Monthly variation and interrelationship of physicochemical characteristics of a perennial pond at a biological park in Patna, Bihar, India

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Abstract
The present study was designed to observe the monthly variation and interrelationship among the physicochemical characteristics of the surface water of a perennial pond situated at Biological park also known as Sanjay Gandhi Jaivik Udyan, Patna. The different physicochemical parameters was determined for the period of two years i.e from May, 2016 to April, 2018 to analyse the pond water quality. The maximum value of water temperature, transparency, total solids, total suspended solids, turbidity, pH, conductivity, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total alkalinity, chloride, total hardness, calcium hardness, magnesium hardness, nitrate, inorganic phosphorus, sodium, potassium were found as 32.6 ± 0.24 °C; 24.57 ± 0.18 cm; 1510.66 ± 4.50 mg/l; 1210 ± 0.89 mg/l; 478.33 ± 2.11 mg/l; 37.46 ± 0.22 NTU; 8.54 ± 0.0245; 542 ± 11.57 µ S cm⁻¹; 101.2 ± 0.089 mg/l; 8.54 ± 0.0245; 542 ± 11.57 µ S cm⁻¹; 101.2 ± 0.089 mg/l; 19.13 ± 0.088 mg/l; 13.68 ± 0.004 mg/l; 1.43 ± 0.0078 mg/l; 7.726 ± 0.025 mg/l, 4.81 ± 0.215 mg/l respectively during the study period. This study therefore gives insight about the existing health of the pond and will be helpful to take suitable measure by the authorities to maintain the healthy environment and wholesomeness of the pond.

Keywords: Interrelationship, Monthly variation, Physicochemical characteristics, Pond

INTRODUCTION
Freshwater is a paramount natural resource and a valuable natural asset (Mohan et al., 2013). It is crucial source for the existence of entire living organisms (Smitha et al., 2007). Unrestrained increase in human population and rapid urbanisation in all over the world is placing great stress upon freshwater resources (Bano et al., 2016). In India, most of the freshwater bodies are not only utilized for drinking purposes, fisheries, navigation, aquifer replenishment, recreation, electric power production, and support of biodiversity but are also used as a place to dispose effluents and solid wastes (Barai and Kumar, 2012, Deshmukh, 2012 and Majumder and Dutta, 2014). In India, since times immemorial, ponds are used to conserve and store water. Pond is significant for environment and also essential for ecological community because it supports aquatic biodiversity, has large carbon sequestration capacity, regulates temperature and humidity (microclimate regulation), ground water recharge, rain water harvesting and other beneficial effects such as aquaculture (Kumar and Padhy, 2015).

The physicochemical characteristic indicates the quality of water in relation of all hydrological properties. Analysis of physicochemical properties of water present limnological conditions and contributes in environment protection process (Verma et al., 2012, Patel and Parikh, 2013, Uddin et al., 2016). A number of workers have done their works on physicochemical parameters of pond water (Paul and Mukherjee, 2006, Chaurasia and Pandey, 2007, Kiran, 2010, Mondal et al., 2011, Prasath et al., 2013, Bhavimani and Puttaiah, 2014, Swarnakar and Choubey, 2016, Kumari and Singh, 2016, Harmoko and Krisnamwati, 2019). The present investigation will gather adequate baseline data to explain contemporary limnological circumstances of the pond as there are many researchers who monitored physicochemical parameters of various ponds at Patna district but almost no work has been reported regarding water quality of Sanjay Gandhi Jaivik Udyan pond. Paul and Sanyal, (2017) studied the seasonal variation of physicochemical characteristics of Sanjay Gandhi Jaivik Udyan pond, Patna (Bihar) India for one year. The objective of the present study was to observe the monthly variation in the pond for the period based on the investigations of two consecutive years i.e. from May, 2016 – April, 2018.
which offers detail perspectives about the ideal levels of parameters necessitated to maintain biodiversity and productivity level of the pond for commercial fisheries.

MATERIALS AND METHODS

Study area: This study was conducted on the pond situated at Sanjay Gandhi Jaivik Udyan Patna, Bihar, India. This pond receives large amount of allochthonous matter (animal sewage, detergents, soaps, run off etc.) from the zoo campus. Three sampling stations were selected in the pond to get an idea of overall situation of the pond. The geographical location of pond is 25°59.6513′N and 85°09.9304′E. Climatic condition of Patna is tropical having three distinct seasons: winter (December to February), summer (March to June), monsoon (July to September), post-monsoon (October – November).

