Ground Water Monitoring Of East Haryana Cities

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Abstract

The National Capital Region (NCR), including East Haryana, is facing a critical water crisis due to rapid urbanization, industrial growth, and over-extraction of groundwater. This study investigates the status of groundwater quality and dynamics in East Haryana cities—specifically Faridabad, Palwal, and Mewat—within the NCR. Through a comprehensive review of literature, site-specific monitoring, and data analysis, the research examines the impact of land use changes, pollution, and climatic variations on groundwater levels and quality. The study focuses on key water quality parameters such as Total Dissolved Solids, hardness, pH, and contaminants like nitrates and heavy metals. The findings emphasize the urgent need for real-time monitoring, sustainable water management practices, and policy integration for long-term water security in the region.

Keywords: Groundwater Monitoring, Delhi NCR, East Haryana, Water Quality, Groundwater Depletion

Introduction

The National Capital Region (NCR) of Delhi is facing an escalating crisis surrounding its groundwater resources, driven by rapid urbanization, population growth, and industrial expansion. As one of India's most densely populated regions, NCR is home to millions who rely heavily on groundwater for drinking, irrigation, and industrial purposes. However, groundwater levels have been declining at an alarming rate due to unsustainable extraction, making it increasingly difficult for residents and industries to access clean, reliable water sources. The region's rapid urban sprawl has led to extensive land use changes, including the replacement of natural recharge zones with impervious surfaces, which drastically reduces the natural infiltration of rainwater into the aquifers. The heavy reliance on borewells in residential, agricultural, and commercial sectors has further exacerbated the problem, with wells being drilled to greater depths in pursuit of dwindling groundwater reserves.

This situation has been compounded by climate change, which affects rainfall patterns and thereby impacts groundwater recharge cycles, making water management even more challenging. Groundwater contamination poses an additional layer of complexity to the region's water crisis. Industrial effluents, untreated sewage, and agricultural chemicals often seep into aquifers, especially in peri-urban areas, leading to elevated levels of toxic contaminants such as heavy metals, nitrates, and pathogens in groundwater. This contamination not only jeopardizes the health of millions but also threatens the ecological balance of the region's riverine and wetland systems, which are dependent on groundwater inflows. The increasing salinity of groundwater, particularly in regions with high agricultural activity, is also a concern, as it diminishes soil productivity and disrupts local agriculture. Furthermore, the depletion and degradation of groundwater resources in NCR Delhi have socio-economic implications. Water scarcity and contamination are closely linked to health issues, reduced agricultural productivity, and economic losses in water-dependent industries, which ultimately impact the livelihoods of many residents.

Literature Survey

Tamrakar and Sharma (2024) reviewed the geospatial techniques used for Land Use Land Cover change detection for the Delhi NCR region over the past two decades. The study draws on a wide range of literature to examine the regional and temporal differences in land use, as well as the various approaches employed. The present study of Tanwar et al. (2023) envisions the influences of land use dynamics on the spatial trend of groundwater depth levels over a period of two decades in the south region of NCT Delhi, India. Gupta et al. (2023) indicates that evaporation is the predominant factor affecting the chemistry of groundwater. The stable isotope shows that the groundwater in the quartzite is mostly meteoric in origin and acting as a recharge area for the nearby alluvium aquifer. Garg et al. (2022) investigated the effects of plummeting groundwater levels on land surface elevations in Delhi NCR using Sentinel-1 datasets acquired during the years 2014–2020. Vaid et al. (2022) stated that out of the eight selected secondary drains for this study, the Goyla dairy outlet came out as the most polluted site in terms of organic pollutants while the Basaidarapur drain was loaded with heavy metal contaminants. Singh (2020) emphasizes the need for clarification of the roles and responsibilities of the government, civil society and private sector. Delhi has complex governance structure due to the simultaneous presence of the Union as well as state government agencies. Kumar et al. (2018) stated that water scarcity in National Capital Region (NCR), Delhi, has gradually become one of the most crucial issues for its citizens in the last few decades. The rapid decline in groundwater level due to heavy abstraction, change in land use pattern, and climate can be seen throughout the NCR. Delhi, the capital city of India, is the third largest city in the country by area and the second largest by population. It supports a population of over 16.7 million (Census of India, 2011). Pandey et al. (2017) describes the process of urbanization and land use changes in the urban ecosystems of the National Capital Territory (NCT) of Delhi and analyzes its impact on Ecosystem Services (ES).

