INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 7.581]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 9, Issue - 6, June - 2023 Publication Date: 30/06/2023

DOIs:10.2015/IJIRMF/202306027 --:-- Research Paper / Article / Review

Study on Physico-Chemical Parameters & Correlation of River Ganga water at Babupur Ghat of Bhagalpur (Bihar).

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Abstract: *The river Ganges, also known as the Ganga, is one of the most iconic and sacred rivers in India. It serves as a crucial source of water for millions of people and supports diverse ecosystems. However, anthropogenic activities and pollution have significantly impacted the physicochemical parameters of the river, affecting its water quality and ecological health. In the present investigation, the physicochemical parameter of the River Ganga at Babupur Ghat of Bhagalpur (Bihar) was analyzed the analysis of the water sample was taken during January – December 2020. Seasonal variations at different sampling sites of Babupur Ghat were observed. The results showed that the fluctuation occurred in physicochemical parameters in different seasons. The correlation coefficient value indicates high positive and negative relationships ($p<0.01$ level) and also show significant positive and negative relationship ($p<0.05$ level). About 11 physicochemical parameters were taken in consideration for the analysis of the river water such as water temperature, Total Alkalinity, pH, Dissolved oxygen, biological oxygen demand, chemical oxygen demand, Turbidity, Electrical conductivity, Phosphate, and Chloride. This paper deal with the study of the river Ganga at Bhagalpur.*

Keyword: *Bhagalpur, Babupur, Physico-chemical, River Ganga.*

1. INTRODUCTION:

Rivers are vital lifelines that sustain human civilizations and support diverse ecosystem. In India, rivers hold immense cultural, social, and economic significance, playing a crucial role in the country's history, mythology, and daily lives of millions of people. Among the numerous rivers in India, the Ganges, holds a special place. The Ganga, commonly referred to as the Ganges, is a significant river in South Asia that flows through Bangladesh and India. It is one of the world's longest rivers, measuring about 2,525 kilometers (1,569 miles) in length. Given that the Ganga is revered as a deity in Hindu mythology and is regarded as sacred by Hindus, it has enormous cultural, religious, and ecological significance. It is one of the most iconic and sacred rivers in the country, revered by millions and considered a symbol of purity (Anthwaletal.,2010). The Ganges River spans across northern India, flowing through multiple states and serving as a source of water for numerous human activities, including agriculture, drinking water, and industrial use. The river supports a rich and diverse ecosystem, hosting a wide range of flora and fauna.

Geography- The Ganga originates in the state of Uttarakhand in northern India, where it is fed by several tributaries, including the Bhagirathi and Alaknanda rivers. It flows for about 2,525 kilometers (1,569 miles) through the plains of northern India and Bangladesh before emptying into the Bay of Bengal (Dubey, 2020).

Biodiversity-The Ganga River system is home to a rich biodiversity of plants and animals. It supports over 140 species of fish, including the critically endangered Ganges River dolphin and several species of turtles. The river also hosts a variety of migratory and resident bird species, such as the endangered Gharial, a crocodile species. The Ganga River basin is also known for its diverse flora, with numerous species of aquatic and terrestrial plants. The river is surrounded

by fertile plains, which are important for agriculture and support a variety of crops, including rice, wheat, and sugarcane (Chauhan & Gopal.,2014).

Cultural significance-The Ganga has a deep cultural significance for Hindus, who consider it a sacred river and an embodiment of the divine. It is believed that bathing in the Ganga can cleanse one's sins and bring spiritual purification. The Ganga is associated with several Hindu mythological stories and is mentioned in ancient Hindu scriptures, such as the Vedas and the Puranas (Kumar, 2017). Many Hindu rituals, festivals, and ceremonies are performed on the banks of the Ganga, including the Kumbh Mela, one of the world's largest religious gatherings. The Ganga is not only considered a sacred river in Hinduism, but it is also revered by other religions such as Buddhism and Jainism. It is also an important symbol of cultural identity and heritage for the people of India and Bangladesh. In conclusion, the Ganga is not just a river, but a cultural, religious, and ecological icon. It holds great spiritual significance for millions of people, supports livelihoods, and sustains a diverse ecosystem. However, pollution and degradation pose significant challenges, and efforts are being made to restore and protect the Ganga for future generations.

