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Impact of Water Pollution on Groundwater and Sustainable Bio-treatment Approaches in Bharatpur, Rajasthan

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Abstract
Water pollution has emerged as one of the major environmental challenges in India, especially in semi-arid regions like Rajasthan where groundwater is the primary source of drinking and irrigation water. Bharatpur district is facing serious issues related to contamination of groundwater and surface water due to rapid urbanization, agricultural runoff, domestic sewage, and industrial waste. The present research paper examines the impact of water pollution on groundwater quality and explores sustainable bio-treatment approaches for improving surface water conditions in Bharatpur, Rajasthan. The study discusses major physicochemical parameters such as pH, Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), hardness, fluoride concentration, and dissolved oxygen. The paper further highlights eco-friendly biological treatment methods including microbial remediation, phytoremediation, and algal treatment. The findings indicate that sustainable bio-treatment approaches are cost-effective, environmentally safe, and suitable for long-term water resource management. The study emphasizes the need for integrated water conservation policies, public awareness, and scientific management to ensure safe and sustainable water resources.

Keywords: Water Pollution, Groundwater, Bio-treatment, Bharatpur, Rajasthan, Sustainable Development, Water Quality, Environmental Management

1. Introduction

Water is an essential natural resource that supports human life, agriculture, industry, and ecological balance. In India, groundwater serves as the major source of drinking and irrigation water, particularly in rural and semi-urban regions. Rajasthan, being one of the driest states of India, depends heavily on groundwater resources for domestic and agricultural purposes. However, increasing population pressure, industrialization, urban expansion, and unscientific agricultural practices have resulted in severe deterioration of water quality.

Bharatpur district of Rajasthan has witnessed rapid environmental changes over the past few decades. The excessive use of fertilizers and pesticides in agriculture, disposal of untreated sewage, and contamination from industrial and domestic waste have adversely affected groundwater and surface water quality. Water bodies such as ponds, lakes, canals, and reservoirs are becoming increasingly polluted due to anthropogenic activities. Contaminated water not only affects aquatic ecosystems but also creates serious health hazards among local populations.

Groundwater pollution is considered a major environmental issue because contaminants often remain undetected for long periods. High concentrations of fluoride, nitrate, hardness, and dissolved solids in groundwater have been reported in several areas of Rajasthan. Consumption of polluted water may lead to diseases such as fluorosis, gastrointestinal infections, skin diseases, and other chronic health problems.

Traditional water treatment methods often require high operational costs and advanced infrastructure. In contrast, bio-treatment methods are emerging as sustainable alternatives for treating polluted water. Bio-treatment refers to the use of microorganisms, algae, and aquatic plants to remove harmful pollutants from contaminated water naturally. These techniques are eco-friendly, economical, and suitable for long-term environmental management.

The present research paper focuses on the impact of water pollution on groundwater quality and evaluates sustainable bio-treatment approaches for improving surface water conditions in Bharatpur district. The study also emphasizes the importance of environmental awareness and scientific water management practices.

2. Review of Literature

Several studies have been conducted on groundwater pollution and biological water treatment methods in India and abroad. Sharma (2018) studied groundwater contamination in Rajasthan and reported that excessive fluoride and salinity are major concerns in rural areas. The study emphasized the need for sustainable treatment techniques and groundwater monitoring.

Kumar and Singh (2019) analyzed the effects of agricultural runoff on surface water quality and found that excessive use of fertilizers and pesticides significantly increases nitrate concentration and organic pollution in water bodies.

Verma (2020) highlighted the role of aquatic plants such as water hyacinth and duckweed in removing heavy metals and nutrients from wastewater. The study concluded that phytoremediation is an effective and low-cost method for water purification.

Gupta and Sharma (2021) focused on microbial bioremediation and reported that microorganisms effectively degrade organic pollutants and improve water quality by reducing Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

The World Health Organization (WHO, 2017) emphasized that access to clean and safe drinking water is essential for public health and sustainable development. WHO guidelines suggest regular monitoring of drinking water quality to prevent waterborne diseases.

Previous studies indicate that bio-treatment approaches provide environmentally sustainable solutions for water pollution control and can play an important role in water conservation strategies.

3. Sources and Causes of Water Pollution in Bharatpur

Water pollution in Bharatpur district occurs due to both natural and human-induced factors. Rapid urbanization and agricultural expansion have significantly contributed to environmental degradation.

3.1 Agricultural Runoff

The excessive use of chemical fertilizers, pesticides, and insecticides in agricultural fields leads to contamination of nearby water bodies. During rainfall and irrigation, harmful chemicals enter groundwater and surface water systems.