Research Methodology

Delhi, the capital city of India, is the third largest city in the country by area and the second largest by population. It supports a population of over 16.7 million (Census of India, 2011). The city has a long history of political dominance by various dynasties. For a long time, its relevance as the political center of India led to the migration of different communities from all over the country, shaping its cultural heritage. The Delhi region is part of the Indo-Gangetic alluvial plains with the Yamuna River flowing eastward through it.

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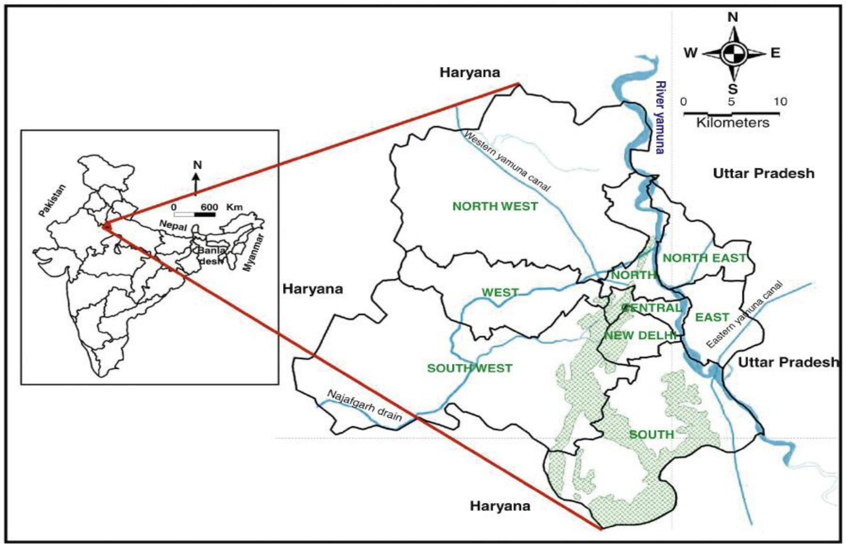

Fig. 1: Location of Delhi City and its Adjoining Areas

Physiography and Climate

The NCT of Delhi is located between 28°249170 N to 28°539000 N and 77°509240 E to 77°209370 E. It encompasses nine revenue districts, and shares boundaries with two neighboring states: Haryana to the north, west, and south; and Uttar Pradesh to the east. Delhi City covers an area of 1483 km^2. The climate of the city is humid subtropical to semiarid with generally dry winters extending from November to January (DES, 2014). The hot and humid summer period from April to July is followed by the monsoon season in July and August, characterized by heavy rainfall with winds blowing from the Arabian Sea. The average temperature of the city varies from 25°C to 45°C from April to July and drops from 22°C to 5°C in December and January (DES, 2014).

Morphology and Geology

The stratigraphic succession of the Delhi region shows that the major rock type occupying the region consists of quartzite, interbedded with minor schists that belong to the Delhi Supergroup. These quartzites are gray to brownish-gray in color with thin to massively thick bedding, doubly plunging toward northeast and southwest as “a coaxially refolded regional anticline” (CGWB, 2006a). Post-Delhi intrusion of quartz veins has been reported in a few places in these rocks (Thussu, 2006). These Proterozoic quartzites act as the basement for the Delhi region (Chatterjee et al., 2009).

