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Impact of Rice Mill Wastewater on the Water Quality of River: A Case Study from Rajim, Chhattisgarh

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ABSTRACT
The Mahanadi River, located in Chhattisgarh, is experiencing significant water pollution near Rajim, primarily due to wastewater discharged by rice mills. This wastewater contains harmful substances such as rice husks, dust, and chemicals, leading to the degradation of the river's water quality. The pollution not only affects the aquatic ecosystem but also poses health risks to local communities dependent on the river for drinking, irrigation, and other daily activities. To assess the extent of this pollution, key water quality parameters are analyzed, including temperature, electrical conductivity (EC), pH, alkalinity, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), total hardness, chemical oxygen demand (COD), and biological oxygen demand (BOD). These parameters help determine the level of contamination and its impact on both the river's ecosystem and the people living nearby, highlighting the need for effective wastewater treatment and pollution control measures.

KEYWORDS: Environmental Impact, Mahanadi River, Physicochemical Parameters, Rice Mill Wastewater, Water Pollution.

INTRODUCTION

Environmental Pollution and Water Pollution: Environmental pollution is the introduction of harmful substances or forms of energy into the environment, disrupting the natural ecological balance and posing a threat to the health of living organisms. Pollution can take various forms, including air, water, soil, and noise pollution. Among these, water pollution is one of the most detrimental to both ecosystems and human health. Water bodies such as rivers, lakes, and oceans are essential to the survival of aquatic life, and they also serve as a crucial resource for human activities. Water pollution is defined as the contamination of water bodies by pollutants, which can be any harmful substance or form of energy that disrupts the natural properties of water. These pollutants can alter the physical, chemical, and biological characteristics of the water, rendering it unfit for human consumption, industrial use, and aquatic life. APHA. (1985).

Water pollution can have a direct and lasting impact on human health and the environment. Polluted water often carries pathogens, heavy metals, chemicals, and other toxins that can cause a range of health issues, from gastrointestinal disorders to long-term diseases like cancer and neurological damage. Additionally, water pollution disturbs aquatic ecosystems, harming fish and other species that depend on clean water for survival. The causes of water pollution are numerous, but the most significant sources include industrial discharges, agricultural runoff, untreated sewage, and urban waste. (Paul, J. et al. 2015a, b).

Industrial and domestic activities are the primary contributors to the increasing levels of water contamination, which not only affect the quality of water but also lead to the depletion of available freshwater resources. Contribution of Rice Mills to Water Pollution: Rice mills, which process large quantities of rice annually, have become significant contributors to water pollution, particularly in rural and agricultural areas. The wastewater discharged from rice mills contains various contaminants that pose serious threats to nearby water bodies like rivers, lakes, and streams. Rice milling involves several stages, including cleaning, polishing, and dehulling, all of which generate wastewater that contains rice husks, dust, chemicals, and other impurities. This untreated wastewater is often released directly into nearby water bodies, leading to contamination. Sharma & Bansal (2016).

The wastewater from rice mills typically consists of several pollutants. One of the major pollutants is rice husks, which are small, lightweight fragments of the rice plant that can float on the surface of the water. These husks not only degrade the water's quality but can also lead to the blocking of waterways, reducing the flow of water and increasing the potential for the spread of diseases. The dust generated during the milling process is another pollutant that settles in the water, further contributing to contamination.

Chemicals used in the milling process for cleaning and coloring rice also add to the pollution load. These chemicals, such as alkalis, acids, and bleaching agents, can have detrimental effects on both the water quality and the aquatic organisms living in the affected water bodies. When these chemicals are discharged without proper treatment, they can cause toxicity, damage aquatic life, and lead to an imbalance in the water's chemical composition. Kaur & Singh (2014).

