IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

TEMPORAL VARIATION IN WATER QUALITY: A STUDY OF HAGANI POND IN BIRKONA VILLAGE, BILASPUR DISTRICT

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Abstract

The water quality of stagnant water in Hagani Pond, located in Birkona, Bilaspur, Chhattisgarh, was studied from January 2023 to June 2023, spanning a six-month period and covering observations from four different directions: North, South, West, and East. This study focuses on the analysis of physico-chemical parameters, including pH, temperature, total dissolved solids, transparency, dissolved oxygen, biochemical oxygen demand, nitrate, and phosphate in water samples from Hagani Pond in Birkona village. The water quality of these samples was compared against the standard values provided by the World Health Organization (WHO) and the United States Salinity Laboratory, regarding both irrigation and drinking water purposes. The highest recorded pH value was 9.4, observed in July 23 at the inner surface of Hagani Pond, indicating the basic nature of the water at the pond's inner surface. Conversely, the lowest pH value recorded was 8.1 at the S-West peripheral direction. The conductivity of the samples consistently exceeded permissible limits (as defined by WHO) and ranged between 961 to 996 µmho/cm in January 23 and April 23. The total dissolved oxygen (DO) level reached 5.8 mg/l in April 2023 at S-North, while the lowest value of 2.4 mg/l was found at S-East in the same month. The maximum observed biochemical oxygen demand (BOD) value was 9.6 mg/l at the S-inner surface in April 2023. Nitrate ion concentrations in the investigated samples varied from 47 mg/l at the S-inner surface in July to 23 mg/l at S-North in January 2023, which exceeded the permissible limit of 45 mg/l set by WHO. During the study period, results for nitrates indicated that some of the water samples at the inner surface of the pond were slightly polluted due to contamination from agricultural and domestic waste. Correlation analysis measured pH showed a strong positive correlation with Nitrates (r = 0.994) in the West Direction and Electrical Conductivity showed a strong positive correlation with Temperature (r = 0.987), Dissolved Oxygen (r = 0.898) in the North Direction of the pond, and with Total Hardness

(r = 0.973) in the East Direction i.e. as the concentration of EC increased the concentration of Calcium and Magnesium ions also increased.

Keywords: *Physicochemical parameters, Water quality, purification treatment*

Introduction

The quality of water is an important parameter for health, and the areas of major concern to environmentalists due to industrialization, urbanization, and modern agricultural practices have a direct impact on water resources. Surface water is the major source of water for rural people [1]. The aim of the Clean Water Act, which is 'To protect and maintain the chemical, physical, and biological integrity of the nation's waters,' establishes the assessment of both water quality and the habitat required for maintaining living organisms [2]. Day-to-day degradation of the pond and its poor water quality has become a serious problem in rural areas due to religious activities like mass bathing during religious days or immersion of idols into the surface water and water bodies around the small pond. Chhattisgarh, the central state of India, is known for various festivals like Navratri, Durga Puja, Ganesh Festival, Teej, etc. [3], increasing the pollution load in them. In India, religious practices have a deep relationship with water bodies [4]. Birkona is a rural area situated 5 km away from Bilaspur city in Chhattisgarh. Hagani Pond [Figure 1] is located in the eastern part of the village. Rural people use it daily for washing clothes, vehicles, animal bathing, and other domestic activities. Water samples from Hagani Pond were collected from the inner surface of the pond and within 200 meters of the peripheral surface from four directions: North, South, East, and West."

Fig—1 Sampling station in four directions of Hagani Pond

Materials and Methods

Study area and collection of water samples

Surface water samples were collected in Birkona village of Bilaspur city. Each water sample was taken during seasonal months from January to October 2023. The samples were collected in prewashed bottles with detergent, diluted HNO3, and doubly de-ionized distilled water, without any air bubbles. The bottles were tightly sealed after collection and labeled in the field. The temperature, pH, TDS, Electrical Conductivity, and Dissolved Oxygen of the samples were measured at the sampling sites at the time of sample collection using a water quality analyzer kit. Transparency of water was measured using a self-made Secchi disk on the spot. The samples were immediately analyzed in the chemistry lab to minimize physicochemical changes [5]. Chemicals used were of AR grade, and analytical methods for water quality parameters were carried out using Standard APHA methods [6]. The standard reagents used in the analysis were prepared using double distilled water.