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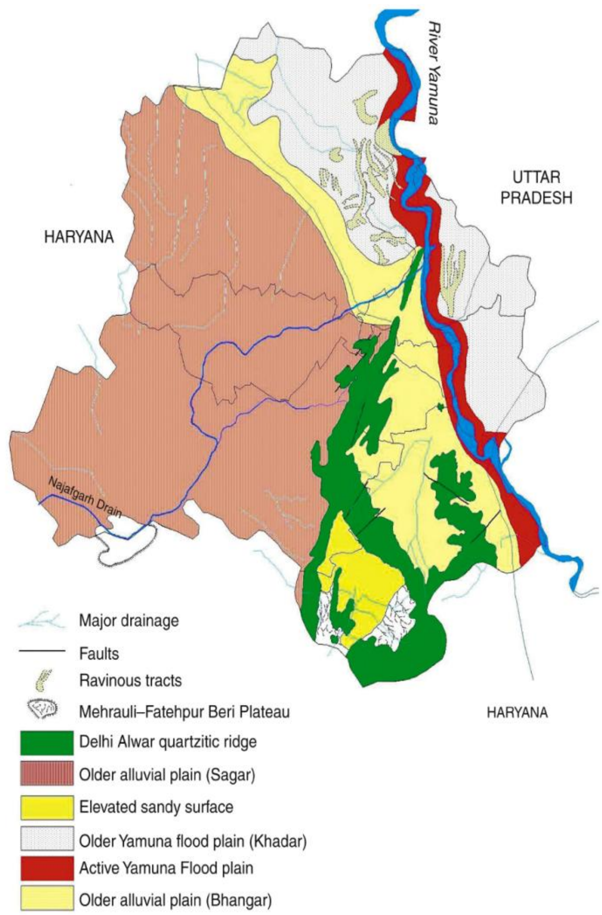

Fig. 2: Geological Map of Delhi. Adapted from Chatterjee et al. (2009)

Groundwater Monitoring

Groundwater monitoring is a critical process for assessing the quality, quantity, and sustainability of underground water resources, which are essential for both human use and ecological balance. Groundwater constitutes a significant portion of the Earth's freshwater reserves, providing about 30% of global freshwater needs and serving as a vital source of drinking water, irrigation, and industrial activities, especially in regions with limited surface water resources. The importance of groundwater monitoring has grown exponentially due to the increasing pressures of rapid urbanization, industrialization, and agricultural expansion, which have led to groundwater depletion, pollution, and significant changes in aquifer levels worldwide. Regular monitoring helps identify trends in groundwater levels, detect contamination, assess recharge rates, and predict future water availability. Furthermore, it is essential for understanding the impacts of climate change on water resources, as variations in rainfall, temperature, and extreme weather events directly influence groundwater recharge and extraction patterns.

Protocol used for Test results				
S. No.	**Tested Parameter**	**Requirement** (Acceptable Limit)	**Permissible Limit** (In the Absence of Alternate Source)	**Protocol Used**
1	Total Dissolved Solids @ 180°c ± 2°c	500 mg/lt.	2000 mg/lt.	**APHA 24^{th} Edition**
2	Total Hardness as $CaCO_3$	200 mg/lt.	600 mg/lt.	
3	Calcium as Ca	75 mg/lt.	200 mg/lt.	
4	Magnesium as Mg	30 mg/lt.	100 mg/lt.	
5	Iron as Fe	1.0 mg/lt.	1.0 mg/lt.	
6	Chloride as Cl	250 mg/lt.	1000 mg/lt.	
`7	Sulphate as SO_4	200 mg/lt.	400 mg/lt.	
8	Fluoride as F	1.0 mg/lt.	1.5 mg/lt.	
9	Nitrate as NO_3	45 mg/lt.	45 mg/lt.	
10	pH @ 25°c	6.5-8.5	6.5-8.5	
11	Total Alkalinity	200 mg/lt.	600 mg/lt.	
12	Color	5 Hazen Units	15 Hazen Units	
13	Odour	Agreeable	Agreeable	**IS 3025 (Part-5) 1983: 2018**
14	Taste	Agreeable	Agreeable	**IS 3025 (Part-8) 1984: RA 2023**
15	Turbidity	1 NTU	5 NTU	**APHA 24^{th} Edition**

Table 1: Limits of water parameter as per IS

Results

- **Groundwater Quality Analysis** revealed elevated levels of pollutants such as iron, nitrates, and fluoride in several sites, exceeding permissible limits.
- **Physicochemical Parameters** such as pH, hardness, and total dissolved solids varied significantly, indicating localized contamination due to industrial effluents and agricultural runoff.
- **Land Use Patterns** showed substantial urban expansion and reduced infiltration zones, exacerbating groundwater depletion.
- **Hydrogeological Study** confirmed that quartzite rock formations dominate the Delhi region's sub-surface, affecting aquifer storage and recharge behavior.
- **Spatial Trends** using past literature and satellite data confirm a steady decline in groundwater levels, particularly in peri-urban zones of East Haryana.