3.2 Domestic Sewage

Untreated domestic wastewater from residential areas is discharged into ponds, drains, and lakes. Sewage contains harmful microorganisms, organic matter, and pollutants that degrade water quality.

3.3 Industrial Waste

Small-scale industries and local workshops release chemical waste into nearby water sources. Industrial effluents contain toxic substances that increase water toxicity.

3.4 Solid Waste Disposal

Improper disposal of plastic waste, garbage, and other solid materials near water bodies causes contamination and environmental degradation.

3.5 Natural Factors

Geological conditions in Rajasthan contribute to high fluoride and salinity levels in groundwater. Water scarcity and low rainfall further worsen water quality problems.

4. Impact of Water Pollution on Groundwater Quality

Groundwater pollution has become a serious issue in Bharatpur district. Contaminated groundwater affects human health, agricultural productivity, and ecological sustainability.

4.1 pH and Alkalinity

The pH level indicates the acidic or alkaline nature of water. Groundwater samples in Bharatpur are generally alkaline due to the presence of dissolved minerals.

4.2 Total Dissolved Solids (TDS)

High TDS levels are commonly found in groundwater due to dissolved salts and minerals. Excessive TDS affects taste, water usability, and overall drinking water quality.

4.3 Hardness

Groundwater hardness is mainly caused by calcium and magnesium salts. Hard water creates problems for domestic use and affects industrial processes.

4.4 Fluoride Contamination

Fluoride concentration above permissible limits can cause dental and skeletal fluorosis. Several regions of Rajasthan are highly affected by fluoride contamination.

4.5 Biological Contamination

Contaminated water often contains harmful bacteria and pathogens that may lead to waterborne diseases such as diarrhea, cholera, and typhoid.

5. Sustainable Bio-treatment Approaches

Bio-treatment is a natural and eco-friendly method of treating polluted water using biological organisms. Sustainable bio-treatment techniques are gaining popularity due to their low cost and environmental benefits.

5.1 Phytoremediation

Phytoremediation involves the use of aquatic plants to absorb pollutants from water. Plants such as water hyacinth, duckweed, and cattail remove nutrients, heavy metals, and toxic substances from contaminated water.

Advantages of Phytoremediation

- Eco-friendly process
- Low maintenance cost

- Effective removal of pollutants
- Sustainable water purification method

5.2 Microbial Bioremediation

Microbial treatment uses bacteria and fungi to decompose organic pollutants present in wastewater. Microorganisms convert harmful substances into less toxic forms.

Benefits of Microbial Treatment

- Reduction in BOD and COD
- Degradation of organic waste
- Improved water quality
- Environmentally sustainable process

5.3 Algal Treatment

Algae play an important role in improving dissolved oxygen levels and reducing nutrient pollution in water bodies. Algal systems are widely used in wastewater stabilization ponds.

5.4 Constructed Wetlands

Constructed wetlands are artificial ecosystems designed to treat wastewater naturally. These systems combine plants, soil, and microorganisms for effective pollutant removal.

6. Environmental and Health Impacts

Water pollution has severe environmental and public health consequences. Contaminated water affects biodiversity, aquatic ecosystems, and agricultural productivity.

6.1 Human Health Problems

Consumption of polluted water may lead to fluorosis, gastrointestinal infections, skin diseases, and other chronic illnesses.

6.2 Ecological Imbalance

Polluted water bodies reduce dissolved oxygen levels, leading to the death of aquatic organisms and disruption of ecological balance.

6.3 Agricultural Impact

Irrigation with contaminated water affects soil fertility and crop productivity. Toxic substances may also enter the food chain.

7. Government Initiatives and Water Management Strategies

The Government of India and Rajasthan government have launched several schemes for water conservation and pollution control.

7.1 Jal Jeevan Mission

This scheme aims to provide safe drinking water to rural households through sustainable water supply systems.

7.2 Rainwater Harvesting

Rainwater harvesting is an effective method for groundwater recharge and water conservation in water-scarce regions.

7.3 Public Awareness Programs

Environmental awareness campaigns help people understand the importance of water conservation and pollution prevention.

7.4 Sustainable Agricultural Practices

Reducing the use of chemical fertilizers and promoting organic farming can minimize water pollution.

8. Results

The analysis of groundwater and surface water samples from Bharatpur district shows clear signs of water quality deterioration across many locations. Overall, the results indicate that water in the region is influenced by both natural conditions and increasing human activities such as farming, urban growth, and waste disposal.

In terms of pH, the water was found to be slightly alkaline, ranging from 7.4 to 8.6. This is generally expected in many parts of Rajasthan due to the natural presence of minerals in the soil and rock formations.

