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Water Quality Assessment and its Impact on Shrimp in the Rupnarayan River: A Comparative Study from February to May of 2022-2024

Rajrupa Ghosh [a++*] and Subhomay Maity [a#]

[a] Department of Environmental Science, Institute of Management Study, 93 Mukundapur Main Road, E. M. Byepass, Kolkata-700099, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The Rupnarayan River is the heart of the Purba Medinipur district of West Bengal, as it is the habitat of a large number of aquatic species and the main drinking, agricultural, irrigation, and cultivation resource. We collected river water samples from the Kolaghat, Alinan, Siuri and Deemari villages near Tamluk in the Purba Medinipur district. Then, we assessed different water quality parameters, such as temperature, turbidity, pH, DO, BOD, salinity, alkalinity, and hardness. We studied the premonsoon phase (Feb-May) and assessed the impact of these

[++] Assistant Professor;
[#] Student of M.Sc.;
**Corresponding author: Email: riku.rock93@gmail.com;*

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parameters on the production of shrimp species. We identified *M. rosenbergi, M. brevicornis, M. monoceros, and Penaeus* vannamei as shrimp species. We also compared the data from 2022 to 2024 (Feb-May) and observed yields of 40%, 60%, and 30% in 2022, 2023 and 2024, respectively.

Keywords: Salinity; alkalinity; hardness; BOD; DO; shrimp; species.

1. INTRODUCTION

The West Bengal Basin has a river called the Rupnarayan. It originates as the Dhaleswari (Dhalkisor) on the slopes of Chhota Nagpur, northeast of Purulia town. In Bankura, it is called the Darakeswar River. The Darakeswar River, which is named Rupanarayan, is joined by the Shilaboti River in the Pachim Medinipur district, close to the town of Ghatal. The Rupnarayan River flows for 70–80 km before joining the Hoogli River near Geokhali in the Purba Medinipur district. It is well known for being an endangered Hilsa fish because of its water quality. The West Bengal Power Development Corporation Limited (WBPDCL) and the Water Treatment Plant, which were constructed along its bank near Kolaghat, West Bengal, are also noteworthy [1,2]. The lower portion of the Rupnarayan River is affected by tidal actions from the Bay of Bengal. The tidal actions range from approximately 3 meters in length in Kolaghat during the rainy season from July to August. The river's average water speeds at this location are 1.8 m/s during the middle tide and 1.6 m/s during the full tide. Similarly, the Purba Medinipur District is affected by the Rupnarayan River tides. The Kolaghat station on the Rupnarayan River is approximately 135 kilometers from the ocean [3,4].

The Rupnaran River is crucial for aquatic life, including fish species. After treatment, this water is also usable for drinking water. This water is also utilized for agriculture; however, it is polluted because of wastewater from the Haldia Industrial Area and effluents from the KTP Plants.

This mix with the tidal water of the Rupnarayan River. As a result, the water became somewhat saline. Water is the most valuable resource and plays a major role in shaping the globe and regulating the climate. For all living things, water pollution treatment is essential. Due to increased industrialization, widespread use of pesticides, and chemical pollutants from fertilizers discharged from agricultural areas, the aquatic environment of living species is becoming more polluted. As a result, water quality and the reduction in aquatic life span are greatly threatened [2,5].

The most precious resource, water, is essential for both forming the world and controlling the climate. Treatment of water contamination is vital for all living organisms. The aquatic habitat of living plants is more contaminated as a result of growing industrialization, widespread pesticide usage, and chemical pollutants from fertilizers released from agricultural areas. Water quality and the shortening of aquatic life spans are consequently seriously endangered [5].

2. AIMS AND OBJECTIVE

- To assess the quality of the water parameters and study their impact on aquaticinhabited species.
- The different measures and concentrations of different minerals in the water samples from different areas were assessed.
- To assess the changes in water quality parameters after contamination with industrial, agricultural and other effluents.
- To study the impact on shrimp species (*M. monopheros, M. rosenbergi, M. brevicornis, and Penaeus vannamei)* and their identification.
- To study the impact on prawn growth and its socioeconomic impact.
- To compare and contrast the data from 2022 to 2024 during the premonsoon phase (Feb-May).