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Water sample Collection Palwal					
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**
Location	Latitude 28.040982 Longitude 77.377817	Latitude 27.983391 Longitude 77.433548	Latitude 27.971112 Longitude 77.436558	Latitude 27.987441 Longitude 77.434748	Latitude 27.968385 Longitude 77.434778

S. No.	Tested Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Total Dissolved Solids @180°c ± 2°c	1150	1090	920	870	1140
2	Total Hardness as CaCO3	390	420	340	420	350
3	Calcium as Ca	88.17	124.24	72.144	76.15	84.16
4	Magnesium as Mg	41.31	72.9	38.88	55.89	34.02
5	Chloride as Cl	231.92	419.86	185.94	303.90	259.91
6	pH @ 25°c	7.18	7.51	7.13	7.49	7.31
7	Total Alkalinity	310	380	210	350	250
8	Color	0	0	0	0	0
9	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
10	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
11	Turbidity	0	0	0	0	0

Table 2: Water Sample collection Palwal

Water sample Collection Faridabad					
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**
Location	TW- Dulahpur	TW- Dalelgarh	TW- Kurali	TW- Shahjahanpur	TW- Mothuka

S. No.	Tested Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Total Dissolved Solids @180°c ± 2°c	976	810	968	594	680
2	Total Hardness as CaCO3	448	428	448	336	456
3	Calcium as Ca	89.77	86.57	92.98	81.76	101
4	Magnesium as Mg	54.43	51.51	54.48	32.07	49.57
5	Total Alkalinity	231.66	213.84	249.48	196.02	235.62
6	Chloride as Cl	296.63	261.16	284.81	136	158.66
7	Sulphate as SO_4	82	72	68	54	68
8	Fluoride as F	0.98	0.84	0.79	0.54	0.68
9	Iron as Fe	0.03	0.03	0.02	0.04	0.02
10	Nitrate (as NO_3)	3.54	4.42	3.09	2.21	3.98
11	pH @ 25°c Turbidity	6.81	7.49	7.47	6.88	7.04

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Table 3: Water sample collection Faridabad

Water sample Collection Nuh (Mewat)				
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**
Location	Latitude 28.212029 Longitude 76.954249	Latitude 27.789852 Longitude 76.952809	Latitude 28.145324 Longitude 76.953244	Latitude 27.793587 Longitude 77.936609

S. No.	Tested Parameter	Sample 1	Sample 2	Sample 3	Sample 4
1	Total Dissolved Solids @ 180°c ± 2°c	596	674	444	888
2	Total Hardness as CaCO3	343	397	216	422
3	Calcium as Ca	41	51	35	45
4	Magnesium as Mg	58	66	31	75
5	Iron as Fe	0.13	0.1	<0.1	0.1
6	Chloride as Cl	152	155	95	180
7	Sulphate as So4	110	56	75	78
8	Fluoride as F	0.10	0.1	0.10	0.1
9	Nitrate as No3	6.9	3.6	12.6	6.1
10	pH @ 25°c	7.81	7.49	7.48	7.45
11	Total Alkalinity	199	254	234	328
12	Color	<5	<5	<5	<5
13	Odour	Agreeable	Agreeable	Agreeable	Agreeable
14	Turbidity	<0.5	<0.5	<0.5	<0.5
15	Taste	Agreeable	Agreeable	Agreeable	Agreeable