Sampling was done monthly for the period of two years from May 2016 to April 2018 using standard methods suggested in APHA, AWWA and WEF (2005). Water samples were collected during the early hours within 9:30 to 10:30 am from the three spots. Average values of the parameters were considered for evaluation. The physicochemical parameters including temperature (atmospheric and water), pH, transparency, specific conductivity, total solids (TS), total dissolve solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), free carbon dioxide, total alkalinity, total hardness, chloride, inorganic phosphorus, nitrate, sodium, potassium, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) of the pond were studied.

Surface water temperature was measured on the sampling spots using a celsius-thermometer graduated up to 110°C (accuracy 0.1°C). Transparency was measured using Secchi disc. Specific conductivity was measured by conductivity meter (Ecotester EC low). Turbidity was recorded using Nephelometer (Systronics digital nephelo-turbidity meter, Model:132). Total solids, total dissolved solids and total suspended solids were estimated using gravimetric method.

pH of the water sample was measured using pH meter (Waterproof pH tester® 10, Eutech instruments). Dissolved oxygen was estimated using standard Winkler’s titration method. Total alkalinity, chloride, total hardness, calcium and magnesium hardness, were analysed by titration method.

Biochemical Oxygen Demand was measured using five days incubation process. Chemical Oxygen Demand was determined using condensation, digestion and titration method. Nitrate and inorganic phosphorous were measured using UV-Vis Spectrophotometer (Model:104 Systronics Ltd., India). Sodium and potassium can be determined accurately by flame photometer (Systronics flame photometer, Model:128). All observations were taken into triplicates.

Statistical analysis: All the computations and calculations of statistical analysis were performed by the methods of Zar (2007), MS excel 2007 and statistical software SPSS Ver 21.0.

RESULTS AND DISCUSSION

The result of monthly variation in physicochemical properties of surface water of Sanjay Gandhi Jaivik Udyan pond are average values of three sites of the pond which depicts the overall situation.

Water temperature: Water temperature has a high influence on the quality of water. It accelerates or slows down the rate of the chemical reactions which takes place in aquatic water bodies (Paul and Mukherjee, 2006; Wilde, 2006). Water temperature was always found lower than the atmospheric temperature. Water temperature showed significant positive correlation with atmospheric temperature (r = 0.975) at the Sanjay Gandhi Jaivik Udyan pond water, which indicates water temperature is affected by atmospheric temperature (Table 1). Monthly water temperatures of Sanjay Gandhi Jaivik Udyan pond recorded from May 2016 to April 2018 indicate that variation of temperature was seasonal, as it rose in summer and fell in winter (Fig. 1). Mean water temperature of two years was found to be 24.225 ± 1.26 °C. The values of water temperature ranged from 12.8 ± 0.2 °C (in January, 18) to 32.6 ± 0.24 °C (in June, 17) (Fig. 1). From the month of March to August gradual increase in water temperature was observed due to increase of solar radiation and analogously prolong day length. Likewise, a systematic decrease in incident sunlight and other climatic factors like cloud coverage explain fall in temperature from months of October (season) to February (winter) and form April onwards again the water temperature increased gradually.

Transparency: Transparency of water body signifies the depth up to which the light can penetrate. Transparency is highly variable and helps to determine the productive zone of water body. From May, 16 to April, 18, the maximum value of transparency recorded in winter season, December, 16 was 24.57 ± 0.18 cm and minimum value of transparency recorded in monsoon season, July, 17 was 16.95 ± 0.62 (Fig 2). The mean value of transparency from May, 16 to April, 18 was 21.47 ± 0.46 cm. Light penetration depends partly on the light flux but mainly on the optical properties of water. The reduced transparency during monsoon months was appeared to be associated with the presence of suspended inorganic substances such as silts and clay in large quantity, which began to settle down after the monsoon and transparency tended to increase through post monsoon and winter months; and finally water bodies, transparency usually decreases also during summer.
months due to reduced water level and disturbances of the basin. (Ohol and Kamble, 2011) have also observed similar results in Ganesh Tank, Miraj, Sangli district of Maharastra. Transparency showed significant negative correlation with turbidity ($r = -0.935$), pH ($r = -0.564$), total dissolved solids ($r = -0.790$), total suspended solids ($r = -0.605$), total solids ($r = -0.935$) (Table 1). Increase in concentration of total dissolved solids, total suspended solids, total solids and turbidity makes water opaque due to addition of clay, silt, and other organic matter thereby reducing the transparency.

