Indian J. Applied & Pure Bio. Vol. 38(3), 1563-1574 (2023). **ISSN: 0970-2091**
A Web of Science Journal

Water quality of selected Pitlakes of Raniganj coal fields, West Bengal, India

[1]Priyaranjan Mondal, [2]Arnab Banerjee and [3*]Debnath Palit

[1]Department of Conservation Biology, Durgapur Government College, Durgapur-713212 (India)
[2]Sant Gahira Guru Vishwavidyalaya, Surguja-497001 (India)
[3]Durgapur Government College, Durgapur-713212 (India)

Abstract

Water is essential for open-pit mining's dust-suppression systems and coal processing units. To meet this requirement, mining companies must buy surface or groundwater supplies from neighbouring domestic or agricultural users. After mining, these water resources are rarely replenished, permanently reducing agricultural production. Whether water is acidic, neutral, or basic depends in large part on the quality of the water. Gunjan Ecological Park Pit Lake's pH value is 7.09 at its lowest, and Joyalvanga 1 Pit Lake has a pH value of 7.88 at its highest. Chora had the lowest level of hardness (180.42 mg/l), while Dalurbandh pit lake had the highest level (334.75mg/l). The lowest DO (Dissolved Oxygen) level was found in Chora pit lake at 3.90 mg/L and the highest DO level was 6.32 mg/ l. Considering the water quality of pitlakes ,it is reflected that water of pitlakes has high mineral and nutrient ccontent which can be used in various aquaculture practices as well as in irrigation for their sustainable use.

Key words : Pitlakes, water quality, sustainable use, Raniganj coalfield area.

When surface mines are shut down, open pits begin to fill with water from a variety of sources, including groundwater recharge, surface water diversion, and active pumping. Water fills open pits left behind after mining operations are finished to create pit lakes. These holes can be filled either through artificial flooding or by letting hydrological processes like precipitation or groundwater infiltration fill them naturally. Pit lake ecosystems are important and environmentally endangered aquatic landscapes as well as a potential source of future biological resources. There might be a wide range of plant and animal species living there, several of which are threatened on a local or global scale. Pit lakes continue to be poorly managed due to a lack of expertise. To provide ecological and environmental benefits in poor countries, wetland and freshwater systems, like Pit Lake,

[1]Research Scholar, [2]Assistant Professor, [3*]Principal,

are essential. These services range from providing fresh water to giving human populations access to profitable services. like the provision of food through fishing and income generation through eco-tourism. Water is essential for open-pit mining's dust-suppression systems and coal processing units. After mining, these water resources are rarely replenished, which permanently reduces agricultural production. Due to a reduced requirement for dust-suppression water, underground mining has a similar impact,but sufficient water is still required for coal cleaning. These effects include the loss of usable water from shallow aquifers, the decline in nearby water levels and changes in the direction of aquifer flow etc. Greater infiltration may lead to increased discharge of impure water, erosion from spoil piles, and other effects where coal is present. Further, water in open cast pit areas recharges shallow groundwater aquifers with poor water quality. In this context, we conducted the current study on the RCF area's selected pit lakes' to evaluate the water quality of pit lakes. For the preparation of the manuscript relevant literature has been consulted[1-20].

Study sites : Between 2018 and 2021, the study was conducted based on data from five pit lakes (PL) in the Raniganj Coalfield region in Burdwan, West Bengal.Burdwan, Birbhum, Bankura, and Purulia districts of West Bengal, as well as the Dhanbad district of Jharkhand, make up the full 1530 square kilometre Raniganj Coalfield Field (RCF). Based on their size, potential for use, and uniform geographic distribution under ECL, we chose the RCF area's pitlakes that cover a portion of West Bengal.