Impact of Pollutants from Rice Mills:

1. Rice Husks, Dust, and Other Impurities: Rice husks and dust are generated during the milling process and are carried along with wastewater into rivers and other water bodies. These impurities increase the turbidity of the water, making it murky and reducing the amount of light penetration, which can affect photosynthesis in aquatic plants. Furthermore, as rice husks and dust accumulate in water, they reduce the overall oxygen levels in the water, which can harm aquatic organisms like fish and other microorganisms that depend on dissolved oxygen for survival.
2. Chemical Substances: In addition to the physical impurities, rice mills often use a variety of chemicals during the milling process. These chemicals include detergents, bleaching agents, and other substances used for cleaning and improving the appearance of rice. When these chemicals enter water bodies, they can alter the pH of the water, making it either too acidic or too alkaline for most aquatic organisms. The presence of such chemicals can lead to the death of fish, invertebrates, and other aquatic species, disrupting the ecosystem. Kumar & Ghosh (2017).
3. Lack of Proper Water Treatment: One of the major issues contributing to water pollution from rice mills is the lack of proper wastewater treatment systems. Many rice mills do not have the necessary infrastructure to treat or filter the wastewater before discharging it into the environment. As a result, the untreated wastewater carries high levels of contaminants into nearby rivers and streams. This lack of treatment results in the continuous accumulation of pollutants in the water, further deteriorating its quality and making it unsafe for both human consumption and aquatic life.

STUDY AREA

The study focuses on the impact of rice mill wastewater on the Mahanadi River in the Rajim-Nawapara region of Chhattisgarh, located at 20°57'54" N latitude and 81°52'54" E longitude. The region is known for its rice mills, which discharge untreated wastewater directly into the river, leading to significant concerns about water quality. This wastewater often contains contaminants like rice husks, dust, and chemicals used in the rice processing, which affect the river's ecological balance and human health. The study aims to examine the extent of this pollution by analyzing the effects on various water quality parameters such as temperature, pH, electrical conductivity, total dissolved solids, total suspended solids, and more. By understanding the impact of rice mill wastewater on the Mahanadi River, this research will help highlight the need for effective pollution control and wastewater management strategies to protect both the environment and public health. (Shrivastava et al 2011).

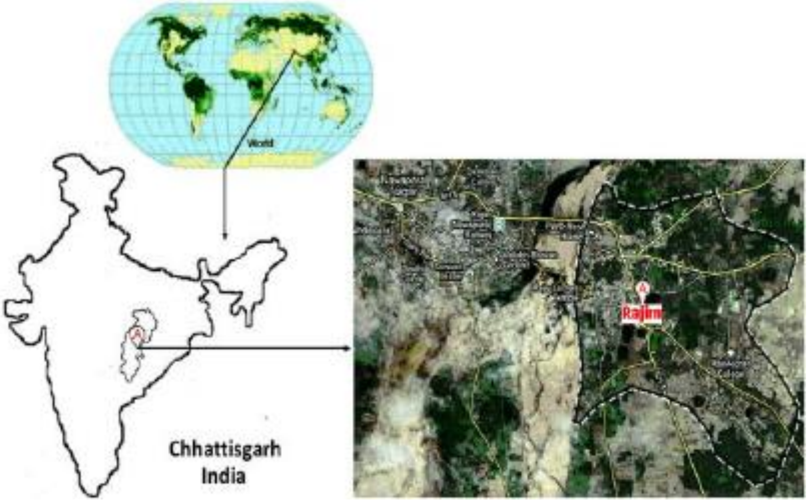


Fig1. Study area

PHYSICOCHEMICAL PARAMETERS FOR MEASURING POLLUTION FROM RICE MILL WASTEWATER

To assess the extent of water pollution caused by rice mill wastewater, several physicochemical parameters are typically monitored. These parameters help determine the impact of the wastewater on water quality and guide efforts to mitigate pollution. The key physicochemical parameters include:

1. Temperature: The temperature of water is a critical factor that influences the rate of chemical reactions and the metabolism of aquatic organisms. Wastewater from rice mills may increase the water temperature, which can reduce the oxygen-holding capacity of water and disrupt aquatic life.
2. Electrical Conductivity (EC): EC measures the ability of water to conduct electricity, which increases with the presence of dissolved salts and chemicals. High EC levels indicate contamination by inorganic substances from industrial effluents.
3. pH: The pH of water indicates its acidity or alkalinity. Wastewater from rice mills can cause fluctuations in pH levels, which can negatively impact aquatic organisms that are sensitive to changes in water chemistry.
4. Alkalinity: This measures the water's ability to neutralize acids. Alkaline substances from rice mill wastewater can alter the natural alkalinity of water, affecting aquatic species that depend on stable pH levels.