Importance- The Ganga has immense cultural and religious significance for Hindus. It is believed to be a goddess in Hindu mythology, and Hindus consider it to be a sacred river that purifies sins and grants spiritual blessings (Singh., 1994). The Ganga is also economically important as it supports a large population living along its banks. It provides water for irrigation, transportation, and various industries, and supports a rich biodiversity of flora and fauna. The Ganga is an important pilgrimage site for Hindus, and millions of people visit its banks every year to take part in religious rituals, bathe in its holy waters, and perform cremation ceremonies for their deceased loved ones.

Pollution-Despite its cultural and religious significance, the Ganga is facing severe pollution challenges. Industrial and domestic waste, agricultural runoff, and untreated sewage are major sources of pollution in the river, causing water quality degradation and threatening the health of the river ecosystem (KOSHY, 2017). The Indian government has launched several initiatives, including the "Namami Gange" project, to clean and rejuvenate the Ganga. These efforts aim to reduce pollution, promote waste management practices and raise awareness about the importance of a clean Ganga.

2. MATERIALS AND METHODS:

The physico-chemical parameters of the Ganga refer to various physical and chemical characteristics that can be measured to assess the quality of the river water. These parameters provide insights into the overall health and pollution levels of the river, and are important indicators of water quality for human consumption, agricultural use, and aquatic life. The water sample was taken from the location, Babupur Ghat, throughout the summer, rainy and winter seasons of 2020. Based on the availability and accessibility of the water across the riverbank, samples were taken. Pre-washed, spotless 1-liter HDPE bottles were used to collect water samples. The samples were carefully moved to the lab for additional chemical analysis while still being kept chilled in the ice box. While other factors were subsequently evaluated in the lab, the site-measured parameters were pH, temperature, dissolved oxygen (DO), CO_2 levels, and bicarbonates. Samples were gathered, stored, transported and tested in accordance with the Standard Methods advised by APHA (2017). Specifics of the outcomes include (Bloetscher, Meeroff, Roblyer, & Prymas, 2018).

3. STUDY AREA:

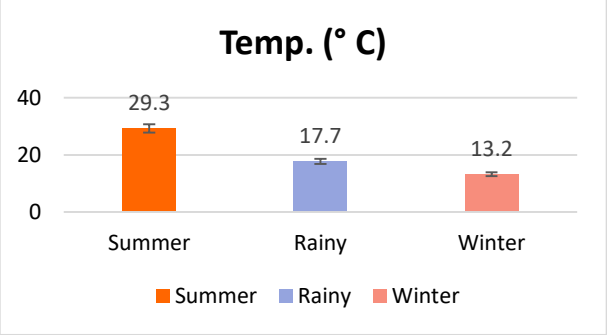
Babupur Ghat, located in Bhagalpur, a city in the Indian state of Bihar, is a historic and iconic riverfront destination that has played a significant role in the cultural, social, and economic life of the region for centuries. Situated on the banks of the mighty Ganges River, Babupur Ghat has been a hub of trade, commerce, and religious activities, drawing people from different walks of life, including traders, pilgrims, and tourists. The history of Babupur Ghat dates back to ancient times, with archaeological evidence suggesting human habitation in the region as early as the Palaeolithic era. Over the centuries, Bhagalpur emerged as an important center of trade and commerce due to its strategic location on the banks of the Ganges River, and Babupur Ghat became a bustling waterfront where boats, barges, and ferries piled along the river, carrying goods and people to various destinations. Babupur Ghat is also has religious and cultural significance. The ghats of Bhagalpur have been a place of pilgrimage for Hindus, who come to take ritual baths in the sacred Ganges River, perform religious ceremonies, and offer prayers. Babupur Ghat is known for its historic temples, including the famous Mandar Hill temple, which is believed to be the abode of Lord Vishnu, a Hindu deity. The annual Makar Sankranti festival, celebrated with great fervor at Babupur Ghat, attracts thousands of devotees who take part in the holy dip in the Ganges and offer prayers to the deities. Apart from its religious and cultural significance, Babupur Ghat has also been an important center of economic activity. The riverfront has served as a major trade and transportation