Physico-chemical parameters of these samples were determined using standard procedures [7]. pH was determined using an Eli co digital pH meter that gives direct values of pH. Conductivity was determined using a digital conductivity meter. Temperature was measured using a thermometer calibrated from 0°C to 100°C. Transparency was observed using a self-made Secchi disc. Total dissolved solids were measured using a Water Quality kit on the spot. Total Hardness: 50 ml of the water sample was titrated against 0.01M EDTA (Disodium salt) solution using Solo Chrome Black T as an indicator for determination of Total Hardness. Dissolved Oxygen and Biochemical Oxygen Demand were determined using a digital DO meter, which gives direct values of DO, and BOD determination is the measurement of dissolved oxygen content of the sample before and after five days of incubation at 20°C. Sulfate content in the water sample was determined using the turbidimetric method. The chloride content in the water sample was determined by titrating the water sample against 0.02M silver nitrate solution using potassium chromate as an indicator. The brucine method was used to determine the nitrate in the water sample [8][9][10]. The stannous chloride method was used for the determination of phosphate (orthophosphate) [11] [12].

Results and Discussion

Temperature in the water is important for its effects on the chemistry and biochemical reactions in organisms. Based on the results, it was noted that the temperature fluctuated between 18°C to 38°C. The lowest value (18°C) was found at site S-W, and the highest temperature value (38°C) at site S-N. Water and wastewater are, of course, subject to the effect of ambient temperature and can become very warm during summer. In the inner part of the pond, there was little difference in temperature from the peripheral part of the pond. During the present study, the minimum temperature was found to be 18°C, and the maximum temperature observed was 36°C on the inner surface.

pH is an indicator of water that is changing chemically. The maximum value of pH was recorded as 9.3 at S-E in the peripheral site, which is higher than the permissible limits of WHO and shows the basic nature of water in the East direction at the peripheral site. The minimum value of pH was recorded as 8.1 at station S-W in the peripheral site. A high pH value of 9.4 was recorded at the inner site of the pond.

Transparency is the measure of suspended minerals, bacteria, plankton, and dissolved organic and inorganic substances. It is often associated with surface water sources. In most waters, turbidity is due to colloidal and extremely fine dispersions. The values varied between 16 cm to 36 cm except for S-N. The results showed that the transparency of the North direction is very turbid, and 16 cm was recorded in the month of May, as maximum suspended particles are present in the North direction.

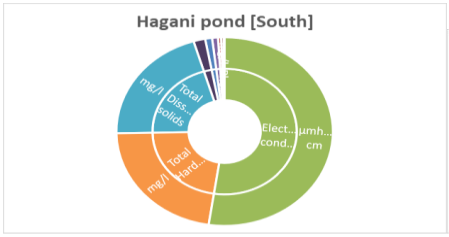
Electrical conductivity is the ability of a substance to conduct electric current. In water, it is the property caused by the presence of dissolved mineral matter. Conductivity is highly dependent upon temperature and therefore is reported normally at 25°C to maintain the comparability of data from various sources. The maximum value of electrical conductivity observed was 996 µmho/cm in April 23 at S-N in the peripheral site. Electrical conductivity was always high in all directions of the pond, exceeding the prescribed limit during the entire study period. Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized, or micro granular suspended form. The permissible limit of TDS for drinking water is 500 mg/l. The observation shows that the TDS is within the permissible range as prescribed by WHO, except for S-N with 418 mg/l. In the present work, total hardness was observed in the range between 270 - 429 mg/l at the North direction and the inner surface of the pond, respectively. This indicates that the water is hard, which is due to a high amount of the metallic ions Ca^{2+} and Mg^{2+} that may be present in surface water. The metals are usually associated with HCO^{3-}, SO_4^{2-}, Cl^-, and NO^{3-}. The presence of calcium in water is due to its deposits of limestone, dolomite, and gypsum materials. Calcium is the major scale-forming constituent in most raw water supplies.

