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# Groundwater Quality Assessment Of Bodh Gaya Block With Special Reference To Guri Bigha, Bihar

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***Abstract:*** Groundwater is the primary source of drinking and domestic water in rural Bihar, particularly in the Gaya district where surface water availability is seasonal and unreliable. The present study evaluates the groundwater quality of Bodh Gaya Block with special reference to Guri Bigha village in Gaya district, Bihar. The assessment focuses on physicochemical characteristics and suitability of groundwater for drinking purposes. A total of Six groundwater samples were collected from hand pumps and bore wells during pre-monsoon season from **Kazichak(S1),Bakraur(S2),Guri Bigha (S3),Bagdaha(S4),Bataspur(S5), and Bhagwanpur(S6).Diferent** Parameters such as **Temperature, pH, EC, Alkalinity,TDS,TH,DO,Phosphate,Chloride,Nitrate,Fluoride,Sulphate,Iron,Calcium,Magnesium,BOD,COD** were analysed using standard APHA methods. The results indicate that groundwater quality in the study area varies spatially and is influenced by geological formation, agricultural runoff, domestic waste disposal, and seasonal fluctuations. The results indicate that most samples fall within permissible limits, but elevated levels of TDS,Iron,Fluoride and Hardness in some locations suggest localized contamination. Water analysis revealed that parts of Guri Bigha fall under poor to unsuitable categories for direct consumption. The study highlights the need for groundwater monitoring, public awareness, and sustainable water management strategies to ensure safe drinking water availability in the region.

***Index Terms*** - Water Quality, Bodh Gaya, Fluoride,Groundwater,Physico-chemical Parameters.

## I. INTRODUCTION

Groundwater is one of the most important natural resources supporting human life, agriculture, and industrial development. In India, nearly 85% of the rural population depends on groundwater for drinking and domestic purposes. Rapid population growth, agricultural intensification, unplanned urbanization, and poor sanitation practices have significantly affected groundwater quality in recent decades. Globally, at least 2.1 billion people still lacked access to safe and clean drinking water (UNICEF, 2025). Particularly in India's rural areas, ensuring equitable and reliable access to clean, safe and potable water continues to be a major environmental and public health concern. At the national level, the health and economic impacts of unsafe water are well documented. Bihar, particularly the Gaya district, heavily depends on groundwater due to inadequate surface water infrastructure and irregular rainfall distribution.

The Bodh Gaya block is a world-renowned historical and spiritual region in the Gaya district of Bihar. It serves as a major Buddhist pilgrimage hub and is home to the UNESCO World Heritage Mahabodhi Temple, surrounded by numerous rural settlements and agricultural lands. It is globally known for its religious and tourism importance, also witnessed increasing pressure on water resources due to tourism expansion and demographic growth.

Most of the Villages of Bodh Gaya Block like Guri Bigha depend almost entirely on hand pumps, bore wells, and tube wells for daily water requirements. However, groundwater contamination caused by Fluoride, Nitrate, Iron, and many Pollutants has emerged as a major environmental and public health concern in many parts of Gaya district.

Several studies conducted in Gaya district have reported excessive Fluoride, high Hardness, Nitrate contamination, and declining groundwater quality. Geological formations dominated by granitic and metamorphic rocks contribute to natural mineral dissolution, while fertilizers and domestic wastewater enhance anthropogenic contamination. Poor waste management and seasonal flooding further deteriorate groundwater quality.

The present study aims to analyse the groundwater quality status of Bodh Gaya Block with special emphasis on Guri Bigha village.

## 2. Objective

The objective include evaluating physicochemical parameters, comparing results with BIS and WHO standards, identifying major contamination issues, and suggesting sustainable management measures for safe groundwater utilization.

## 3. Study Area

Guri Bigha village is located in Bodh Gaya Block of Gaya district, Bihar, India. The village lies approximately 10 km from Bodh Gaya town and around 20 km from Gaya city. The region falls under the tropical monsoon climatic zone having hot summers, moderate rainfall, and dry winters. The average annual rainfall ranges between 950–1100 mm, most of which occurs during the southwest monsoon season.

The geology of the area mainly consists of hard rock formations, alluvial deposits, granite, and metamorphic rocks that influence groundwater chemistry. Agriculture is the dominant occupation, and excessive dependence on groundwater for irrigation has increased extraction rates. The major groundwater sources include shallow hand pumps, tube wells, and dug wells.

The study area experiences seasonal groundwater fluctuations due to monsoonal recharge and overexploitation during summer months. Lack of proper drainage, sanitation infrastructure, and waste disposal systems also contributes to groundwater contamination risks. The sampling stations are **Kazichak(S1), Bakraur(S2), Guri Bigha(S3), Bagdaha(S4), Bataspur(S5), and Bhagwanpur(S6)**

## 4. Materials and Methods

Groundwater samples were collected from different hand pumps, bore wells, and tube wells located in Guri Bigha village and nearby areas of Bodh Gaya Block during pre-monsoon period. Samples were collected in clean polyethylene bottles following standard sampling procedures.