**Total solids:** The total solids can be determined by adding up of suspended as well dissolved solids present in water (Qureshimatva et al, 2015). Increased concentration of TS lowers the transparency in water. TS in Sanjay Gandhi Jaivik Udyan pond was recorded from May 2016 to April 2018 (Fig. 3). From May, 16 to April, 18, the lowest value of TS recorded during winter season in December, 16 was 604 ± 2.25 mg/l and from the highest value of TS recorded during monsoon season in July, 17 was 1510.66 ± 4.50 mg/l (Fig 3). Round the year average TS from May, 16 to April, 18 was 1002.944 ± 50.414. Total solids showed significant negative relation with transparency ($r = -0.957$), and significant positive relation with total alkalinity ($r = 0.667$), inorganic phosphorous ($r = 0.550$), sodium ($r = 0.530$), total suspend-
Table 1. Correlation between the physicochemical parameters of Sanjay Gandhi Jaivik Udyan pond.

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**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)
ed solids \( r = 0.630 \), total dissolved solids \( r = 0.823 \), turbidity \( r = 0.966 \) (Table 1). Nutrient status of pond also increases with increasing TS.

**Total dissolved solids:** Water is often called the universal solvent. Large numbers of minerals, metals, organic matters, inorganic salts mainly calcium, magnesium, sodium, potassium, chlorides etc., (size: less than 2 microns) are dissolved in it (Charkhabi and Sakizadeh, 2006). TDS in drinking water originate from sewage and wastewater. Total dissolved solids showed significant positive relation with water temperature \( r = 0.502 \), total alkalinity \( r = 0.594 \), total solids \( r = 0.823 \), sodium \( r = 0.434 \), turbidity \( r = 0.774 \) (Table 1). The trend of monthly variation of total dissolved solids (TDS) of Sanjay Gandhi Jaivik Udhyang pond was similar to the trend of monthly variation of TS. From May, 16 to April, 18, the lowest value of TDS recorded during winter season in December, 16 was 211.33 ± 1.437 mg/l and, the highest value of TDS recorded during monsoon season in July, 17 was 1210 ± 0.89 mg/l (Fig 3). Round the year average TDS from May, 16 to April, 18 was 785.91 ± 37.79. It may be due to the addition of the allochthonous matter in the pond.

**Total suspended solids:** Total suspended solids (TSS) are the solids which drift or float in the water. It can include sediment, sand, clay, silt, gravel, planktons etc. These solids are too light to get settled at the bottom of the pond. Bathing in water with high TSS is not suitable Gay and Proop, (1993). Total dissolved solids showed significant positive relation with water temperature \( r = 0.502 \), total alkalinity \( r = 0.594 \), total solids \( r = 0.823 \), turbidity \( r = 0.774 \) (Table 1). Monthly variation in total suspended solids (TSS) of Sanjay Gandhi Jaivik Udhyan pond was recorded from May 2016 to April 2018 (Figure 3). From May, 16 to April, 18, the highest monthly value of TSS recorded during monsoon season in July, 16 was 478.33 ± 2.11 mg/l the lowest value of TSS recorded during summer season in April, 16 was 31 ± 1.18 mg/l (Fig 3). Round the year average TSS from May, 16 to April, 18 was 219.027 ± 29.0390 mg/l.