Table 4: Water sample collection Nuh

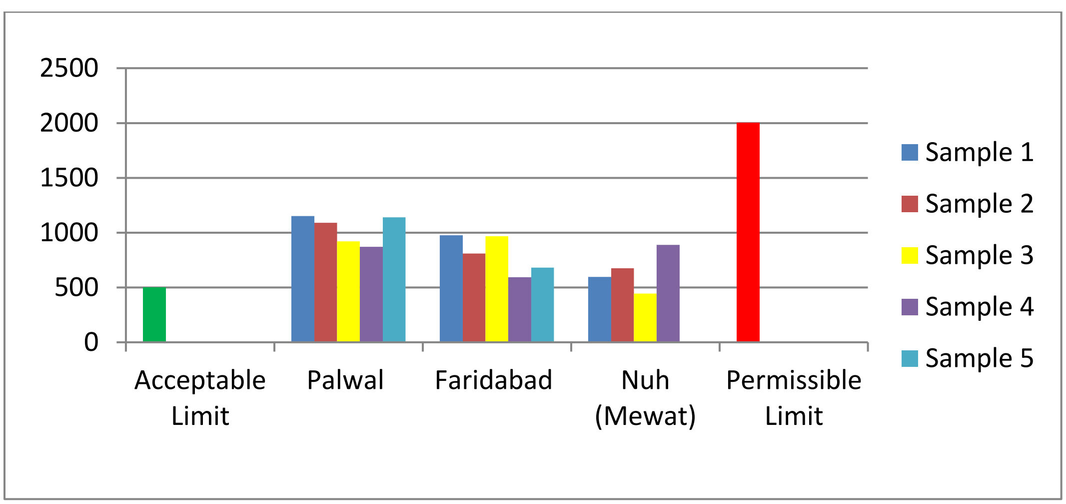

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Fig. 3: Total Dissolved Solids (mg/ltr.)

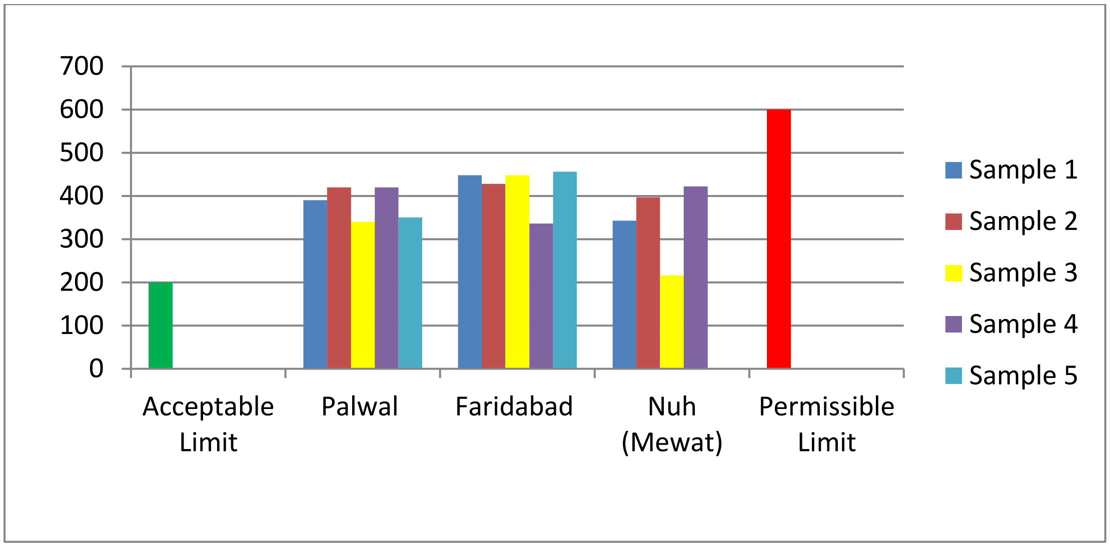

Fig. 4 : Total Hardness as $Caco_3$ (mg/ltr.)

