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Impact of Monsoon Recharge on Groundwater Hydrochemistry at Siddhpur in Patan District

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Abstract: Groundwater is the principal source of drinking and irrigation water in Siddhpur town and surrounding villages of Patan district, Gujarat. Seasonal monsoon recharge plays a crucial role in modifying groundwater levels and hydrochemical characteristics in this semi-arid region. The present study evaluates the impact of monsoon recharge on groundwater hydrochemistry at Siddhpur during 2023–2025 through systematic sampling before and after the southwest monsoon. Physicochemical parameters, major ions, and hydrochemical facies were analyzed to understand recharge processes, geochemical evolution, and suitability of groundwater for drinking and irrigation. Results indicate dilution effects during post-monsoon periods, improvement in water quality in most locations, and localized enrichment of dissolved salts and nitrate in areas influenced by anthropogenic activities. The study highlights the significance of monsoon-driven recharge in sustaining groundwater quality and provides recommendations for groundwater management and protection.

Keywords: *Groundwater Hydrochemistry, Monsoon Recharge, Siddhpur, Patan District, Gujarat, Water Quality, Major Ions.*

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I. INTRODUCTION

Groundwater resources in semi-arid regions of India are highly dependent on monsoon rainfall for recharge. In north Gujarat, including Patan district, groundwater constitutes the primary source of potable and irrigation water due to limited perennial surface water bodies. Siddhpur, a historic town with growing urbanization and intensive agriculture in its surroundings, has experienced increasing stress on groundwater resources in recent decades. Thorium (IV) in in 6-, 8- or 10-coordination number are known in the present work we wish to report the synthesis and characterization of a series of complexes of these metals with a schiff base ligand (L) which is derived from the condensation of p-ethyl amino benzoate aniline and o-methyl p-(N,N'-dicyanoethyl) amino benzaldehyde (Sharma, N.K., 2024). Lanthanides and actinides ion generally present a high coordination number and the type of polyhedron obtained influences the nature of the coordinating ligands (Sharma, N.K., 2025). Many Indian States have limited resources and lack their own disaster management plans (Sharma, N.K., 2025). Schiff bases formed by different aldehydes are in wide use for the synthetic purpose in organic synthesis and in coordination chemistry of metal complexes (Sharma, N.K., 2024). The respective metal salt solutions were

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treated with ligands solution in the required molar concentrations (Sharma, N.K., 2024).The NEP 2020 recognizes the importance of technology and innovation in science education and seeks to promote the integration of these elements into the curriculum (Sharma, N.K., 2023). Mass spectral studies of schiff based ligands chosen and prepared four complex formation and peaks show in their mass spectra (Sharma and Banshal, 2023).The discs were removed with the help of flamed forceps from their respective vials and placed in the plates 15 mm away from the edge, at equal distance and sufficiently separated from each other to avoid overlapping of zone of inhibition, finally pressed them lightly with forceps to make complete contact with surface of medium (Sharma, et. al. 2023). The solutions of complexes were prepared in DMF with varied concentrations Aspergillus fumigates, Candida albicans using paper disc technique in PDA medium (Sharma and Singh, 2022). The NEP 2020 emphasizes a multidisciplinary and integrated approach to science education (Sharma, N.K., 2022). These hazards threaten millions of lives and cause large scale financial, infrastructure, agriculture and productivity losses that seriously hinder India's overall development (Sharma and Banshal, 2023). Nutrient agar was poured into plates, keeping depth of the medium 4.0mm (Sharma and Banshal, 2023). The some of the new complexes were screened for antifungal activity against A.niger, (Sharma, N.K., 2022). The solutions of complexes were prepared in DMF with varied concentrations Aspergillus fumigates, Candida albicans using paper disc technique in PDA medium (Sharma and Dikshit, 2017).Freeman-Carroll (F.C.), Coats-Redfern (C.R.) and Horowitz-Metzger (H.M.), methods were used to evaluate different kinetics parameters from the TGA curves (Sharma and Dwivedi, 2016). The rate of loss of mass vs temperature (DTG) plots were used as TGA curves. The decomposition data for the complexes are in corporate (Sharma, et.al, 2016). Thorium (IV) and Uranium (VI) belong to the actinide series. In comparison to Lanthanides in which the 4f orbitals are not accessible for bonding, the 5f of actinides, extend spatially into the outer valence region of the atom (Sharma and Dikshit, 2015). Thorium (IV) in in 6-, 8- or 10- coordination number are known in the present work we wish to report the synthesis and characterization of a series of complexes of these metals with a schiff base ligand (L) (Sharma and Dikshit, 2015). Thorium (IV) and Uranium (VI) belong to the actinide series. In comparison to Lanthanides in which the 4f orbitals are not accessible for bonding, the 5f of actinides, extend spatially into the outer valence region of the atom (Sharma and Dikshit, 2015). The results set a scientific foundation for sustainable groundwater monitoring and management while supporting rural water safety planning, policy creation (Patel, et. al., 2025). The study demonstrates that combined application of nitrogen and phosphorous significantly improves plant growth and yield attributes compare to unfertilized control (Patel, et. al., 2025a). To identify spatial trends and regions with physicochemical or microbial contamination posing health risks (Ranpura, et. al., 2025b). Groundwater is a key source of potable water in arid and semiarid regions, with over 60 % of India population relying on it for domestic and agriculture use (Ranpura, et. al., 2025c).

