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In-depth Analysis of Physico-Chemical parameters of Ground Water Condition in the Vicinity of Sugarmills, Meerut

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ABSTRACT
Sugar industry has a unique significance in the industrial map of India and always thought to be one of the pioneering food industries as well as one of most polluting industries. Ground water is highly affected when waste water is discharged untreated or semi-treated. So, physico-chemical characterises of ground water quality in the vicinity areas of two randomly chosen sugar industries i.e. Daurala sugar mill (A) and Bajaj Hindustan sugar industry Ltd (B) located in Meerut, district, Uttar Pradesh for three seasonal periods (November, January and April) during 2021-22 was observed and analysed. Colour, temperature, pH, DO, BOD, COD, Chloride, TS, TDS TSS, Sulphate, Oil and grease, Fluoride have been monitored and analyzed. The taken water samples were compared with the prescribed limit of BIS. The achieved outcomes of the analysis indicate that all the parameters used were found within the permissible limit except a few. This advocates that constant area monitoring should be made by government agencies along with common public vigilance to manage the ground water quality.

Keywords - Sugar mill, Waste-water/ effluent, Ground water-suitability, Physico-chemical parameters

Introduction

Today's globalization-pattern leads the modern world on the super highway to rapid industrialization and causes a serious environmental problem via polluting the water through the uses of organic and in-organic chemicals. Among all, sugar industry is one of the highly polluting industry. At every step/stages of sugar manufacturing process, the discharging waste water by sugar industries contains a high level of contaminations; therefore, it is assumed to be one of the most water polluting industries. Sugar industries are marked as the larger users of water. So, they cause the water pollution in plenty amount through its discharge of harmful elements from sugar industries usually around 5000 cubic metre per day by a single industry. Now-a-days, water pollution in the vicinity of sugar industries is often observed if the sugar industries release the untreated waste water into the natural water resources. Eventually, it will affect the ground water. So, proper monitoring will play a major role to control over the water pollution in nearby areas of sugar industries. Numerous studies have investigated the impacts of sugar wastewater on

groundwater quality, revealing a range of environmental concerns [1-3].

In their 2015 study, Kumar & Srikantaswamy [4] focused on assessing the quality of wastewater from a sugar industry using physico-chemical parameters. Arivoli *et al.* [5] also assessed how sugar mill effluent affects the quality of groundwater in the Cuddalore District of Tamil Nadu, India. In this series, Deshmukh [6] in 2014 observed and reported that assuredly, water is the most necessary resource not only for livelihood but also for the advancement of industry and economy.

Material and Methods

Groundwater sampling around Sugar Mills A and B was accurately executed to assess the water quality at various distances from the both mills. For Sugar Mill A, sampling locations covers A1 to A5, with distances ranging from 1 to 7 KMs. Location A1 situated near the Petrol Pump represented the closest point, while A5, located at Jat Mahkma, Mohmadpur, HAYAK was taken as the outermost sampling point. Similarly, for Sugar Mill B, locations B1 to B5 were taken, with the English Win Shop representing the closest point (B1) and the Petrol Pump marking the outermost point (B5), at a distance of 7 KMs. The physico-chemical analysis of ground water in vicinity areas of both sugar mills was carried out as the standard methods for ground water testing.

Sampling procedures at each location point followed the use of pre-cleaned containers, ensuring the integrity of the collected groundwater samples. A 2 litre volume was collected in triplicate to provide robust data for analysis. Each container was meticulously labelled, indicating the location, date, and time of the sampling event. The triplicate samples were then securely transported to the laboratory for subsequent analysis, enabling a comprehensive analysis of the groundwater quality at varying distances from Sugar Mills A and B. This systematic approach ensures the reliability of the data set, contributing essential insights into potential environmental effects linked with groundwater quality in proximity to sugar production activities.

Result and Discussion

In-depth Analysis of Groundwater Suitability: Seasonal Trends (2021-2022) in the Vicinity of Sugar mill A

Colour: The groundwater in the surrounding areas of Sugar mill A exhibited transparency, appearing colourless as per BIS standards, indicating no significant presence of coloured substances.

Temperature: Temperature variations were observed in groundwater across different sample locations and seasons. These values were within acceptable limits, suggesting no undue influence on water quality due to temperature.

pH: The pH levels of groundwater samples were within the BIS-recommended range of 6.0-8.5. These pH levels are conducive to various aquatic life forms.