3. METHODS

3.1 Study Location

In the Sahid Matangini Block of Purba Medinipur, large-scale cultivation of these marine shrimps is carried out in the villages of Kolaghat, Alinan, Siuri, and Deemari. These villages are located close to Tamluk town, which is the district capital of Purba Medinipur.

The study was performed from February to May of 2022 to 2024.

Chart 1. Study site details

Area name	Latitude & Longitude
Kolaghat	22°26'08''N 87°52'59''E
Tamluk	22°17'25''N 87°56'05''E

3.2 Method for Analysis

1. Temperature

The temperature of the water was measured with a mercury-filled Celsius thermometer that ranged from 0 to 50 °C. After being submerged in the sample water for one minute, the thermometer was ultimately retrieved. Temperature plays a major role in shrimp growth. Increased temperature also has an impact on shrimp growth. The ideal temperature for shrimp is between 26 and 30°C [6-8].

2. pH

A digital pH meter (EUTECH pH 700) was used to measure the water pH of the collected samples. The instruments were calibrated using buffer solutions with pH values of 7 and 10 before use. Without exceeding the maximum immersion level, the pH probe was submerged in the water samples that were going to be examined. After the sample was shaken slightly and allowed to stabilize, the final pH was recorded. The pH range that shrimp species need to survive is between 7 and 8.5. In addition to causing stress and a soft shell, higher or extreme pH also impacts the survival rates of shrimp [6,9].

3. Turbidity

The measurement of turbidity has a significant impact on water quality. The ability of light to enter water is affected by turbidity, which in turn affects algae growth and photosynthetic activity. Lovibond TB 210 IR equipment for measuring turbidity. For species of shrimp, turbidity is also crucial. The ability of shrimp species to grow is also impacted by more turbid water. The discharge of various industrial pollutants and effluents into the Rupnarayan River affects both the turbidity of the river and the survival of shrimp species [8- 10].

4. Alkalinity

The titration method was used to measure the alkalinity of the water (APHA, 1992). After the burette was rinsed with distilled water, 0.1 N sulfuric acid (H_2SO_4) was added to normalize the pH using Na2CO3. A 250 ml conical flask was filled with a 10 ml sample and five drops of the phenoptheline indicator solution. The volume of the titrate was measured after adding five drops of methyl orange indicator to the sample and titrating it with 0.1 N sulfuric acid (H_2SO_4) until it turned pale pink. Elevated alkalinity influences not only the water's pH but also the types of shrimp that inhabit it. The ideal range for alkalinity is 150–180 ppm [9,11,12].

5. Hardness

Measures of the total hardness parameter are also significant for water quality. Elevated levels of hardness also have an impact on shrimp species and water quality. First, the EDTA measurement was noted. Next, the sample was removed, and 1-2 ml of the ammonia buffer solution was added to one well. When the wine-red Eriochrome Black T Indicator color appears, the solution is titrated. EDTA: The titration was stopped, and readings were obtained when the color changed to royal blue. Using the titration method of ethylenediaminetetraacetic acid (EDTA), the hardness of the water was determined [11,13].

6. Nitrate

An essential component of water quality is nitrate, and nitrate concentration measurements are crucial for water quality. The photometer instruments employ the chromotropic acid technique to test nitrate [14].

7. Dissolve oxygen (DO)

DO is a crucial indicator of water quality. Do is the primary indication of water. For shrimp species to survive, DO is crucial. The sample was extracted in a DO bottle with a tight cap, 2 ml of alkaline azide and 2 ml of manganous sulfate were added, the sample was allowed to settle for 30 minutes, the sample was inverted 5–6 times, the sample was transferred to a conical flask, and the sample was titrated with sodium thiosulfate solution. Using the modified Winkler technique, the amount of dissolved oxygen was determined [15].

