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Original Research Paper

Chemistry

ASSESSMENT OF GROUNDWATER AND SURFACE WATER QUALITY IN PARTUR REGION, JALNA DISTRICT (MAHARASHTRA): A PHYSICO-CHEMICAL ANALYSIS

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ABSTRACT This research paper provides a quantitative assessment of the hydrochemical quality of surface and groundwater resources in the Partur region of Jalna district, Maharashtra, India. Water samples were systematically collected across 10 strategic sampling locations representing borewells, dug wells, and surface water bodies during pre-monsoon and post-monsoon periods. A total of nine physico-chemical parameters were analyzed, including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chlorides ($C1^{-}$), Nitrates (NO^{3-}) and Alkalinity. The results demonstrate that while pH levels remain mostly within permissive limits (6.8 to 8.2), parameters such as TDS, Total Hardness, and Nitrate concentrations exceed the desirable limits established by the Bureau of Indian Standards (BIS, IS 10500:2012) and World Health Organization (WHO) at multiple sites. Hydrochemical calculations confirm that intense agricultural activity, application of nitrogenous fertilizers, mineral dissolution, and rock-water interactions in the basaltic terrain of the Deccan Traps are the primary drivers of localized water degradation. Strategic monitoring and sustainable resource management are urgently required for the Partur sub-basin.

KEYWORDS : Total Hardness (TH), Calcium (Ca2+), Magnesium (Mg2+), Chlorides (C1-), Nitrates (NO3-) and Alkalinity, BIS, WHO

1 INTRODUCTION

Water is an essential natural resource required for human consumption, agricultural irrigation, and ecological balance. In the semi-arid Marathwada region of Maharashtra, ground and surface water resources face critical quality and quantity pressures due to erratic rainfall, recurring droughts, and intensive agricultural production (Barkved et al., 2014; Dandge & Patil, 2018). Jalna district, located in the Godavari River basin, relies heavily on subsurface aquifers situated within hard-rock basaltic formations (Deccan Traps) for domestic and agricultural needs (Deshpande et al., 2021).

The Partur region within the Jalna district represents an ecologically vulnerable agrarian belt where intensive cultivation, unchecked extraction of groundwater, and excessive application of chemical fertilizers pose risks of non-point source contamination (Aher, 2017). Dissolution of rocks, mineral leaching, and agricultural runoff frequently elevate levels of dissolved solids, total hardness, and nitrate in local aquifers (Singh et al., 2019). Despite growing concerns regarding water quality across the district, comprehensive localized studies focusing specifically on the Partur tehsil remain limited. This study aims to evaluate the essential physico-chemical parameters of water sources in the Partur region, calculate parameter variations, compare findings against national and global standards, and identify the primary natural and anthropogenic factors influencing water suitability.

2 MATERIAL AND METHODS

Study Area and Sampling: The study area is located in the Partur block of Jalna district, Maharashtra, falling within the semi-arid drought-prone zone of Marathwada. A total of 10 representative water sampling sites (S_1 to S_{10}) were designated across open dug wells, deep borewells, and surface water bodies in and around Partur. Samples were collected in pre-cleaned 1-liter high-density polyethylene (HDPE) bottles using standard procedures prescribed by APHA (American Public Health Association, 1998).

Sampling Code	Location / Source Type	Latitude / Longitude (Approx.)	Primary Water Use
S_1	Partur Town (Borewell)	19.58°N, 76.21°E	Drinking & Domestic
S_2	Ashti Village (Dug Well)	19.62°N, 76.15°E	Agriculture & Drinking
S_3	Babultora Road (Borewell)	19.55°N, 76.25°E	Domestic
S_4	Lower Dudhna Reservoir Feeder (Surface)	19.53°N, 76.18°E	Irrigation & Municipal
S_5	Watur Phata (Borewell)	19.65°N, 76.29°E	Domestic
S_6	Rewagaon (Dug Well)	19.50°N, 76.12°E	Agriculture
S_7	Satona Village (Borewell)	19.59°N, 76.32°E	Drinking
S_8	Shiradhon (Dug Well)	19.48°N, 76.22°E	Agriculture & Domestic
S_9	Partur Industrial Area Outskirt (Borewell)	19.57°N, 76.20°E	Commercial /Domestic
S_{10}	Selu Road Interface (Borewell)	19.60°N, 76.27°E	Drinking

Analytical Methods: Physico-chemical analysis was carried out using standard analytical methods (APHA, 1998; Biswas & Gahalod, 2025)

pH and Electrical Conductivity (EC): Measured *in situ* using calibrated digital pH meters and conductivity meters.