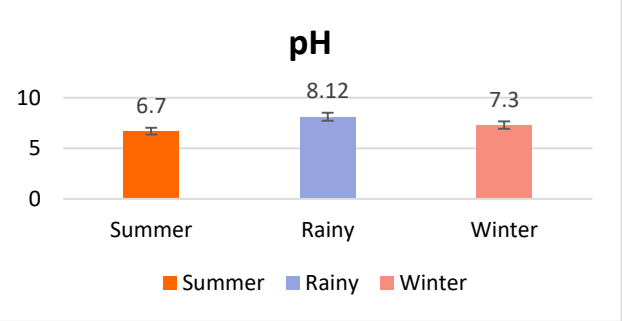
hub, facilitating the movement of goods such as grains, spices, silk, and other commodities. The ghats of Bhagalpur have been known for their vibrant markets, where traders from different parts of the country come to buy and sell various goods, making it a hub of commercial activities. In recent years, Babupur Ghat has also emerged as a popular tourist destination, attracting visitors from across India and abroad who come to witness the rich cultural heritage, historical significance, and natural beauty of the region. The riverfront offers stunning views of the Ganges River, with its ghats, temples, and bustling activities providing a unique and picturesque experience for tourists.

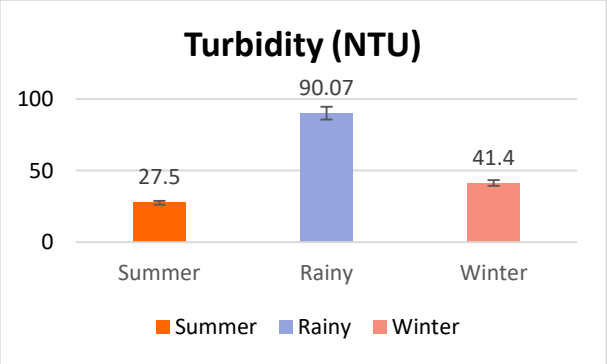
Figure 1 Satellite image showing course of river Ganges in Bhagalpur district.

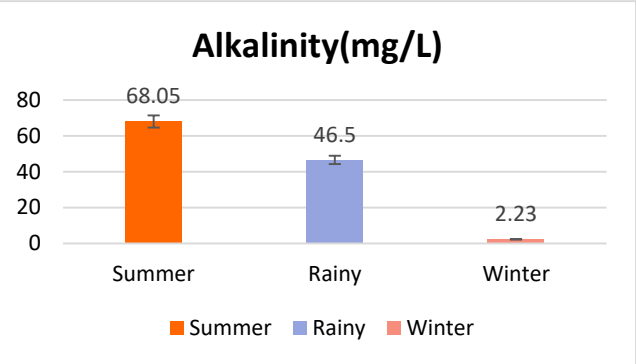
Table: 1 Result of Seasonal Physico – chemical characteristics of River Ganga at Babupur Ghat, Bhagalpur, Bihar

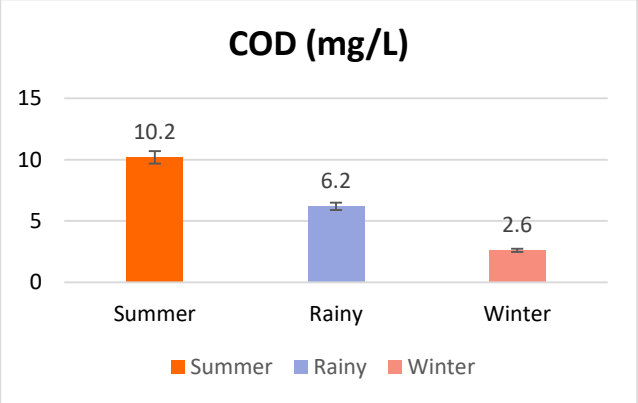
Parameters	Summer	Rainy	Winter
Temp. (° C)	29.3 ± 0.5	17.7± 1.4	13.2± 1.3
pH	6.7 ± 0.3	8.12 ± 0.3	7.3 ± 0.3
Turbidity (NTU)	27.5 ± 0.9	90.07 ± 1.7	41.4 ± 0.8
Conductivity	220.6 ± 1.8	141.6 ± 2.9	146.02 ± 2.16
HCO_3(mg/L)	62.5 ± 1.2	43.6 ± 2.1	59.1 ± 1.0
Alkalinity (mg/L)	68.05 ± 1.1	46.5 ± 2.9	45.9 ± 2.23
DO (mg/L)	4.1 ± 0.1	7.7 ± 0.6	5.6 ± 0.8
BOD (mg/L)	2.1 ± 0.2	3.3 ± 0.4	3.1 ± 0.3
COD (mg/L)	10.2 ± 0.4	6.2 ± 0.7	2.6 ± 0.3
Chloride (mg/L)	27.9 ± 0.4	38.4 ± 0.2	26.8 ± 1.2
Phosphate (mg/L)	0.096 ± 0.0	0.097 ± 0.0	0.083 ± 0.0