## 5. Analytical Methods

The physicochemical parameters were analysed using standard procedures recommended by the American Public Health Association (APHA, 2022). Parameters such as pH, EC, TDS, Temperature, COD and Dissolved Oxygen were measured in situ using portable water testing instruments. Chemical parameters including Alkalinity, Hardness, Chloride, Nitrate, Fluoride, Calcium, BOD, Magnesium, Sulphate, Phosphate and Iron were analysed in the laboratory of P.G.Department of Botany,Magadh University,Bodh-Gaya by water testing kits which were supplied by Nice Chemical(P)Ltd. Cochin Kerala.

## 6. Parameters Used and their Significance

| **Parameter** | **Significance** |
|---|---|
| **pH** | **Indicates acidity or alkalinity** |
| **EC** | **Measures ionic concentration** |
| **TDS** | **Indicates dissolved mineral content** |
| **TH** | **Reflects calcium and magnesium concentration** |
| **Alkalinity** | **Determines buffering capacity** |
| **Chloride** | **Indicates salinity and sewage contamination** |
| **Nitrate** | **Associated with agricultural pollution** |
| **Fluoride** | **Excess causes fluorosis** |
| **Iron** | **Causes staining and health concerns** |
| **Ca & Mg** | **Contribute to hardness** |
| **D O** | **Indicates water freshness** |
| **Sulphate** | **Affects drinking water aesthetics and human health** |
| **Phosphate** | **Indicates algal growth** |
| **BOD** | **Tracks the biodegradable organic waste** |
| **COD** | **Measures all oxidizable organic and inorganic contaminants** |

| S.No. | Parameters | Experimental Area Location | | | | | |
|---|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 | S6 |
| 1. | Temperature(°C) | 28 | 29 | 26 | 28 | 27 | 27 |
| 2. | PH | 7.23 | 7.20 | 7.37 | 7.23 | 7.35 | 6.77 |
| 3. | E. Conductivity(mg/I) | 360 | 1130 | 2480 | 2220 | 790 | 1510 |
| 4. | TDS(mg/I) | 225 | 725 | 1625 | 525 | 975 | 750 |
| 5. | Total Hardness(mg/I) | 444 | 684 | 888 | 428 | 808 | 720 |
| 6. | Alkalinity (mg/l) | 88 | 128 | 140 | 244 | 276 | 488 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7. | **Chloride (mg/l)** | **56** | **328** | **340** | **248** | **746** | **140** |
| 8. | **Nitrate(mg/I)** | **1.50** | **1.58** | **12.40** | **8.49** | **8.62** | **11.80** |
| 9. | **Fluoride(mg/I)** | **0.64** | **1.05** | **1.53** | **1.04** | **1.51** | **0.84** |
| 10. | **Iron(mg/I)** | **0.30** | **1.51** | **1.20** | **0.80** | **0.30** | **1.0** |
| 11. | **Calcium(mg/I)** | **51.2** | **81.6** | **169.2** | **107.4** | **56** | **128** |
| 12. | **Magnesium(mg/I)** | **18.43** | **29.37** | **28.8** | **38.59** | **32.83** | **46.08** |
| 13. | **DO(mg/l)** | **7.3** | **6.0** | **6.9** | **6.1** | **6.2** | **6.4** |
| 14. | **Sulphate (mg/l)** | **20** | **23** | **18.1** | **17.9** | **19.4** | **17.1** |
| 15. | **Phosphate(mg/I)** | **0.03** | **0.04** | **0.03** | **0.05** | **0.08** | **0.06** |
| 16. | **BOD(mg/l)** | **2.3** | **2.7** | **2.6** | **2.1** | **2.0** | **2.4** |
| 17. | **COD(mg/l)** | **5.6** | **5.7** | **4.9** | **4.1** | **6.3** | **6.2** |

***TABLE 1: SHOWING DIFFERENT PARAMETERS USED IN GROUND WATER ANALYSIS OF BODHGAYA BLOCK***

## 7. Results and Discussion

The ground water quality parameters have given in **Table-1.** And data has been comparing withWHO (2011) and IS: 10500 standards for drinking water.

**Temperature:** Temperature of water plays an important role for living beings. Quality of water is also maintained by temperature. The temperature of different sampling points ranges from **$26^{o}$C to $29^{o}$C.**

**pH:** The pH of ground water ranges from **6.77 to 7.37** which is within the range of drinking purposes, proposed by ISI 1991 is **6.5 to 8.5.**

**Electric conductivity:** EC of water samples ranged between the values of **100 μ S/cm to 800 μ/cm** are generally considered acceptable. The value of EC range from **360 to 2480 μ/cm.**

**TDS (Total Dissolve Solid):** All the samples are analyzed to have TDS values in the rangeof **225** mg/l to **1625** mg/l, which were well within the BIS Limit between **500 mg/l** to **2000 mg/l.**