Monsoon recharge not only replenishes groundwater levels but also alters groundwater chemistry through dilution, water–rock interaction, and mobilization of surface-derived solutes. Understanding seasonal hydrochemical variations is essential for evaluating water suitability, identifying contamination sources, and planning sustainable groundwater management. This study investigates changes in groundwater hydrochemistry associated with monsoon recharge at Siddhpur during the period 2023–2025.

➢ *Objectives*

- To assess pre- and post-monsoon variations in groundwater physicochemical parameters.
- To evaluate changes in major ion chemistry and hydrochemical facies due to monsoon recharge.
- To examine groundwater suitability for drinking and irrigation across seasons.
- To identify natural and anthropogenic factors influencing groundwater quality.

II. STUDY AREA

Siddhpur is located in Patan district of northern Gujarat and lies within a semi-arid climatic zone. The region experiences hot summers, mild winters, and receives the majority of its annual rainfall (approximately 600–700 mm) during the southwest monsoon (June–September). Geologically, the area is characterized by Quaternary alluvial deposits comprising sand, silt, clay, and kankar (calcareous nodules). Groundwater occurs under unconfined to semi-confined conditions and is tapped through dug wells, tube wells, and hand pumps.

Land use in and around Siddhpur includes urban settlements, agricultural fields, religious tourism infrastructure, and localized waste disposal sites. These activities influence groundwater recharge quality and hydrochemistry, particularly during monsoon infiltration.

III. MATERIALS AND METHODS

➢ *Sampling Strategy*

Groundwater samples were collected from 25 representative locations, including dug wells, bore wells, hand pumps, and municipal supply sources within Siddhpur town and nearby villages. Sampling was carried out twice annually—pre-monsoon (May–June) and post-monsoon (October–November)—from 2023 to 2025, yielding a total of 150 samples.

Sampling locations were selected to represent different land-use settings such as residential areas, agricultural zones, market areas, and low-lying recharge-prone locations. Samples

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were collected in clean polyethylene bottles following standard protocols.

➢ *Analytical Methods*

Physicochemical and hydrochemical parameters were analyzed using standard procedures (APHA methods):

- pH, electrical conductivity (EC), and total dissolved solids (TDS): Measured using portable meters.
- Total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}): Titrimetric methods.
- Major cations (Na^{+}, K^{+}): Flame photometry.
- Major anions (HCO_3^{-}, Cl^{-}, SO_4^{2-}, NO_3^{-}): Titrimetric, spectrophotometric, and ion chromatography methods.
- Quality control: Ionic balance error was maintained within ±5% for analytical reliability.

➢ *Hydrochemical Analysis*

Hydrochemical facies were identified using Piper trilinear diagrams. Gibbs diagrams were employed to infer the mechanisms controlling groundwater chemistry (precipitation dominance, rock–water interaction, evaporation). Seasonal variations were statistically evaluated using paired comparisons between pre- and post-monsoon datasets.

IV. RESULTS

➢ *Seasonal Variation in Physicochemical Parameters*

Pre-monsoon groundwater samples exhibited higher EC and TDS values, indicating concentration of dissolved salts due to evaporation and limited recharge. Post-monsoon samples generally showed reduced EC and TDS, reflecting dilution from monsoon recharge. Groundwater pH remained neutral to slightly alkaline throughout the study period.