8. Iron

Iron is a crucial indicator of water quality. There are two major states of iron: ferrous and ferric. The water turns reddish-brown when ferrous ions move from ferric to ferrous. The accuracy with which iron is estimated is crucial. A photometer was used for the measurements. Using the 1, 10 phenanthroline technique, iron was estimated [16].

9. BOD

BOD, or biological oxygen demand, is a crucial indicator of water quality. It is the type of dissolved oxygen needed for aerobic bacteria to stabilize the decomposable organic matter present in water. Once the DO concentration has been obtained, the bottle needs to be stored within the "BOD incubator." However, other parameters, such as humidity and pressure, should be maintained, and the temperature should be set at 20 °C. After five days, the bottle was removed from the incubator, and the final DO concentration was measured at the same temperature. The amount of dissolved oxygen used by the bacteria over the course of the five days to break down the organic materials in this diluted water is indicated by the difference between the starting and final DO values [7,17].

Table 1. Physicochemical parameter of Rupnarayan river February to May 2022

Parameters	February	March	April	May
pH	7.77	7.7	7.71	7.63
Temperature (°C)	20.7	29.1	30.2	30.8
Turbidity (NTU)	150	150	230	220
TDS (mg/lit)	177	353	526	331
Conductivity(µS/Cm)	355	706	1051	663
Hardness as CaCo3 in (mg/lit)	126	160	190	150
Alkainity CaCo3in (mg/lit)	130	144	176	134
Chloride (mg/ltr)	35.45	130.456	321.886	192.928
Iron (mg/ltr)	0.3	.56	1.10	.67
Nitrate(mg/ltr)	4.43	4.43	5.759	3.987
Dissolve oxygen(mg/ltr)	4.5	4.2	4.7	5
Biological oxygenDemend (BOD) as (mg/ltr)	4	4	4	4.6

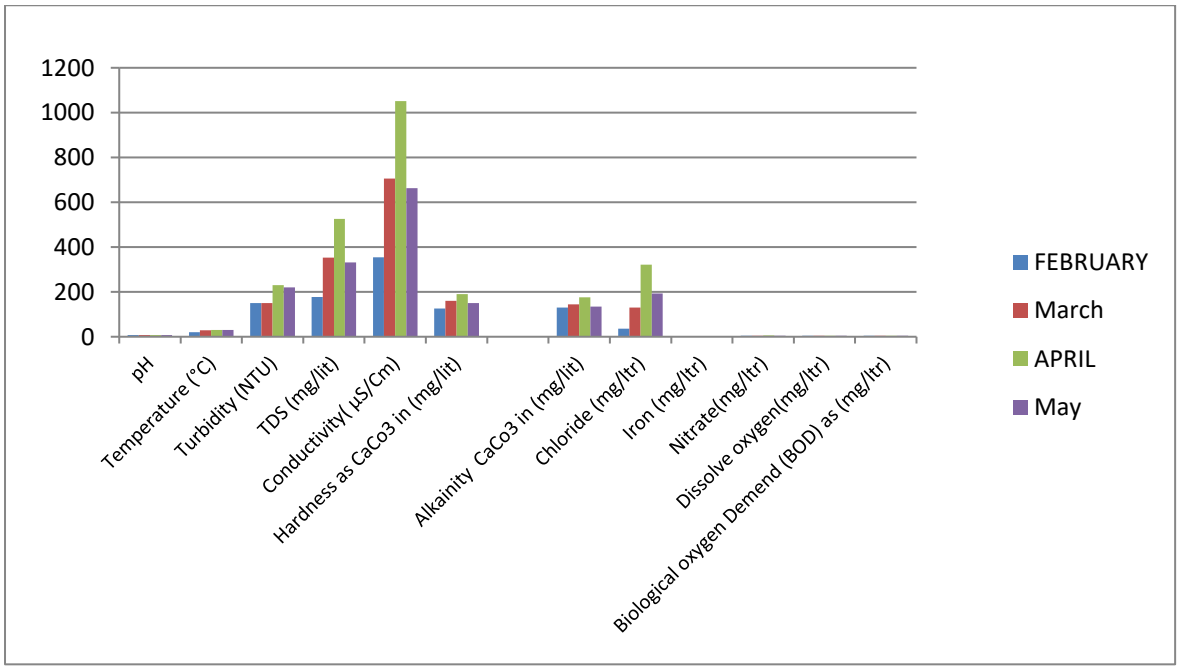


Fig. 1. Bar graph showing physicochemical parameter of Rupnarayan river February to May 2022

