WATER QUALITY OF BRAHMANI RIVER – AN ANALYTIAL STUDY AT EFFLUENT DISCHARGE POINT OF ANGUL AND DHENKANAL INDUSTRIAL COMPLEX, ODISHA

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Abstract:
The Brahmani River, a lifeline for the state of Odisha, serves as a crucial water source supporting diverse ecosystems and human activities. However, industrialization in the Angul and Dhenkanal regions has raised concerns about water quality, particularly at the effluent discharge points. This study presents a comprehensive analysis of the water quality of the Brahmani River, focusing on the impact of industrial effluents from the Angul and Dhenkanal Industrial Complex. The research investigates key physicochemical parameters and pollutant concentrations to provide insights into the current state of water quality and potential environmental implications. The rapid industrial growth in the Angul and Dhenkanal regions has led to an increased discharge of effluents into the Brahmani River, raising questions about the overall water quality. This study aims to assess the impact of industrial activities on the river's health by conducting a detailed analysis of water quality parameters at specific effluent discharge points. The research employs a rigorous analytical approach, involving the collection of water samples at strategic locations along the Brahmani River near the discharge points of the Angul and Dhenkanal Industrial Complex. The collected samples undergo a thorough analysis of physicochemical parameters, including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and heavy metal concentrations.

Keywords: *Brahmani River, Angul and Dhenkanal Industrial Complex, Physicochemical Parameters, BOD, COD, pH, Heavy Metal Concentrations, Regulatory Standards, Industrial Effluents*

1.0 INTRODUCTION

Water, the essence of life, is a critical resource that sustains ecosystems, supports biodiversity, and is indispensable for human survival. In the context of India, a country marked by diverse landscapes and a rich cultural tapestry, rivers play a pivotal role in shaping the nation's socio-economic and environmental fabric. However, the escalating demands of rapid urbanization and industrialization have led to a growing concern about the degradation of water quality in Indian rivers, particularly at points where industrial effluents are discharged. The thesis titled "Water Quality of Indian Rivers – An Analytical Study at Effluent Discharge Points" embarks on a journey to delve into the intricacies of water quality within the context of industrial effluent discharge. As industries expand to meet the demands of a burgeoning population and a dynamic economy, the consequential impact on water resources cannot be understated. This study aims to comprehensively analyse and evaluate the quality of water at specific discharge points along Indian rivers, focusing on the presence and concentration of pollutants introduced by industrial effluents. The research unfolds against the backdrop of global concerns about water pollution and its detrimental effects on ecosystems, aquatic life, and public health. By honing in on discharge points, where industrial effluents directly interface with the river ecosystem, the study seeks to provide valuable insights into the specific challenges faced by Indian rivers.

The objectives of this thesis are multi-fold. Firstly, it aims to assess the current state of water quality at selected discharge points, employing a rigorous analytical approach. Through the identification and quantification of various pollutants, the study will delineate the specific nature of contaminants introduced by industrial activities. Secondly, it aspires to examine the environmental and health implications of the observed water quality, drawing connections between pollutant levels and potential consequences for ecosystems and human populations downstream.

Scope of the work:

The scope of this project encompasses a comprehensive investigation into the issue of Non-Revenue Water (NRW) and the associated challenges of leak detection within water supply pipelines in India. The primary objective is to contribute valuable insights to the understanding and mitigation of NRW, focusing on technological solutions, policy frameworks, and community engagement.

Problem Statement:

The water quality of Brahmani River is facing unprecedented challenges due to the discharge of industrial effluents, presenting a critical environmental and public health concern. Rapid industrialization, fuelled by the demands of a burgeoning population and economic growth, has led to an alarming increase in the release of pollutants into rivers, particularly at effluent discharge points. The Brahmani River, a lifeline for many communities, is grappling with an acute crisis – the deterioration of its water quality due to the relentless discharge of industrial effluents. This predicament is not unique; it mirrors a broader environmental challenge facing rapidly industrializing regions worldwide. As industries burgeon to meet the demands of a swelling population and economic expansion, the repercussions on water bodies like the Brahmani River are dire. The situation is exacerbated at specific discharge points, where industrial pollutants flow unchecked into the river, unleashing a cocktail of contaminants. The absence of rigorous analytical studies focused on these discharge points hampers our ability to devise targeted interventions and regulatory frameworks. Without a comprehensive grasp of the problem's intricacies, efforts towards sustainable water management are impeded, perpetuating the cycle of environmental degradation and human suffering. This knowledge serves as the foundation for crafting effective policies, enforcing regulations, and fostering collaborations between industry stakeholders, governmental bodies, and local communities. Only through concerted, interdisciplinary efforts can we safeguard the Brahmani River – and other water bodies worldwide – from the perils of industrial pollution, ensuring a sustainable future for generations to come.