Dissolved Oxygen: The DO levels in the groundwater samples met the BIS standard of 4 to 8 mg/L during the seasonal trends. Adequate DO levels suggest the presence of dissolved oxygen to support aquatic organisms.

Biochemical Oxygen Demand: The BOD levels in the groundwater samples were generally low, with many samples showing zero BOD, indicating minimal organic pollution. In cases where BOD was detected, values were within acceptable limits. Continuous monitoring is essential to detect any emerging trends in organic pollution.

Chemical Oxygen Demand: The COD values were generally within the BIS limit of 10 mg/L, with some samples showing zero COD. This suggests a relatively low presence of both organic and inorganic pollutants in the groundwater.

Chlorides: The chloride levels in the groundwater samples were within the BIS limit of 250 mg/L. In November 2021, chloride levels ranged from 105.65 to 165.44 mg/L, in January 2022 from 89.75 to 156.34 mg/L, and in April 2022 from 80.44 to 136.65 mg/L.

These values indicate no significant impact from chloride contamination.

Total Suspended Solids: TSS levels were generally within acceptable limits, meeting the BIS standard of 5 mg/L. However, some samples showed zero TSS, suggesting minimal suspended solids in the groundwater.

Total Dissolved Solids: TDS levels in the groundwater samples exceeded the BIS limit of 500 mg/L in some instances. In November 2021, TDS levels ranged from 335.87 to 448.34 mg/L, in January 2022 from 305.56 to 390.54 mg/L, and in April 2022 from 388.88 to 644.87 mg/L. Elevated TDS levels may indicate the presence of dissolved ions and should be investigated further.

Sulphate: The sulphate levels in the groundwater samples were within the BIS limit of 200 mg/L. In November 2021, sulphate levels ranged from 53.73 to 75.29 mg/L, in January 2022 from 46.39 to 62.46 mg/L, and in April 2022 from 57.54 to 80.83 mg/L. These values suggest moderate levels of sulphate, and continuous monitoring is essential to assess any trends.

Oil and Grease: Oil and grease levels in the groundwater samples were generally absent or negligible, meeting the BIS standard of 0 mg/L. However, some samples in April 2022 showed a minimal presence (1.13 mg/L) that should be monitored to prevent any potential contamination.

Fluoride: Fluoride levels in the groundwater samples were within the BIS limit of 1.0 mg/L. These concentrations pose no immediate health risks, but continuous monitoring is crucial to ensure compliance with standards.

The groundwater in the vicinity areas of Sugar mill A generally meets the BIS standards for physico-chemical parameters. However, elevated TDS levels in some samples may warrant further investigation. The absence of significant pollution indicators such as high BOD, COD, and chloride levels is a positive sign. Continuous monitoring and periodic assessments are assumed to be essential to ensure the sustained quality of groundwater in the chosen areas.

Table-1. Outcomes of Physico-chemical parameters of groundwater of surrounding areas of Sugar mill A (Seasonal Trends) 2021-2022

Parameters	Sample Locations	Physico-Chemical Parameters of Groundwater of Surrounding areas of Sugar mill A (Seasonal Trends) 2021-2022		
		November 2021	January 2022	April 2022
Colour BIS Limit Colourless	A1	Transparent	Transparent	Transparent
	A2	Transparent	Transparent	Transparent
	A3	Transparent	Transparent	Transparent
	A4	Transparent	Transparent	Transparent
	A5	Transparent	Transparent	Transparent
Temperature (ºC)	A1	30.34±1.1	24.12±1.1	31.72±1.9
	A2	30.54±1.7	23.54±1.2	30.62±1.5
	A3	31.72±1.2	24.23±2.1	30.23±1.4
	A4	32.82±0.5	25.34±1.1	30.72±3.1
	A5	32.43±5.1	25.23±0.5	31.64±1.5
pH	A1	6.9±0.4	7.1±0.7	7.2±0.6

