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QUALITATIVE EVALUATION OF LIMNOLOGICAL FACTORS OF THE PERENNIAL LENTIC WATER BODIES OF DISTRICT DHANBAD, JHARKHAND BY USING WATER QUALITY INDEX

Sharmila Kumari[1]* and Shailendra Kumar Sinha[2]

[1]Department of Zoology, P. K. Roy Memorial College, Dhanbad – 826004, Jharkhand, India.
[2]Department of Zoology, Binod Bihari Mahto Koyalanchal University, Dhanbad- 828130, Jharkhand, India.

***Corresponding Author: Sharmila Kumari**

Department of Zoology, P. K. Roy Memorial College, Dhanbad – 826004, Jharkhand, India.

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ABSTRACT

In the present study an endeavour has been made to assess the physico- chemical properties of Pandey Pond and Karbala Pond of district Dhanbad, Jharkhand, during November 2020 to October 2021. A total of twelve parameters were analysed according to standard methods of APHA. Water Quality Index is a mathematical approach, used to assess the water quality status and determine whether the water is fit for drinking or not. Physical and chemical parameters, including Temperature, pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), Alkalinity, Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{+}), Magnesium (Mg^{2+}), Chloride (Cl^{-}), and Nitrate (NO_3^{-}) were analysed to calculate the Water Quality Index with reference to standards given by the Bureau of Indian Standards (BIS) and World Health Organization (WHO). According to calculated WQI, 61.86 for Pandey Pond (S1), shows poor quality status and cannot be used for drinking and other domestic purposes without treatment. 78.58 for Karbala Pond (S2) shows very poor-quality status as per water quality index rating.

KEYWORDS: Alkalinity, Physico-chemical, Conductivity, Water Quality Index.

INTRODUCTION

Water is an extremely crucial and valuable resources for the survival of all living organisms on this planet Earth. It is the habitat to a diverse range of aquatic species. According to the Upanishada, there are five fundamental elements: Kshiti (Soil), Aup (Water), Tweja (Fire), Byoma (Sky), and Marut (Air) (Panch Tatwa Yah Adhara Sharira), crucial part of our ecosystem.[1,2,3] Among these components, water is the most essential for every living organism especially to the mankind.

An ecosystem's functional characteristics are determined by the interactions between its physical, chemical and biological aspects.[4] The limnological factors of any aquatic ecosystem have a significant impact on the structure, dispersion, growth, abundance and diversity of any aquatic organisms.[5,6,7,8]

In India, particularly in rural and residential regions, ponds and other fresh water bodies have long been used as a conventional source of water for many household applications, including drinking.[9] Many anthropogenic activities such as use of detergents, agricultural pesticides, industrial and mining activities etc. have damaged the water quality (physical and chemical) and the biological diversity of these lentic water bodies.[10]

Water Quality Index is a mathematical approach and was proposed by Brown and his co-workers.[11] It is used to convert a large number of limnological data into a single value.[12] Many alternative techniques have since been developed for calculating Water Quality Index (WQI). There are different water quality indices like, Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), Oregon Water Quality Index (OWQI), US National Sanitation Foundation Water Quality Index (NSFWQI), British Columbia Water Quality Index (BCWQI) are used globally.[13, 14,15,16,17]

The present study is an attempt to evaluate the physical and chemical properties of two ponds (viz, Pandey Pond & Karbala Pond) of district Dhanbad and by using the result of Water Quality Index, we could make the inference, whether the water of these two ponds is suitable for human use.

MATERIALS AND METHODOLOGY

Study area:

Dhanbad district is situated in the state of Jharkhand covering an area of about 2879 square kilometres. It lies between 23°79'98" N latitude and 85°93'05" E longitude. Dhanbad is also known as the coal capital of India due to its rich coal mines present in the district. Major parts of Dhanbad economy depends upon coal mining and

industries. Tata Steel, Indian Iron and Steel company (IISCO), BCCL etc., played a major role in economic development of Dhanbad. The climatic condition of district Dhanbad is characterized by tropical climate or dryness. It is very hot during pre-monsoon (March to June) and experience cold from November to February. July and August are the wettest months. The average annual rainfall in the district is approx. 1300 mm.