Objectives:

- To determine the pH, TDS, BOD, COD etc of water sample of different sampling locations.
- To find out the methods & techniques used to reduce the water pollutions.
- To find out water sample analysis for further six months i.e. post winter & summer seasons.
- To find out the effect of deteriorating water quality on human & aquatic life.

2.0 LITERATURE REVIEW:

Water quality is a complex subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. From the user's point of view, the term "water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water.

Singh et.al [1] assess and map the spatial distribution of surface water quality of the Mahanadi, Odisha by using GIS.APHA's standard laboratory procedure has been adopted to assess the quality of ground water. The spatial distribution map of pH, Chlorides, Magnesium and sulphate shows that, these parameters are within range as per standard. Kamal [2] carried out on physicochemical parameter of river water affects the biological characteristics and indicates the status of water quality. Different types of Physicochemical parameters of water are pH, DO, BOD, COD, Chloride, TDS, Nitrate, Sulphates, TH, EC and Fluoride. These parameters are solely responsible for water quality. Rout [3] carried out an analysis was carried out by taking certain important parameters like pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), Chloride, total dissolved oxygen (TDS), Nitrate, sulphates, total hardness (TH), electrical conductivity (EC) and Fluoride. Sahu [4] describes the effect of poor water quality on human health was noted for the first time in 1854 by John Snow, when he traced the outbreak of cholera epidemic in London to the Thames River water which was grossly polluted with raw sewage. Mona A. Hagras et.al [5] assessed the quality of groundwater and to characterize the hadrochemical characteristics of the surface water in Odisha, surface water samples were collected from different cities of Odisha analysed for 15 water quality parameters. Khare et.al [6] carried out on water quality assessment of Mahanadi, Sambalpur. He was done water analysis for the parameters like pH, DO, BOD, COD, TDS, calcium, Magnesium and Hardness for lake water. Venkatesharaju et al., [7] signifies water recourses have critical importance to both natural and human development. It is essential for agriculture, industry and human existence. Water is one of the most abundant compounds of the ecosystem. Shimaa M. Ghoraba et.al [8] collected many ground water samples from different districts of Mahanadi, Odisha. The groundwater recorded a wide range in TDS. Chloride is one of the most important parameters in assessing the water quality and higher concentration of chloride indicates higher degree of organic pollution. Sayyed et.al [9] assessed the surface water from the south-eastern part of Odisha city for the seasonal variation in their quality parameters. Using Piper diagram, the hydrogeochemical facies were identified and the surface waters were classified with regards to the changes in their major chemical compositions. Adetunde et.al [10] have studied the area and investigated physicochemical and bacteriological qualities of surface water in the north areas and south local government areas of State, Odisha. Water samples were collected from different areas of North and South local areas. The desirable limit of TDS is 500 mg/l.

3.0 METHODOLOGY:

1. Study Area Selection:
   - Identify and select specific sites along the Brahmani River for sampling, focusing on key effluent discharge points from industrial establishments.
   - Ensure representation from diverse industrial sectors to capture variations in effluent composition.
2. Sampling Design:
   - Establish a systematic sampling plan, considering factors such as distance downstream from discharge points, seasonal variations, and potential points of human interaction.
   - Implement a longitudinal sampling approach to monitor changes over time.
3. Water Sample Collection:
   - Utilize appropriate sampling equipment, ensuring proper sterilization to prevent contamination.
   - Collect water samples at regular intervals, both vertically and horizontally, to capture variations in water quality at different depths and locations.
4. Physicochemical Analysis:
   - Conduct on-site measurements for temperature, pH, dissolved oxygen (DO), and conductivity using calibrated meters.
   - Transport collected samples to the laboratory for further analysis of parameters such as turbidity, total dissolved solids (TDS), and salinity.
5. Chemical Analysis:
   - Employ standardized laboratory techniques to analyse water samples for the presence and concentration of pollutants, including heavy metals (e.g., lead, mercury, cadmium), organic compounds, and nutrients (e.g., nitrogen and phosphorus).
   - Use methods such as spectrophotometry, chromatography, and atomic absorption spectroscopy for accurate quantification.
6. Microbiological Analysis:

- Assess microbial contamination through the analysis of indicators such as faecal coliforms and E. coli.
- Employ membrane filtration or multiple-tube fermentation methods for microbial quantification.