**Total Hardness:** The temporary hardness of water is only due to dissolved of Calcium and Magnesium bicarbonate salt in water, whereas permanent hardness is due to presence of chlorides of Calcium and Magnesium salt in water. The value of total hardness ranges **428 mg/l** to **888 mg/l.** The BIS Limit is **200 mg/l** to **600 mg/l.**

**Alkalinity**: Generally ground water associated with dissolved carbon dioxide, bicarbonates and hydroxides which occur due to dissolution of minerals in the soil. The value of alkalinity ranges from **88 to 488** mg/l, whereas BIS limit is **200 mg/l** to **600mg/l.**

**Chloride:** The chloride values ranges from **56 mg/l to 746 mg/l** in the present sample. The permissible limit of chloride in drinking water is **250mg/l to 1000mg/l** as suggested by WHO and ISI. The higher concentration of chloride may affect heart and kidney disease.

**Nitrate:** The biochemical oxidations of nitrogenous substances coming from domestic wastes are main source of nitrate in Ground Water concentration of nitrate. In the present study its value varies from **1.50 mg/l to 12.40 mg/l**. The permissible limit of WHO health based guide line values is **45mg/I.**

**Fluoride:** As per BIS the permissible limits of fluoride concentration in drinking water is **1.0 to 1.5 ppm** with a rider lesser the fluoride is better, as fluoride is injurious to health. The water samples were value between **0.64 to 1.53 mg/l.**

**Iron:** The concentration of iron varies from **0.30mg/l to 1.51 mg/l** whereas permissible limit of iron is **1.0 mg/l to 1.50mg/l.**

**Calcium:** The value of calcium hardness varied from **51.2 mg/l to 169.2 mg/l.** which were well within the BIS Limit between **75 mg/l** to **200 mg/l.**

**Magnesium:** The value of Magnesium of all water samples ranged between **18.43 mg/l to 46.08 mg/l.** The BIS Limit is **30 mg/l to 100 mg/l**

The values of **BOD (2.0mg/l to 2.7 mg)/l, COD (4.1 mg/l to 5.7 mg/l),** and **DO (6.0 mg/l to 7.3 mg/l)** level was well within the limits.

**Phosphate:** The value of phosphate was **0.03 mg/l to 0.08** mg/l.

**Sulphate:** The concentration of Sulphate varies from **17.1 mg/l to 23 mg/l.**

The groundwater quality analysis revealed significant spatial variation among sampling locations. The pH values ranged moderately alkaline, generally remaining within acceptable limits. Electrical conductivity and TDS values indicated mineralization due to prolonged rock-water interaction.

Total hardness values in several groundwater samples exceeded desirable limits, indicating dominance of calcium and magnesium ions. Hard water conditions are common in Gaya district because of geological weathering processes. Elevated alkalinity was observed in some samples due to bicarbonate-rich formations.

Fluoride concentration in a few locations exceeded the BIS permissible limit of 1.5 mg/L, indicating potential fluorosis risk. Fluoride contamination in Gaya district is primarily geogenic and associated with fluoride-bearing minerals in granitic rocks. High iron concentration was also observed in some groundwater sources, causing undesirable taste, staining, and potential health impacts.

Nitrate contamination was found in areas near agricultural fields and densely populated settlements. Excessive use of nitrogen fertilizers, poor sanitation, and seepage from waste disposal sites contribute to nitrate accumulation in groundwater.

Samples collected near densely inhabited areas showed poorer water quality compared to relatively isolated locations. The study indicates that groundwater quality deterioration in Guri Bigha is influenced by both natural geological conditions and anthropogenic activities.

## 8. Major Issues Identified

1. Excess fluoride concentration in selected groundwater sources.
2. High iron content may cause aesthetic and health problems.
3. Nitrate contamination due to agricultural runoff and poor sanitation.
4. Increasing groundwater extraction and declining water table.
5. Lack of regular groundwater monitoring systems.
6. Inadequate wastewater and solid waste management.
7. Dependence on untreated groundwater for drinking purposes.

## 9. Conclusion

The present study concludes that groundwater quality in Bodh Gaya Block, particularly in Guri Bigha village, is under increasing environmental stress. While several parameters remain within permissible limits, elevated fluoride, nitrate, iron, and hardness levels in certain locations pose potential health risks. All groundwater sources are not suitable for direct consumption without treatment.

The deterioration of groundwater quality is caused by both natural geological factors and anthropogenic activities such as excessive groundwater extraction, agricultural practices, and poor sanitation infrastructure. Sustainable groundwater management and regular monitoring are essential for ensuring long-term water security in the region.

## 10. Recommendations

1. Regular groundwater quality monitoring should be conducted at village and block levels.
2. Fluoride and iron removal treatment systems should be installed in affected areas.
3. Rainwater harvesting and artificial recharge structures should be promoted.
4. Farmers should adopt controlled Organic fertilizers application practices.
5. Public awareness programs regarding safe drinking water should be organized.
6. Proper sanitation and waste management systems must be implemented.
7. Government agencies should establish more community water purification units in vulnerable villages.
8. Periodic health surveys should be conducted in fluoride-affected regions.

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