Total Dissolved Solids (TDS): Determined via gravimetric measurement (evaporation method) and verified using conductometry.

Total Hardness (TH), Calcium (Ca^{2+}), and Magnesium (Mg^{2+}): Analyzed by EDTA complexometric titrations.

Chlorides (Cl^{-}): Estimated using Argentometric titration (Mohr's method) with silver nitrate ($AgNO_3$).

Alkalinity: Analyzed via acid-base titration using standard H_2SO_4 with phenolphthalein and methyl orange indicators. 3-

Nitrates (No^{3-}): Determined using UV-Visible spectrophotometry.

3 Calculations:

1. Magnesium Concentration Calculation: Magnesium content is derived by subtracting Calcium hardness from Total Hardness (all values expressed in mg/Las $CaCO_3$):

$$Mg2+(mg/L) = \frac{(\text{Total Hardness as } CaCO_3 - \text{Calcium Hardness as } CaCO_3) \times 24.31}{100.09}$$

2. Sodium Adsorption Ratio (SAR) for Irrigation Suitability:

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

(where ionic concentrations are expressed in milliequivalents per liter, meq/L)

3. Water Quality Index (WQI) Sub-index Calculation: The sub-index (q_i) for each parameter is computed based on its ideal value (v_o) and BIS standard (S_i):

$$q_i = \left(\frac{v_i - v_o}{S_i - v_o}\right) \times 100$$

(where v_i is the measured experimental value, v_o= 7for pH and v_o= 0for other chemical parameters)

4 RESULTS AND DISCUSSION: The analytical values obtained across the 10 sampling sites in the Partur region are summarized below alongside the standard limits defined by BIS (IS 10500:2012) and WHO (2009).Table no-2 Showing the chemical parameter of water sample collected from various sampling location

Table No.2 Showing the Chemical Parameter of Water Sample Collected From Various Sampling Location

Parameter (mg/L)	BIS Desir-able	BIS Per-missible	Sample Mean ±SD	Sample Range (Min - Max)	Sites Exceeding Desirable Limit (%)
pH	6.5 – 8.5	No re-laxation	7.54 ± 0.42	6.85 – 8.20	0%
EC (S/cm)	750	2250	1120 ± 340	640 – 1850	70%
TDS	500	2000	745 ± 215	410 – 1220	80%
Total Hardness	200	600	385 ± 110	180 – 560	90%
Calcium	75	200	88 ± 28	42 – 145	60%
Mag-nesium	30	100	41 ± 14	18 – 68	70%
Chlorides	250	1000	195 ± 65	85 – 340	20%
Nitrate ($No-_3$)	45	No re-laxation	58 ± 22	22 – 98	60%
Total Alkalinity	200	600	245 ± 55	150 – 350	70%

Parameter (mg/L)	BIS Desir-able Limit	BIS Per-missible Limit	Sample Mean ± SD	Sample Range (Min – Max)	% Exceeding Desirable Limit
Sulphates ($SO2-_4$)	200	400	142 ± 48	65 – 280	10%
Fluoride ($F-$)	1.0	1.5	1.15 ± 0.38	0.50 – 1.85	40%
Sodium ($Na+$) (	—	200	118 ± 38	52 – 195	0% (vs. Permissible)
Potassium ($K+$)	—	12	14.2 ± 6.5	3.5 – 28.0	50% (vs. Typical standard)
Iron ($Fe2+/Fe3+$)	0.3	No re-laxation	0.48 ± 0.22	0.12 – 0.92	60%
Sodium Adsorption Ratio (SAR)	10 (Excel lent)	18 (Good)	2.85 ± 0.88	1.25 – 4.40	0% (Suitable for Irrigation)

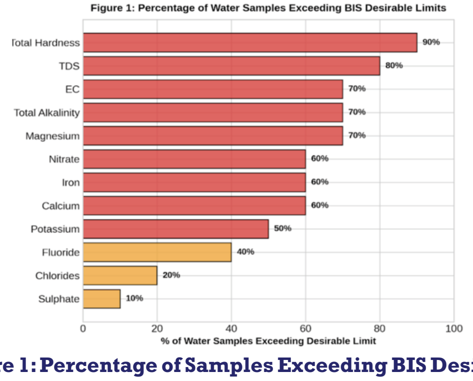

Figure 1: Percentage of Samples Exceeding BIS Desirable Limits: Percentage of Water Samples Exceeding Limit (0--100%). Highlights the severity of contamination at a glance. It clearly shows that Total Hardness (90%) and TDS (80%) are the most widespread issues in Partur.