Table -1. Synoptic Account of study sites

Name of the pitlakes	Latitude	Longitude	Eleva-tion	Area of mining	Block	Nearest village/town
Chora	23° 40'21.4"N	87°12'21.9"E	74.8 m.	Bankola	Pandabeswar	Chora
Joyalvanga 1	23°41'40.2"N	87°17'20.3"E	84 m.	Bankola	Pandabeswar	Joyalbhanga
Dalurbandh	23°42'48.4"N	87°15'46.4"E	79.9 m.	Pandabeswar	Pandabeswar	Dalurbandh
Kumardihi	23°39'54.5"N	87°1'49.6"E	94.5 m.	Satgram	Jamuria	Sripur
Gunjan ecolo-gical park	23p 39'54.5"N	87p 1'49.6"E	94.5 m.	Satgram	Jamuria	Sripur

A detailed description of selected pit lakes in the study area according to their age, area and depth is also represented in Table-2.

Table–2. Selected pitlakes and their age area depth

Sl no.	Name of the pit lake	Age (years)	Area	Depth(feet)
PL01	Chora	30	8.027	80
PL02	Joyalbhanga 1	35	> 12.84	70
PL03	Dalurbandh	40	> 16.05	100
PL04	Kumardihi	30	9.63	100
PL05	Gunjan ecological park	40	40.13-48.16	80

Water sample analysis:

Each of the five pit lakes used for physicochemical research was separated into four sectors due to their size. Using established procedures and recommendations, water samples were taken from each sector during the premonsoon (middle of April each year), monsoon (middle of August each year), and post-monsoon (middle of December each year) seasons between 2018 and 2021. In the results, the value of each parameter was expressed as a mean with standard deviations. Testing for the physicochemical properties of water samples was done using the American Public Health Association's recommended standards[1].

pH - For aquatic life, pH is a crucial limiting chemical element.The H^+ or OH^- ion activity may injure or kill stream creatures if the water in a stream is sufficiently acidic or basic, disrupting the metabolic interactions of aquatic animals (Table-3). Fig. 1 depicts the seasonal variation of water pH for a time span of four years.

Table-3. Variation of pH of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	7.42 ±0.45	7.27± 0.53	7.17 ±0.27	7.54± 0.89	7.35±0.16
Joyalvanga 1	7.74 ±0.78	8.12± 0.57	8.16± 0.50	7.49 ±0.98	7.88±0.32
Dalurbandh	7.44 ±0.88	7.36 ±0.94	7.05± 0.48	7.39± 0.89	7.31±0.18
Kumardihi	7.38± 0.73	7.53± 0.51	6.36± 0.46	7.31 ±0.61	7.15±0.53
Gunjan Ecological Park	7.30± 0.33	7.2± 0.41	6.57 ±0.79	7.27 ±0.26	7.09±0.35

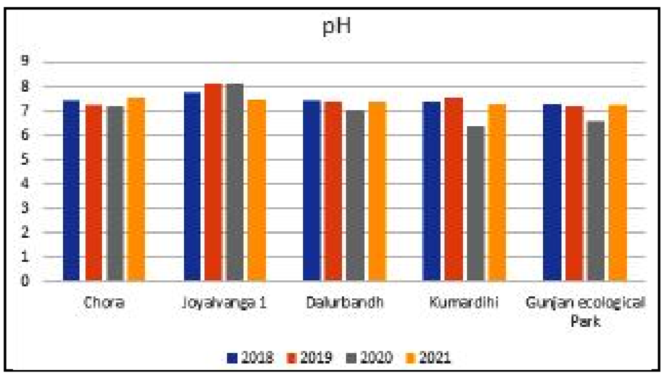

Fig. 1. Seasonal variation of pH in the water samples from 2018 to 2021

Conductivity: How strongly water conducts an electrical current may be determined by looking at its conductivity. Conductivity in water can be impacted by inorganic dissolved particles such as sodium, magnesium, calcium, iron, and aluminium cations or nitrate, nitrate, sulphate, and phosphate anions. Streams that flow over clay soils often have greater conductivities because clay soils include elements that ionise when they are cleaned into the water. Groundwater inflows can result in comparable effects based on the bedrock they pass through. Data on conductivity values of studied water samples were represented in table-4. Figure 2 represents seasonal variation of conductivity value of studied water samples.