Table 2. Physicochemical parameter of Rupnarayan river February to May 2023

Parameters	February	March	April	May
pH	7.70	7.7	7.65	7.58
Temperature (°C)	24.5	26.7	29.8	31.6
Turbidity (NTU)	230	450	590	470
TDS (mg/lit)	310	583	1018	1110
Conductivity(µS/Cm)	621	1165	2037	2220
Hardness as CaCo3 in (mg/lit)	178	220	465	308
Alkainity CaCo3 in (mg/lit)	158	196	428	204
Chloride (mg/ltr)	92.17	241.06	490.628	581.38
Iron (mg/ltr)	.58	.6	1.3	1.35
Nitrate(mg/ltr)	3.987	4.873	7.531	9.303
Dissolve oxygen(mg/ltr)	4.5	4.7	4.3	5.3
Biological oxygen Demend(BOD) as (mg/ltr)	4.1	4.2	3.7	4.7

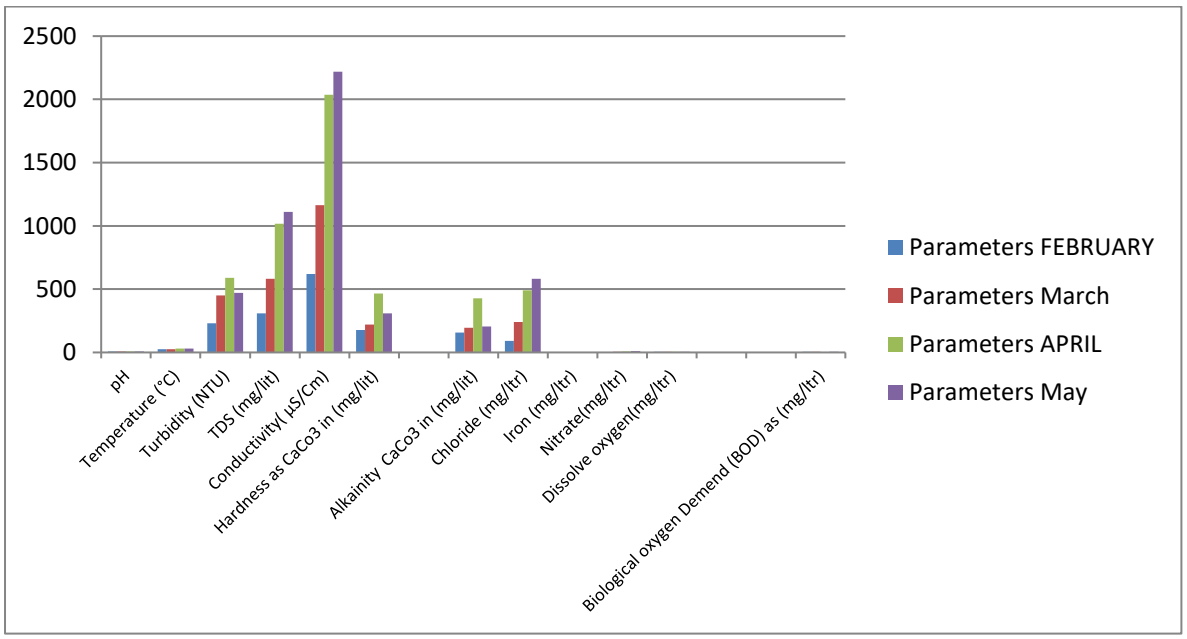


Fig. 2. Bar graph showing physicochemical parameter of Rupnarayan river February to May 2023