5. Total Dissolved Solids (TDS): TDS refers to the total amount of dissolved substances, such as salts, minerals, and metals, in water. High TDS levels indicate contamination and can negatively affect water quality.
6. Total Suspended Solids (TSS): TSS measures the solid particles suspended in water. High TSS levels can reduce water clarity, hinder photosynthesis, and affect aquatic habitats.
7. Total Solids (TS): TS include both TDS and TSS, providing an overall measure of the solid content in water, which reflects the extent of contamination.
8. Total Hardness: Hardness is due to the presence of calcium and magnesium ions in water. High hardness levels can affect the suitability of water for various uses, including drinking and irrigation.
9. Chemical Oxygen Demand (COD): COD indicates the amount of oxygen required to break down organic pollutants in water. High COD levels suggest the presence of large amounts of organic contaminants.
10. Biochemical Oxygen Demand (BOD): BOD measures the amount of oxygen consumed by microorganisms to decompose organic matter. Elevated BOD levels reflect a higher concentration of biodegradable pollutants, leading to oxygen depletion in the water.

These parameters provide critical insights into the quality of water affected by rice mill wastewater and help determine the necessary actions for mitigating pollution and improving water quality.

OBJECTIVE

The primary objective of this study is to assess the environmental and water quality impacts of wastewater discharged by rice mills, focusing on the Mahanadi River. The study aims to examine how the wastewater from rice mills, containing dissolved impurities, chemicals, and organic matter, contributes to the pollution of river water. By analyzing various water quality parameters such as temperature, electrical conductivity (EC), pH, alkalinity, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), total hardness, chemical oxygen demand (COD), and biochemical oxygen demand (BOD), the study seeks to quantify the extent of contamination caused by rice mill effluents.

Additionally, the study will explore the effects of these pollutants on both aquatic life and human health in the surrounding areas. The objective is to understand how the pollutants compromise water quality, disrupt ecosystems, and pose risks to public health. Thakur & Upadhyay (2018).).

Furthermore, this study intends to identify potential methods and technologies for effectively treating rice mill wastewater, thereby reducing its harmful impact on the environment and ensuring the sustainable use of water resources. Ultimately, the research aims to provide recommendations for mitigating water pollution, enhancing water quality, and supporting the health of both ecosystems and local communities. Rames & Singh (2019).

SAMPLING

In this study, wastewater samples were collected from the Mahanadi River to analyze the impact of rice mill effluents on water quality. Sampling was conducted at various points along the river, extending up to 5 kilometers downstream from the point where the wastewater from the rice mill enters the river. A total of 7 samples were taken, with one sample collected at every 1-kilometer interval in the direction of the river's flow. This approach allowed for a comprehensive analysis of how the water quality changes as the wastewater mixes and disperses along the river.

The sampling points were chosen strategically to represent different stages of the river's flow after the effluent discharge. The first sample was taken directly at the point of wastewater discharge, and subsequent samples were taken at 1, 2, 3, 4, and 5 kilometers downstream. This spatial distribution of samples provided insights into the dilution and dispersion patterns of pollutants, allowing for a better understanding of how the rice mill effluent affects water quality as it travels through the river.

PHYSICO-CHEMICAL CHARACTERISTICS OF THE EFFLUENT

To understand the impact of rice mill wastewater on water quality, the physico-chemical characteristics of the effluent were assessed at each sampling point. These included parameters such as temperature, pH, electrical conductivity (EC), alkalinity, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), total hardness, chemical oxygen demand (COD), and biochemical oxygen demand (BOD). The variation in these parameters with distance from the rice mill discharge point provided valuable insights into the extent of pollution and its dispersal in the river system.