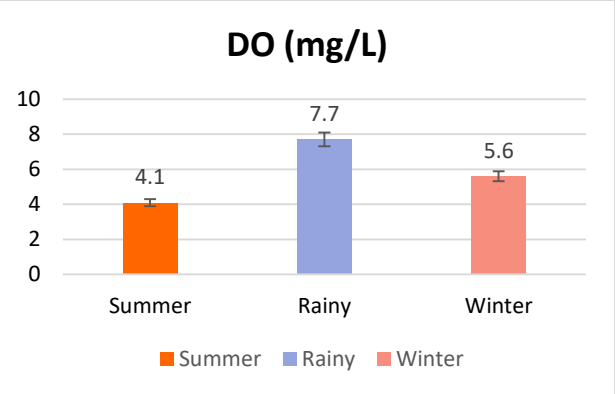

Temp. (° C)
40
20
0
29.3
17.7
13.2
Summer
Rainy
Winter
Summer Rainy Winter

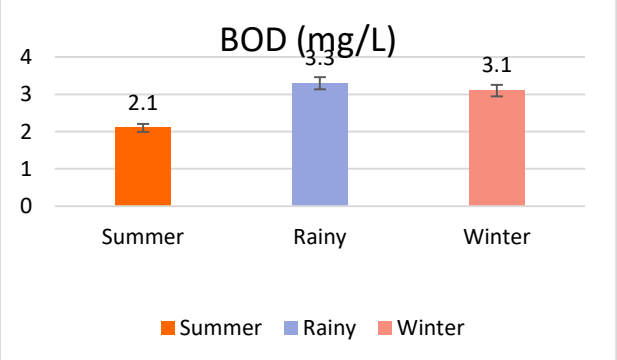

pH
10
5
0
6.7
8.12
7.3
Summer
Rainy
Winter
Summer Rainy Winter

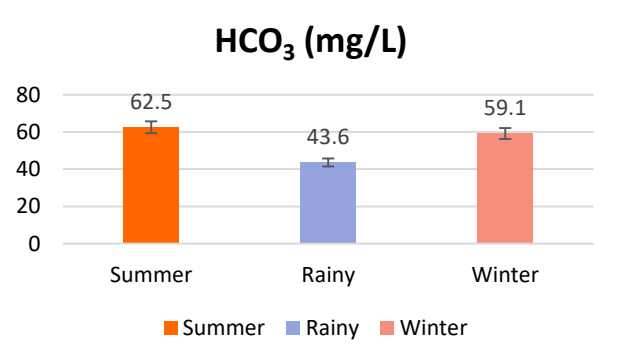

Turbidity (NTU)
100
50
0
27.5
90.07
41.4
Summer
Rainy
Winter
Summer Rainy Winter

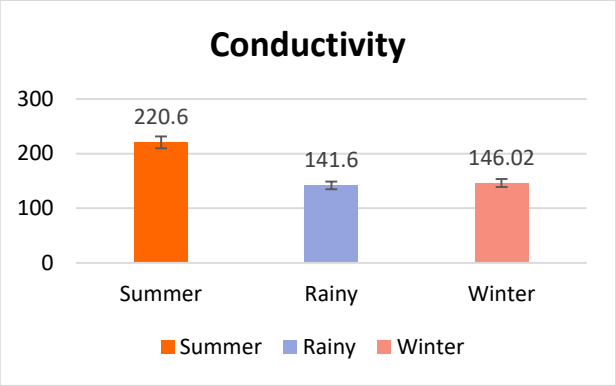

Alkalinity(mg/L)
80
60
40
20
0
68.05
46.5
2.23
Summer
Rainy
Winter
Summer Rainy Winter

