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Seasonal Variations in Physico-Chemical Parameters of Ground and Surface Water in the Hisua Block, Nawada, Bihar

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Abstract: ***Access to safe water is vital for public health, yet large sections of rural India rely on untreated sources such as ponds, dug wells, and hand pumps. These sources are highly vulnerable to seasonal fluctuations in quality due to climatic factors and anthropogenic pressures. This study examined the seasonal variation of selected physico-chemical parameters in surface and groundwater sources of Hisua block, Nawada district, Bihar. Samples were collected during pre-monsoon, monsoon, and post-monsoon seasons (2021–2023) and analyzed for pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphate, nitrate, chloride, and iron using standard methods. Results indicated significant seasonal differences. Surface water (ponds) showed extreme turbidity during monsoon (up to 134 NTU), phosphate enrichment (>0.5 mg/L), and elevated BOD and COD, exceeding safe limits recommended by BIS (2012) and WHO (2017). Groundwater sources (wells and hand pumps) were comparatively stable but exhibited consistently low DO (<2.5 mg/L) and occasional iron concentrations near the upper permissible limit (0.3 mg/L). Seasonal rainfall was found to dilute dissolved solids while increasing suspended matter and nutrient concentrations. The findings emphasize the need for routine monitoring, protective measures for surface waters, and community-level treatment of drinking water. These results have direct implications for water management and public health in semi-rural Bihar.***

Keywords: Water quality, Seasonal variation, Ponds, Wells, Hand pumps, Physico-chemical parameters, Bihar

1. Introduction

Water quality is a cornerstone of public health and socio-economic development. Contaminated water remains a global concern, contributing to waterborne diseases that affect millions each year. The **World Health Organization (WHO, 2017)** estimated that poor drinking water accounts for nearly half a million annual deaths from diarrheal disease. In India, although governmental initiatives such as the *Jal Jeevan Mission* have expanded safe water supply, rural populations often continue to depend on untreated sources like ponds, shallow wells, and hand pumps ([CGWB, 2020]).

In tropical monsoon regions, seasonal changes strongly influence water quality. Rainfall can dilute dissolved solids and recharge aquifers, but it can also mobilize sediments, nutrients, and organic matter into water bodies. Agricultural runoff, detergent use, and domestic wastewater frequently exacerbate contamination during the monsoon ([Ravikumar et al., 2013]; [Singh et al., 2020]).

Several studies across India confirm seasonal influences. **Jemi and Jacksin (2011)** found temple ponds in Tamil Nadu to have higher nutrient concentrations during monsoon, while **Tidame (2012)** reported seasonal variability in rural ponds of Maharashtra. **Soni and Bhatt (2008)** documented turbidity surges in Gujarat ponds linked to runoff. However, studies on seasonal water quality in South Bihar remain sparse, despite its reliance on groundwater and ponds for daily needs.

Hisua block of Nawada district represents a typical rural setting where surface ponds are multipurpose (bathing, washing, livestock) and often unprotected, while groundwater is accessed via traditional dug wells and hand pumps. The present study aimed to:

1) Evaluate seasonal variations in physico-chemical parameters of surface and groundwater sources in Hisua block.
2) Compare observed results with **BIS (2012)** and **WHO (2017)** standards.
3) Identify potential risks to community health and suggest management strategies.

2. Materials and Methods

2.1 Study Area

Hisua block lies in Nawada district, Bihar, spanning approximately 125 km². The region experiences a tropical monsoon climate, with annual rainfall averaging 1000–1200 mm, primarily during June–September. Agriculture is the principal livelihood, and water demand is met through ponds, shallow dug wells, and hand pumps.

2.2 Sampling

Five villages (Bagodar, Sonsa, Dona, Bhadseni, and Daulatpura) were selected, and three sources were sampled from each: ponds (P1–P5), dug wells (W1–W5), and hand pumps (H1–H5), totalling 15 sites. Samples were collected during pre-monsoon, monsoon, and post-monsoon seasons over two years (2021–2023).

Samples were collected in acid-washed polyethylene bottles, rinsed with source water before collection, and transported in insulated boxes at ~4 °C. Dissolved oxygen was fixed on-site using Winkler's reagents **as per APHA (1998)**.