Sample Site	Distance Location	Km
Site 1	Before rice mill Rijim	1 km
Site 2	Outlet point of rice mill	0 km
Site 3	After outlet of rice mill	1 km
Site 4	After outlet of rice mill	2 km
Site 5	After outlet of rice mill	3 km
Site 6	After outlet of rice mill	4 km
Site 7	After outlet of rice mill	5 km

Table 1: sample site and Distance location

The following details are provided about Physicochemical Parameters and their Testing Methods, which are commonly used in water quality testing:

Parameter	Method of testing
temperature	Thermometer
Electrical Conductivity	Digital Electrical Conductivity Meter
pH	pH meter
Alkalinity	Titrometric Method
TDS	Digital TDS meter
TSS	Gravimetric Method
TS	Gravimetric Method
Total Hardness	Titrometric Method
COD	Titrometric Method
BOD	Titrometric Method

Table 2: physicochemical Parameter and method of testing.

Table 3: Physico-chemical Parameters of sample water (November-December) 2018

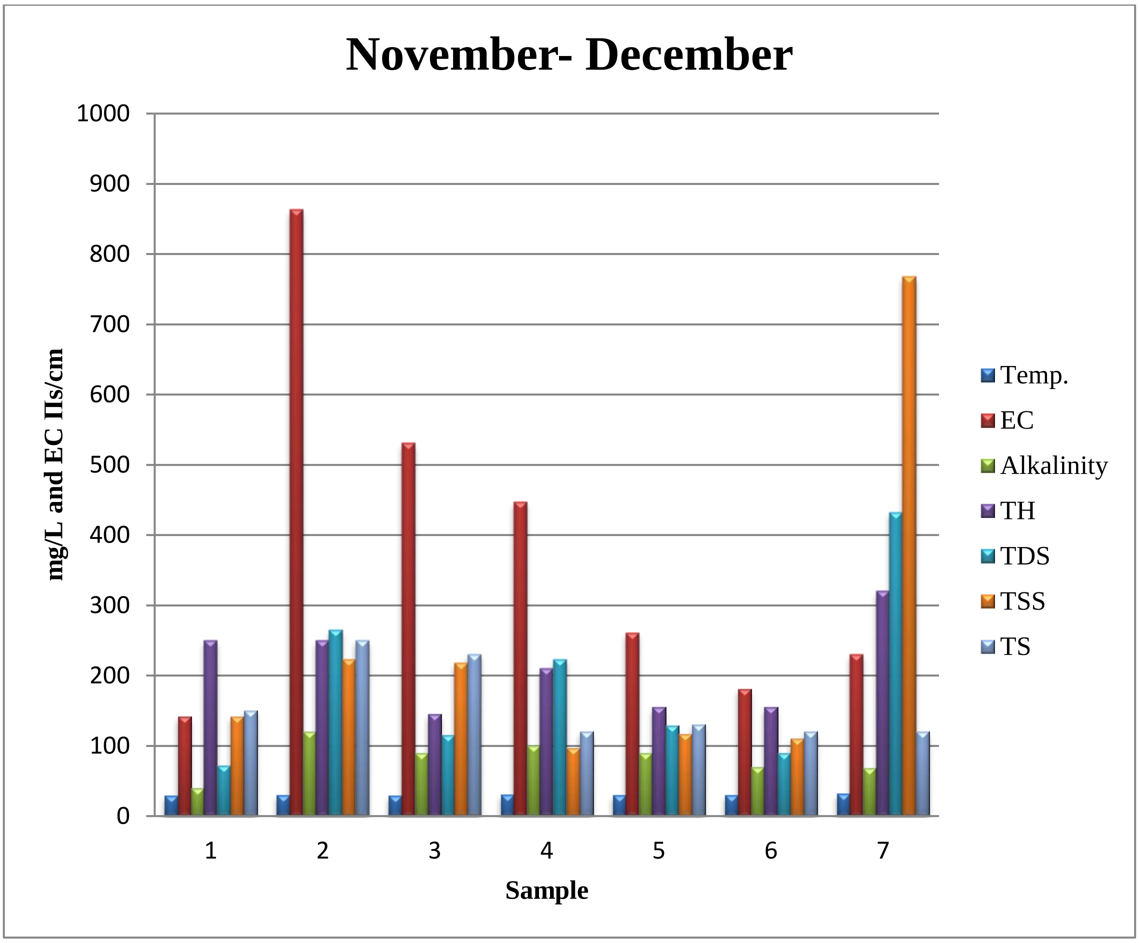
S. NO.	Parameter	Unit of measurement	WHO	BIS	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
1	Colour				Blac	Blac	Blac	Blac	Blac	colou	Colou