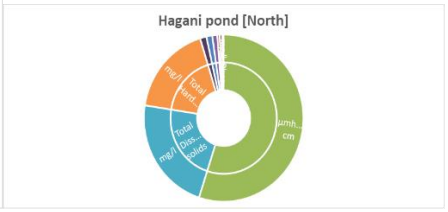
Oxygen, which is dissolved in water, is known as Dissolved Oxygen (DO), and it is essential for all living and floating organisms. Dissolved oxygen in water is essential to aquatic life. DO is the most important factor in determining whether aerobic or anaerobic organisms carry out biological changes. Its solubility in water depends upon temperature, salinity, water movements, etc. During the present study, the maximum DO level observed was 5.8 mg/l at S-N, and the minimum value of 2.4 mg/l was found at S-E in April 2023. During the present investigation, it was observed that the BOD value in all the samples collected from different sampling stations during the entire period of the study remained much higher than 6 mg/l as recommended by WHO. The maximum value of BOD observed was 9.6 mg/l at the inner site of the pond in April 23. BOD value indicates the amount of oxidizable organic matter present in the solution. BOD is a measure of the amount of oxygen used in the respiratory processes of microorganisms in oxidizing the organic matter in the sewage and for the further metabolism (oxidation) of cellular components synthesized from the wastes.

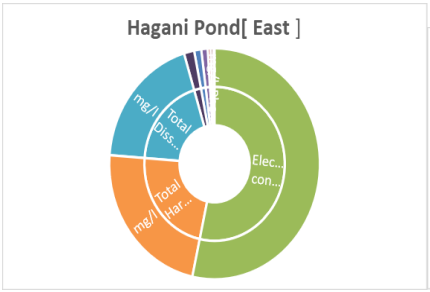
Nitrogen compounds, which are highly oxidized, are commonly present in surface water because they are the end products of aerobic decomposition of organic nitrogenous matter. Significant sources of nitrates in Hagani Pond are chemical fertilizers from cultivated land and drainage from livestock feedlots. The nitrate ion in the investigated samples was found to be 47 mg/l at the inner site of the pond in the month of July, which was within the permissible limit [45 mg/l] set by WHO. It is a dangerous indicator of pollution, especially in children less than six months of age who drink water containing nitrate; symptoms include shortness of breath and blue baby disease.

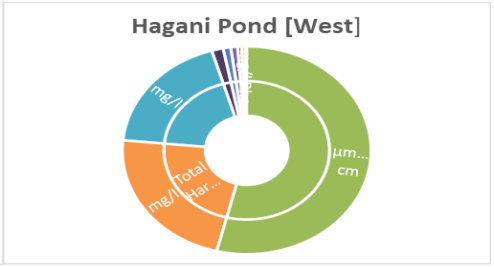
Phosphorus occurs in natural waters and wastewater in the form of various phosphates. Surface waters seldom contain high concentrations of phosphates, since they are utilized by plants, whereas groundwater usually contains appreciable amounts of phosphate. The USPHS has recommended a maximum permissible limit of 0.1 mg/l total phosphate in drinking water. During the entire study period and at all the sampling stations, phosphate was found to be much above the recommended limit, reaching a maximum value of 2.2 mg/l at the North direction in the month of July 2023. Phosphate may occur in surface waters because of leaching from minerals or ores, from agricultural runoff, and as a major element of municipal sewage due to the utilization of synthetic detergents.