7. Biological Assessment:
    - Conduct biological assessments to gauge the health of aquatic ecosystems.
    - Employ bioindicators such as macroinvertebrates to evaluate the impact of pollutants on the river's biotic integrity.
8. Data Analysis:
    - Utilize statistical tools and software for data analysis, including descriptive statistics, correlation analysis, and spatial mapping.
    - Compare results across different sampling points and seasons to identify patterns and trends.
9. Temporal Analysis:
    - Implement a temporal analysis by collecting samples at regular intervals throughout the year to capture seasonal variations.
    - Analyse data to identify patterns and trends in water quality parameters over time.
10. Health Risk Assessment:
    - Evaluate potential health risks to communities relying on the Brahmani River for various purposes.
    - Use established models to assess the exposure pathways and quantify health risks associated with waterborne contaminants.
11. Regulatory Compliance Assessment:
    - Assess the compliance of industrial effluent discharge with existing environmental regulations and standards.
    - Identify instances of non-compliance and correlate them with observed water quality parameters.
12. Stakeholder Engagement:
    - Engage with local communities, environmental organizations, and regulatory authorities to gather qualitative insights into the socio-economic implications of water quality degradation.
    - Incorporate local knowledge to enhance the contextual understanding of the study area.
13. Reporting and Recommendations:
    - Compile the findings into a comprehensive report, including detailed analyses, graphical representations, and recommendations for mitigating pollution and improving water quality.
    - Communicate results to relevant stakeholders through scientific publications, community meetings, and regulatory forums.

By implementing this robust methodology, the study aims to provide a thorough and nuanced analysis of the water quality at effluent discharge points along the Brahmani River, contributing valuable insights for sustainable water management and policy formulation.

3.1 Materials

pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units". Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of five is ten times more acidic than water having a pH of six.

Diagram of pH

As this diagram shows, pH ranges from 0 to 14, with 7 being neutral. pHs less than 7 are acidic while pHs greater than 7 are alkaline (basic). Normal rainfall has a pH of about 5.6-slightly acidic due to carbon dioxide gas from the atmosphere. You can see that acid rain can be very acidic, and it can affect the environment in a negative way.

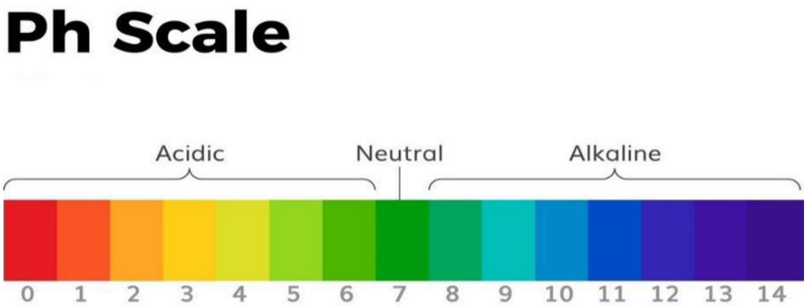

Fig1. Measure of pH Scale

Fig 2. pH measuring using digital pH meter.

3.1.1 Determination of TDS:

Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter that are dissolved in water.

Water is a good solvent and picks up impurities easily. Pure water - tasteless, colourless, and odourless -- is often called the universal solvent. Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water: Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter that are dissolved in water.

3.1.2 Biochemical Oxygen Demand (BOD):

It is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water.

BOD reduction is used as a gauge of the effectiveness of wastewater treatment plants. BOD of wastewater effluents is used to indicate the short-term impact on the oxygen levels of the receiving water.

Biochemical oxygen demand is the amount of oxygen required for microbial metabolism of organic compounds in water. This demand occurs over some variable period of time depending temperature, nutrient concentrations, and on the enzymes available to indigenous microbial populations. The amount of oxygen required to completely oxidize the organic compounds to carbon dioxide and water through generations of microbial growth, death, decay, and cannibalism is total biochemical oxygen demand (Total BOD).