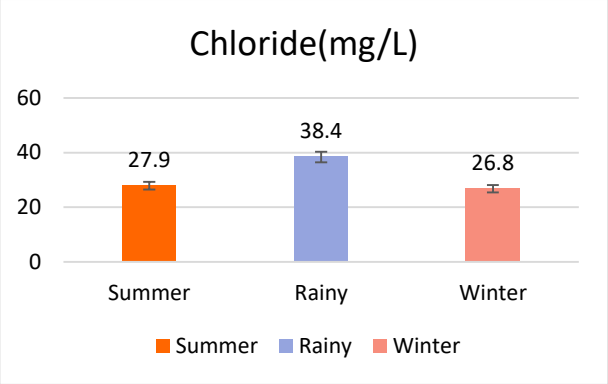

COD (mg/L)
15
10
5
0
10.2
6.2
2.6
Summer
Rainy
Winter
Summer Rainy Winter


DO (mg/L)
10
8
6
4
2
0
4.1
7.7
5.6
Summer
Rainy
Winter
Summer Rainy Winter


BOD (mg/L)
4
3
2
1
0
2.1
3.3
3.1
Summer
Rainy
Winter
Summer Rainy Winter


HCO3 (mg/L)
80
60
40
20
0
62.5
43.6
59.1
Summer
Rainy
Winter
Summer Rainy Winter





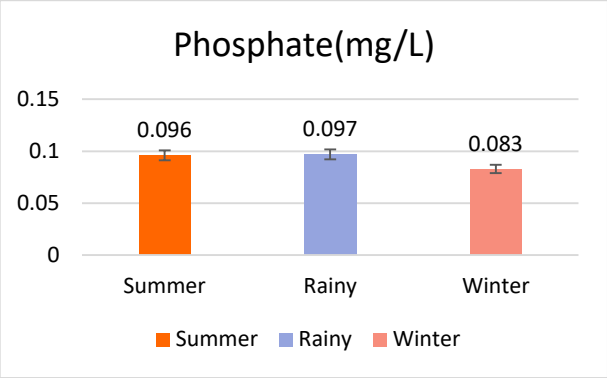


Table 2 - Result of correlation of physicochemical parameter of River Ganga water.

Correlations											
	Tem	**pH**	**Tur**	**Cond**	**HCO**	**Alka**	**DO**	**BOD**	**COD**	**Cl**	**PO_4**
Temp	1										
pH	-.566	1									
Tur	-.481	.868**	1								
Cond	.691*	-.572	-.694*	1							
HCO	.620*	-.715**	-.812**	.893**	1						
Alka	.823**	-.387	-.342	.746**	.553	1					
DO	-.573	.917**	.956**	-.677*	-.780**	-.441	1				
BOD	-.332	.232	.456	-.448	-.281	-.254	.329	1			

COD	.954**	-.397	-.333	.606*	.463	.874**	-.434	-.318	1		
Cl	.449	-.645*	-.856**	.785**	.733**	.553	-.831**	-.535	.393	1	
PO4	.578*	.194	.284	.279	.036	.508	.195	-.041	.678*	-.168	1
Ar	-.319	-.152	-.294	.231	.456	-.078	-.217	.267	-.406	.322	-.554
Pb	-.686*	.289	-.053	-.187	-.032	-.582*	.073	.189	-.697*	.073	-.569

*. Correlation is significant at the 0.05 level
**. Correlation is significant at the 0.01 level

4. RESULT AND DISCUSSION:

1. Water temperature: According to the physico-chemical investigation of the Babupur ghat water, the temperature ranged from 13.2± 1.3°C in the winter to 29.3 ± 0.5°C in the summer. Results show that summertime temperatures were higher, wintertime temperatures were lower and monsoon season temperatures were in the middle. Temperature is positively correlated to conductivity, bicarbonates quantity and phosphate quantity at $p < 0.05$ level. At $p < 0.01$, temperature is also positively correlated to alkalinity and COD.

2. pH : The pH value varied seasonally, reaching a maximum of 8.12 ± 0.3 in the rainy season and a minimum of 6.7 ± 0.3 in the summer. According to the findings, greater pH levels were seen in the rainy and lower ones in the summer, while the winter season saw an intermediate value. The link between pH and turbidity, DO, HCO_3 is quite significant.