The analytical results of surface water samples for the Hagani Pond in Birkona in Bilaspur District are shown in the **Tables and its correlation and pi chart analysis** below for four directions in Hagani Pond :









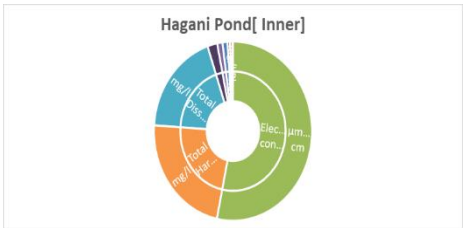


Table No.1: Seasonal Physico-Chemical Study of water samples collected from sampling station

HAGANI POND NORTH PERIPHERAL DIRECTION 2023

S.No	Parameters	Units	Months			
			Jan-23	**Apr-23**	**Jul-23**	**Oct-23**
1	Temperature	℃	21	38	32	24
2	pH	-	8.9	8.7	9.1	8.5
3	Electrical conductivity	µmho/cm	978	996	990	984
4	Transp.	cm	18	14	24	22
5	Total Dissolved solids	mg/l	399	402	418	407
6	Total Hardness	mg/l	316	290	296	270
7	Dissolved oxygen	mg/l	5.5	5.8	4.6	5.4
8	Biological Oxygen Demand	mg/l	8.6	9.4	6.8	8.3
9	Phosphate	mg/l	0.15	0.18	0.22	0.19
10	Nitrate	mg/l	23	28	33	31

	Temp.	**pH**	**EC**	**TDS**	**TH**	**DO**	**BOD**	**PO_4^{3-}**	**NO_3^-**
Temp.	1.000								
pH	0.117	1.000							
EC	0.987	0.000	1.000						
TDS	0.266	0.464	0.309	1.000					
TH	-0.198	0.709	-0.354	-0.287	1.000				
DO	0.027	-0.680	0.025	-0.916	-0.045	1.000			
BOD	0.118	-0.629	0.107	-0.898	-0.015	0.995	1.000		
PO_4^{3-}	0.471	0.268	0.537	0.955	-0.488	-0.755	-0.727	1.000	
NO_3^-	0.405	0.030	0.505	0.886	-0.684	-0.639	-0.629	0.969	1.000

Table 1(a) Correlation Analysis of Hagani Pond [North Peripheral Direction]

Table No.2: Seasonal Physico-Chemical Study of water samples collected from sampling station

HAGANI POND SOUTH PERIPHERAL DIRECTION 2023

S.No	Parameters	Units	Months			
			Jan-23	**Apr-23**	**Jul-23**	**Oct-23**
1	Temperature	℃	19	37	32	22
2	pH	-	8.7	8.3	8.2	8.8
3	Electrical conductivity	µmho/cm	961	969	976	982
4	Transp.	cm	16	14	20	18
5	Total Dissolved solids	mg/l	379	362	370	357
6	Total Hardness	mg/l	410	422	416	428
7	Dissolved oxygen	mg/l	2.5	2.8	3.6	3.4
8	Biological Oxygen Demand	mg/l	6.9	8.7	6.3	8.2
9	Phosphate	mg/l	0.13	0.15	0.2	0.17
10	Nitrate	mg/l	32	30	35	33

	Temp.	pH	EC	TDS	TH	DO	BOD	PO_4^{3-}	NO_3^-
Temp.	1.000								
pH	-0.887	1.000							
EC	0.122	0.025	1.000						
TDS	-0.333	-0.059	-0.784	1.000					
TH	0.214	0.175	0.798	-0.992	1.000				
DO	0.220	-0.265	0.898	-0.487	0.479	1.000			
BOD	0.257	0.213	0.172	-0.739	0.730	-0.226	1.000		
PO_4^{3-}	0.378	-0.493	0.764	-0.336	0.303	0.964	-0.353	1.000	
NO_3^-	-0.209	-0.109	0.495	0.150	-0.124	0.766	-0.769	0.778	1.000

Table 2(b) Correlation Analysis of Hagani Pond [South Peripheral Direction]

Table No.3: Seasonal Physico-Chemical Study of water samples collected from sampling station

