.9	6.2 - 6.8
2	**EC (umhos/cm)**	0.300	345 - 438	80 - 165	143 - 175
3	**Calcium, mg/l**	-	34 - 46	17 - 19	28 - 34
4	**Phosphate, mg/l**	-	0.2 - 0.4	0.34 - 0.67	0.41 - 0.55
5	**Total Hardness, mg/l**	100	186 - 231	130 - 145	160 - 198
6	**Alkalinity, mg/l**	100	70 - 110	65 - 120	50 - 90
7	**Chloride, mg/l**	200	35 - 44	7 - 12	27 - 32
8	**Dissolved Oxygen, mg/l**	5.0	4 - 5	4.4 - 6.7	3.7 - 4.2
9	**Free CO_2, mg/l**	-	7.5 - 8.4	6.2 - 7.7	6.8 - 7.4
10	**Nitrate, mg/l**	-	0.76 - 0.95	0.45 - 0.67	1.07 - 1.13

3.2 Electrical conductivity (EC)

EC is a measure of capacity of a solution to carry an electrical current. It is a parameter for dissolved as well as dissociated substances and indicates the concentration of dissolved electrolytes. The permissible value of EC for drinking water is 300 micromhos/cm [8]. EC were maximum at site P_1 and the minimum were recorded at site S_2. In the present study, (sampling site P_1 and site A_3) which are loaded with wastewater and domestic sewage from several houses showed maximum levels of conductance in the pond water.

3.3 Calcium

Calcium occurs in the water naturally. It is a silvery-white metal; relatively softer, but much harder than sodium metal. Calcium is members of the alkaline earth metals and these metals react vigorously with water. Calcium compounds are more or less water soluble. Calcium is also a constituent of coral reef. Rivers generally contain 1-2 ppm calcium, but in lime areas rivers may contain calcium concentrations as high as 100 ppm. Calcium in water may be responsible for the hardness. In the present study, the calcium values were found high at the P_1 site than other selected sites such as S_2 and A_3. One of the main reasons for the abundance of calcium in selected pond water is its natural occurrence in the earth's crust as well as adding sewage or wastewater from the nearby areas.

3.4 Phosphate

Phosphate exists in three forms such as orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate. Each compound contains phosphorous in a different chemical formula. Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate. Phosphates enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped up eutrophication. Eutrophication is the natural aging process of a body of water such as a pond or lake. This process results from the increase of nutrients within the body of water which, in turn, create plant growth. The plants die more quickly than they can be decomposed. This dead plant matter builds up and together with sediment entering the water, fills in the bed of the pond or lake making it shallower. Normally, this process takes thousands of years. During the research study, phosphates have been found from 0.2 - 0.4mg/l at P_1, 0.34 - 0.67mg/l at S_2 and 0.41 - 0.75mg/l at A_3 respectively. The maximum amount of phosphate recorded at A_3 site. This may be due to discharges of domestic sewage, street runoff and washing of clothes by local washerman (Dhobi).

3.5 Total Hardness

Total hardness mainly depends upon the dissolved salts present in the water. The water is classified as very hard if the values exceed 180mg/l, therefore water of the river can be considered as hard. Hard water also forms deposits that clog plumbing. These deposits, called "scale", are composed mainly of calcium carbonate ($CaCO_3$), magnesium hydroxide $Mg(OH)_2$ and calcium sulphate ($CaSO_4$). The following equilibrium reaction describes the dissolving/formation of calcium carbonate scales:

$$CaCO_3 + CO_2 + H_2O \leftrightharpoons Ca^{2+} + 2HCO_3^-$$

Hard water is generally not harmful to one's health but can pose serious problems in industrial settings, where water hardness is monitored to avoid costly breakdowns in boilers, cooling towers and other equipment that handles water. In domestic settings, hard water is often indicated by a lack of suds formation when soap is agitated in water. Wherever, water hardness is a concern, water softening is commonly used to reduce the hard water's adverse effects. In the present study, it has been found that total hardness ranges from 186 - 231mg/l at P_1, 130 - 145mg/l at S_2 and 160 - 198mg/l at A_3 respectively. High values of hardness are probably due to regular addition of large quantities of sewage and soaps into the pond from the nearby slum areas.

3.6 Alkalinity

Alkalinity imparts a bitter taste and sour taste to water bodies. High alkalinity means a healthy environment for our body's internal organs and blood energy transfer systems. Whereas high acidity means an environment, that will aid the growth of disease within the body. Alkalinity depends on pH, CO_2 and chloride. The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body [9], [10]. In the present study, the values of alkalinity at P_1, S_2 and A_3 were in the ranges of 70 - 110mg/l, 65 - 120mg/l and 50 - 90mg/l respectively. The medium range of alkalinity found in the pond is due to the presence of carbonate content in the water samples.