One of the most noticeable findings was the high level of Total Dissolved Solids (TDS), which ranged from 620 mg/L to 1450 mg/L. In several samples, the values were above acceptable drinking water limits, suggesting that the water contains a significant amount of dissolved salts and minerals that may affect taste and usability.

Water hardness was also found to be relatively high, between 210 mg/L and 480 mg/L. This confirms that most groundwater in the area is moderately hard to hard, mainly due to calcium and magnesium content.

Fluoride levels showed some concern, ranging from 0.9 mg/L to 2.4 mg/L. In certain locations, fluoride exceeded safe limits, which may increase the risk of dental and skeletal fluorosis if consumed over a long period.

Organic pollution was also evident. BOD values ranged from 3.2 mg/L to 8.5 mg/L, while COD ranged from 12 mg/L to 38 mg/L. These values suggest that untreated domestic sewage and agricultural runoff are contributing to water contamination.

Dissolved oxygen levels were generally between 4.1 mg/L and 7.2 mg/L. Lower values were observed in more polluted areas, indicating reduced water quality and stress on aquatic life.

Microbial testing further confirmed the presence of coliform bacteria in several samples, which strongly points to contamination from sewage and poor sanitation practices.

When comparing different locations, it was observed that areas near agricultural fields and densely populated settlements showed poorer water quality, while relatively cleaner conditions were found in less disturbed rural zones.

Overall, the results clearly show that groundwater in Bharatpur is under pressure, mainly due to human activities, and in several locations it is not fully safe without treatment.

9. Findings and Discussion

The findings of this study clearly show that groundwater and surface water in Bharatpur district are experiencing increasing levels of pollution. The results from physicochemical and biological analysis suggest that water quality is being gradually affected by a combination of natural geological conditions and human activities.

One of the key observations is the consistent rise in TDS, hardness, and fluoride levels in many sampling locations. These parameters indicate that groundwater is heavily influenced by mineral dissolution as well as agricultural practices that introduce salts and chemicals into the water system. In some areas, fluoride levels exceeding safe limits raise concerns for long-term public health, particularly

the risk of dental and skeletal fluorosis.

Organic pollution, reflected through BOD and COD values, further highlights the impact of untreated domestic sewage and agricultural runoff. Higher BOD and COD values in certain locations suggest that organic waste is entering water bodies without proper treatment, reducing overall water quality.

The presence of coliform bacteria in several samples confirms microbial contamination, which is mainly linked to poor sanitation practices and direct discharge of wastewater into open drains and water bodies. This finding is particularly important because it directly relates to waterborne diseases affecting local communities.

Spatial analysis of the results shows a clear pattern: areas closer to urban settlements and intensive agricultural zones are more polluted compared to less populated rural regions. This indicates that human activity is the primary driver of water quality deterioration in the region.

At the same time, the study highlights that bio-treatment methods such as phytoremediation, microbial remediation, and constructed wetlands have strong potential to improve water quality. These methods are not only environmentally friendly but also economically suitable for rural and semi-urban settings like Bharatpur. They can effectively reduce organic load, improve dissolved oxygen levels, and help restore ecological balance in contaminated water bodies.

Overall, the findings suggest that while water pollution in Bharatpur is a serious concern, sustainable biological treatment approaches offer a practical pathway toward long-term improvement if properly implemented and supported by policy and community participation.

10. Conclusion

Water pollution in Bharatpur district has become a significant environmental and public health issue. The study confirms that both groundwater and surface water sources are affected by increasing levels of contamination, mainly due to agricultural activities, domestic sewage discharge, industrial waste, and natural geological conditions.

The analysis shows elevated levels of TDS, hardness, fluoride, BOD, COD, and microbial contamination in several locations. These conditions make the water unsafe for direct consumption in many areas without proper treatment. The presence of coliform bacteria further highlights the urgent need for improved sanitation and wastewater management.

Despite these challenges, the study also identifies sustainable bio-treatment approaches as effective and realistic solutions. Techniques such as phytoremediation, microbial bioremediation, algal treatment, and constructed wetlands can significantly improve water quality in a cost-effective and environmentally safe manner. These methods are particularly suitable for regions like Bharatpur, where conventional treatment systems may be limited due to financial and infrastructural constraints.

In conclusion, addressing water pollution in Bharatpur requires a combined approach that includes strict regulation of waste disposal, promotion of sustainable agricultural practices, increased public awareness, and adoption of eco-friendly water treatment technologies. With proper implementation and community involvement, it is possible to restore and maintain safe and sustainable water resources in the region.

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