**Turbidity:** Turbidity is the amount suspended matter present in any aquatic body, because of which the aquatic body loses its transparency. Higher the concentration of total suspended solids, higher will be the turbidity. Suspended solids include silt, clay, sand, planktons, waste water etc. The mean value of turbidity was found to be 33.027 ± 0.5529 NTU which ranged between 37.46 ± 0.22 NTU to 29 ± 0.44 NTU where lowest concentration of turbidity was recorded during summer season in April, 16 and the highest value of turbidity recorded during monsoon season in August, 17 (Fig 4). In monsoon season the concentration of TDS show increasing trend because huge amount of allochthonous matter from the

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Conductivity: Conductivity of water signifies about its extent to pass electric current. It depends on various factors like valence of ions, concentration and mobility of ions, temperature etc. (University of Virginia Physics Department, 2003, Qureshimatva, 2015, Paul et al., 2015). Conductivity in water is due to ionization of dissolved inorganic solids. Pure water has zero conductivity. In the present study, the maximum value of conductivity recorded during summer season in May, 17 was 542 ± 0.966, total solids (r = 0.774), total suspended solids (r = 0.635) (Table 1). More the suspended particles present, more will be the turbidity. This confirms the correlation between turbidity and total suspended solids. As concentration of turbidity is inversely proportional to clarity of water, more the turbidity, lesser the clarity of water or transparency.

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pH: The pH is a measure of concentration of H⁺ ions in water, therefore it helps to determine acidity as well as alkalinity of water. pH is important limiting factor for aquatic organisms. The pH of pond water of was slightly alkaline (Fig 5). pH increased in winter months but decreased in summer months. From May, 16 to April, 18, the highest value of pH recorded in May, 16 was 8.54 ± 0.0245 (summer) and lowest value of pH recorded in January, 17 was 7.96 ± 0.0245 (winter) (Fig 5). The average value of pH of two year study was 8.22 ± 0.0392. Most of the ponds and lakes of India are alkaline in nature (Sharma et al.,1984). Slight seasonal changes indicate well acid-base buffering capacity (Hagens et al. 2015). pH is associated with photosynthesis in water. High pH value signifies high photosynthetic activity as pH value increases with the extraction of carbon dioxide from water. It also promote the growth of algae. Similar to this study, higher level of pH was observed during the summer season by (Jagher and Rawat, 2003) in tropical lake of Jodhpur, Rajasthan, India. pH showed high significant positive correlation with conductivity (r = 0.644), total alkalinity (r = 0.870), chloride (r = 0.833), hardness (r = 0.892), sodium (r = 0.895), potassium (r = 0.908), nitrate (r = 0.914), inorganic phosphorus (r = 0.870) (Table 1) which indicate discharge of waste water into the pond.

BOD: Biological Oxygen Demand (BOD): Biochemical oxygen demand (BOD) is a measure of the amount of oxygen needed by microorganisms to decompose the organic matter. BOD was analyzed on monthly basis between May 2016 to April 2018 (Fig 7). The average BOD from May, 16 to April, 18 was found to be 12.34 ± 0.26 mg/l. The range of BOD was recorded as 6.73 ± 0.074 mg/l to 2.24 ± 0.035 mg/l (maximum value was observed during monsoon season in July, 16 and minimum value was recorded during post-monsoon season in September, 16) (Fig 7). The highest demand of oxygen in the water was recorded during monsoon season was due addition of waste water. The observed values of BOD suggest that this pond is moderately polluted. Yadav et al., (2013) also found similar results in fresh water pond of Orai, U.P., Central India as ob-
observed in the present study. Biological Oxygen Demand showed significant positive correlation with water temperature ($r = 0.553$), chemical oxygen demand ($r = 0.527$), hardness ($r = 0.501$), calcium hardness ($r = 0.526$), magnesium hardness ($r = 0.512$), sodium ($r = 0.505$) and negative correlation with dissolved oxygen ($r = -0.478$) (Table 1). Bacteria present in the water consumed the dissolved oxygen to degrade the organic matter present in water. When concentration of biological oxygen demand is high, the concentration of dissolved oxygen levels decreases, this proves the strong negative correlation between biological oxygen demand and dissolved oxygen.

**Chemical Oxygen Demand (COD):** The Chemical Oxygen Demand (COD) in a water body measures the amount of oxygen needed to oxidise the inorganic chemicals present. COD showed significant positive correlation with Biological Oxygen Demand ($r = 0.527$). The average concentration of COD from May, 16 to April, 18 was found to be $12.34 \pm 0.267$ mg/l (Table 1). The value of COD ranged from $9.656 \pm 0.049$ mg/l to $14.27 \pm 0.114$ mg/l (minimum value was observed during winter season in January, 17 and maximum value was observed during post monsoon season in October, 17) (Fig 7). (Nag and Gupta, 2014) also found similar results in various ponds located in Santiniketan, West Bengal, India as observed in the present study.