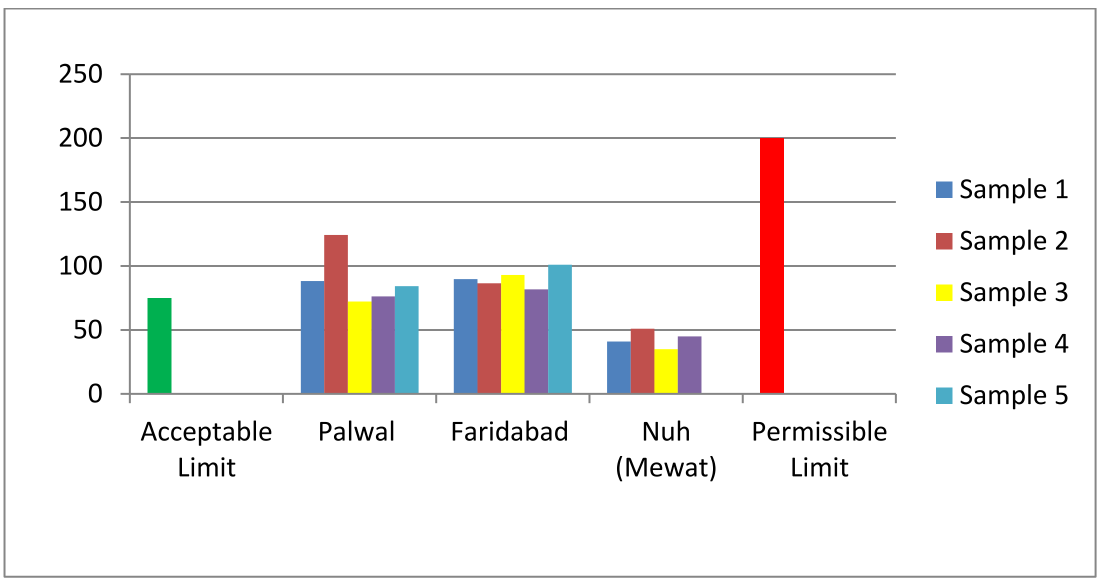

Fig. 5: Calcium as $Caco_3$ (mg/ltr.)

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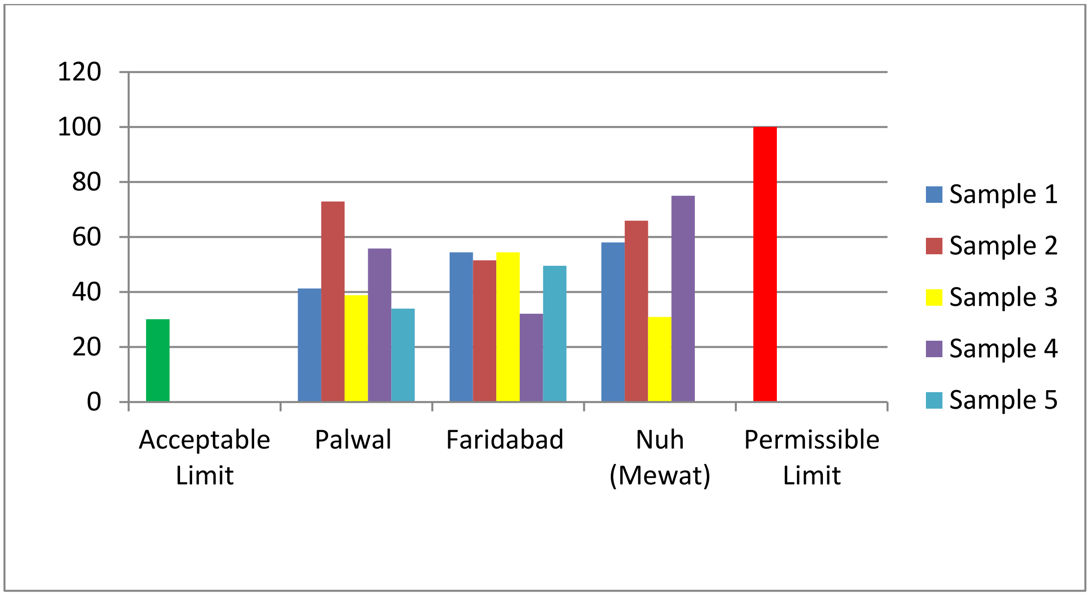

Fig. 6: Magnesium as Mg (mg/ltr.)