➢ *Major Ion Chemistry*

Calcium and magnesium dominated among cations, while bicarbonate and chloride were the principal anions. Post-monsoon samples displayed increased bicarbonate concentrations, suggesting enhanced carbonate dissolution during recharge. Sodium and chloride concentrations decreased in most locations after monsoon, although localized increases were observed near urban drains and agricultural fields.

➢ *Hydrochemical Facies*

Piper diagram analysis revealed predominantly Ca–Mg–HCO_3 and mixed Ca–Mg–Cl facies. A seasonal shift toward bicarbonate-dominated facies was observed in post-monsoon samples, indicating fresh recharge influence. Some samples retained chloride-rich character, reflecting longer residence time or anthropogenic inputs.

➢ *Drinking and Irrigation Suitability*

Comparison with drinking water standards showed that most post-monsoon samples met permissible limits for major parameters, while pre-monsoon samples occasionally exceeded limits for TDS, hardness, and nitrate. Irrigation indices such as Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) generally improved after monsoon recharge, enhancing water suitability for agriculture.

V. DISCUSSION

➢ *Influence of Monsoon Recharge*

Monsoon recharge exerts a clear diluting effect on groundwater chemistry at Siddhpur, reducing salinity and hardness in most wells. Recharge water promotes carbonate weathering and flushing of shallow aquifers, leading to seasonal improvement in water quality.

➢ *Anthropogenic Influences*

Localized nitrate enrichment in post-monsoon groundwater suggests leaching of fertilizers and sewage-derived contaminants during rainfall infiltration. Urban runoff and improper waste disposal contribute to spatial heterogeneity in hydrochemical responses to recharge.

➢ *Comparison with Regional Studies*

The observed hydrochemical trends are consistent with studies from other parts of north Gujarat, where monsoon recharge temporarily improves groundwater quality but long-term sustainability depends on controlled abstraction and pollution prevention.

VI. CONCLUSIONS

- Groundwater hydrochemistry at Siddhpur shows distinct seasonal variation influenced by monsoon recharge.
- Post-monsoon groundwater generally exhibits lower salinity, hardness, and improved suitability for drinking and irrigation.
- Hydrochemical facies shift toward Ca–Mg–HCO_3 type after monsoon, indicating fresh recharge contribution.
- Anthropogenic activities lead to localized deterioration, particularly with respect to nitrate contamination.

VII. RECOMMENDATIONS

- Promote rainwater harvesting and managed aquifer recharge to enhance dilution and sustainability.
- Monitor nitrate and chloride in urban and agricultural zones regularly.
- Regulate groundwater abstraction during pre-monsoon months to prevent quality deterioration.
- Improve sanitation and fertilizer management to reduce contaminant leaching during monsoon.

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VIII. LIMITATIONS AND FUTURE WORK

The study focuses on major ion chemistry; future research should include isotopic tracers, trace elements, and microbial indicators to better quantify recharge sources and residence times.