The two selected fresh water ponds are situated in two different geographical regions of Dhanbad. Pandey pond (S1) also known as Dulal Pond situated in the residential area of Dhanbad lies between the latitude 23° 50'50" N and longitude 86°25'33" E. The pond receives dumps from the nearby houses and is highly used by the local residents for domestic purposes.

Karbala talab (S2) is located in coalmining area of BCCL [Jharia Coalfield region (JCF)] of Dhanbad. It lies between latitude 23°44'03" N & longitude 86°24'12" E.

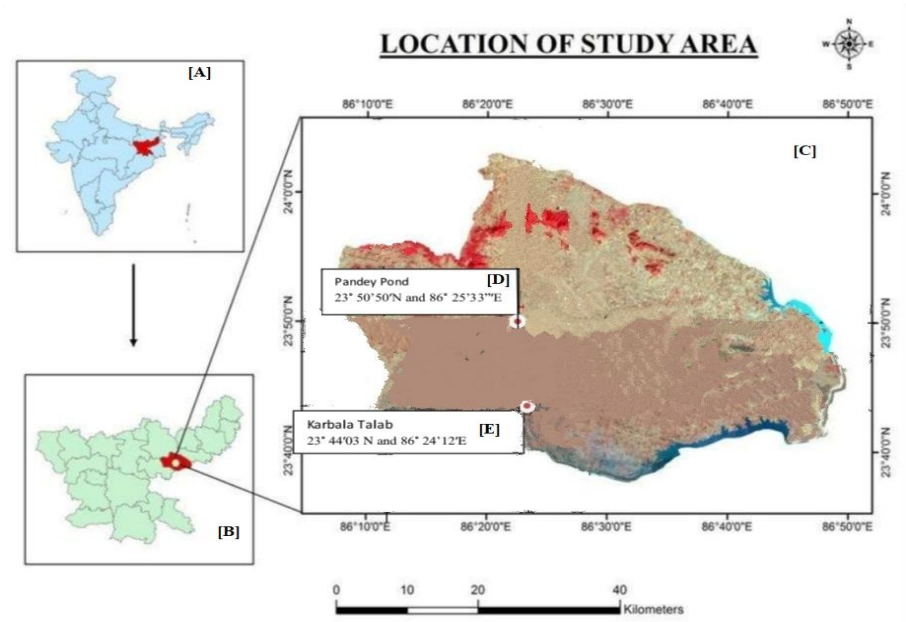


Figure 1: Location of the study area is shown on a map. [A] A map of India showing the state of Jharkhand. [B]Location of district Dhanbad in the map of Jharkhand. [C] Location of two study area i.e., [D] Pandey Pond (S1) and [E] Karbala Talab (S2) in the map of District Dhanbad.

Sampling and Analysis

Water samples were collected from the above mention water bodies for the assessment of physical and chemical analysis. Water sampling was performed monthly between 8:00 a.m. to 11:00 a.m. from November 2020 to October 2021. The water samples collected in 1liter pre washed Polyethylene bottles.

Water temperature was measured at the sampling site using Celsius thermometer (0° to 100° C). pH and electrical conductivity were measured at the sampling site using a portable conductivity and pH meter.
Other parameters like dissolved oxygen, total hardness, alkalinity, calcium, total dissolved solids, magnesium, chloride, nitrate and sodium were analysed according to standard methods.[18]

Calculation of Water Quality Index (WQI)

Water quality index developed by Brown and his co-workers,[11] provides an expression for the overall water quality based on limnological parameters. Water quality index is a mathematical equation, is used to evaluate the water quality and determine whether the water is suitable for drinking and other domestic purposes. It takes into account a multitude of water quality parameters with reference to the Indian standards BIS[19] and World health organization WHO.[20]