2.3 Analytical Methods

Physico-chemical parameters were measured using standard protocols recommended by **APHA (1998)** and **IS:3025**

(1966). pH was measured with a digital pH meter; turbidity with a nephelometer; TDS gravimetrically by evaporation; alkalinity by acid titration; DO and BOD by Winkler's method; COD by dichromate reflux; nitrate by phenol-disulfonic acid method; phosphate by stannous chloride method; chloride by argentometric titration; and iron by 1,10-phenanthroline spectrophotometry.

2.4 Data Interpretation

Values were compared with permissible limits defined by **BIS:10500 (2012)** and **WHO (2017)**. Descriptive statistics and seasonal comparisons were carried out, and graphical representations were used to illustrate variations.

3. Results

3.1 pH

All samples showed neutral to slightly alkaline pH (7.0–7.8), well within BIS/WHO guidelines. Minor seasonal variations occurred, with lower values in ponds during the monsoon.

3.2 Turbidity

Ponds recorded high turbidity during monsoon (up to 134 NTU), far exceeding the BIS limit of 5 NTU. Wells and hand pumps remained within safe levels (<6 NTU). Seasonal surges in turbidity were linked to runoff and human activity, consistent with reports from Tamil Nadu and Gujarat ([Jemi & Jacksin, 2011]; [Soni & Bhatt, 2008]).

3.3 TDS

A clear dilution effect was observed during monsoon: ponds decreased from 500 mg/L (pre-monsoon) to 330 mg/L (monsoon), before rising again post-monsoon (520 mg/L). Wells and hand pumps followed similar trends. All values remained close to but generally below the BIS limit (500 mg/L).

3.4 DO

Ponds showed elevated DO during monsoon (up to 5.2 mg/L), while wells and hand pumps consistently remained below 2.5 mg/L, suggesting stagnation and microbial consumption of oxygen in groundwater.

3.5 Nutrients

Phosphate exceeded the WHO's indicative limit (0.5 mg/L) in ponds across all seasons, peaking at 0.65 mg/L. Nitrate remained within permissible limits (<50 mg/L), indicating low fertilizer leaching during the study.

3.6 Chloride and Iron

Chloride ranged from 220–260 mg/L, approaching the upper permissible limit (250 mg/L). Iron concentrations (0.1–0.3 mg/L) occasionally reached the BIS limit, particularly in post-monsoon groundwater.

3.7 BOD and COD

Ponds had higher BOD and COD values compared to groundwater, reflecting organic pollution. Peaks occurred during the monsoon, likely due to domestic discharges and agricultural runoff.

Table 1. Seasonal variation of physico-chemical parameters in surface and groundwater sources of Hisua block, Nawada, Bihar

Source	Season	pH	Turbidity (NTU)	TDS (mg/L)	DO (mg/L)	Phosphate (mg/L)	Chloride (mg/L)	Iron (mg/L)
Ponds	Pre-Monsoon	7.14	10	500	3	0.65	260	0.2
	Monsoon	7	134	330	5.2	0.58	250	0.3
	Post-Monsoon	7.18	50	520	3.5	0.62	240	0.3
Wells	Pre-Monsoon	7.12	1.2	480	2.5	0.29	240	0.1
	Monsoon	7.12	5.8	290	2	0.62	250	0.2
	Post-Monsoon	7.15	6.4	510	1.9	0.6	260	0.2
Hand Pumps	Pre-Monsoon	7.2	1.2	470	1.5	0.58	240	0.2
	Monsoon	7.22	4.8	485	2	0.58	250	0.2
	Post-Monsoon	7.25	5.4	495	1.5	0.6	250	0.2