**Total alkalinity:** As per (Bheemappa et al., 2015), "total alkalinity is a measure of the substances in water that have acid-neutralizing ability". There are various factors that affect total alkalinity these include hydroxide ions, bicarbonates, carbonates etc. (Lodh et al., 2014, and Paul et al., 2010, 2014). The variation of total alkalinity was seasonal, as it rose in summer and fell in winter (Fig 8). The average total alkalinity from May, 16 to April, 18 was found to be $211.11 \pm 7.94$ mg/l. The range of total alkalinity was recorded as $150.267 \pm 0.13$ mg/l to $269.36 \pm 0.157$ mg/l (minimum value in winter season, January, 18 and maximum value in summer season, May, 17) (Fig 8). During summer season, because of high degradation of plants, organisms and organic waste, concentration of carbonate and bicarbonate thereby alkalinity also increased. (Mondal et al., 2011) has also observed a similar result in a pond of Burdwan Municipality, Burdwan, West Bengal, India. Total alkalinity exhibited significant positive correlation with pH ($r = 0.870$), chloride ($r = 0.6750$), conductivity ($r = 0.644$), total hardness ($r = 0.826$), calcium hardness ($r = 0.762$), magnesium hardness ($r = 0.742$), nitrate ($r = 0.809$), inorganic phosphorus ($r = 0.823$), sodium ($r = 0.749$), potassium ($r = 0.781$), total solids ($r = 0.667$), total dissolved solids ($r = 0.594$), turbidity ($r = 0.704$) (Table 1).

**Chloride:** Chloride ions in water bodies are ubiquitous in nature. In freshwater it is found in low concentration, that may be due to natural or anthropogenic causes. Water softeners to remove calcium and magnesium ions, sewage contamination, and fertilizers like potassium chloride are primarily responsible for addition of chloride ions in water. Low concentration of chloride does no harm but at higher concentration osmoregulation in aquatic organisms gets disturb. In the present study mean value of chloride from May, 16 to April, 18, was $52.50 \pm 1.63$ mg/l. The lowest value of chloride was recorded in winter season, in the month of January, 17. It was found to be $36.59 \pm 1.35$ mg/l and the highest value of chloride recorded in summer season, May, 17 was $63.51 \pm 0.13$ mg/l (Fig 8). Low concentration of chloride might be due to absence of agricultural activities near the sampling sites and absence of rocky soils (Costa et al., 2015, Richter and Netto, 1991). The highest value of chloride content was reported in summer season. This is mainly due to run-off containing sewage from the campus of the Sanjay Gandhi Zoological park and evaporation of water.