HAGANI POND EAST PERIPHERAL DIRECTION 2021

S.No	Parameters	Units	Months			
			Jan-23	**Apr-23**	**Jul-23**	**Oct-23**
1	Temperature	°C	20	34	32	30
2	pH	-	8.5	8.9	9.1	9.3
3	Electrical conductivity	µmho/cm	981	989	986	983
4	Transp.	cm	18	16	20	24
5	Total Dissolved solids	mg/l	351	366	378	359
6	Total Hardness	mg/l	419	427	423	422
7	Dissolved oxygen	mg/l	2.9	2.4	3.1	3
8	Biological Oxygen Demand	mg/l	7.9	8.2	7.2	8.4
9	Phosphate	mg/l	0.11	0.13	0.19	0.14
10	Nitrate	mg/l	29	31	33	30

	Temp.	pH	EC	TDS	TH	DO	BOD	PO_4^{3-}	NO_3^-
Temp.	1.000								
pH	0.722	1.000							
EC	0.873	0.293	1.000						
TDS	0.768	0.520	0.695	1.000					
TH	0.892	0.369	0.973	0.569	1.000				
DO	-0.310	0.282	-0.628	0.112	-0.698	1.000			
BOD	-0.010	0.102	-0.086	-0.646	0.139	-0.480	1.000		
PO_4^{3-}	0.583	0.616	0.371	0.920	0.245	0.488	-0.713	1.000	
NO_3^-	0.722	0.486	0.655	0.998	0.517	0.157	-0.697	0.932	1.000

Table 3(b) Correlation Analysis of Hagani Pond [East Peripheral Direction]

Table No.4: Seasonal Physico-Chemical Study of water samples collected from sampling station HAGANI POND WEST PERIPHERAL DIRECTION 2023							
S.No	Parameters	Units	Months				
			Jan-23	**Apr-23**	**Jul-23**	**Oct-23**	
1	Temperature	°C	18	35	36	29	
2	pH	-	8.1	8.6	8.9	8.5	
3	Electrical conductivity	µmho/cm	977	980	983	975	
4	Transp.	cm	16	19	22	18	
5	Total Dissolved solids	mg/l	343	346	358	350	
6	Total Hardness	mg/l	411	417	413	419	
7	Dissolved oxygen	mg/l	3.9	3.5	3.3	3.7	
8	Biological Oxygen Demand	mg/l	9.3	9.2	9.2	8.8	
9	Phosphate	mg/l	0.15	0.13	0.17	0.13	
10	Nitrate	mg/l	27	30	32	29	

]

	Temp.	pH	EC	TDS	TH	DO	BOD	PO_4^{3-}	NO_3^-
Temp.	1.000								
pH	0.946	1.000							
EC	0.651	0.728	1.000						
TDS	0.686	0.881	0.604	1.000					
TH	0.464	0.276	-0.365	0.056	1.000				
DO	-0.937	-0.977	-0.848	-0.814	-0.141	1.000			
BOD	-0.173	-0.148	0.569	-0.214	-0.823	-0.058	1.000		
PO_4^{3-}	0.063	0.342	0.671	0.603	-0.763	-0.405	0.510	1.000	
NO_3^-	0.930	0.994	0.801	0.875	0.175	-0.992	-0.036	0.418	1.000

Table 4(b) Correlation Analysis of Hagani Pond [West Peripheral Direction]

Table No 5 Seasonal Physico-Chemical Study of water samples collected from sampling station HAGANI POND INNER DIRECTION 2023							
S.No	Parameters	Units	Months				
			Jan-23	Apr-23	Jul-23	Oct-23	
1	Temperature	°C	19	36	33	27	
2	pH	-	8.5	8.8	9.4	8.4	
3	Electrical conductivity	µmho/cm	988	989	986	981	
4	Transp.	cm	20	18	24	22	
5	Total Dissolved solids	mg/l	348	349	355	357	
6	Total Hardness	mg/l	422	425	423	429	
7	Dissolved oxygen	mg/l	3	3.3	3.6	3.1	
8	Biological Oxygen Demand	mg/l	9.3	9.6	9.1	8.9	
9	Phosphate	mg/l	0.11	0.1	0.13	0.09	
10	Nitrate	mg/l	37	39	47	44	