Table – 4. Variation of Conductivity of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	541 ±30.05	499.33± 53.29	460 ±60.92	540 ±31.22	510.08±38.62
Joyalvanga 1	448.67 ±227.45	542.33± 67.95	537.33 ±66.73	593.33±21.08	482.67±74.34
Dalurbandh	452.33± 98.88	445.00± 102.22	457.33 ±92.81	435± 70.53	447.42±9.70
Kumardihi	469.67± 41.06	377.33 ±168.05	408.33 ±194.56	454± 48.87	427.33±42.29
Gunjan Ecological Park	563.67± 143.15	563.33 ±143.92	565.67 ±151.01	560± 145.08	563.17±2.35

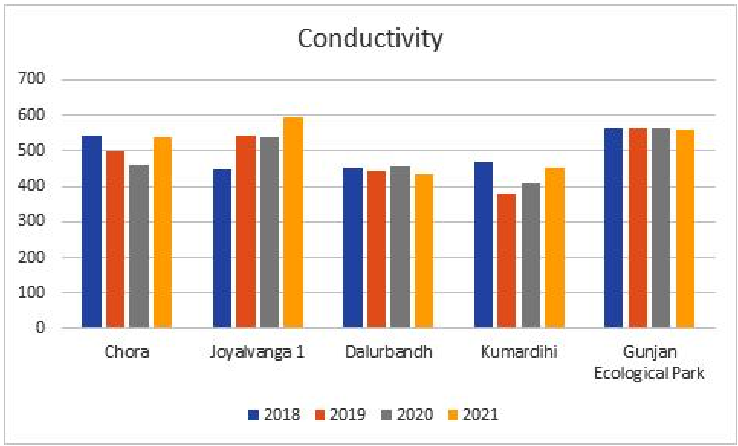

Fig. 2. Seasonal variation of conductivity in the water samples from 2018 to 2021

Total Dissolved solids: Water that has not less than 250 parts per million (ppm) of total dissolved solids (TDS), is tapped at one or more bore holes or springs, and originates from an underground water source that is geologically and physically protected is considered mineral water.When mineral water emerges from the source, it must have a consistent level and ratio of minerals and trace elements, taking into account the cycles of natural oscillations. This sets mineral water apart from other types of water. Table-5 represents the total dissolved solids of water samples of pitlakes. Table-5 represents the TDS value of water samples of pitlakes from 2018-2021. Figure 3 represents the seasonal variation of water samples for a span of fours years in selected pitlakes of RCF region.

Table-5. Variation of Total Dissolved solids of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	326.33 ±16.17	373.67± 99.03	341 137.22	321.67± 4.04	340.67±23.49
Joyalvanga 1	450 ±32.08	450.33± 31.82	417.33± 77.78	430.00± 0.00	441.25±22.16
Dalurbandh	340.67± 56.62	464.33± 252.85	476.67± 243.64	308.00 ±1.73	397.42±85.58
Kumardihi	495.67± 225.46	381.67 ±22.85	381.67± 25.32	322.33± 36.95	395.34±72.50
Gunjan Ecological Park	425± 54.95	465.33 65.86	465.33 ±39.26	368.67± 27.14	431.08±45.75