3. Turbidity (Tur) : The turbidity value was maximum in the rainy season at 90.07± 1.7 NTU and lowest in the summer season at 27.5 ± 0.9 NTU. Results show that higher turbidity was seen in the monsoon and lowest in the summer, with intermediate values seen in the winter months. A higher value of turbidity is seen during the monsoon season as a result of the inflow of rainwater from catchment areas that washes away silt, sand, and cloudiness. The link between turbidity and DO is positive at level of significance $p < 0.01$.

4. Conductivity : Electrical conductivity was higher in the summer, at 220.6 ±1.8 mhos/cm, and lowest in the rainy season, at 41.6 ± 2.9 mhos/cm. The findings show that higher electrical conductivity was seen in the summer, lowest in the monsoon and intermediate in the winter. Conductivity is positively correlated to alkalinity, bicarbonates and chloride quantity at level of significance $p < 0.01$ and negatively correlated to DO at level of significance $p < 0.05$.

5. HCO_3: The HCO_3 value was recorded higher in summer of 62.5 ± 1.2 and lowest in rainy of 43.6 ± 2.1. HCO_3 concentration is positively related to chloride concentration and negatively correlated to DO at $p < 0.01$.

6. Total alkalinity : The value of total alkalinity was maximum in the summer at 68.05 ±1.1mg/L and lowest in the winter season at 45.9 ± 2.23mg/L. Results show that higher total alkalinity was seen in summer, lower total alkalinity was seen in winter seasons, and intermediate values were shown in rainy. Alkalinity and COD have strong positive relation at $p < 0.01$ whereas it has negative relation with lead concentration at $p < 0.05$.

7. Dissolved oxygen (DO) : The DO value was 7.7 ± 0.6 mg/L at its highest during rainy season and 4.1± 0.1 mg/L at its lowest during the summer season. The findings show that higher DO was seen in the rainy and lower DO in the summer, whereas intermediate values were seen in the winter season. Demand for oxygen exhibits strong negative correlations with chloride concentration.

8. The biological oxygen demand (BOD) : value was greater in the rainy season (3.3 ± 0.4mg/L) and lower in the summer (2.1 ± 0.4mg/L). The findings show that higher BOD was seen in the rainy, lowest in the summer and intermediate in the winter.

9. Chemical oxygen demand (COD) : The COD value was observed at a high of 10.2 ±0.4 mg/L in the summer and at a minimum of 2.6 ± 0.3 mg/L in the winter. The findings show that higher COD levels were seen in the summer and lowest levels in the winter, while intermediate levels were seen in the rainy season. Chemical oxygen demand and phosphate levels have a strong positive association and COD has negative correlation with lead.

10. Chloride: The chloride value was greater during rainy conditions (38.4 ± 0.2 mg/L) and lower during winter conditions (26.8 ± 1.2 mg/L). The findings show that higher chloride levels were seen in the rainy, lower levels in the winter, and intermediate levels in the summer.

11. Phosphate : The phosphate value was 0.097 ± 0.0 mg/L at its highest during rainy season and 0.083 ± 0.0 mg/L at its lowest during the winter season. Results show that higher phosphate levels were seen in the monsoon and lower levels in the winter, with intermediate levels seen in the summer season.

5. CONCLUSION:

The current study provides a complete description of the physico-chemical properties and water quality of Babupur Ghat in the Bhagalpur district. The physico-chemical characteristics of the water showed different seasonal changes during the summer, rainy, and winter seasons. The correlation coefficient shows the substantial positive and negative relationships between physico-chemical parameters. Positive correlation denotes a direct relationship between two parameters (one parameter other parameter), whereas negative correlation denotes an inverse relationship (one parameter 1/other parameter). When one parameter rises, the other parameter falls, according to positive correlation, and vice versa for negative correlation. The correlation coefficient value aids in determining the best course of action for reducing Babupur ghat contamination. To keep the river water at its purest and best quality, there is also a need to raise awareness among the populace. At the Babupur ghat in the Bhagalpur district, methods for removing water pollution should be used, and the pollution level should be continuously monitored in order to improve the quality of the water.

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