For the purpose of calculating water quality index, Indian Standards BIS[19] for drinking water (IS:10500) have been taken into consideration **(table 1).**

Table 1: Standards for drinking water as per mentioned BIS[19]& WHO.[20]

Parameters	BIS Standards (Desirable limit)	WHO Standards (Desirable limit)
Temp	-	-
pH	6.5 - 8.5	7.0 – 8.5
Dissolved Oxygen (DO)	4 – 6 mg/L	-

Alkalinity	200 mg/L	-
Total Dissolved Solids (TDS)	500 mg/L	500 mg/L
Total Hardness (TH)	200 mg/L	200 mg/L
Calcium (Ca2+)	75 mg/L	200 mg/L
Magnesium (Mg 2+)	30 mg/L	50 mg/L
Electrical Conductivity (EC)	300 µs/cm	180-1000 µs/cm
Chlorides	250 mg/L	250 mg/L
Nitrate	45 mg/L	50 mg/L
Sodium	-	150 mg/L

For the calculation of WQI, following steps are involved as follows:

Step 1: for the calculation of unit weight factors for each parameter by using the equation as given below

$Wn = K / Sn$

Where,
Wn is the unit weight for the n^{th} parameter,
Sn is the standard value for the nth parameter,
K is the constant of proportionality.

$K = 1/ 1/S1+ 1/S2+ 1/S3+ 1/S4\ldots.. 1/Sn$

$$= \frac{1}{\sum 1/Sn}$$

Step 2: for the calculation of sub index (Qn) value by using the given expressions

$Qn = [(Vn - Vi)] / [(Sn - Vi)] \times 100$

Where,
Qn is the sub index of n^{th} parameter
Vn is the mean value of the nth parameters
Sn is the standard value (IS: 10500) for the nth parameter
Vi is the ideal value for each parameter in pure water (generally Vi is 0 for most of the parameters except pH and DO)

Step 3: WQI is calculated as follows:
$= \sum WnQn$
Overall $WQI = \sum WnQn / \sum Wn$

Where,
Wn is the unit weight for n^{th} parameter
Qn is the sub index of n^{th} parameter.

RESULT AND DISCUSSION

Monthly variations in the physico-chemical parameters of 2 sites (fresh water ponds) from November 2020 to October 2021 are being summed up in **table 2** and **figure 2**. At both regions some striking differences in the physical and chemical values were found.

pH:
Potential of Hydrogen or pH is the quantitative measure of acidic and basic nature of any aqueous solution. For any aquatic habitat, being the extremely acidic or alkaline can be hazardous to the ecosystem's overall health. The pH ranges from 7.1 to 7.7 (mean ±SD = 7.36± 0.18) in S1. In S2 PH ranges from 7.1 to 7.9 (7.4±0.25). According to BIS[19] (IS: 10500) and WHO [20] permissible limit is 6.5 to 8.0 for drinking water.

Temperature:
One of the most crucial characteristics of water since it controls the ability of self-purification of water bodies and has a direct impact on the pH and DO of any aquatic ecosystem.[21] During the present study water temperature values of Pandey Pond S1 ranged between 16º C to 34º C (5.74±1.66) and in Karbala talab S2 temperature ranges between 18ºC to 36ºC (5.67±1.63). Additionally, temperature may have an impact on biological and metabolic process of aquatic organisms.[22,23]

Dissolved oxygen (DO):
DO is a crucial parameter of any aquatic ecosystem, plays a major role in the growth, survival, dispersion, behaviour and metabolic process of fishes and any other aquatic Organisms.[24] In Pandey Pond (S1), DO ranges from 5.8 to 7.2 mg/L(6.33±0.45). Dissolved oxygen in Karbala Pond (S2) ranged from 3.8 to 5.6 mg/L (4.46±0.57). As per the standards suggested by BIS, DO ranges from 4 to 6 mg/L is desirable range for the aquatic life.[25,26] In both locations, higher concentration of DO was recorded during rainy season and low DO in summer season. Many authors have also observed similar findings as highest value of DO in Rainy season and lower value of DO during summer season.[27,28,29,30]