3.1.3 Manometric method:

This method is limited to the measurement of the oxygen consumption due only to carbonaceous oxidation. Ammonia oxidation is inhibited. The sample is kept in a sealed container fitted with a pressure sensor. A substance that absorbs carbon dioxide (typically lithium hydroxide) is added in the container above the sample level. The sample is stored in conditions identical to the dilution method. Oxygen is consumed and, as ammonia oxidation is inhibited, carbon dioxide is released. The total amount of gas, and thus the pressure, decreases because carbon dioxide is absorbed. From the drop of pressure, the sensor electronics computes and displays the consumed quantity of oxygen

4. RESULTS AND DISCUSSIONS

BOD along the Stretches of River Brahmani (Rourkela). The water quality of rivers is regularly monitored by State Pollution Control Board in 39 monitoring stations. The water quality (in terms of annual average BOD) of Brahmani are presented in Table

Table 1: BOD along the Stretches of River Brahmani (Rourkela).

Sl	Sampling Station	Approx km from D/s	BOD (mg/l)
1	Panposh U/S		1
2	Panposh D/S (Deogaon Village)	200 km from Discharge point	3.7
3	Panposh D/S (1/2 Km away from Deogaon Village)	1 km from D/S	3.2
4	Panposh FD/s (Jalda Village)	4 km D/S	2.7

Table 2: BOD in River Brahmani Water at different locations.

Year	Panposh U/S	Panposh D/S	Rourkela D/S	Boniagarh	Rengali	Samal	Kamalanga U/S	Kamalanga D/S	Bhuban	Dharmasala	Pottamundai
	1	2	3	4	5	6	7	8	9	10	11
1999	**2.9**	**5.4**	**4.0**	**2.8**	**2.**	3	3.5	4.6	3.6	3.7	3.0
2000	**2.9**	**4.3**	**3.21**	2.9	2.65	2.75	2.7	4.2	3.5	3.5	3.3
2001	2.2	3.6	2.9	2.5	2	2	2.5	4.2	2.4	2.3	2.5
2002	2.3	4.8	3.3	2.3	2	1	2.2	3.7	2.7	2.6	2.3
2003	1.38	3.55	2.31	1.12	1.56	1.76	1.38	2.46	2.03	1.47	1.44
2004	1.2	4	3	1.4	1	1	1.3	2.6	1.6	1.6	1.4
2005	1	3.8	2.7	1	1.2	1.2	1.5	1.5	1.2	0.9	1.2

Further classification of industries has Pollution Control Board as "Grossly Polluting Industries" based on been done by Central their water pollution load. If the total BOD load from an industry exceeds 100Kg/Day or if its effluent contains any hazardous chemicals, then the industry is categorized as Grossly Polluting

Industry. Orissa has 18 such industries. Status of these industries operating in the state is compiled in Table below.

Table 3: Grossly Polluting Industries in Orissa

SI.	Name of the Industry	Public Sector/ Private Sector	Category	Effluent Recipient Place	Concerned River
1	NALCO, CPP, Angul (Industrial effluent other than ash overflow, Ash	Public Sector	Thermal Power	Nandira Jhor	Brahmani
2	NTPC, Kahnia (Industrial effluent)		Thermal Power	Tikira River	Brahmani
2a	NTPC, Kahnia (Ash Pond overflow effluent)		Thermal Power	Tikira River	Brahmani
3	TTPS (NTPC), Talcher (Industrial Effluent)		Thermal Power	Nandira Jhor	Brahmani
3a	TTPS (NTPC), Talcher (Ash pond overflow effluent)		Thermal Power	Nandira Jhor	Brahmani
4	Central Orissa Straw Board	Private sector	Pulp and Paper	Mahanadi	Mahanadi
5	Steel Township Rourkela	Public Sector	Urban Body	Koel River	Brahmani
6	Fertilizer Rourkela Plant, SAIL, Rourkela	Public Sector	Nitrogeneous Fertilizer	Guradih Nallah	Brahmani
7	ICCL (CPP), Choudwar, Cuttack	Private sector	Thermal Power	Birupa	Birupa
8	IDL Chemicals, Sonaparbat, Rourkela	Private sector	Explosive	Balijodi Nallah	Brahmani
9	Rourkela Steel Plant, Rourkela (Coke oven byproduct effluent)	Public Sector	Iron and steel	Guradih Nallah	Brahmani
10	Fertilizer Township Rourkela	Public Sector	Urban Body		Brahmani