BIS Limit 6-8.5	A2	7.1±0.4	7.0±0.8	7.1±0.4
	A3	7.0±0.8	7.3±0.7	6.9±0.3
	A4	7.1±0.3	7.1±0.4	7.3±0.9
	A5	6.8±0.7	7.5±0.7	8.12±0.4
DO (mg/L) BIS Limit 4 to 8 (mg/L)	A1	8.12±0.3	7.11± 0.2	7.54± 0.2
	A2	7.67± 0.2	7.72± 0.4	7.87± 0.4
	A3	7.23± 0.1	8.11± 0.3	7.65± 0.3
	A4	7.92± 0.1	7.45± 0.3	8.23± 0.4
	A5	7.82± 0.1	7.12± 0.3	7.88± 0.3
BOD (mg/L) BIS Limit 0 (mg/L)	A1	1.44± 0.2	1.67± 0.4	1.87± 0.3
	A2	0.0	0.0	0.0
	A3	0.0	0.0	0.0
	A4	0.0	0.0	0.0
	A5	0.0	0.0	0.0
COD (mg/L) BIS Limit 10(mg/L)	A1	8.23± 0.3	8.45± 0.4	6.98± 0.2
	A2	9.45± 0.7	8.13± 0.3	7.34± 0.4
	A3	8.12± 0.4	6.45± 0.2	7.23± 0.4
	A4	0.0	0.0	0.0
	A5	0.0	0.0	0.0
Chloride (mg/L) BIS Limit 250 (mg/L)	A1	165.44±3.1	105.65±2.1	136.65±3.1
	A2	156.34±4.1	96.45±1.9	134.32±2.9
	A3	145.87±2.9	89.75±1.8	128.31±3.9
	A4	134.45±3.2	80.44±1.4	100.65±5.8
	A5	111.98±2.1	76.23±1.7	97.45±4.1
TS (mg/L) BIS Limit 500 (mg/L)	A1	534.85±12	448.34±14	644.87±13
	A2	422.76±17	397.76±11	513.87±12
	A3	427.87±8.3	355.65±9.6	498.65±8.9
	A4	417.73±7.5	335.87±8.2	489.65±10
	A5	416.87±10	328.87±9.3	420.76±8.3
TDS (mg/L) BIS Limit 500 (mg/L)	A1	419.76±13	390.54±6.2	488.45±17
	A2	426.86±10	378.98±9.4	459.87±14
	A3	430.62±9.7	305.56±8.9	433.56±9.5
	A4	405.76±9.9	317.98±4.7	388.88±8.3
	A5	410.98±11	316.33±8.2	390.45±7.4
TSS (mg/L) BIS Limit 5 (mg/L)	A1	4.23± 0.3	3.23± 0.5	4.12± 0.5
	A2	3.45± 0.3	0.0	0.0
	A3	0.0	2.45± 0.3	0.0

	A4	0.0	0.0	0.0
	A5	0.0	0.0	0.0
Sulphate (mg/L) BIS Limit 200 (mg/L)	A1	62.43±1.3	53.73±2.1	75.29±2.2
	A2	56.34±1.2	62.46±3.6	80.83±2.7
	A3	70.43±2.1	57.54±2.1	65.72±1.7
	A4	52.54±1.3	47.54±2.4	62.56±2.1
	A5	61.43±1.9	46.39±3.1	71.62±2.2
Oil and Grease (mg/L) BIS Limit 1.0	A1	0.0	0.0	0.0
	A2	0.0	0.0	0.0
	A3	0.0	0.0	1.13± 0.3
	A4	0.0	0.0	0.0
	A5	0.0	0.0	0.0
Fluoride (mg/L) BIS Limit 1.0	A1	0.87 ±0.1	0.62 ±0.1	0.93 ±0.2
	A2	0.82 ±0.1	0.60 ±0.1	0.95 ±0.3
	A3	0.81 ±0.3	0.55 ±0.2	0.90 ±0.1
	A4	0.79 ±0.2	0.50 ±0.1	0.88 ±0.2
	A5	0.78 ±0.1	0.50 ±0.1	0.69 ±0.1

All experiments were performed in triplicate, Values are means of ± SD

In-depth Analysis of Groundwater Condition:

Seasonal Trends (2021-2022) in the Vicinity of Sugar mill B

Colour

The groundwater in the vicinity areas of Sugar mill B exhibited colour characteristics that were transparent and within the BIS limits.

Temperature

Temperature variations were observed in groundwater samples from different locations and seasons, but within acceptable limits, suggesting no significant impact on water quality due to temperature.

pH

The pH levels of groundwater samples were within the BIS-recommended range of 6.0-8.5. In November 2021, pH values ranged from 7.0 to 7.2, in January 2022 from 7.0 to 7.2 and in April 2022 from 7.0 to 7.2. These pH levels are generally conducive to various uses of groundwater.

Dissolved Oxygen

DO levels in the groundwater samples met the BIS standard of 4 to 8 mg/L. In November 2021, DO levels ranged from 6.45 to 8.22 mg/L, in January 2022 from 6.56 to 8.11 mg/L, and in April 2022 from 6.45 to 7.91 mg/L. Adequate DO levels are essential for sustaining aquatic life in groundwater.

