

## **Studies Related to Physico-Chemical Characteristics of Water of Surya Kund a Religious Pond Located in Gaya Town of Bihar, India**

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### **Abstract**

The present study deals with the investigation related to physico-chemical characteristics of water of the Surya kund, a religious pond located in Gaya Town of Bihar, India. Besides temperature, 17 other limnological parameters have been studied following standard methods for sampling at 3 different sites of the pond. The physico-chemical parameters like transparency, pH, DO, BOD, COD, free CO<sub>2</sub>, total alkalinity, conductivity, CaCO<sub>3</sub>, TSS, TDS, Chloride, Ammonia, Nitrite, Nitrate, Phosphate, etc. have shown distinct temporal and seasonal variations during the study period of the pond. Higher nutrient contents like nitrate and phosphate were observed to be present in the pond. The results of water transparency, dissolved oxygen, BOD, COD, CO<sub>2</sub>, total alkalinity, conductivity, CaCO<sub>3</sub>, hardness, TSS, nitrate and phosphate were correlated with various physico-chemical parameters in the pond. The physico-chemical quality of water of the pond revealed the poor water quality standards. These specific characteristics indicated towards the contamination of water due to a number of factors including local resident's sewerage outlet and leaving behind of the worship materials like flowers, garlands, disposal of incomplete burnt worship (hawan) materials, fruits as offerings, leafs etc. as organic matter in the pond. The two years (February, 2012 - January, 2014) of survey reflects higher degree of pollution in the pond.

*Key words:* Physico-chemical study, Surya Kund Gaya, Nutrient contents, BOD,COD, Hardness.

## Introduction

Water is one of the most essential natural resource for life of humans and other living organisms after air. The availability of fresh water for human consumption is limited in quantity on the earth. Adding to the problem is the increasing evidence that chemical wastes and sewage improperly discarded are showing up in our water today.

The religiously important Gaya Town is the district headquarters of Gaya district and the headquarters of Magadh Division of Bihar state. Gaya has its geographical position as 24° 46' 60N latitude, 85° 01' 0E longitude and average altitude of 111 meters (364 ft), situated in South Bihar on the bank of revered river the Falgu. The river Falgu is known since prehistoric times for performing on its banks the rituals of "Pind Daan" or oblation, a holy ritual offered by the Hindus to ensure peace (Moksha) for the departed souls of their ancestors.

The ponds in Gaya are perennial in nature. They are not only important for performing rituals with the pond water after a dip bath, rather they are also used as water bodies for bathing and other domestic purposes by the local population (mostly people belonging to lower strata and lower income group along with poor literacy rates) living since long back around these ponds. The objective of the present work is to study the water quality a prominent pond namely the Surya Kund.

Water of this pond is feared to have got polluted due to dip bath of large number of pilgrims who come to perform Pind Daan at its bank. Moreover, this pond becomes most visited

place on the occasion of the Chhath Puja by the local population, which falls some times in the month of November every year. People do not only take dip in these ponds rather dispose flowers, fruits and other puja ingredients out of religious belief. These activities of large number of pilgrims and locals are sure to affect the quality of water of this pond.

Although a number of investigations have been made by the researchers but a little information is known about the systematic limnological studies in water bodies of south Bihar. It is important to note that no qualitative, quantitative or ecological study on limnology was made so far from religious ponds of Gaya town. The Surya Kund situated in the thickly populated area receives various types of sewage *i.e.*, domestic sewage, cattle shed sewage etc. Hence an attempt into the limnological investigation in relation to the different physico-chemical characteristics of water of the Surya Kund was undertaken in the present investigation for a period of two years (February, 2012 - January, 2014).

### *Sampling sites:*

To study the limnological changes, regular sampling of water was done fortnightly during the period starting from February 2012 to January 2014 from three distinct selected sites of the pond:

*Site one (T<sub>1</sub>):* This site is located at the entrance from the western side of the pond where several sewage points were observed.

*Site two (T<sub>2</sub>):* This site is located just at the middle point of southern side where no sewage is observed at all.

*Site three (T<sub>3</sub>):* This site is located at the eastern side of the pond where quite a few major sewage points are located.