					kish colour	kish colour	kish colour	kish colour	kish colour	rles	rless
2	Odour		Unobjectionable	Unobjectionable	Foul smell	Foul smell	Foul smell	Foul smell	Foul smell	Odourless	Odourless
3	Temperature	^{0}C	-	-	29	30	29	31	30	30	32
4	Electrical conductivity	µs/cm	750	-	142	863	531	447	261	181	230
5	pH	pH scale	6.5-8.5	6.5-8.5	8	8.1	7.8	7.4	7.8	6.8	6.7
6	Alkalinity	mg/L	500	200-600	40	120	90	100	90	70	68
7	Total Hardness	mg/L	300- 600	200-600	250	250	145	210	155	155	320
8	D.O.	mg/L	>4-6	>4-6	14	12	9	11	8	12	13
9	C.O.D.	mg/L	<20	<20	19	20	20	19	20	19	18
10	TDS	ppm	500-2000	500-2000	72	265	115	223	129	90	432
11	TSS	mg/L	-	-	142	223	218	97	117	110	768
12	TS	mg/L	1000		150	250	230	120	130	120	120

Table 4: Physico-chemical Parameters of sample water (February- March) 2019

S. NO.	Parameter	Unit of measurement	WHO	BIS	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
1	Colour		-	-	Blackish colour	Blackish colour	Blackish colour	Blackish colour	Blackish colour	colourless	Colourless
2	Odour		Unobjectionable	Unobjectionable	Foul smell	Foul smell	Foul smell	Foul smell	Foul smell		Odourless
3	Temperature	^{0}C	-	-	29	30	29	30	30	30	31
4	E.C.	µs/cm	750	-	185	668	416	446	608	340	373
5	pH	pH scale	6.5-8.5	6.5-8.5	8	7.5	7.5	7.1	7.1	7.2	7.2

6	Alkalinity	mg/L	500	200-600	50	120	100	80	80	70	70
7	Total Hardness	mg/L	300- 600	200-600	260	255	150	200	160	165	320
8	D.O.	mg/L	>4-6	>4-6	13	11	9	11	9	11	12
9	C.O.D.	mg/L	<20	<20	22	30	25	20	29	29	20
10	TDS	ppm	500-2000	500-2000	92	135	208	223	304	170	187
11	TSS	mg/L	-	-	150	265	212	127	139	143	141
12	TS	mg/L	1000		160	270	240	150	170	160	160