Biochemical Oxygen Demand

The BOD levels in the groundwater samples were within the BIS limit of 0 mg/L, indicating a minimal to zero organic pollution level.

Chemical Oxygen Demand

The COD values were within the BIS limit of 10 mg/L, suggesting a minimal presence of both organic and inorganic pollutants in the groundwater. In November 2021, COD levels ranged from 6.83 to 9.23 mg/L, and no COD was detected in January and April 2022.

Chlorides

Chloride levels in the groundwater samples were within the BIS limit of 250 mg/L. In November 2021, chloride levels ranged from 95.34 to 177.45 mg/L, in

January 2022 from 122.34 to 127.34 mg/L, and in April 2022 from 96.65 to 157.87 mg/L.

Total Suspended Solids

TSS levels were within acceptable limits, meeting the BIS standard of 5 mg/L. In November 2021, TSS levels ranged from 2.23 to 3.12 mg/L, in January 2022 from 0.0 to 2.89 mg/L, and in April 2022 from 0.0 to 3.12 mg/L.

Total Dissolved Solids

In November 2021, TDS levels ranged from 400.76 to 588.54 mg/L, in January 2022 from 410.56 to 423.76 mg/L, and in April 2022 from 488.76 to 534.87 mg/L. TDS levels in the groundwater samples were observed and found within the BIS limit of 500 mg/L.

Sulphate

Sulphate levels in the groundwater samples were within the BIS limit of 200 mg/L. In November 2021, sulphate levels ranged from 71.82 to 98.51 mg/L, in January 2022 from 70.72 to 80.83 mg/L, and in April 2022 from 63.82 to 85.62 mg/L. These values suggest a moderate presence of sulphate, and continuous monitoring is essential.

Oil and Grease

Oil and grease levels in the groundwater samples were generally within the BIS standard of 1.0 mg/L. In November 2021, levels ranged from 1.1 to 1.4 mg/L, and no oil and grease were detected in January and April 2022.

Fluoride

Fluoride levels in the groundwater samples were observed within the BIS limit of 1.0 mg/L. In November 2021, levels ranged from 0.76 to 1.10 mg/L, in January 2022 from 0.88 to 0.94 mg/L, and in April 2022 from 0.82 to 0.97 mg/L.

The groundwater in the nearby areas of Sugar mill B generally meets the BIS standards for physico-chemical parameters. The absence of BOD and low levels of COD indicate good water quality. The moderate levels of sulphate suggest the need for continuous monitoring to ensure sustainable groundwater quality.

Table-2. Outcomes of Physico-chemical parameters of groundwater of surrounding areas of sugar mill B (Seasonal Trends) 2021-2022

Parameters	Sample Locations	Physico-Chemical Parameters of Groundwater of Surrounding areas of Sugar mill B (Seasonal Trends) 2021-2022		
		November 2021	January 2022	April 2022
Colour BIS Limit Colourless	B1	Transparent	Transparent	Transparent
	B2	Transparent	Transparent	Transparent
	B3	Transparent	Transparent	Transparent
	B4	Transparent	Transparent	Transparent
	B5	Transparent	Transparent	Transparent
Temperature (ºC)	B1	32.54±0.9	25.43±1.1	34.54±1.9
	B2	33.54±1.2	26.54±1.5	35.23±1.6
	B3	33.54±2.1	26.65±1.2	34.72±1.5
	B4	34.92±1.0	25.65±1.0	34.65±1.8
	B5	30.54±1.2	25.54±1.2	34.45±1.0
pH BIS Limit	B1	7.2±0.5	7.2±0.7	7.0±0.8
	B2	7.1±0.3	7.2±0.5	7.1±0.5