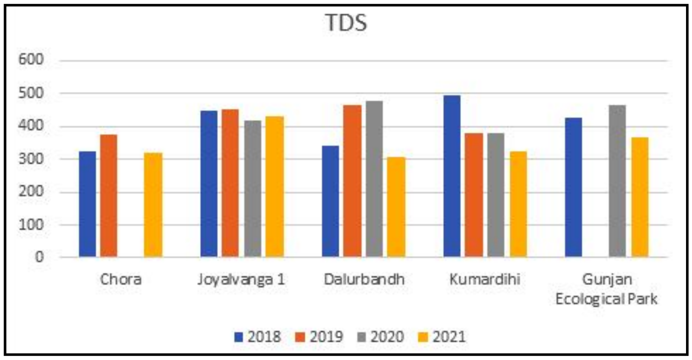

Fig. 3. Seasonal variation of TDS in the water samples from 2018 to 2021

Dissolved oxygen: This is the volume of dissolved oxygen in water. It can be stated as a percentage of dissolved oxygen or measured in mg/L. Fish and other aquatic life use dissolved oxygen for their existence. The DO is affected by the following factors: water temperature, suspended particles, dissolved salts, atmospheric pressure (and thus altitude), the presence of reducing chemicals, and live organisms. Both the generation and consumption of oxygen in water can be attributed to the aquatic flora and fauna. It is the amount of oxygen that is dissolved in water and comes from both the atmosphere and aquatic plants during the photosynthesis process. DO of five pitlakes are represented in table-6. Fig. 4 represents the seasonal variation of dissolved oxygen for a span of four years.

Table- 6. Variation of Dissolves oxygen of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	3.83 ±0.35	3.6± 0.98	4.23± 0.70	3.93± 0.23	3.90±0.26
Joyalvanga 1	5.03± 0.35	4.77± 0.75	4.40 ±0.87	5.13± 0.72	4.83±0.33
Dalurbandh	6.43± 0.55	6.33± 0.40	6.17± 1.10	6.33 ±0.81	6.32±0.11
Kumardihi	5.03± 0.15	4.73± 0.50	4.73 ±0.81	5.13± 0.32	4.91±0.21
Gunjan Ecological Park	4.3± 0.44	3.3± 0.44	4.63± 0.47	4.43± 0.40	4.17±0.59

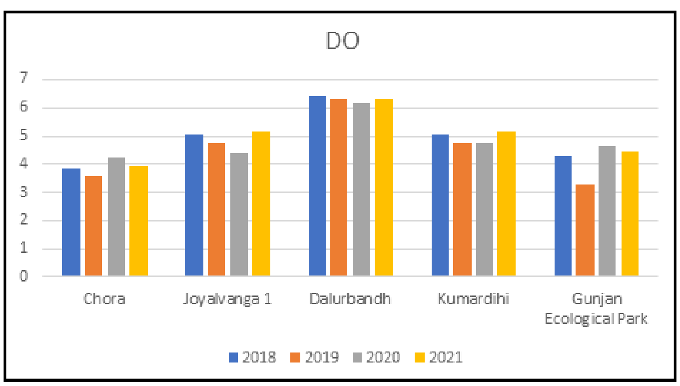

Fig. 4. Seasonal variation of DO in the water samples from 2018 to 2021

Biochemical oxygen demand : It measures the amount of oxygen (O_2) that bacteria need to aerobically oxidise and break down organic materials in water. Less oxygen is available to aquatic life and more organic materials are present when the BOD is higher. The BOD test is necessary to determine how much oxygen organic matter needs to decompose. The intensity and concentration of organic compounds in the water sample are measured. It aids in determining the degree of pollution in the water sample. A BOD level over 5 mg/L indicates contaminated water. Evaluating their BODs at the inlet and output also aids in determining the efficacy of effluent treatment plants. BODs of five pitlakes are determined and are listed below in Table-7.

Table-7. Variation of Bio-chemical oxygen demands of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	1.37±0.12	1.47±0.25	1.67±0.72	1.37±0.53	1.47±0.14
Joyalvanga 1	2.63±0.42	2.97±0.70	2.33±0.57	2.30±0.48	2.56±0.31
Dalurbandh	3±0.46	2.93±0.76	2.80±0.10	2.93±0.57	2.92±0.08
Kumardihi	2.1±0.75	2.20±0.72	2.87±0.50	2.10±0.22	2.34±0.37
Gunjan Ecological Park	2.67±1.10	2.63±1.14	3.23±0.99	2.13±0.29	2.67±0.45