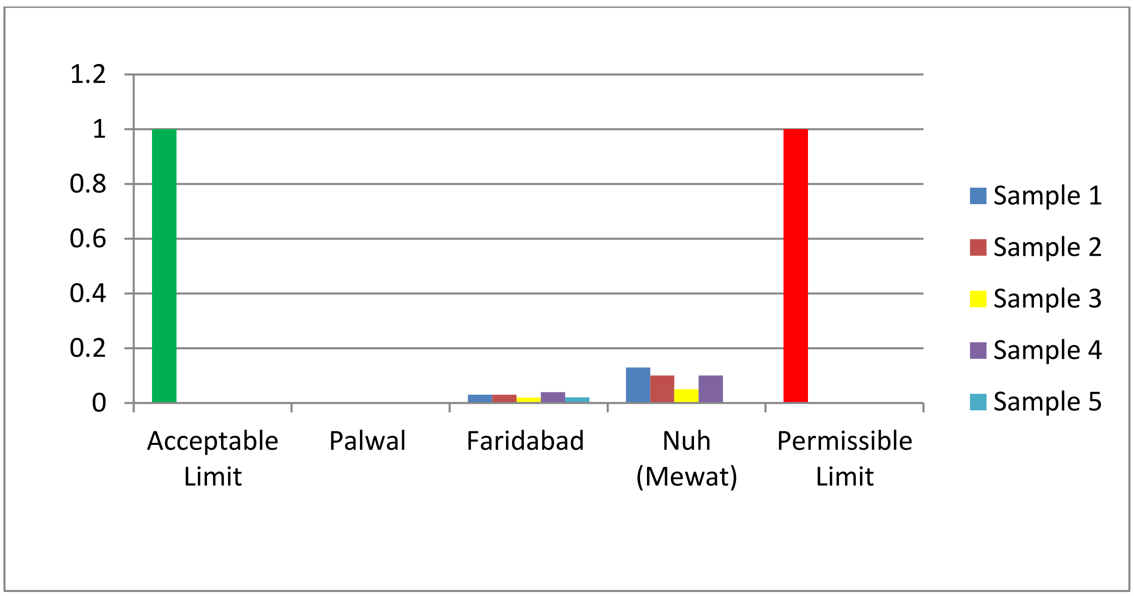

Fig. 7: Iron as Fe (mg/ltr)

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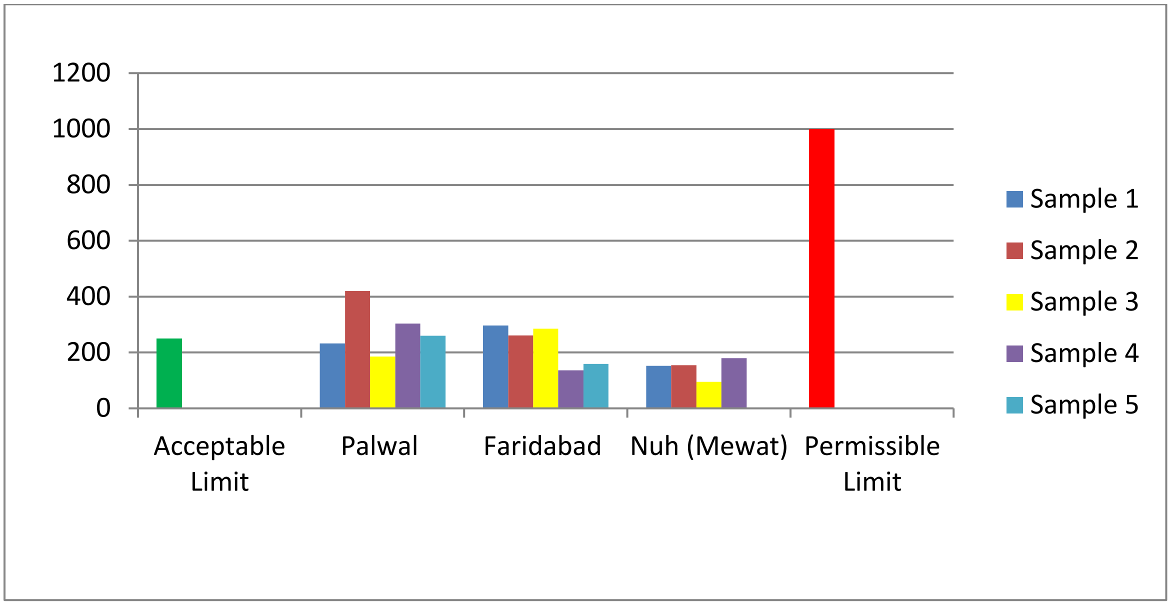

Fig. 8: Chloride as Cl (mg/ltr.)