The selection of stations has been done mostly on the basis of proximity of major industries and municipal townships which are expected to make significant contributions to the pollution load. The Talcher industrial complex is situated on the bank of the river Brahmani which is about 8-10 KM away from the river bank. The present work deals with the assessment of water quality of the river Brahmani polluted by the waste effluent of Talcher industrial complex drained through the Nandira

Table 4: Location of sampling stations

Sr. No.	Name of the sampling location
1	River Brahmani at Samal Barage
2	Talcher upstream of River Brahmani
3	Nandira downstream before confluence point at Pump house

4	River Brahmani at Kamalanga village

Test samples have been collected from the above same sampling station and tested in a water Testing lab. The following test results are shown below.

Table 5: Physio Chemical Analysis of Water Sample of River Brahmani at Samal Barrage.

Physio Chemical Analysis of Water Sample of River Brahmani at Samal Barrage.					
Period of Sampling Year Sep 2022- January 2023					
sl no	**Parameter**	**Unit**	Std as per IS : 10500	Sep-22	Jan-23
1	pH		6.5 - 8.5	7.7	8.2
2	DO	Mg/L	4	6.7	6.9
3	TDS	Mg/L	500	600	480
4	BOD	Mg/L	3	2.7	2.8
5	COD	Mg/L	10	24	21

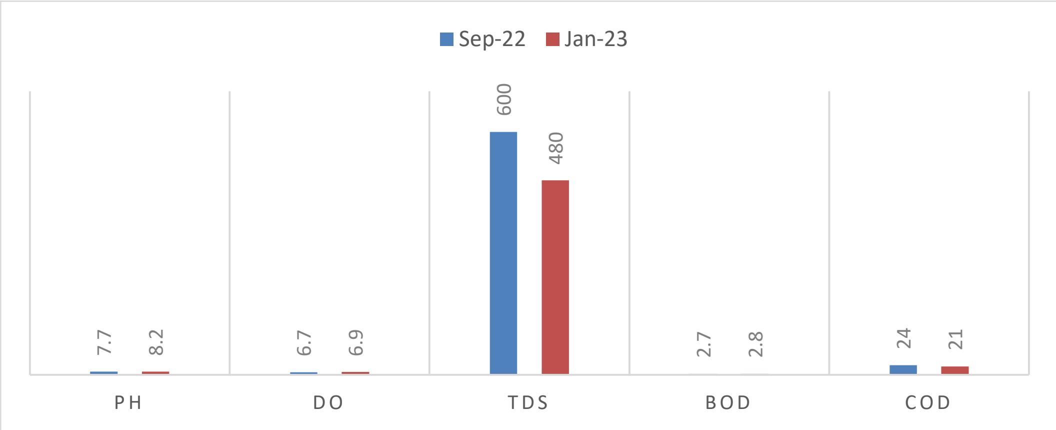

Fig 3: Comparison of results of the month of Sep and Jan for Physio Chemical Analysis of Water Sample of River Brahmani at Samal Barrage.

Table 6: Physio Chemical Analysis of Water Sample of River Brahmani at Talcher U/S.

Physio Chemical Analysis of Water Sample of River Brahmani at Talcher U/S.					
Period of Sampling Year Sep 2022- January 2023					
S. No	**Parameter**	**Unit**	**Std as per IS: 10500**	**Sep-22**	**Jan-23**
1	pH		6.5 - 8.5	7.9	8.5
2	DO	Mg/L	4	6.7	6.5
3	TDS	Mg/L	500	620	510
4	BOD	Mg/L	3	2.6	2.5
5	COD	Mg/L	10	25	23