**Total hardness, Calcium Hardness and Magnesium Hardness:** Calcium and magnesium ions are main responsible factors for hardness. It also caused by iron, aluminium, zinc, manganese, barium and strontium, but due to their small concentrations they do not significantly contribute to the total hardness. In this study the mean total hardness of Sanjay Gandhi Jaivik Udhyan pond was found to be $241.347 \pm 9.29$ (Fig 9). From May, 16 to April, 18, the maximum value was recorded during winter season in January, 17 was $333.33 \pm 2.581$ mg/l and the minimum value of total hardness was recorded during summer season in May, 16 was $163 \pm 1.18$ mg/l (Fig 9). High concentration of total hardness in summer season may be due to the regular addition of sewage of animals of the zoo and detergents and soaps used by the
visitors. Low concentration of total hardness in winter season is due to minimum concentration of carbonates and bicarbonates of calcium which shows is due to the less pollution. (Patil and Ti-jare, 2001) have observed similar results in God-chirol Lake, India. Hardness showed significant positive correlation with conductivity (r = 0.867), biological oxygen demand (r = 0.501), total alkalinity (r = 0.826), chloride (r = 0.873), calcium hardness (r = 0.857), magnesium hardness (r = 0.884), nitrate (r = 0.846), inorganic phosphorus (r = 0.826), sodium (r = 0.857), potassium (r = 0.924) (Table 1). The total hardness shows strong correlation coefficient with calcium and magnesium hardness in the water because the two main cations that make water hard are calcium (Ca$^{2+}$) and magnesium (Mg$^{2+}$). Calcium and magnesium ions contribute to bone and scale formation in fish. Calcium helps in active regulation of osmotic pressure in the fluids in aquatic organisms. It maintains accurate levels of salts in aquatic organisms for usual function of heart, kidney, muscle and nerve. (Prasath et al., 2013 and Lalitha et al., 2004). Deficiency of calcium can cause reproductive problems in animals. In this study variation in calcium hardness of Sanjay Gandhi Jaivik Udhyon pond was recorded from May 2016 to April 2018 (Fig 9). The mean value of calcium hardness was found to be 73.27 ± 3.08 mg/l which ranged between 48.07 ± 0.020 mg/l to 101.2 ± 0.089 mg/l where lowest concentration of calcium hardness was recorded during winter season in January, 18 and the highest value of calcium hardness recorded during summer season in May, 17 (Fig 9). Monthly variation in magnesium hardness of Sanjay Gandhi Jaivik Udhyon pond was recorded from May 2016 to April 2018 (Fig 9). The mean value of magnesium hardness was found to be 13.06 ± 5.12 mg/l which ranged between 9.26 ± 0.093 mg/l to 19.13 ± 0.068 mg/l where lowest value of magnesium hardness was recorded during summer season in May, 16 and the highest value of magnesium hardness recorded during summer season in January, 17 (Fig 9). Aquatic animals can tolerate wide range of calcium hardness concentrations (Wurts, 2015). Calcium Hardness showed significant positive correlation with total hardness (r = 0.857) and magnesium hardness (r = 0.902), calcium hardness (r = 0.857) (Table 1).

**Nitrates**: Inorganic nitrogen is important for the growth of plants and animals, but excessive concentration of nitrate can cause adverse health effects in aquatic organisms and speed up the growth of algae (Tank and Chippa, 2013). Monthly variation in nitrate of Sanjay Gandhi Jaivik Udhyon pond was recorded from May 2016 to April 2018 (Fig10). The average nitrate from May, 16 to April, 18 was found to be 1.30 ± 0.02. From May, 16 to April, 18, the highest value of nitrate recorded during summer season in May, 16 was 1.56 ± 0.004 mg/l and the lowest value of nitrate recorded during winter season in January, 18 was 1.11 ± 0.0044 mg/l (Fig10). Higher concentration may be due to influx of runoff from the zoo campus containing animal sewage. Many research shows highest value of nitrogen is associated with pollution of animal origin (Hill, 2005). High nitrate value causes algal bloom while nitrate at low level leads to increased lipid content in algae and in turn affect the water ecosystem. In the present investigation nitrate showed a bit lower value than what observed by Gayathri et al., (2013) in Nallugguddda Lake, Bangalore. Nitrate showed significant positive relation with pH (r = 0.914), conductivity (r = 0.646), biological oxygen demand (r = 0.526), total alkalinity (r = 0.809), chloride (r = 0.785), hardness (r = 0.846), inorganic phosphorus (r = 0.915), sodium (r = 0.916), potassium (r = 0.913) (Table 1). Nitrates and phosphates accelerate the growth of aquatic plant and algae. Early growth leads to early death which increases the amount of organic waste in water, which promotes the bacterial decomposition, because of this biological oxygen demand increases.

**Inorganic phosphorus**: Phosphorous in freshwater is predominantly present in inorganic forms. The greatest sources are synthetic detergents, human waste and fertilizers. The higher concentration of phosphorous, therefore, is representative of pollution. In this study the mean inorganic phosphorus of Sanjay Gandhi Jaivik Udhyon pond was found to be 0.60 ± 0.08 (Fig 10). From May, 16 to April, 18, highest value of inorganic phosphorus recorded during summer season in May, 17 was 1.43 ± 0.0078 mg/l and the lowest value of inorganic phosphorus recorded during winter season in January, 18 was 0.105 ± 0.0066 mg/l (Fig 10). Inorganic phosphorus showed significant positive relation with pH (r = 0.876) total alkalinity (r = 0.823), hardness (r = 0.826), calcium hardness (r = 0.858), magnesium hardness (r = 0.798), nitrate (r = 0.915), sodium (r = 0.886), potassium (r = 0.876), total solids (r = 0.550), turbidity (r = 0.556) (Table 1). (Golder and Chattopadhyay, 2016) in a tropical lake of West Bengal and (Lodh et al., 2014) in ancient lakes of Udaipur City, Tripura, India have also observed similar results.