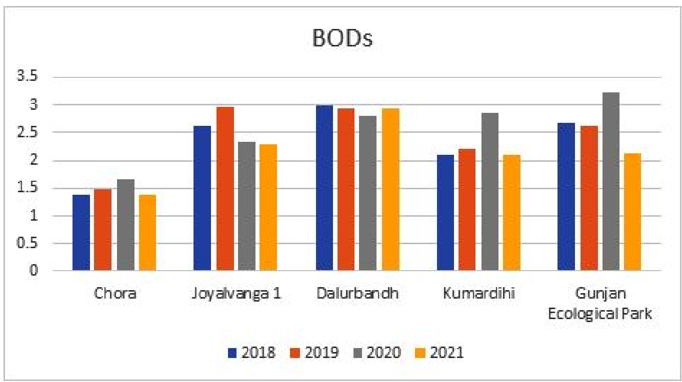

Fig. 5. Seasonal variation of BOD in the water samples from 2018 to 2021

Alkalinity : The amount of bicarbonates, carbonates, and salts of humic and fulvic acids in water dictates how alkaline it is[6]. The alkalinity of five pitlakes are listed below in Table 8. Fig. 6 represents the seasonal variation of alkalinity in water sample.

Table-8. Variation of Alkalinity of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	32.67±5.69	33.33±7.57	36±4	33.33±4.62	33.83±1.48
Joyalvanga 1	28±8	29.00±6.00	28±10	30.67±4.62	28.92±1.26
Dalurbandh	39.67±7.23	34.67±13.65	32±14	38.67±4.62	36.25±3.56
Kumardihi	23.67±4.04	24.00±4.58	30±7.8	22.67±4.62	25.09±3.33
Gunjan Ecological Park	22±7.21	24.67±10.26	28±12	18.67±2.31	23.34±3.96

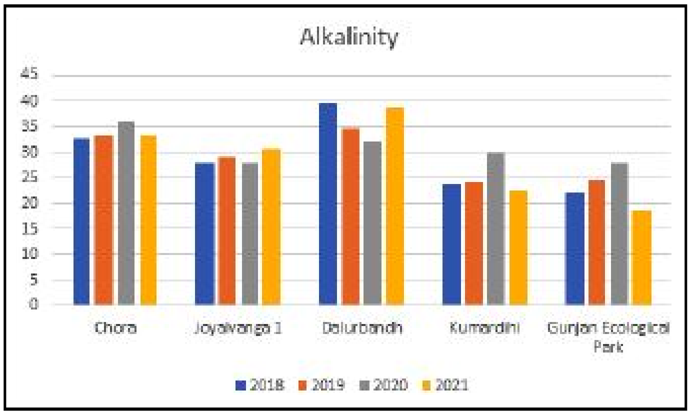

Fig. 6. Seasonal variation of alkalinity in the water samples from 2018 to 2021

Chloride: If water comes into touch with fertilisers or industrial trash, its chloride content may rise. Seawater and certain minerals can also produce chlorine. High blood pressure might result from the presence of chloride above the allowed maximum of 250 mg/L. Additionally, it contributes to pipe corrosion, the blackening of stainless steel, and the salty taste of water. The chloride content of water sample of five pitlakes is represented in table-9. Fig. 7 represents the seasonal variation of chloride of water samples of selected pitlakes of RCF region.

Table-9. Variation of Chloride of the water samples

Study sites	2018	2019	2020	2021	Mean
Chora	54.57± 28.76	54.87 ±28.51	55.50 ±28	38.29± 0.58	50.81±8.35
Joyalvanga 1	43.75± 12.45	44.98 ±13.70	48.76± 8.49	43.96 ±13.84	45.36±2.33
Dalurbandh	44.45 ±13.76	41.09± 11.43	44.09 ±16.1	44.29± 15.13	43.48±1.60
Kumardihi	47.13± 13.09	44.80± 11.40	46.83 ±13.1	46.95± 13.51	46.43±1.09
Gunjan Ecological Park	50.28± 23.07	43.95 ±11.25	51 ±22.5	43.29± 10.96	47.13±4.07