Table 3. Physicochemical parameter of Rupnarayan river February to May 2024

Parameters	February	March	April	May
pH	8	7.59	7.5	7.7
Temperature(°C)	22.2	26.2	33	32.3
Turbidity (NTU)	100	250	500	600
TDS (mg/lit)	250	459	1140	1600
Conductivity(µS/Cm)	500	919	2280	3210
Hardness asCaCo3 in (mg/lit)	170	210	334	420
Alkainity CaCo3in (mg/lit)	150	156	184	180
Chloride (mg/ltr)	75.154	120.53	595.56	801.17
Iron (mg/ltr)	0.3	0.5	1.58	1.8
Nitrate(mg/ltr)	6.645	5.316	13.29	19.935
Dissolve oxygen(mg/ltr)	5	4.3	4.8	4.3
Biological oxygen Demend(BOD) as (mg/ltr)	4.8	4	4	3.6

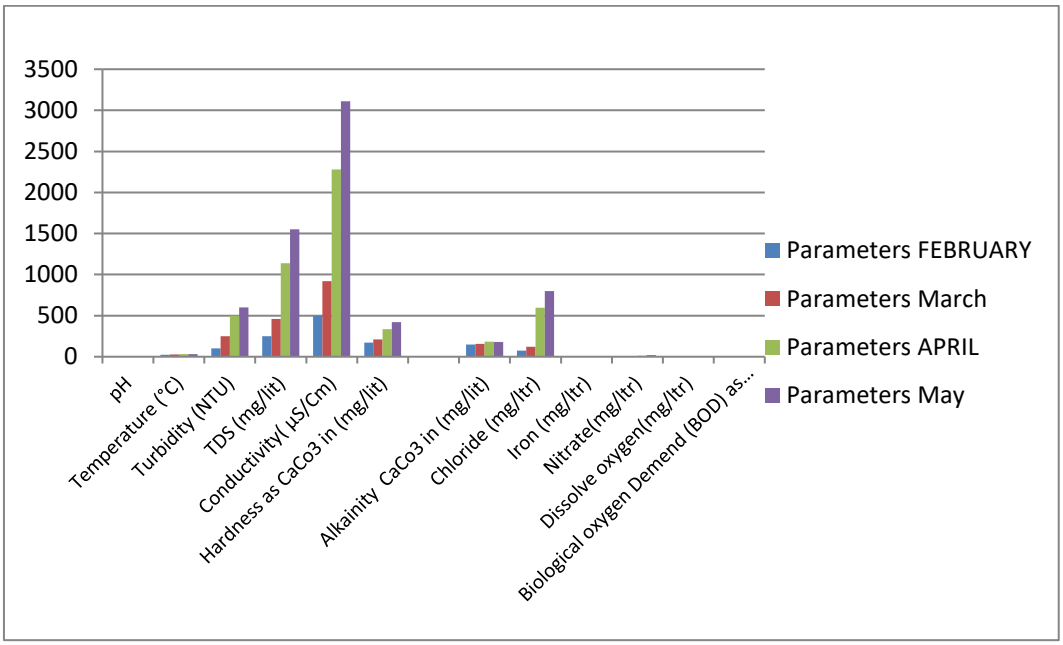


Fig. 3. Bar graph showing physicochemical parameter of Rupnarayan river February to May 2024