#### *Data collection and analysis of water :*

Air temperature was recorded by a digital centigrade thermometer (-50°C to +150°C) on the d sampling dates. Water samples were collected fortnightly in clear plastic bottles from surface (max. 20 cm deep) and vegetated zone of three different sites of the pond. Water samples were collected in three replicates from surface, column and bottom of each site and mean values of all three observations were taken into consideration. For BOD estimation, water samples were collected separately in dark glass bottles. Among physico-chemical parameters like water temperature, pH, DO, free Carbon-dioxide, total alkalinity and conductivity, some of them were measured at the site while some other parameters were tested within 24 hrs of collection from the sites.

#### *Analysis of water sample :*

A total of 17 limnological parameters of water viz., temperature, transparency, pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, free Carbon-dioxide, total alkalinity, conductivity, CaCO<sub>3</sub> hardness, total suspended solid, total dissolved solid, chloride, ammonia, nitrite, nitrate and phosphate were determined at PG Department of Environmental science, A.N. College Patna. All the parameters were analyzed following the standard methods<sup>1-3</sup> APHA<sup>4</sup>.

## **Results**

### **Climatic condition in different tropical**

countries as well as in India three distinct seasons are usually observed. They are - pre monsoon (summer), monsoon and post monsoon (winter). In Gaya Bihar, pre monsoon (March - June) is characterized by comparatively higher range of air temperature, longer day time and very occasional rain/storm. The monsoon season (July - September) has a higher humidity value and usually normal rainfall. It has relatively shorter day time. On the other hand the post monsoon period (October - February) is characterized by lower range of air temperature, shorter day time and to some extent lower precipitation.

#### *Physico-chemical characteristics of water of Surya Kund Gaya:*

The average range and monthly variations of different physico-chemical characteristics of water of the Surya Kund Pond are represented in Table (1). The water temperature followed the same trend at all three sites of the pond. Trend of monthly fluctuation in the surface water temperature was exactly identical to that of the atmospheric temperature. The temperature remained at minimum during the winter season (around 17°C) while it increased to a maximum (around 35°C) during the summer season. The temperature was observed to be highest (35.22°C) during the beginning of study period (May, 2012) at site T<sub>2</sub>.

The transparency did not show any definite seasonal pattern at three sites. It was observed to be very low (21.75 cm) in June, 2012 at site T<sub>3</sub> but increased slightly during winter season. The pH had been found to be highest at the beginning of the study. The value ranged from 7.04 to 8.63. It increased slightly during the following rainy season.

The dissolved oxygen content was observed to be maximum at site S<sub>2</sub>. The dissolved oxygen value ranged from 2.41 mg/l (site T<sub>2</sub>) to 8.67 mg/l (site T<sub>3</sub>). The value of dissolved oxygen decreased during summer and increased in winter season.

BOD values ranged from 9.17 mg/l at site S<sub>2</sub> during February, 2012 to 60.03 mg/l at site S<sub>3</sub> during June, 2013. BOD values became higher during the summer months and its value was lower at site T<sub>2</sub> with respect to values at site T<sub>1</sub> and T<sub>3</sub>. Increased BOD values were further observed in the second year of our study.

The chemical oxygen demand was minimum in February, 2012 (38.3 mg/l) at the site T<sub>2</sub> and maximum in summer (266 mg/l) at the site T<sub>3</sub>. However, the values were comparatively higher during the summer periods.

The value of free CO<sub>2</sub> recorded upper value during the summer period (11.24 mg/l at site T<sub>3</sub>). The high values of total alkalinity were observed during summer and rainy season. It was lower in winter season at all three sites of observation. Highest value was observed at site T<sub>3</sub> (237 mg/l) in July, 2013 and lowest value was recorded at site T<sub>2</sub> (130.09 mg/l) in February, 2012.

The conductivity value varied from 409.19 µmhos/cm at site T<sub>2</sub> in February, 2012 to 1532.73 µmhos/cm at site T<sub>3</sub> in July, 2013. In general it was higher at T<sub>1</sub> and T<sub>3</sub> sites in comparison to the T<sub>2</sub> site. Conductivity decreased

during winter season followed by progressive increase during summer.

The CaCO<sub>3</sub> hardness value of was higher at T<sub>1</sub> and T<sub>3</sub> sites with respect to T<sub>2</sub> site. The maximum mean value was recorded during summer (300.01 mg/l) at T<sub>3</sub> site which had a decreasing trend in monsoon and was lowest in the winter. The lowest CaCO<sub>3</sub> hardness value was observed at T<sub>2</sub> site (137.65 mg/l) in the month of November, 2013. The maximum value was observed in summer at T<sub>3</sub> site (256.04 mg/l) and the minimum value was recorded in the winter at T<sub>2</sub> site (109.72 mg/l).