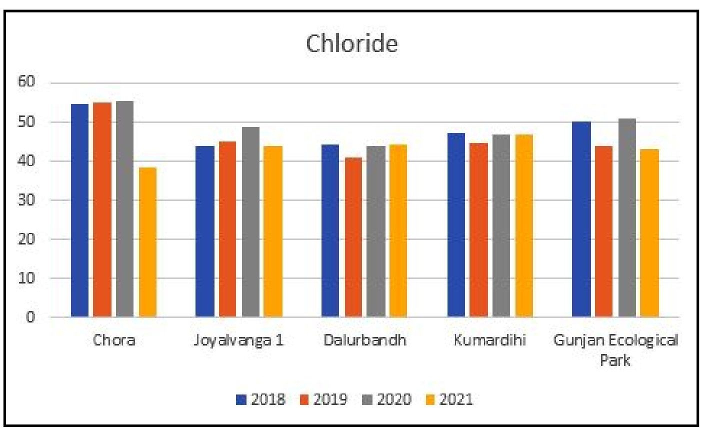

Fig. 7. Seasonal variation of chloride in the water samples from 2018 to 2021

A sample of water's nitrate nitrogen naturally occurring in streams, nitrate is the type of nitrogen that has undergone the greatest oxidation. Chemical fertilisers, decaying plant and animal waste, household effluents, sewage sludge discharged on land, industrial discharge, leachates from garbage dumps, and atmospheric washout are the primary sources of nitrate. Although it can be found in many types of water bodies, because of its organic origin, the concentration may be higher in places close to coal mines. Data on nitrate nitrogen content in water samples of selected pitlakes of RCF is depicted in table-9. Fig. 8 represents the seasonal variation of nitrate nitrogen content of the water sample of pitlakes of RCF region.

Table-9. Variation of Nitrate nitrogen of the water sample

Study sites	2018	2019	2020	2021	Mean
Chora	2.18±0.71	2.18±0.50	1.72±0.60	2.02±0.88	2.03±0.22
Joyalvanga 1	0.68±0.46	0.68±0.55	1.06±0.64	0.83±0.44	0.81±0.18
Dalurbandh	3.32±2.04	3.26±1.99	2.63±1.39	2.98±1.68	3.05±0.32
Kumardihi	0.82±0.08	0.72±0.08	0.98±0.73	0.82±0.08	0.84±0.11
Gunjan Ecological Park	1.15±0.52	1.09±0.48	1.89±0.53	1.05±0.48	1.30±0.40

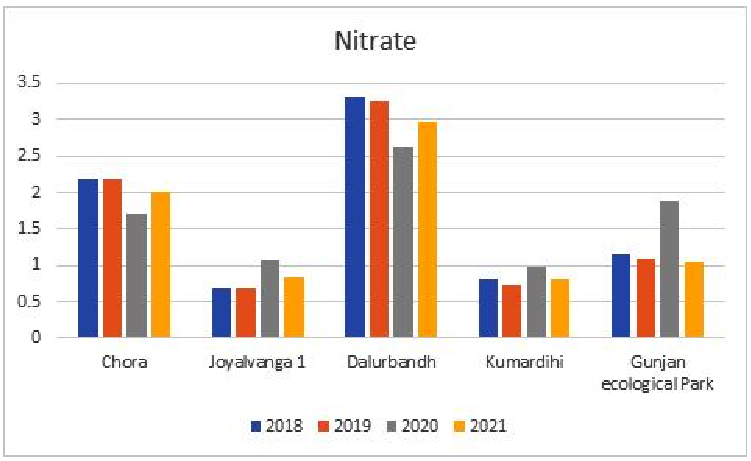

Fig. 8. Seasonal variation of nitrate nitrogen in the water samples during 2018 to 2021

Phosphate : The main form of phosphorus found in sewage and natural waterways is phosphates. It is one of the fundamental components required for plant growth. However, an increase in its concentration might hasten the process known as eutrophication, which is the loss of oxygen from the water body due to an increase in the concentration of organic and mineral nutrients. Even while phosphate causes issues in surface waters, it is important for the biological breakdown of sewage. Table 10 represents the phosphate content of water samples of selected pitlakes of RCF region. Fig. 7 reflects the seasonal variation of phosphate in water samples of selected pitlakes of RCF region.