Alkalinity
A water body's buffering capacity or alkalinity is a measure of its ability to neutralize acids and so maintain a relatively steady pH level. The range of alkalinity lies between 77 mg/L to 112 mg/L (93±10.19) in S1. And 180 mg/L to 210 mg/L (189±11.42) in S2. According to BIS total alkalinity should not exceed 200 mg/L. The values of S1 are within the permissible limit whereas the values of S2 is just exceeding the desirable limit as proposed by BIS.

Total Dissolved Solids (TDS):
Total dissolved solids values ranged from 426 mg/L to 597 mg/ L at S1 (Pandey Pond) with general mean and SD (510.42±41.34). At S2, TDS varied from 804 mg/L to 1098 mg/L (968.66±88.48). TDS values for both sites exceed the desirable limit as per BIS & WHO.

Electrical Conductivity (EC):
Conductivity is the ability of water to conduct electrical current. The quantity of conductive ions present in the water does indeed have a significant impact on conductivity. EC in the present study were found ranging from 605 µs/cm to 879 µs/cm (736±89.24) at Pandey Pond (S1) and 986 µs/cm to 1321 µs/cm (1139.58±107.33) at Karbala Talab (S2).

Total Hardness (TH), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}):
The total of the calcium and magnesium content defines the total hardness. The value of measured TH varied from 82 mg/L to 120 mg/L (101.58±12.12) in S1 while values of TH ranged from 286 mg/L to 331 mg/L (306.92±14.96) were recorded in S2.

Another essential component for aquatic life is calcium ions which is often more abundant in almost all natural water bodies.[31] The concentration of calcium (Ca^{2+}) in S1 and S2 ranged from 18.7 mg/L to 33.8 mg/L (26.64±4.8) and 66.3 mg/L to 88 mg/L (76.28±6.95) respectively.

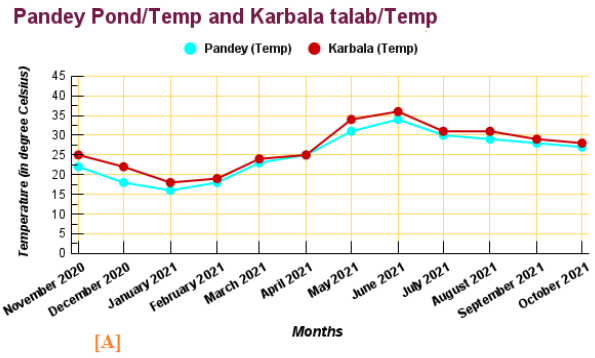
Magnesium is the key element for the growth of chlorophyll and serves as a limiting factor for the phytoplankton growth.[32] The value of Mg^{2+}varied from 0.36 mg/L to 17.7 mg/L (8.71±5.66) in S1 while in S2, Mg^{2+}oscillated between 20.83 mg/L to 40.15 mg/L (28.25±6.48).

Chlorides (Cl^-):
The concentration of chloride at S1, ranged from 32 mg/l to 50 mg/L (40.31±5.63) while 98 mg/L to 134 mg/L (117.92±11.3) at S2 were recorded during November 2020 to October 2021.