Total dissolved solids (TDS) value was observed to be at minimum during monsoon and at maximum during the summer season.

The chloride content findings at three observation sites showed little variation during the winter and early summer seasons. Its sharp increase during the summer months was observed distinctly at T<sub>1</sub> site, found to be 89.79 mg/l at T<sub>2</sub> site it was 192.18 mg/l, but at the later site the observed value declined abruptly during the rainy season.

The values of ammonia increased sharply from winter season months to summer season months. Nitrite did not show any definite seasonal pattern at all three sites. The nitrate content at three sites remained at maximum during winter and decreased with the beginning of the summer. The phosphate content at three sites was observed to be highest during summer season and decreased steeply through the rainy season.

Table 1  
Physico-chemical characteristics of water of the Surya Kund Gaya  
(February, 2012 - January, 2014)

Physico-chemical Characteristics	Range	Surya Kund Pond Gaya Mean±S.D.
Water temperature (°C)	17.02- 35.22	27.31±3.47
Transparency (cm)	21.75 - 84.69	57.13 ± 7.95
pH	7.04 - 8.63	7.46 ± 0.50
DO (mg.l <sup>-1</sup> )	2.41 - 8.67	5.98 ± 1.60
BOD (mg.l <sup>-1</sup> )	9.17 - 60.03	30.48 ± 6.25
COD (mg.l <sup>-1</sup> )	38.30 - 266.00	163.32 ± 31.48
Free CO <sub>2</sub> (mg.l <sup>-1</sup> )	0.00 - 11.24	4.09 ± 1.11
Total alkalinity (mg.l <sup>-1</sup> )	130.09 - 237.00	181.14 ± 32.16
Conductivity (μmos.cm <sup>-1</sup> )	409.19 - 1532.73	901.31 ± 101.88
CaCO <sub>3</sub> hardness (mg.l <sup>-1</sup> )	137.65- 300.01	227.81± 30.01
Total suspended solid (mg.l <sup>-1</sup> )	106.72-254.62	196.49 ± 659.04
Total dissolved solid (mg.l <sup>-1</sup> )	317.67- 798.56	570. 18 ± 72.31
Chloride (mg.l <sup>-1</sup> )	55.10-191.33	130.91 ± 30.21
Ammonia (mg.l <sup>-1</sup> )	0.21-8.33	3.12 0.30
Nitrite (mg.l <sup>-1</sup> )	0.05-0.35	0.16 ± 0.12
Nitrate (mg.l <sup>-1</sup> )	0.16-2.91	1.10 ± 0.26
Phosphate (mg.l <sup>-1</sup> )	0.16 -3.13	1.29 ± 0.30

## Discussion

The water and air temperature is found to go more or less hand in hand presumably due to standing water and relatively small size of the water body. According to Welch<sup>5</sup> smaller the body of water, more quickly it reacts to changes in the atmospheric temperature. The effect of air on the water temperature did seem to affect the mixing of water body where stratifications clearly developed during summer and winter with a spring and autumn overturn.

Transparency of water in the pond was at minimum during summer while maximum values were observed in the post monsoon months respectively. At T<sub>1</sub> and T<sub>3</sub> sites the

transparency values of water is observed to be low. It may be due to inflow of sewage effluents. It is known that low values were primarily due to turbidity and it may be due to suspended particles carried by inflow of sewage effluents in the pond.

pH of the pond remained mostly alkaline throughout the period of investigation. It virtually showed very little variation on monthly basis. It has reported that the high pH is associated with the phytoplankton maxima<sup>6</sup>. Similarly, dissolved oxygen showed a very clear picture in these observations The increase of oxygen during winter months as in the present study could be attributed to low temperature<sup>7</sup>. The oxygen deficit during summer

is a characteristic feature of a productive wetland<sup>7,8</sup>. Thus the results of oxygen content during summer in Surya Kund indicates the nature of this pond. Increase in organic decomposition plays the active role in oxygen content in nutrient rich tropical wetland where organic pollution is high and has very little oxygen dissolved in them<sup>9,10</sup>. This observation supports the findings in the Surya Kund. However, oxygen holding capacity of water reduces at higher temperature.