Analysis of Temp., EC, Alkalinity, TH, TDS, TSS and TS

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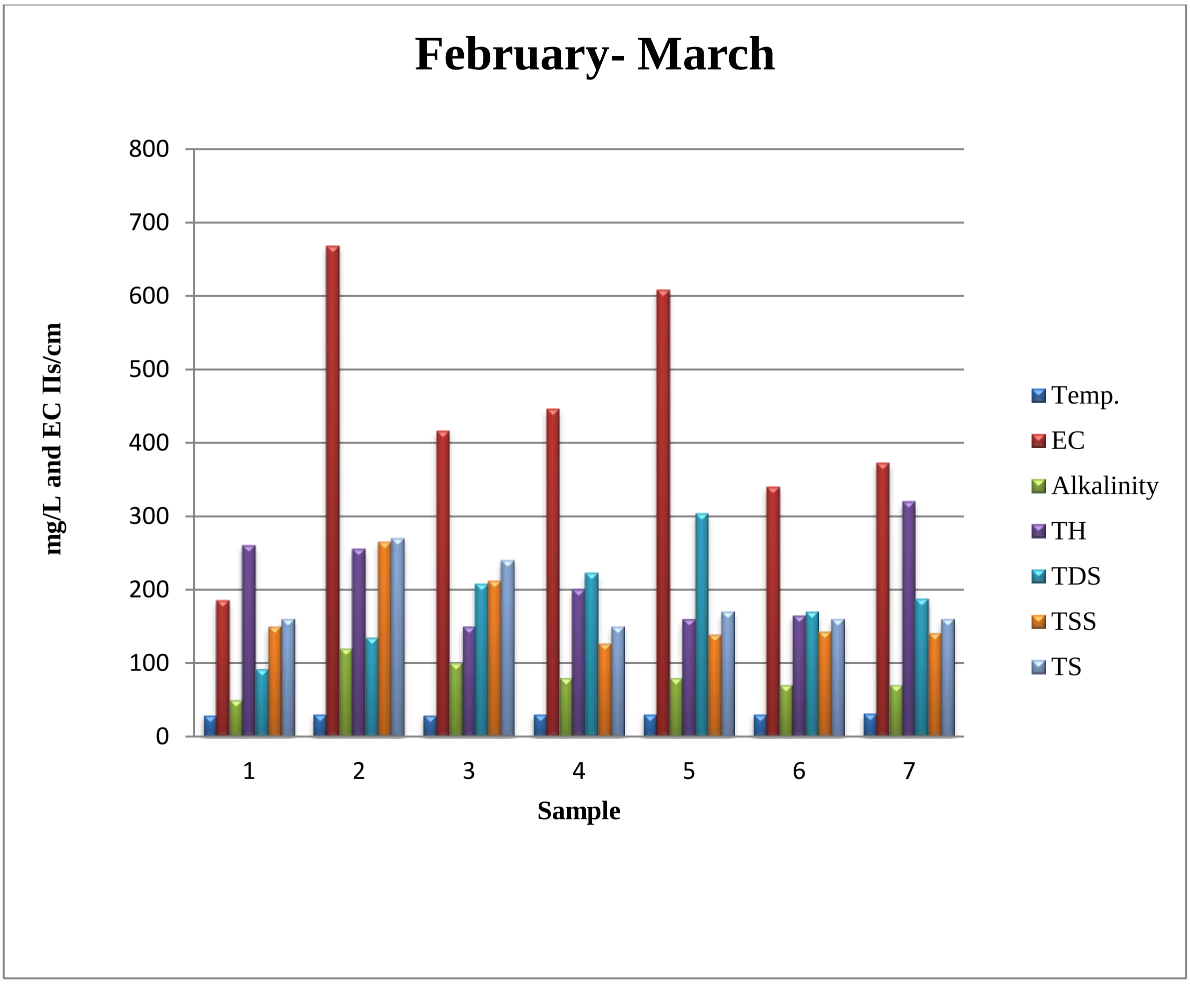

Analysis of Temp., EC, Alkalinity, TH, TDS, TSS and TS

RESULTS AND DISCUSSION

The analysis of wastewater discharged from rice mills into the Mahanadi River was conducted to examine the impact of rice mill effluents on the water quality. The results of the study, based on various physicochemical parameters, are presented and discussed below. The parameters assessed include Electrical Conductivity (EC), pH, Alkalinity, Total Hardness (TH), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and Total Solids (TS). The results for different sampling sites and seasons (November-December and February-March) are summarized in Table 1, while the methods used for testing are shown in Table 2. The permissible limits set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS) are presented in Table 3 and Table 4.