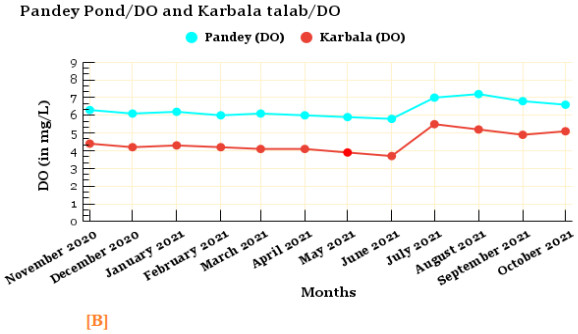
Households' sewages, utilisation of agrochemicals, industrial effluents, urban waste products, septic tank waste, and animal feeds are the main sources of chloride.[27,28,33] The presence of a significant amount of organic matter with both allochthonous and autochthonous origins may be the cause of the elevated chloride concentration.[34]

Table 2: Seasonal variations in the limnological parameters of two perennial lentic water bodies during November 2020 to October 2021.

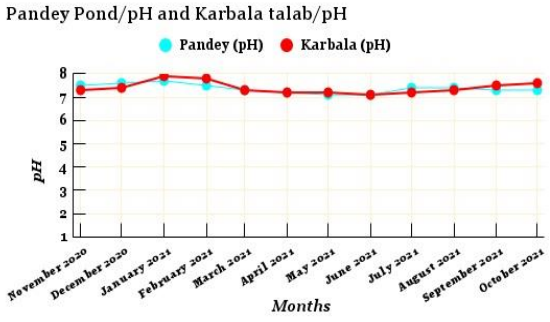
Parameters	Pandey Pond (S1)				Karbala Talab (S2)			
	Range (Min.-Max.)	Mean	Standard Deviation (SD)	Standard Error (SE)	Range (Min. - Max.)	Mean	Standard Deviation (SD)	Standard Error (SE)
Temp	16° C - 34°C	25.08	5.74	1.66	18° C - 36°C	26.8	5.67	1.63
pH	7.1 - 7.7	7.36	0.18	0.054	7.1 - 7.9	7.4	0.25	0.073
Dissolved Oxygen (DO)	5.8 - 7.2 mg/L	6.33	0.458	0.132	3.7 - 5.5 mg/L	4.467	0.57	0.16
Alkalinity	77 - 112 mg/L	93	10.19	2.94	173 - 210 mg/L	189.5	11.42	3.29
Total Dissolved Solids (TDS)	426 - 597 mg/L	510.42	41.34	11.93	804 - 1098 mg/L	968.66	88.48	25.54
Total Hardness (TH)	82 - 120 mg/L	101.58	12.12	3.49	286 - 331 mg/L	306.92	14.96	4.32
Calcium (Ca2+)	18.7 - 33.8 mg/L	26.64	4.8	1.39	66.3 - 88 mg/L	76.28	6.95	2.007
Magnesium (Mg 2+)	0.36 - 17.7 mg/L	8.71	5.66	1.63	20.83 - 40.15 mg/L	28.25	6.485	1.87
Electrical Conductivity (EC)	583 - 879 µs/cm	736	89.24	25.76	986 -1321 µs/cm	1139.58	107.33	30.98
Chlorides	32 - 50 mg/L	40.31	5.63	1.63	98 - 134 mg/L	117.92	11.3	3.26
Nitrate	0.93 - 1.84 mg/L	1.42	0.25	0.072	1.79 - 4.03 mg/L	2.78	0.71	0.205
Sodium	18 - 36 mg/L	26.91	5.78	1.67	53.3 - 68.2 mg/L	61.35	4.38	1.26


Pandey Pond/Temp and Karbala talab/Temp
Pandey (Temp)
Karbala (Temp)
Temperature (in degree Celsius)
Months

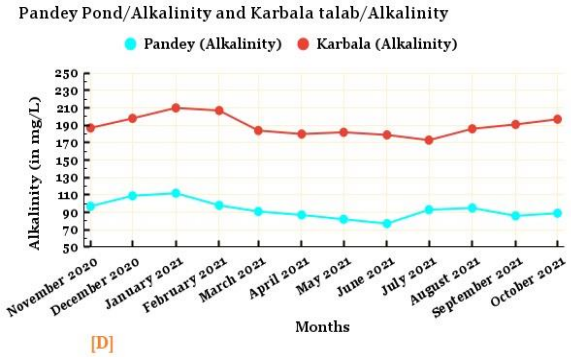
[A]