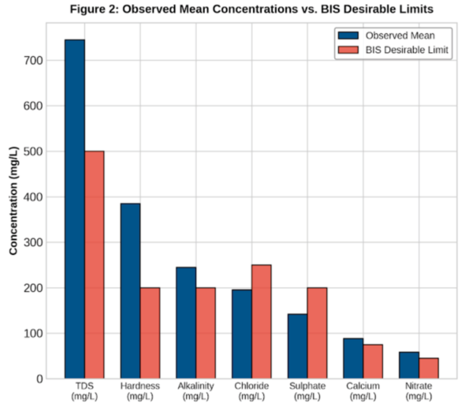

Figure 2: Observed Mean Concentrations vs. BIS Desirable Thresholds: Provides a direct side-by-side comparison between the experimental mean values and the Indian standard safe thresholds (BIS IS 10500:2012).

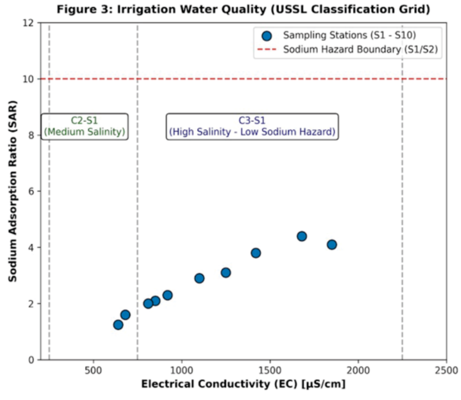

Figure 3: US Salinity Laboratory (USSL) Diagram for Irrigation Suitability: Electrical Conductivity (EC in μ S/cm): Classifies groundwater for agricultural use. Plotting the 10 stations demonstrates that most samples fall under the C3-S1 category (High Salinity Hazard with Low Sodium Hazard).

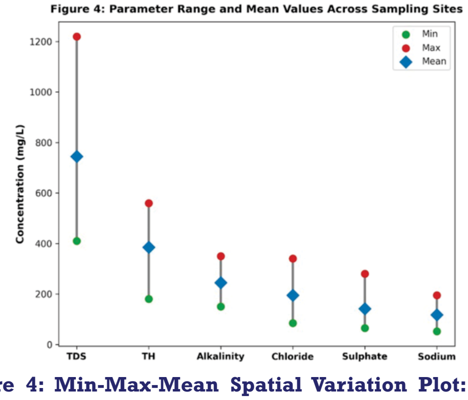

Figure 4: Min-Max-Mean Spatial Variation Plot: Parameters (TDS, TH, Alkalinity, Chloride, Sulphate, Sodium): Showing the range of dispersion across all sampling stations (S_1--S_{10}), demonstrating spatial variability caused by local basaltic rock weathering and agricultural activities.

DISCUSSION

pH and EC: The pH values in Partur range from 6.85 to 8.20, indicating slightly alkaline conditions well within safe limits. Electrical Conductivity (EC) averaged 1120 μS/cm, reflecting substantial ion concentrations released through weathering of minerals in Deccan basalts (Deshpande et al., 2021).

Total Dissolved Solids (TDS) and Hardness: 80% of samples exceeded the desirable BIS threshold of 500 mg/Lfor TDS.Total Hardness values ranged up to 560 mg/L, classifying the majority of groundwater sources as "hard" to "very hard" water. This is attributable to dissolution of calcium and magnesium carbonate minerals during rock-water interaction (Ramakrishnaiah et al., 2009; Biswas & Gahalod, 2025).

Nitrate Contamination: Nitrate concentration exceeded the mandatory safety threshold of 45 mg/Lin 60% of sampled locations, reaching a maximum of 98 mg/Lin rural open wells (S_2, S_6). Elevated nitrate levels are primarily linked to agricultural non-point source pollution, return flow of irrigation water, and extensive use of synthetic nitrogenous fertilizers across the Partur agrarian belt (Aher, 2017; Dandge & Patil, 2021).