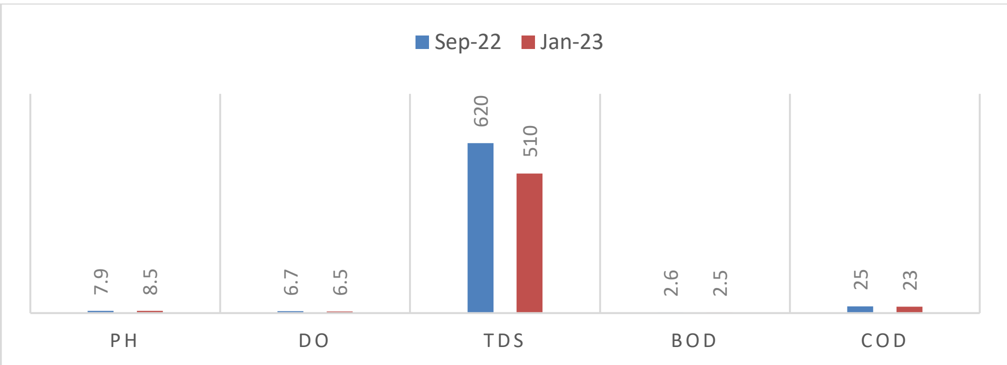

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Fig 4: Comparison of results of the month of Sep and Jan for Physio Chemical Analysis of Water Sample of River Brahmani at Talcher U/S.

Table 7. Physio Chemical Analysis of Water Sample of River Brahmani at Nandira D/S.

Physio Chemical Analysis of Water Sample of River Brahmani at Talcher U/S.					
Period of Sampling Year Sep 2022- January 2023					
sl no	**Parameter**	**Unit**	**Std as per IS: 10500**	**Sep-22**	**Jan-23**
1	pH		6.5 - 8.5	7.6	8.1
2	DO	Mg/L	4	6.9	6.7
3	TDS	Mg/L	500	610	485
4	BOD	Mg/L	3	2.2	2.1
5	COD	Mg/L	10	23	24

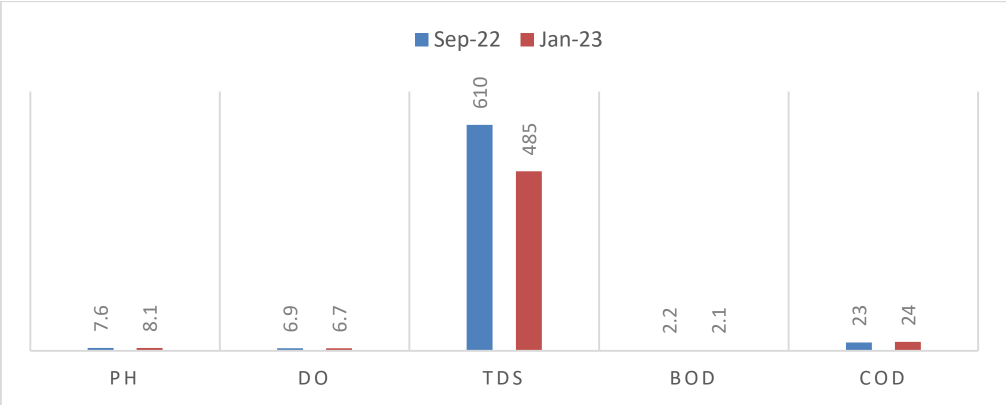

Fig 5: Comparison of results of the month of Sep and Jan for Physio Chemical Analysis of Water Sample of River Brahmani at Nandira D/S.

5.Conclusions

In the wake of rapid industrialization and economic growth, the Brahmani River system has become a focal point of concern regarding water quality, especially at locations where industrial effluents are discharged.

- This analytical study aimed to comprehensively investigate the water quality at effluent discharge points along the Brahmani Rivers, shedding light on the intricate dynamics of pollution, its impact on ecosystems, and the potential risks to human health.
- The findings of this study will reveal a complex tapestry of water quality parameters, emphasizing the multifaceted nature of pollution introduced by industrial activities.
- Physicochemical analyses uncovered significant variations in temperature, pH, dissolved oxygen, and conductivity, providing insights into the altered environmental conditions resulting from effluent discharge.
- Chemical analyses exposed the presence of heavy metals, organic compounds, and nutrients, underscoring the diverse array of pollutants contributing to water quality degradation.

Water quality is a complex subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. From the user's point of view, the term "water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example, for drinking water should be pure, wholesome, and potable. Similarly, for irrigation dissolved solids and toxicants are important, for outdoor bathing pathogens are important and water quality is controlled accordingly.

Future Scope:

- Physiochemical parameters of the river at other regions may be determined.
- Microbiological assessments illuminate the extent of microbial contamination, may be conducted.
- pointing to potential health risks for communities relying on the Brahmani River for various purposes.

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