**Sodium**: Sodium is natural constituent of any aquatic body. But due to addition of pollution sources such as precipitation run off, soap solution and detergent from the compound of Sanjay Gandhi Biological park leads to rise in sodium level in the pond. The variation of sodium was seasonal, as it rose in summer and fell in winter (Fig 10). The average value of sodium from May, 16 to April, 18 was found to be 6.35 ± 0.166 mg/l. The range of sodium was recorded as 5.123 ± 0.065 mg/l to 7.726 ± 0.025 mg/l (lowest value in winter season, January, 17 and highest value in
summer season, May, 16) (Fig 10). This is mainly due to influx of waste water from the compound of the biological park. Another reason for the highest value of sodium during this season may be attributed to the fact of reduction in the volume of water of pond due to the process of evaporation. The low concentration of sodium observed in January due to the bioaccumulation by living organisms. Similar observation was also found by (Umerfaruq and Solanki, 2015) in Bibi Lake, Ahmedabad, Gujarat, India. Sodium showed significant positive relation with pH (r = 0.895), conductivity (r = 0.696), biological oxygen demand (r = 0.505), total alkalinity (r = 0.749), chloride (r = 0.851), hardness (r = 0.857), calcium hardness (r = 0.928), magnesium hardness (r = 0.876), nitrate (r = 0.916), potassium (r = 0.887), total solids (r = 0.530), turbidity (r = 0.525) (Table 1). Sodium is strongly correlated with nitrite. This means that most of the sodium may be present as nitrate form (Baudisch, 1921).

Potassium: Potassium is an essential element for both aquatic plants and animal as both surface and ground water bodies contains it APHA, AWWA, WEF, (2005). Potassium maintains the osmotic pressure in the cells of aquatic organisms. Excessive level of potassium restrains the uptake of micronutrients by aquatic plants Cochrane and Cochran, (2009). Potassium showed significant positive relation with pH (r = 0.908), conductivity (r = 0.676), total alkalinity (r = 0.781), chloride (r = 0.842), hardness (r = 0.924), nitrate (r = 0.913), inorganic phosphorus (r = 0.876), sodium (r = 0.887) (Table 1). High organic matter content in pond water and alkaline pH values maintain the moderate concentration of potassium in pond water Sandhya and Benarjee, (2016). Monthly variation in potassium of Sanjay Gandhi Jaivik Udyan pond was recorded from May 2016 to April 2018 (Fig10). From May, 16 to April, 18, the highest value of potassium recorded during summer season in May, 17 was 4.81 ± 0.215 mg/l the lowest value of potassium recorded during winter season in January, 18 was 1.03 ± 0.85 mg/l (Fig 10). The average value of potassium from May, 16 to April, 18 was recorded as 2.75 ± 0.19 mg/l. Similar observation was found by Multu and Kurnaz (2018) in Celtek pond, located in north of Sivas province on the southern slopes of the mountain Celtek, Turkey. At lower concentration potassium is not harmful but at higher concentration potassium can do severe damage to the water quality (Tailing, 2010).

Conclusion
In conclusion, the present study, on water quality parameters at Sanjay Gandhi Jaivik Udyan, Patna showed significant positive correlation between pH, conductivity, total alkalinity, chloride, hardness, sodium, potassium, nitrate, inorganic phosphorus. Some parameters also exhibited strong negative correlation with other parameter. DO exhibited high negative correlation with water temperature, pH, chloride, total hardness, nitrate, inorganic phosphorus, sodium, another negative correlation was observed between transparency and turbidity, pH, total dissolved solids, and total solids. Influx of organic and inorganic material from the biological park enhanced the concentration of total solids, turbidity etc. which reduce the transparency of water. It is therefore necessary to maintain a good pond water quality as per BIS standards as it will help in farming of fishes, that will require manpower, ultimately leading to employment of skilled personnel. Other ways to improve the quality of pond can be stoppage of the influx of sewage water as well as proper management of pet and animal waste.

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