3.3 Sampling of Species

Juvenile shrimp seed collection method from the river: A significant number of people, mostly women, gather junenile shrimp seed on the riverbank in the Purba Mednipur district, particularly in the kolaghat to tamluk area, between the months of March and May, from 10 p.m. to 7 a.m. When the water flow reaches its greatest during high tide, they employ nets to gather the young seeds, which happens two hours later during low tide. Kolaghat, Sahid Matangini, and Tamluk block shrimp seed harvesting for the past two years and have provided local communities with an extra revenue stream. The natives of this region made nets out of triangles of bamboo, which they called "kolle jal" in the vernacular. Additionally, circular scoop nets are utilized. For the next three months, the collected folks made every effort to gather this immature seed because they are not fishermen in this area, and this is their additional source of income. We spoke with some locals in Kolaghat during our survey, and they told us that we may ship these young seeds to Bangladesh and make good money doing so. He obtained these young seeds from the locals and gave them a portion for 0.75–1/-. We saw locals who live along the riverbank gather 800-1000 immature seeds every day. They also sell fish in retail fish markets in Kolaghat, Tamlulk, Kakatia, and Mecheda at 200–300/-per kg, although sometimes they sell them at 400–500/-per kg. Some Kolaghat fishermen use this jal and gather shrimp. Numerous others in this region, from Kolaghat to Tamluk, also benefitted from using water from the Rupnarayan River. It is evident that some individuals utilized mughri to catch shrimp. Retail prices for M. rosenbergi and M. brevicornis range from RS 400 to RS 500/kg [18-20].

In two previous years, the abundance of the whiteleg shrimp (*Penaeus* vannamei) in the Rupnarayan River increased rapidly (2022–2024). The people who reside on the Rupnarayan River bank have also made great efforts to gather shrimp. Our survey area in the Purba Medindipur district extends from Kolaghat to Tamluk, but we also collected much useful information from many people, especially Kathi and Nandigram, who helped gather shrimp before selling them and making money from the market. This "vennami" prawn is becoming increasingly in demand. When we conduct surveys in this field, we obtain comprehensive and informative information. Several varieties of "Veri" from the Purba Medinipur district also use the Rupnarayan River for shrimp cultivation. These shrimp also grow Nandigram, Khejuri, and Kathi-3 blocks [20].

Fig. 4. *Penaeus vennamei*

Fig. 5. Shrimp catching at Kolaghat

Fig. 6. *M. rosenbergi*

Fig. 7. *M. brevicornis and M. monoceros*

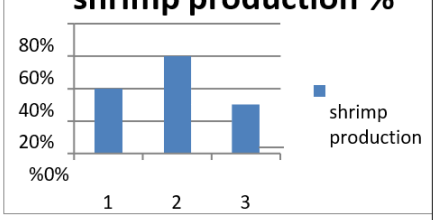
Year	Shrimp production %
 2022	40%
2023	60%
2024	30%

Fig. 8. Comparative study of shrimp production data for 2022, 2023, and 2024 (Feb-May)

Identification of shrimp species:

- ***Macrobrachium rosenbergi-***

It is a freshwater shrimp. The length of the shrimp was 30 cm. The color of this shrimp is brounish, but some species are greenish. This type of shrimp contains 11-14 drosal teeth and 8-11 ventral teeth. The first pair of legs is very thin, but the second pair of legs is the most powerful. Females and males are differentiated by their abdomen [21,22].

- ***Michrobrachium bravicornis-***

It is also a freshwater shrimp. The color of the shrimp is brownish or pinkish. Joint appendages

were also present. It is also found in the Rupnarayan River near Kolaghat [23].

- ***Microbrachium monoceros-***

It is also a freshwater shrimp. It is found in the Rupnarayan River. The color of this species is slightly brown. Thin hairy coverage was found throughout the body [24].

4. RESULTS AND DISCUSSION

Shrimp species growth and productivity are also influenced by water quality parameters. The growth of shrimp species is also influenced by the water pH, total dissolved solids, total hardness, alkalinity, and chloride content. We also constructed a water quality analysis chart, which displays additional water parameters [25], such as temperature, turbidity, pH, alkalinity, and hardness that affect shrimp species growth and productivity. The water of the Rupnarayan River also has an increased iron content. In April and May, the concentration of chloride increased as well. The salinity in this river has increased as a result of the increase in chloride concentration. The premonsoon season (February to May) is when we conducted the survey. Temperature, iron, and chloride concentration all affect how quickly organisms grow.