Table-10. Variation of Phosphate of the water samples

Study sites	2018	2019	2020	2021	Mean
Chora	3.76±1.73	3.81±1.87	3.52±1.32	3.66±1.77	3.69±0.13
Joyalvanga 1	1.25±0.18	1.58±0.70	1.59±0.40	1.22±0.16	1.41±0.20
Dalurbandh	1.41±0.54	1.37±0.53	1.74±0.08	1.42±0.55	1.49±0.17
Kumardihi	2.55±2.31	3.62±1.43	2.30±1.04	2.52±2.34	2.75±0.59
Gunjan Ecological Park	1.58±0.26	1.91±0.83	2.68±1.46	1.45±0.06	1.91±0.55

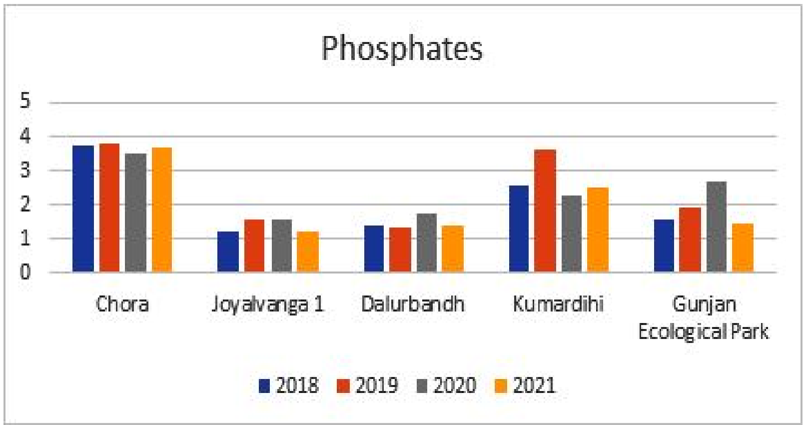

Fig. 9. Seasonal variation of phosphate in the water samples from 2018 to 2021

Hardness : It is a measure of the calcium and magnesium content of a water sample, which is what causes soap to precipitate. A sample's hardness is expressed as equivalent $CaCO_3$ in mg/L. Although its effects on human health may not be particularly noticeable, they are very serious in industrial settings where they can cause expensive failures in cooling towers, boilers, and other equipment. Hardness value of water samples of selected pitlakes of RCF region are represented in table-11. Fig. 10 depicts the seasonal variation of hardness of water samples of selected pitlakes of RCF region.

Table-11. Variation of Hardness of the water samples

Study sites	2018	2019	2020	2021	Mean
Chora	170±26.46	176±22.54	209±36	166.67±23.09	180.42±19.44
Joyalvanga 1	338.67±53.12	319±68.51	348±123	333.33±57.74	334.75±12.12
Dalurbandh	229.33±40.86	227.33±44.41	259±39	214.67±16.17	232.58±18.77
Kumardihi	190.33±68.06	201±95.36	200±91	188.00±68.35	194.83±6.63
Gunjan Ecological Park	302.33±96.82	272.67±118.16	309±173	290.67±99.14	293.67±15.92