Pandey Pond/DO and Karbala talab/DO
Pandey (DO)
Karbala (DO)
DO (in mg/L)
Months

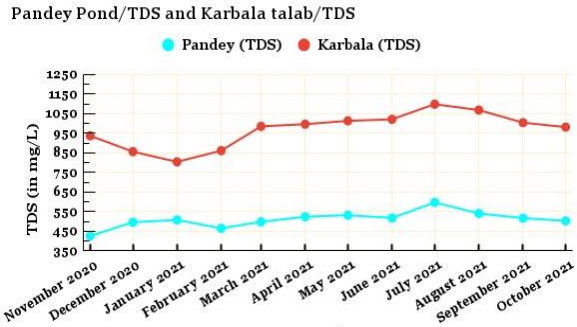
[B]


Pandey Pond/pH and Karbala talab/pH
Pandey (pH)
Karbala (pH)
pH
Months

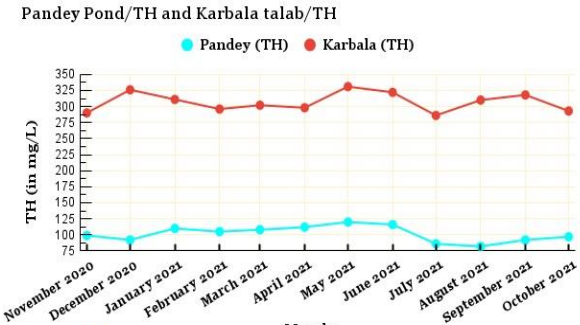
[C]


Pandey Pond/Alkalinity and Karbala talab/Alkalinity
Pandey (Alkalinity)
Karbala (Alkalinity)
Alkalinity (in mg/L)
Months

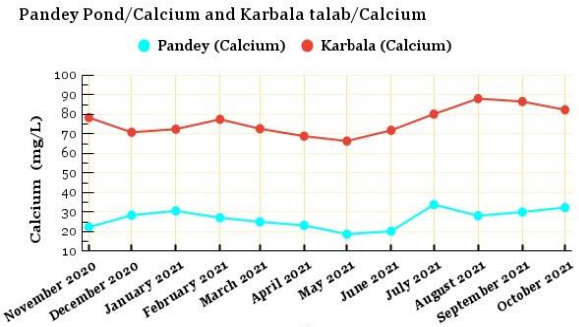
[D]


Pandey Pond/TDS and Karbala talab/TDS
Pandey (TDS)
Karbala (TDS)
TDS (in mg/L)
Months

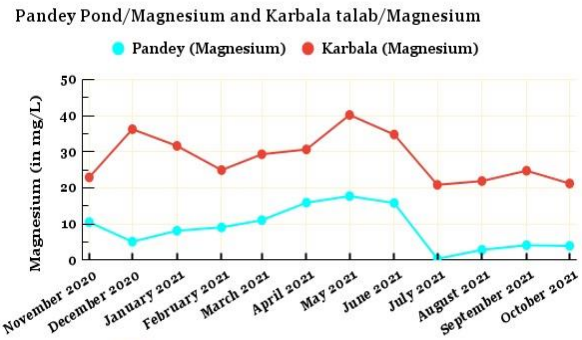
[E]