- A comparative study conducted in 2022–2024 from February to May revealed that the water quality also impacts the shrimp species.
- We also demonstrated that the temperature increased in April and May of each year during our study period. The temperature will increase even further in 2024. Elevated temperatures have an impact on the survival of shrimp species and increase the organic load.
- The temperature also increases in April and May. The growth and output of shrimp species are also influenced by temperature in the months of April and May in 2024.
- The amount of dissolved oxygen (DO) decreases as a result of rising temperatures. The DO level is a crucial component of water quality on which aquatic life depends. A decrease in DO has an impact on aquatic life. As a result, a significant number of shrimp species were affected in 2024.
- Compared to the previous two years, 2024 had an impact on growth and production. Although the Rupnarayan River is a freshwater river, pollution causes waste materials to mingle with the water during high tide, increasing turbidity. Shrimp species were similarly impacted by high turbidity. The Rupnarayan River water is enriched with turbidity during April and May at approximately 1000 NTU, which also affects shrimp production.
- Other crucial parameters for water are pH and alkalinity. The pH of the water rises during February 2024 (pH 8.5), and consequently, shrimp growth is likewise decreased by highly poisonous and alkaline water.
- We also observed that during April and May, there was a significant increase in the chloride concentration. An increase in chloride content also affects the concentration of iron, hardness, conductivity, and total dissolved solids (TDS). Shrimp gills are similarly affected by hard water if the hardness increases. During the first two months of each year, due to the high TDS, the nitrate concentration also increased, which also reduced shrimp growth. In addition, a high level of conductivity represents a high amount of ions in river water. As a result, a significant reduction in shrimp production and growth was observed.
- Every year, during the months of May and April, a significant increase in iron concentration was also observed. An increase in iron content is a significant determinant of water quality in the Rupnarayan River. Over the course of the three-year trial, there was a discernible change in the iron concentration. Aquatic creatures, particularly fish and shrimp species, are similarly impacted by changes in iron concentration. This iron concentration increases in the trophic chain and affects human health after consumption.
- Numerous human activities also affect river water hydrology and ecosystems. Shrimp growth is also impacted by numerous chemical contaminants. Pollution causes harm to species, such as gill damage, white spots, and tail rot.
- Although the Rupnarayan River is a freshwater river, the water became saline for the next two months, which had a significant impact on the shrimp species. Because of pollution and waste water discharge, changes in water quality significantly impact the growth of shrimp species. The temperature of the water will increase rapidly by 2024, which will have an impact on species survival [6,8].

5. CONCLUSION

- Maintaining water quality is crucial for aquatic life as well. Changes in the water quality of the Rupnarayan River also affect aquatic ecology. Following treatment, sewage waste is released, which also enhances the quality of the water. The current study demonstrated that parameters related to water quality, including pH, temperature, turbidity, hardness, alkalinity, TDS, chloride, iron, DO, and BOD concentration, also fluctuate. If these variations persist throughout the year, they may have an effect on the development and yield of the shrimp species found in this river.
- Additionally, locals gather young shrimp species that have an impact on the river's native shrimp ecosystem. This kind of gathering also has an impact on the shrimp species' natural habitat of shrimp species.
- Some unscrupulous people employ methyl parathion and cypermethrin, which also affect aquatic organisms, to trap shrimp in the dark. These chemicals have devastating effects on the natural ecology and water quality of shrimp. The natural environment of the shrimp species will be restored if the government takes proactive steps and increases its initiatives in this area to stop this behavior.
- Community awareness of this goal should be increased, and people should be encouraged to dispose of household garbage properly and to recognize the value of water in restoring its quality. The government should take greater steps to maintain water quality.
- Should the aforementioned actions be taken, the ecosystem supporting shrimp species will be enhanced, and the water quality of the Rupnarayan River will be restored.
- Some unscrupulous people employ methyl parathion and cypermethrin, which also affect aquatic organisms, to trap shrimp in the dark. These chemicals have devastating effects on the natural ecology and water quality of shrimp.
- The natural ecosystem of the shrimp species will be restored if the government stops this activity and takes positive action in this area. Raising community awareness of the need to recover water quality and encouraging residents not to discharge domestic waste will also help in this activity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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