6-8.5	B3	7.1±0.7	7.3±0.4	7.0±0.2
	B4	7.1±0.4	7.1±0.4	7.0±0.1
	B5	7.2±0.2	7.1±0.3	7.2±0.2
DO (mg/L) BIS Limit 4 to 8 (mg/L)	B1	6.98±0.3	6.56± 0.4	8.22± 0.5
	B2	6.56± 0.7	7.12± 0.3	8.11± 0.7
	B3	6.56± 0.3	7.98± 0.4	7.32± 0.3
	B4	8.45± 0.2	6.92± 0.4	7.98± 0.3
	B5	7.12± 0.6	6.45± 0.7	7.91± 0.5
BOD (mg/L) BIS Limit 0 (mg/L)	B1	0.0	0.0	1.32± 0.5
	B2	0.0	0.0	0.0
	B3	0.0	0.0	0.0
	B4	0.0	0.0	0.0
	B5	0.0	0.0	0.0
COD (mg/L) BIS Limit 10(mg/L)	B1	9.23± 0.4	6.83± 0.3	7.54± 0.2
	B2	6.54± 0.5	6.45± 0.3	7.12± 0.3
	B3	0.0	0.0	0.0
	B4	0.0	0.0	0.0
	B5	0.0	0.0	0.0
Chloride (mg/L) BIS Limit 250 (mg/L)	B1	177.45±3.9	127.34±2.3	157.87±2.5
	B2	155.76±2.5	122.34±4.1	140.23±3.2
	B3	148.34±2.3	95.34±4.6	112.76±1.9
	B4	140.34±4.1	97.92±2.4	96.65±2.4
	B5	92.65±4.1	110.54±4.2	97.56±4.2
TS (mg/L) BIS Limit 500 (mg/L)	B1	776.76±10	665.87±17	712.87±12
	B2	632.76±14	576.87±8.3	698.54±12
	B3	587.45±9.8	487.65±8.7	534.76±8.6
	B4	496.87±10	489.56±9.1	487.86±10
	B5	511.76±12	455.83±5.6	477.52±9.3
TDS (mg/L) BIS Limit 500 (mg/L)	B1	588.54±19	423.76±8.6	534.87±13
	B2	533.61±15	410.56±5.4	531.56±19
	B3	521.86±8.8	400.76±9.2	510.76±7.3
	B4	490.76±9.3	405.65±7.3	488.76±9.3
	B5	497.33±15	416.89±8.9	490.88±8.9
TSS (mg/L) BIS Limit 5 (mg/L)	B1	2.23± 0.6	2.98± 0.2	3.12± 0.6
	B2	2.12± 0.4	0.0	2.89± 0.3
	B3	1.45± 0.4	1.86± 0.4	3.12± 0.6
	B4	0.0	0.0	0.0

	B5	0.0	0.0	0.0
Sulphate (mg/L) BIS Limit 200 (mg/L)	B1	98.51±2.9	78.82±2.3	85.62±2.4
	B2	89.87±1.5	80.83±2.5	80.72±1.4
	B3	90.66±2.7	71.82±1.4	80.12±1.3
	B4	78.88±2.2	70.72±1.4	80.73±2.1
	B5	74.77±2.3	68.55±2.3	63.82±1.3
Oil and Grease (mg/L) BIS Limit 1.0	B1	1.4±0.4	1.1±0.5	1.3±0.3
	B2	1.1±0.3	0.0	0.0
	B3	0.0	0.0	0.0
	B4	0.0	0.0	0.0
	B5	0.0	0.0	0.0
Fluoride (mg/L) BIS Limit 1.0	A1	0.97 ±0.1	0.88 ±0.2	1.10 ±0.3
	A2	1.11 ±0.2	0.94 ±0.1	1.02 ±0.2
	A3	0.93 ±0.2	0.92 ±0.1	0.98 ±0.3
	A4	0.92 ±0.1	0.88 ±0.2	0.92 ±0.2
	A5	0.88 ±0.1	0.76 ±0.2	0.82 ±0.2

All experiments were performed in triplicate, Values are means of ± SD

Thorough Analysis of Groundwater Suitability: Sugar Mills A and B Vicinity

The attained results uncover that Sugar Mill A and Sugar Mill B have approximately similar impacts on the physico-chemical composition of the groundwater quality in their respective vicinities (A1 to A5 for Sugar Mill A as well as B1 to B5 for Sugar Mill B). This is in reference to the impact that these mills have on groundwater quality. In general, the groundwater that surrounds both mills is transparent and falls below acceptable limits for water parameters such as temperature, pH, DO, BOD, COD, chloride, TS, TDS, TSS, sulphate, oil and grease, and fluoride. On the other hand, certain parameters in particular areas occasionally approach or transcend the permitted limits, which pinpoints the possibility of environmental stress. For the purpose of mitigating any potential negative influence on groundwater quality and ensuring environmentally sustainable practices, it is essential for both Sugar Mill A and Sugar Mill B to continue monitoring and adopting good wastewater management techniques. Deshmukh [6] realized and reported that assuredly, water is the most necessary resource not only for livelihood but also for the advancement of industry and economy.

Conclusion

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