Pandey Pond/TH and Karbala talab/TH
Pandey (TH)
Karbala (TH)
TH (in mg/L)
Months

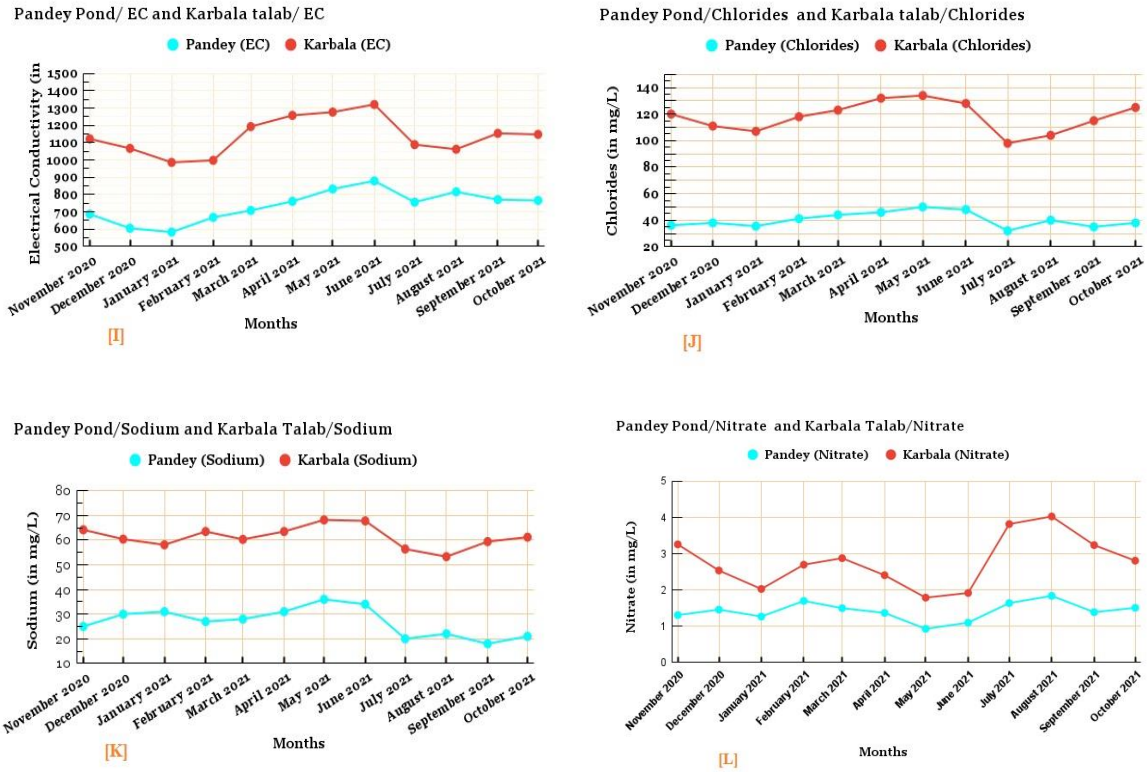
[F]


Pandey Pond/Calcium and Karbala talab/Calcium
Pandey (Calcium)
Karbala (Calcium)
Calcium (mg/L)
Months

[G]


Pandey Pond/Magnesium and Karbala talab/Magnesium
Pandey (Magnesium)
Karbala (Magnesium)
Magnesium (in mg/L)
Months

[H]



[Figure 2: Monthly variations in the physico-chemical parameters viz., [A] Temperature, [B] Dissolved Oxygen, [C] Ph, [D] Alkalinity, [E] Total Dissolved Oxygen (TDS), [F] Total Hardness (TH), [G] Calcium (Ca^{2+}), [H] Magnesium (Mg^{2+}), [I] Electrical Conductivity (EC), [J] Chloride (Cl^-), [K] Sodium (Na^+), [L] Nitrate (NO_3^-) of two sites (Pandey Pond (S1) & Karbala Talab (S2) from November 2020 to October 2021].

Nitrate (NO_3^-):
The utilization of fertilisers, biological fixation, atmospheric precipitation and industrial waste are the major sources of nitrate. [35] Nitrate values in the present study were found ranging between 0.93 mg/L to 1.84 mg/L (1.42±0.25) in S1. In S2, nitrate concentration ranged from 1.79 mg/L to 4.03 mg/L (2.78±0.71).