1. Electrical Conductivity (EC)

Electrical conductivity (EC) measures the ability of water to conduct electrical current, which is a reflection of the concentration of dissolved salts and ions in the water. The EC values ranged significantly across the sampling locations. In the period of November-December, the minimum EC value was found to be 142 µS/cm at site 1, while the maximum value was 863 µS/cm at site 2. During the February-March period, EC values ranged from 185 µS/cm (site 1) to 668 µS/cm (site 2). The increase in EC at certain sites is an indication of higher concentrations of dissolved ions, possibly due to the effluents discharged from the rice mills. Higher EC values suggest contamination from organic and inorganic pollutants such as salts, minerals, or chemicals, indicating deterioration in the water quality at those sites.

2. pH

The pH of the water is a critical parameter that reflects the acidity or alkalinity of the water. It plays an essential role in determining the solubility and availability of nutrients and metals in the water, which can significantly affect aquatic life. In the November-December period, the pH values ranged from 6.7 (site 7) to 8.1 (site 2), while in the February-March period, the pH ranged from 7.1 (site 4 and site 5) to 8.0 (site 1). The pH values remained within a neutral to slightly alkaline range throughout the study, indicating that the water is not excessively acidic or alkaline. This is a positive factor for the health of aquatic ecosystems, as extreme pH values could harm aquatic organisms. The slight fluctuation in pH across different sites suggests that there may be local variations in pollution levels, but overall, the pH does not present a major environmental concern in the river.

3. Alkalinity

Alkalinity is a measure of the water's ability to neutralize acids and maintain pH stability. Alkaline substances are vital for buffering the water against sudden changes in pH, which is important for maintaining the health of aquatic life. In the November-December period, the alkalinity values ranged from 40 mg/L (site 1) to 120 mg/L (site 2). In the February-March period, alkalinity values ranged from 50 mg/L (site 1) to 120 mg/L (site 2). Alkalinity levels remained within a moderate range, which suggests that the water quality is being maintained well in terms of buffering capacity. However, at certain sites, especially near the rice mill outlets, the higher alkalinity values could be indicative of effluent contamination from the rice mills, as certain chemicals used in rice processing may alter alkalinity levels.

4. Total Hardness (TH)

Total hardness in water is primarily due to the presence of calcium and magnesium salts. High hardness levels can affect water usability for various purposes such as drinking, irrigation, and industrial processes. In the November-December period, the total hardness ranged from a minimum value of 145 mg/L (site 3) to a maximum value of 320 mg/L (site 7). During the February-March period, the hardness ranged from 150 mg/L (site 3) to 320 mg/L (site 7). The variation in hardness across the sampling sites suggests that certain sites are more affected by the effluent discharge, as rice mill wastewater can contain high concentrations of dissolved salts, leading to increased hardness levels. Elevated hardness values can also indicate the presence of dissolved minerals that may impair water quality for agricultural or domestic uses.

5. Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a key parameter that indicates the health of aquatic ecosystems. Higher DO levels are favorable for aquatic life, while lower levels can signify the presence of organic pollution, which consumes oxygen as it decomposes. In the November-December period, DO values ranged from a minimum of 8 mg/L (site 5) to a maximum of 14 mg/L (site 1). During February-March, the DO ranged from 9 mg/L (site 3) to 13 mg/L (site 1). Higher DO levels are generally considered to be beneficial for aquatic organisms, but the decrease in DO levels at certain sites, particularly those located farther downstream, could be indicative of organic pollution from the rice mill wastewater. The variation in DO suggests that the rice mill effluent may have a localized effect on water quality, but overall, the river remains conducive to aquatic life in many areas.

6. Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) measures the amount of oxygen required to oxidize the organic matter present in water. High COD values suggest the presence of organic pollutants, which can deplete oxygen levels in the water and negatively affect aquatic life. In the November-December period, COD values ranged from a minimum of 18 mg/L (site 7) to a maximum of 20 mg/L (site 2). In the February-March period, COD values ranged from 20 mg/L (site 7) to 30 mg/L (site 2). The increase in COD values, particularly at sites closer to the rice mill discharge, suggests that the wastewater contains significant amounts of organic pollutants. This is a serious concern, as it could lead to oxygen depletion and the deterioration of water quality over time.

7. Total Dissolved Solids (TDS)

TDS measures the concentration of dissolved solids in water, including salts, minerals, and organic matter. High TDS values can reduce the water's suitability for drinking and agricultural uses. In the November-December period, TDS values ranged from a minimum of 90 mg/L (site 6) to a maximum of 432 mg/L (site 7). In the February-March period, TDS values ranged from 92 mg/L (site 1) to 304 mg/L (site 5). The higher TDS values at sites near the rice mill discharge indicate a significant increase in the concentration of dissolved solids, which is a direct consequence of the effluent's impact on the river's water quality. Elevated TDS levels can also impair the aesthetic qualities of the water, making it unfit for consumption and other uses.

8. Total Suspended Solids (TSS)

Total Suspended Solids (TSS) refers to the particles suspended in water, including silt, organic matter, and pollutants. High TSS levels can lead to water turbidity, reducing light penetration and negatively impacting aquatic life. In the November-December period, TSS values ranged from a minimum of 97 mg/L (site 4) to a maximum of 768 mg/L (site 7). In the February-March period, TSS values ranged from 127 mg/L (site 4) to 262 mg/L (site 2). The elevated TSS values, particularly near the rice mill discharge sites, suggest contamination by rice husks, dust, and other particulate matter from the milling process. These pollutants contribute to the degradation of water quality and could have harmful effects on aquatic organisms, as well as water clarity.

9. Total Solids (TS)

Total Solids (TS) is the sum of TDS and TSS. Elevated TS values indicate the presence of dissolved and suspended solids in the water, which can lead to reduced water quality. In the November-December period, TS values ranged from a minimum of 120 mg/L (site 4) to a maximum of 250 mg/L (site 2). In the February-March period, TS values ranged from 150 mg/L (site 4) to 270 mg/L (site 2). The increase in TS values, particularly at sites closer to the rice mill effluent, indicates the accumulation of both dissolved and suspended solids, which may degrade water quality and limit its use for various purposes.

CONCLUSION

The results of the study on the impact of rice mill wastewater on the Mahanadi River indicate that the discharge from rice mills significantly affects water quality, particularly in terms of Electrical Conductivity (EC) and Chemical Oxygen Demand (COD). The parameters of Alkalinity, pH, Total Hardness, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), and Total Solids (TS) in both well water and river water samples were found to be within the permissible limits set by regulatory authorities such as WHO and BIS. This suggests that, in general, these parameters do not pose significant threats to the environment or public health.

However, the values of EC and COD were found to exceed the acceptable limits, indicating the presence of excessive dissolved salts and organic pollutants in the wastewater. While the EC values showed minor variations from permissible limits, the COD values exhibited significant deviations. This suggests that the rice mill wastewater contains high levels of organic matter, which can lead to oxygen depletion in the river and harm aquatic life. In the case of well water samples, higher EC and COD values were observed closer to the rice mill, indicating local contamination due to the wastewater discharge.

For river water, the highest EC and COD values were recorded at the discharge point and downstream, compared to upstream samples. This further emphasizes the negative impact of the rice mill effluent on the water quality of the Mahanadi River. Despite the treatment of wastewater before discharge, the variations in certain parameters suggest that the current treatment methods employed by rice mills are not fully effective.

Therefore, it is confirmed that the wastewater treatment processes in place are insufficient to mitigate the pollution caused by rice mill discharges. It is essential for the rice mills to implement more efficient treatment systems to ensure that the wastewater meets the required standards before disposal. Improved treatment methods will help in minimizing the environmental impact and safeguarding the water quality for both aquatic life and human consumption.

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