The BOD values indicate that the pond can be placed in a wetland category, *i.e.*, eutrophic<sup>11</sup>. Maximum values of BOD have been recorded in summer and in general it is found that the water of sewage sites has higher BOD values. Low values of BOD in winter may be due to lesser quantity of total solids/dissolved solids/suspended solids. The present observation agrees with the findings<sup>12-14</sup>.

The COD values convey the quantity of organic matter in the water which have been oxidised. The increase of COD during summer is correlated with the decomposition of suspended organic matter which releases the soluble organic matter in the water. This type of relationship is also been observed by several researchers<sup>15-18</sup>. The decrease in COD during the rainy season is due to dilution of dissolved organic matter. The high value of COD in the Surya Kund Pond of Gaya during summer season is due to low water level and high decomposition rates.

Free CO<sub>2</sub> in the water body, generally appears when the oxygen remains low or absent. The minimum value of CO<sub>2</sub> was observed in January. The peak value of this parameter

was observed in the months of summer, which might be due to decomposition of organic matter by microbes in the bottom resulting in the rapid production of free Carbon-di-oxide as has also been reported by several researchers<sup>19,20</sup>.

The increase in total alkalinity during summer months appears to be due to the concentration of nutrients in water. It is observed that alkalinity is inversely related with the level of water<sup>21</sup>. During the winter season, due to slow rate of decomposition of organic matter, CO<sub>2</sub> production is in less quantity. Dilution plays an important factor in reducing the alkalinity values. The total alkalinity remains always higher in eutrophic water<sup>22</sup>.

Water becomes a conductor of electricity when minerals and other inorganic substances are dissolved in it and the conductivity is proportional to the amount of dissolved substances. The present observation about the relationship between conductivity and TDS is very much similar to the findings<sup>23</sup>. Conductivity decreased during winter followed by progressive increase in summer. Conductivity value was maximum in May-June when the water level in the pond was at its minimum level.

The maximum values of CaCO<sub>3</sub> hardness were recorded during summer season which had a decreasing trend in monsoon and reached at lowest values in winter season. During winter season the decomposition rate of organic matter decreases and as a result CO<sub>2</sub> is not liberated into the aquatic medium. Generally decrease in the hardness of water depends with the advent of rains and accordingly it increases with the decrease in water levels.

Total suspended solid and total dissolved solid values were maximum in summer and minimum in winter. The value of total suspended solid and total dissolved solid was high in the pond. It may be due to receiving the sewage water and suspended substances from the surrounding areas.

Pre monsoon observations recorded highest chloride values when water level was at its low level followed by monsoon and post monsoon observations with high water levels. The rise of chlorides level is due to increase in summer temperature and subsequent evaporation. The high amounts of chloride in freshwaters have been considered generally due to pollution. High concentration of chloride content reflects the increasing pollution in the pond.

Ammonia is generally present in the aquatic ecosystem as the dissociated ammonium ion ( $\text{NH}_4^+$ ). The highest ammonia content is also observed to correspond with the period of high decomposition rate. The presence of higher amounts of ammonia and ammonium compounds is the indication of sewage fed polluted water bodies. In this study, the value of ammonia is higher confirming a high degree of pollution by organic matter in the pond. Nitrite is an intermediate compound of nitrogen reduction or ammonia oxidation and mostly found in the sewage contaminated water bodies. Due to very unstable nature of nitrite it shows no definite pattern of seasonal cycle formation. However, within an aquatic system nitrate is primarily of animal origin as the tropical waters, particularly unpolluted ones are deficient in nitrates. In the Surya Kund the nitrates are relatively much higher than the limit. Nitrate value was higher in winter and

lower in summer. It is difficult to draw any correlation of nitrates with any other physico-chemical factors while the nitrates are a prime index for immediate fertility of water. These findings confirm the present observations also. Among the major nutrients, the importance of phosphates in water bodies is well documented. It is reported that the addition of phosphate brings about an eutrophication mechanism by increasing the bacterial content, increase in oxygen demand, increase in production of growth factors for the algae and lastly the increase in growth of algae<sup>24</sup>. The increased phosphate levels also indicate higher degree of pollution. Higher amount of phosphate in Surya Kund during summer season may be due to the concentration of nutrients in water and possible release of phosphate from sediments. The nitrate - phosphate ratio (N:P) in water body could be used diagnostically to indicate the degree of pollution by sewage. The N: P ratio can also be used to show the recovery rates after the diversion of the sewage from the water bodies. The present observations are in conformity with these findings.

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