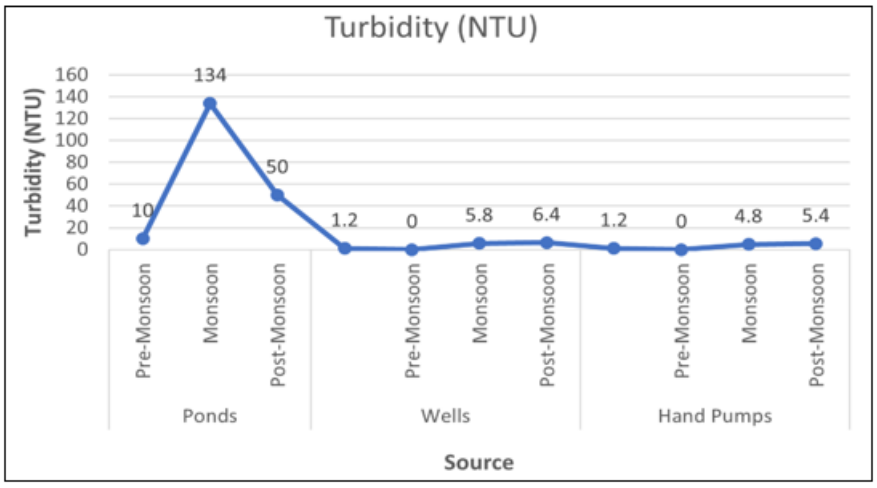

Figure 1: Graph showing seasonal variation in turbidity

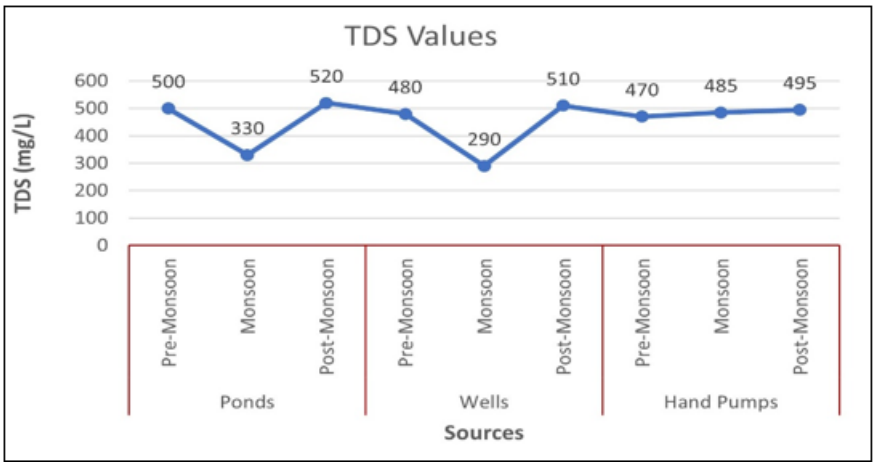

Figure 2: Graph showing seasonal variation in Total Dissolved Solids (TDS)

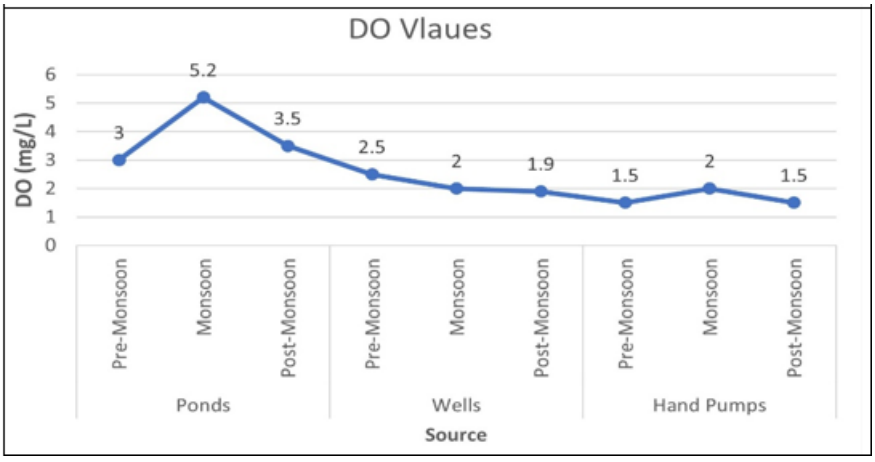

Figure 3: Graph showing seasonal variation in Dissolved Oxygen (DO)