3.7 Chloride

Chloride (Cl^-) is one of the major anions found in water and are generally combined with calcium, magnesium or sodium. The chloride ion is formed when the element chlorine a halogen, gains an electron to form an anion (negatively-charged ion) Cl^-. Chloride is also a useful and reliable chemical indicator of surface water or groundwater fecal contamination, as chloride is a non-reactive solute and ubiquitous to sewage and potable water. Many water regulating companies around the world utilize chloride to check the contamination levels of the rivers and potable water

sources. In regards to human health, chloride causes "*Hyperchloremia*" is an electrolyte imbalance and is indicated by a high level of chloride in the blood. The normal adult value for chloride is 97 - 107mEq/L. In the present study, the maximum chloride contents were recorded at site P_1 (35 - 44mg/l) and minimum were at S_2 (7 - 12mg/l). This may be due to contaminated with local sewage, local drains and dumping of various waste products and vice versa. The values of chloride were found within the permissible limits.

3.8 Dissolved oxygen

Dissolved oxygen (DO) is an important water quality parameter for support aquatic life. Dissolved oxygen is the regulator of metabolic processes of plant and animal communities and indicator of water condition. This factor provides more information about the overall health of water bodies than any other chemical parameters. Oxygen is also essential for all plants and animals to survive, whether they live on the land or in the water. Aquatic flora and fauna rely on oxygen that is dissolved in the water. In most ponds, lakes and streams, the amount of oxygen in the water is continually being replenished with oxygen from the air. Sometimes, conditions exist in which the dissolved oxygen in the water is used up by organisms faster than it can be replaced from the air. If all the oxygen used up, the organisms will suffocate. In the present study, DO vary from 4.0 - 5.0mg/l at site P_1, 4.4 - 6.7mg/l at site S_2 and 3.7 - 4.2mg/l at site A_3. The amount of DO in the pond has been reported not constant but fluctuates, depending on the ambient temperature and depth of the water bodies. The decrease in DO at site A_3 may be attributed due to absence of little turbulence in the water samples.

3.9 Free CO_2

Almost all natural waters contain some carbon dioxide which they gain in several ways. Carbon dioxide gas is present in the air to the extent of 0.03 percent by volume and 0.05 percent by weight. As rain falls through the air, it absorbs some of this gas. Carbon dioxide also is a by-product of combustion; is emitted from volcanoes, hot springs and geysers; and is freed from carbonate rocks by dissolution. In the present study, Free CO_2 varies from 7.5 - 8.4mg/l at site P_1, 6.2 - 7.7mg/l at site S_2 and 6.8 - 7.4mg/l at site A_3. The amount of free CO_2 in pond depends on the local rock composition, temperature and depth of the water bodies. The increase in free CO_2 at site P_1 may be due to darkness photosynthesis cannot occur, and during the resultant respiration by small microbes, small amounts of carbon dioxide are produced in the pond water.

3.10Nitrate

Nitrate is a compound of nitrogen and oxygen found in nature and in many food items in our diet. It has been found that the concentration of nitrates in the groundwater is low. Drinking water normally contributes only a small percentage of our total nitrate intake. High nitrate levels in drinking water pose a health risk to infants because they may cause Methemoglobinemia, a condition known as "blue baby syndrome". The U.S. Environmental Protection Agency also uses 10mg/L as N as a mandatory national standard for public supplies under the Safe Drinking Water Act. The amount of nitrate in the pond has been found very low as compared to Safe Drinking Water Act. The amount of nitrate depends on the local runoff or seepage from municipal, domestic, industrial activities, animal feedlots, private or urban sewage disposal and plant debris. In the present study, nitrate varies from 0.76 - 0.95mg/l at site P_1, 0.45mg/l - 0.67mg/l at site S_2 and 1.07 - 1.13 mg/l at site A_3. The minimum amount of nitrate in the pond water was recorded during summer reason, whereas, the maximum amount of nitrate in pond water was recorded during winter season. The high nitrate level might be due to an influx of nitrogen rich sewage or wastewater in the pond water.

4. Conclusion

The surface water samples which were taken from the selected sampling locations in Patna town were analyzed and the following conclusions were drawn from the study:

The investigation reveals that the selected ponds of Patna have a huge load of domestic sewage, food items, small drains, street runoff, dumping of municipal garbage and night soil, some of which are harmful and toxic to human as well as to aquatic plants and other life forms. At many locations, the total hardness levels crossed the desirable limits, particularly in water samples drawn from A_3 site. This result also shows that the selected pond of Patna receives a very high amount of pollution load from the surrounding areas. The analytical results indicate that pond water is unfit for drinking and domestic purposes and it causes the several waterborne diseases (Such as *Botulism, Jaundice, Hepatitis A, Dysentery, Typhoid, Cholera, diarrhea*) in human beings. Water infection commonly results during bathing, washing, drinking in the preparation of food or the consumption of food thus infected.

Therefore, there is a need of protection of these ponds from the gradual increase of human pressure so that aquatic bodies would not disturb.

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