	Temp.	pH	EC	TDS	TH	DO	BOD	PO_4^{3-}	NO_3^-
Temp.	1.000								
pH	0.566	1.000							
EC	0.177	0.291	1.000						
TDS	0.156	0.172	-0.889	1.000					
TH	0.199	-0.461	-0.787	0.639	1.000				
DO	0.721	0.966	0.142	0.327	-0.224	1.000			
BOD	0.360	0.081	0.910	-0.864	-0.460	0.021	1.000		
PO_4^{3-}	0.078	0.857	0.384	-0.033	-0.772	0.701	0.016	1.000	
NO_3^-	0.367	0.595	-0.594	0.893	0.300	0.702	-0.677	0.373	1.000

Table 5(b) Correlation Analysis of Hagani Pond [Inner Peripheral Direction]

CONCLUSION

Based on the extensive study conducted on the water quality of Hagani Pond in Birkona, Bilaspur, Chhattisgarh, spanning from January 2023 to June 2023 and considering the parameters analyzed, several significant conclusions can be drawn.

First and foremost, the seasonal variation in water quality, as evidenced by the fluctuations in temperature, pH, and other physico-chemical parameters, underscores the dynamic nature of aquatic ecosystems. The observed temperature range of 18°C to 38°C reveals the influence of environmental conditions on water quality and highlights the need for continued monitoring, especially in regions subject to extreme climatic variations. The variations in pH, conductivity, and dissolved oxygen levels across different sampling sites emphasize the heterogeneity of water quality within the pond. The high pH levels observed, particularly at the inner surface of Hagani Pond, signify the presence of basic substances in the water. Conversely, lower pH levels in the peripheral areas suggest variations in water chemistry and potential sources of contamination. The consistently elevated values of electrical conductivity and total dissolved solids, exceeding permissible limits, are indicative of increased mineral content and potential pollution sources. These findings emphasize the necessity for effective strategies to manage and mitigate the impact of pollutants on the pond's water quality. The elevated biochemical oxygen demand (BOD) levels throughout the study period raise concerns about organic matter loading in the water. This indicates a pressing need for wastewater treatment and improved management practices in the area to prevent further deterioration of water quality. The presence of nitrate levels above WHO-recommended limits, particularly in the inner surface samples, underscores the importance of addressing agricultural and domestic waste runoff to reduce nitrate contamination. Such contamination can have adverse health implications, especially for children. Lastly, the phosphate levels found to exceed recommended limits highlight the potential sources of pollution from various human activities, including the use of synthetic detergents. Addressing these issues and adhering to the suggested water quality guidelines and

standards, as provided by WHO, is crucial to maintaining a healthy and sustainable aquatic environment in Hagani Pond.

In conclusion, this study sheds light on the complex dynamics of water quality in Hagani Pond, serving as a valuable resource for environmental management and sustainable development in the region. It underscores the importance of regular monitoring and the implementation of measures to safeguard this essential water source for both aquatic life and the communities it serves. The findings offer critical insights for future conservation efforts and underscore the need for a holistic approach to preserve and improve the water quality in this vital ecosystem.

.16 mg/l.

Correlation studies recorded indicate a strong negative correlation between temperature and dissolved oxygen(r=-0.937) for the entire study period, temperature had a strong positive correlation with Nitrates(r=0.930). During the same period, pH showed a strong positive correlation with Nitrates (r = 0.994) in the West Direction of Hagani pond

In the correlation study it was observed that Electrical Conductivity has shown a strong positive correlation with Temperature (r = 0.987), Dissolved Oxygen (r = 0.898) in the North Direction of the pond, and with Total Hardness (r = 0.973) in the East Direction i.e. as the concentration of EC increased the concentration of Calcium and Magnesium ions also increased. In the study period results indicated a Strong Positive correlation between Phosphates and Nitrates in all directions.

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