Sulphate (So^{2-}_4): Sulphate levels across the Partur sampling points averaged 142 mg/L, with only one sampling point (S_9, near the industrial outskirt) exceeding the desirable threshold of 200 mg/L at 280 mg/L. The primary natural source of sulphate in the region stems from the dissolution of gypsum and weatherable sulfur-bearing minerals within the weathered basaltic regolith. Higher localized concentrations are linked to agricultural run-off containing synthetic superphosphate fertilizers and local agro-industrial discharges. Sulphate concentrations below 250 mg/L do not pose health hazards, though higher levels can cause a bitter taste and laxative effects in sensitive populations.

Fluoride (F^-): Fluoride values ranged between 0.50 mg/L and 1.85 mg/L, with 40% of the sites exceeding the desirable limit of 1.0 mg/L. Geological formations in the Deccan Traps contain fluoride-bearing minerals such as fluorapatite, biotite, and amphiboles. Under alkaline ground conditions (pH 7.5--8.2), anion exchange between hydroxyl ions (OH^-) and fluoride ions (F^-) in clay minerals facilitates fluoride leaching into groundwater aquifers. Ingestion of water exceeding 1.5 mg/L over long periods presents risks of dental fluorosis and early-stage skeletal fluorosis among rural communities in Partur.

Cation Interrelationships (Na^+ and K^+): Sodium concentrations (52--195 mg/L) remain within the upper permissible safety boundary of 200 mg/L. Sodium enters the system through feldspar weathering in silicate rocks and plagioclase dissolution. Potassium levels (3.5--28.0 mg/L) showed moderate elevation in agricultural dug wells (S_2, S_6, S_8), exceeding typical natural background levels (< 10 mg/L). This elevation directly reflects the intensive application of potash (K_2O) fertilizers in cotton, soybean, and sugarcane cultivation across the Partur agrarian sector.

Iron (Fe^{2+}/Fe^{3+}): Iron content in 60% of deep borewell samples exceeded the BIS prescribed maximum desirable limit of 0.3 mg/L, peaking at 0.92 mg/L. Basaltic rocks are naturally rich in ferro-magnesian minerals (pyroxenes, olivines, and magnetite). Under reducing (anoxic) conditions deeper in deep borewell aquifers, insoluble ferric iron (Fe^{3+}) dissolves into soluble ferrous iron (Fe^{2+}). High iron levels lead to turbidity, reddish-brown staining, brackish taste, and encrustation in water distribution pipes.

Sodium Adsorption Ratio (SAR) & Agricultural Suitability: The computed SAR values ranged from 1.25 to 4.40, well below the critical threshold of 10.0. Low SAR combined with moderate-to-high Electrical Conductivity indicates that groundwater in Partur falls primarily under the C3-S1 (High Salinity - Low Sodium) category according to the US Salinity Laboratory classification. While the low sodium hazard prevents soil structure degradation (alkalization), the high salinity hazard requires proper drainage management and periodic leaching to prevent soil salt accumulation during crop irrigation.

CONCLUSION

The comprehensive hydrochemical and physico-chemical evaluation of surface and groundwater in the Partur region (Jalna District, Maharashtra) demonstrates significant spatial variations driven by both natural geogenic and anthropogenic mechanisms. The pH remains within permissible drinking thresholds (6.85–8.20), a major proportion of sampled sites exceed the desirable limits. The Total Dissolved Solids (80%), Total Hardness (90%), Nitrate (60%), and Iron (60%). Elevated nitrate levels (up to 98 mg/L) and potassium levels directly reflect agricultural runoff, return flow, and non-point source contamination from heavy synthetic fertilizer application in the agricultural belt. Fluoride concentrations exceeded 1.0 mg/L across 40% of locations due to water-rock interaction, mineral dissolution, and base-exchange reactions within the basaltic Deccan Traps. Long-term consumption of untreated groundwater in these specific zones poses potential dental and skeletal health risks to local rural populations. Based on the Sodium Adsorption Ratio (SAR = 1.25--4.40), groundwater across Partur is classified as low sodium hazard (S1), rendering it safe regarding soil permeability and structure. However, elevated Electrical Conductivity places the water under a high salinity hazard (C3), necessitating effective soil drainage management and salt leaching practices to ensure long-term crop productivity.Recommendations

To mitigate further water quality degradation in Partur sub-basin, immediate measures should be community-level defluoridation and iron-removal filtration systems for affected borewells. Promotion of Precision Agricultural Practices to regulate nitrogenous and potassic fertilizer usage. Rainwater harvesting and artificial recharge structures to dilute heavy dissolved solid and hardness concentrations in hard-rock aquifers.

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