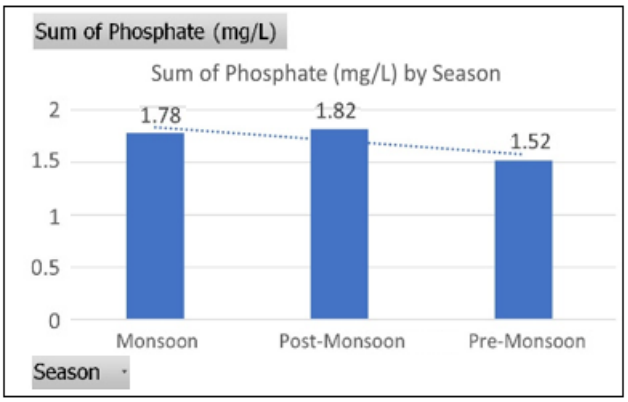

Figure 4: Graph showing seasonal variation in Phosphate

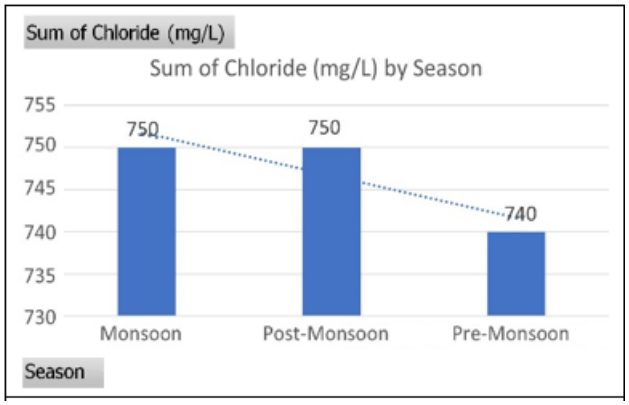

Figure 5: Graph showing seasonal variation in Chloride

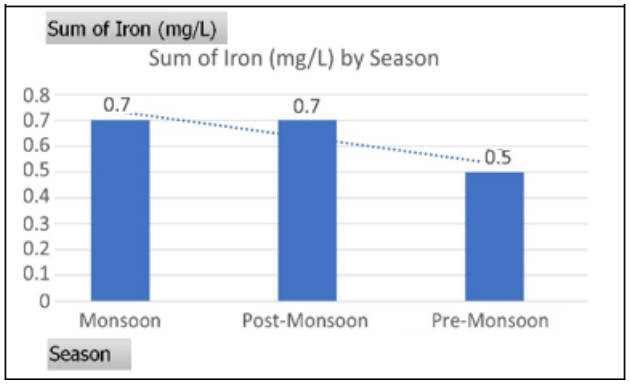

Figure 6: Graph showing seasonal variation in Iron

4. Discussion

The findings demonstrate that water quality in the Hisua block is strongly influenced by seasonal dynamics. Ponds were most affected, showing high turbidity, phosphate enrichment, and organic load during the monsoon. This pattern parallels other studies on rural ponds across India ([Tidame, 2012]; [Jemi & Jacksin, 2011]).

Groundwater sources were comparatively resilient but exhibited consistently low DO, indicating limited aeration and possible microbial contamination risks. Elevated iron in post-monsoon groundwater suggests geochemical leaching, a common issue in Bihar aquifers.

The dual role of monsoon is evident: while it dilutes TDS and replenishes aquifers, it also introduces pollutants into open water bodies. High turbidity and phosphate are of public health concern, as they may shield microorganisms from disinfection and promote eutrophication ([WHO, 2017]).

5. Conclusion

This study highlights the vulnerability of rural water sources in the Hisua block to seasonal changes:

- **Ponds** showed poor quality during the monsoon, exceeding turbidity and phosphate limits.
- **Groundwater** was relatively safer but impaired by low dissolved oxygen and occasional iron contamination.
- Seasonal rainfall acted as both a diluting and contaminating agent.

6. Recommendations

1) Restrict pond use to non-drinking purposes unless treated.
2) Promote household-level treatment (boiling, chlorination, filtration).
3) Implement seasonal monitoring by local health authorities.
4) Raise community awareness about water contamination risks.

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