Sodium (Na^+):
Sodium concentration ranged from 18 mg/L to 36 mg/L (26.91±5.78) were estimated in S1 (Pandey Pond) and 53.3mg/L to 68.2 mg/L (61.35±4.38) in S2 (Karbala Talab). Higher concentration of Na^+ renders the water unfit for irrigation use.[36]

Water Quality Index (WQI):
Quality index is an important mathematical tool for the better assessment of water quality of any aquatic ecosystem.
WQI is calculated in few steps as given in **table 3.**
Water quality index represents the water quality status in 5 categories is mentioned in **table 4.**

Table 3: Steps for the calculation of Water Quality Index for the two water bodies [Pandey Pond (S1) & Karbala Talab (S2)].

	Parameters	BIS STD. (Sn)	K = 1/∑ 1/Sn	Wn = K/Sn	Qn = Vn/Sn x100	WnQn
Pandey Pond (S1)	pH	8.5	2.463847467	0.289864408	24	6.956745789
	DO	5	2.463847467	0.492769493	96	47.30587136
	EC	300	2.463847467	0.008212825	245.3333333	2.014879706
	Alkalinity	200	2.463847467	0.012319237	46.5	0.572844536
	TDS	500	2.463847467	0.004927695	102.0833333	0.503035524
	TH	200	2.463847467	0.012319237	50.79166667	0.625714596
	Ca^{2+}	75	2.463847467	0.0328513	35.52222222	1.166951163
	Mg^{2+}	30	2.463847467	0.082128249	29.03333333	2.384456826
	Cl^-	250	2.463847467	0.00985539	16.12666667	0.158934587
	NO_3^-	45	2.463847467	0.054752166	3.151851852	0.172570716
				∑ Wn = 1		**∑ WnQn = 61.86200481**

	Parameters	BIS STD. (Sn)	K = 1/∑ 1/Sn	Wn = K/Sn	Qn = Vn/Sn x100	WnQn
Karbala Talab (S2)	pH	8.5	2.463847467	0.289864408	27	7.826339013
	DO	5	2.463847467	0.492769493	105	51.74079681
	EC	300	2.463847467	0.008212825	379.8611111	3.119732788
	Alkalinity	200	2.463847467	0.012319237	94.75	1.167247737
	TDS	500	2.463847467	0.004927695	193.7333333	0.954658765
	TH	200	2.463847467	0.012319237	153.4583334	1.89048963
	Ca^{2+}	75	2.463847467	0.0328513	101.7	3.340977165
	Mg^{2+}	30	2.463847467	0.082128249	94.175	7.73442784
	Cl^{-}	250	2.463847467	0.00985539	47.16666667	0.464845889
	NO_3^{-}	45	2.463847467	0.054752166	6.190740741	0.338956464
				∑ Wn = 1		**∑ WnQn = 78.5784721**

Table 4: Water Quality Status Categories developed by Brown and his co-workers.[11]

Water Quality Index	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76 - 100	Very Poor
>100	Unfit for Consumption

The highest calculated WQI were recorded for Karbala talab (S2), i.e., 78.56 and 61.9 for Pandey Pond (S1). WQI of S2 is higher than S1. Both the locations fall in the poor to very poor-quality category.

CONCLUSION

The recent investigation gives an overall picture on the water quality status of the two Ponds viz. Pandey Pond (S1) and Karbala Talab (S2). Analysis of monthly variations in limnological parameters such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), alkalinity, total dissolved solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^{-}), nitrate (NO_3^{-}), and sodium (Na^{+}) were found to be in higher concentration in Karbala Talab (S2) than Pandey Pond (S1). Water quality index (WQI) showed poor to very-poor-quality status of S1 and S2 respectively.

So, on the basis of foregoing discussion, it can be concluded that with proper treatment and regular water quality monitoring by competent authorities can improve the water quality of the two above mentioned pond. Further, it can also be utilized for fish culture and irrigation purpose.

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