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REFERENCES

[1]. Patel, B., Ranpura, D., Sharma, N.K. and Soni, J.Y. (2025). Assessment of Drinking Water Quality in Palanpur Division, JCHR(2025) 15:(5),542-550.
[2]. Patel, B., Ranpura, D., Sharma, N.K. and Soni, J.Y. (2025a). Effect of Nitrogen and Phosphorus Levels on Soil, water Quality and Crop Yield in Different Villages of Palanpur Taluka, International Journal of Environmental Science vol. 11, No. 23, page 7038-7044 (2025).
[3]. Ranpura, D., Patel, B., Sharma, N.K. and Soni, J.Y. (2025b). Chemical and Microbial Insights:Banaskantha Water Study. Journal of Chemical Health Risks (2025) 15(4), 2911-2919.
[4]. Ranpura, D., Patel, B., Sharma, N.K. and Soni, J.Y. (2025c). Groundwater Quality Assessment in Selected Taluka of Banaskantha District, Gujarat:A Physicochemical and Microbiological Investigation, International Journal of Environmental Science vol. 11, No. 23, page 7054-7061 (2025).
[5]. Sharma, N.K. and Dikshit, S.N. (2015). Synthesis, Structure and Spectral Studies of Some Thorium (Iv) and Dioxouranium (Vi) Complexes with Nitrogen Donor Ligand, NSS J., 2, 25 (2015).
[6]. Sharma, N.K. and Dikshit, S.N. (2015). Synthesis, Structure and Spectral Studies of Some Thorium (Iv) and Dioxouranium (Vi) Complexes with Nitrogen Donor Ligand. (PART-2), NSS J., 1,12 (2015).
[7]. Sharma, N.K. and Dikshit, S.N. (2015). Electronic Spectral and Structural Studies of Some Thorium (Iv) and Dioxouranium (Vi) Complexes with Nitrogen Donor Ligand, DSS J., 1,15, 2015.
[8]. Sharma, N.K., Gupta, M. and Dwivedi, V. (2016). Thermo Gravimetric Analysis of Th (IV) Complexes with some Nitrogen Donor Ligands International Journal of Scientific Research and Growth Volume-1 Issue-4 125-133 October 2016.
[9]. Sharma, N.K. and Dwivedi, V. (2016). Thermal Studies Of Uo_2 (Vi) Complexes With Some Nitrogen Donor Ligands, IJSRG Volume-1 Issue-4, 134-137, October 2016
[10]. Sharma, N.K. and Dikshit, S.N. (2017). Synthesis, Spectral And Antimicrovial Studies of Some Thorium (IV) and Dioxouranium (VI) Complexes with Nitrogen Donor Ligand, IJSRG volume 2 , issue 1 April 2017
[11]. Sharma, N.K. (2022). Antimicrobial Studies of some new actinide metal complexes with some nitrogen donor ligands, IJSRG Vol. 7, 2, 34-41 (2022).
[12]. Sharma, N.K. and Bansal, A.K. (2023). Antimicrobial Studies of some new actinide metal complexes with some nitrogen donor ligands, The Journal of Oriental Research Madras Vol.XCIV – IV, 90-103 (2023).
[13]. Sharma, N.K. and Bansal, A.K. (2023). Analysis of Water Quality Parameters of Man Sagar Lake Jaipur, Kanpur Philosopher Vol X, Issue V, 83-88, May (2023)
[14]. Sharma, N.K. (2022). NEP 2020: Features, Importance in Educational and Role of Teacher, Techno Learn: An International Journal of Educational Technology, Volume 12, No. (02) : 237-246. December (2022)
[15]. Sharma, N.K. and Singh, N.K. (2022). Antimicrovial studies of some Thorium (IV) and Dioxouranium (VI) Complexes with nitrogen donor ligand, IJSRG, Volume-7 Issue-1, 18-27, April-2022
[16]. Sharma, N.K., Dwivedi, V., Solanki, P., and Bhardwaj, M. (2023). E. Coli, Pseudomonas Species, Aspergillus niger, Candida species, and spectral studies of Th (NO3) Complex With 4CABPT Ligand, Journal for Re-Attach Therapy and Developmental Diversities, 06 (06): 895-900, September 2023.
[17]. Sharma, N.K. and Bansal, A.K. (2023). 4-NN-BIS-2'-Cyanoethyl Amino Benzaldehyde and 2-Methyl-4-NN-BIS-2'- Cyanoethyl Amino Benzaldehyde And Aniline, Journal of survey in Fisheries Science 10(1)1474-1476 (2023)
[18]. Sharma, N.K. (2023). A Study of NEP-2020 in Higher Education, TechnoLEARN: an International Journal of educational Technology, 13(02): 75-80, December 2023 DOI: 10.30954/2231-4105.02.2023.2
[19]. Sharma, N.K. (2024). Synthesis and Characterization of Thorium(IV) and Dioxouranium (VI) Complexes with Schiff base Ligands, Recent Trends and Development in Research, ISBN- 978-81-967940-0-2, 2024, https://doi.org/10.62823/EXRE/2024/01/01.3
[20]. Sharma, N.K. (2024). Thermal study of new synthesized complexes with schiff base ligand, Emerging Trends in Chemical Environment Science for Sustainable Development, ISBN- 978-81-958915-9-7, https//www.insprajournals.com 2024

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan793

[21]. Sharma, N.K. (2024). Disaster management in india and covid 19, The new Education Policy, April 2025, pg no.142-146, ISBN- 978-93-6717-938-3.
[22]. Sharma, N.K. (2024). AM1 and PM3 computed heat of formations122 (Kcal/mol) total energy electronics energies, core-core repulsion energies and L.P.'s for schiff base ligand", The new Education Policy, Publisher- Geh press, ISBN- 978-93-6717-938-3, Page no.119-122
[23]. Sharma, N.K. (2024). Synthesized complexes with Schiff base ligands and their semi empirical study, Futuristic Trends in Chemical and Material Science, ISBN- 978-81-19545-59-9, Page no.29-39, July 2024, www.bmppublisher.com