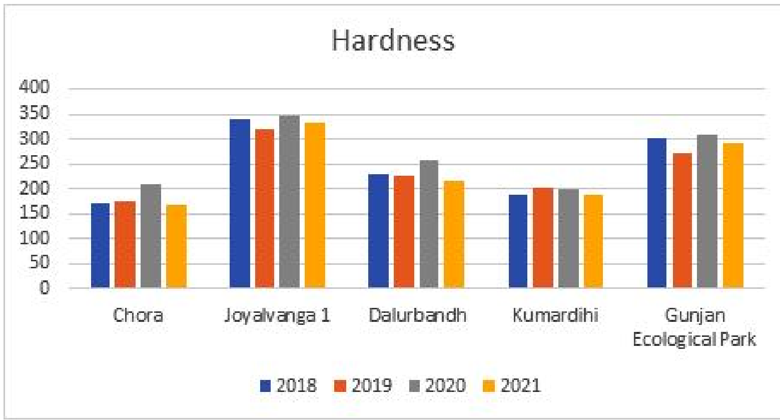

Fig. 10. Seasonal variation of hardness in the water samples from 2018 to 2021

In the presend, study, various physico-chemical traits were analysed to evaluate the water quality of selected pitlakes of RCF region.

In Gunjan Ecological Park Pit Lake's pH value was 7.09 at its lowest, and Joyalvanga 1 Pit Lake's pH value is 7.88 at its highest. Water's ability to neutralise acid is measured by its alkalinity, which is defined by the presence of hydroxyl ions that can combine with hydrogen ions in the solution.The samples from the pit lake in Gunjan Ecological Park had the lowest value of this value (23.34 mg/l), and the samples from the pit lake in Dalurbandh had the highest value (36.25 mg/l). Most of the samples' low alkalinity values show that both weak and strong bases are absent. It causes the water's ion exchange capacity to decrease.

Chora had the lowest level of hardness (180.42 mg/l), while Joyalvanga 1 pit lake had the highest level (334.75 mg/l). Hardness and alkalinity are both crucial elements of water quality.Hardness is a measure of the total amount of divalent salts (calcium, magnesium, iron, etc.), but it cannot be used to determine which of these elements is or are the cause of the hardness.

pH is used to determine whether water is acidic, neutral, or basicThe lowest DO (Dissolved Oxygen) level was found in Chora pit lake at 3.90 mg/l and the highest level was recorded in Dalurbandh pit lake at 6.32 mg/l (table-3 and 4).

The direct diffusion of air across the air-water interface can be responsible for the higher DO level. Additionally, it might be caused by direct sunlight penetrating the expansive surface of wetlands, which can sustain phytoplankton photosynthetic activities and aid in maintaining the DO level.

BOD levels were observed to range from 1.47 mg/l in samples from Chora Pit Lake to 2.92 mg/l in samples from Dalurbandh Pit Lake. High levels of biologically oxidizable organic matter and many microorganisms may contribute to a higher BOD value (Verma *et al*., 1994). For Chora pit lake, the minimum TDS value was established to be 340.67 mg/l, and the maximum TDS value was found to be 441.25 mg/l.

Water samples from Kumardihi Old OCP Pit Lake had the lowest EC level (427.33 s/cm), whereas water samples from Gunjan Ecological Park Pit Lake had the highest EC level (563.17 s/cm). The water samples' EC values are used to identify the ionic components that are present in the water body.

The TDS and Salinity concentrations are responsible for the variance in EC value between sourcesin the Joyalvanga 1 pit lake, the phosphorus level was determined to be the lowest (1.41 mg/l), while in the Chora pit lake, the highest (3.69 mg/l).

The lowest concentration of nitrate nitrogen was identified in Joyalvanga 1 (0.81 mg/l) while the highest concentration (3.05 mg/l) was recorded in Dalurbandh Pit Lake. Nitrites, an altered form of nitrates that can exist for a brief period, can seriously sick both wildlife and people.

The results obtained during the present investigation revealed significant variation in the water quality parameters among the studied pitlakes of RCF region. Mostly the water has high mineral and nutrient content and hence can be utilized for aquaculture practices, irrigation practices for agriculture, ecotourism point and other sustainable use of water resources. This would also promote sustainable water use on one hand and on the other it would promote conservation of ground water and other surface water resources.

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