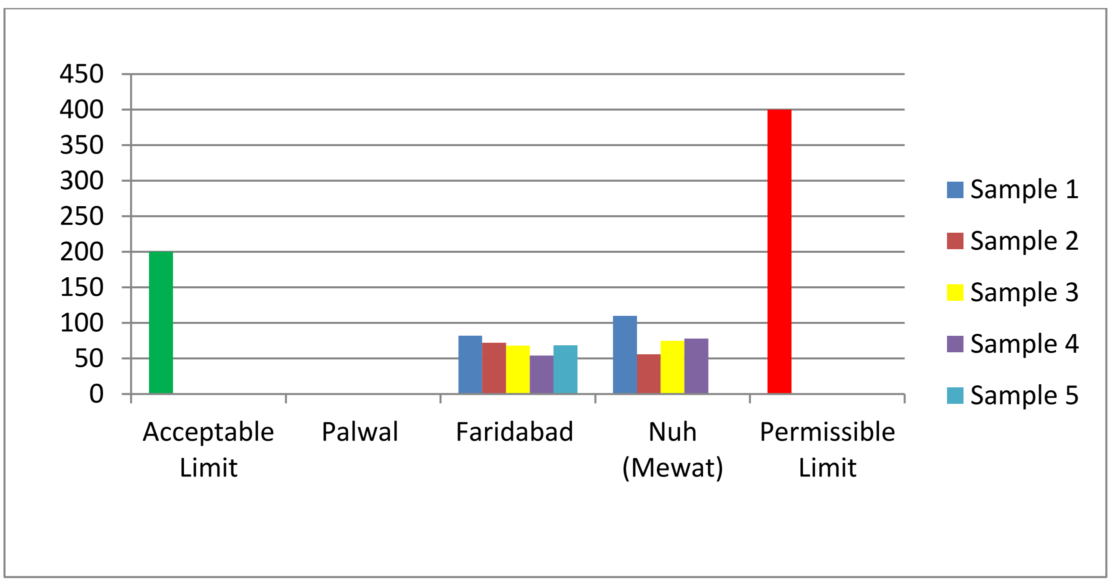

Fig. 9: Sulphate as SO_4 (mg/ltr.)

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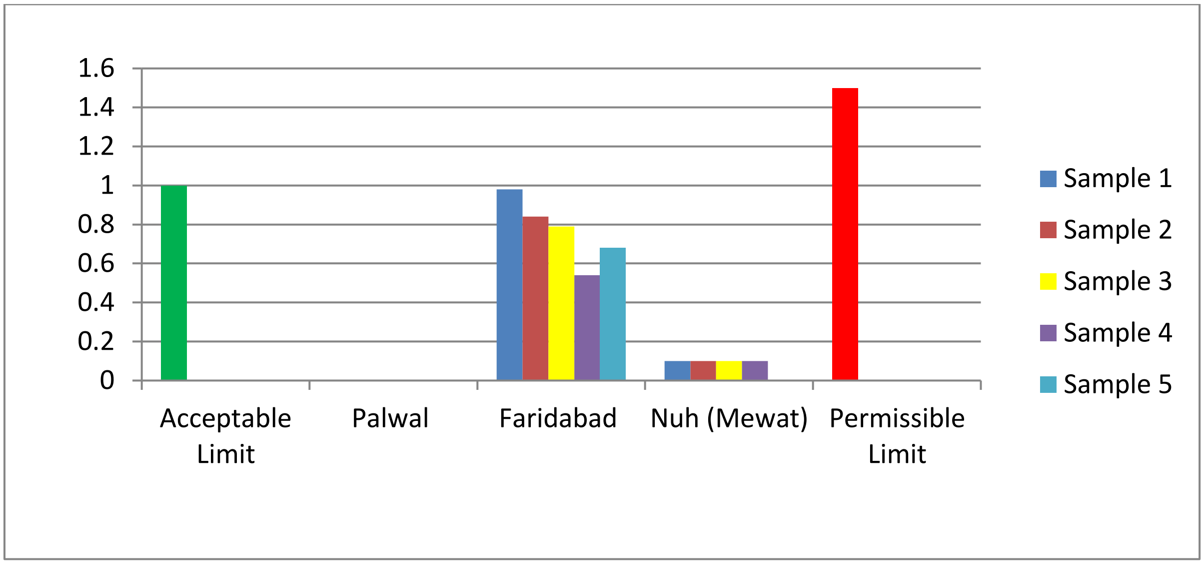

Fig. 10: Fluoride as Fe (mg/ltr.)

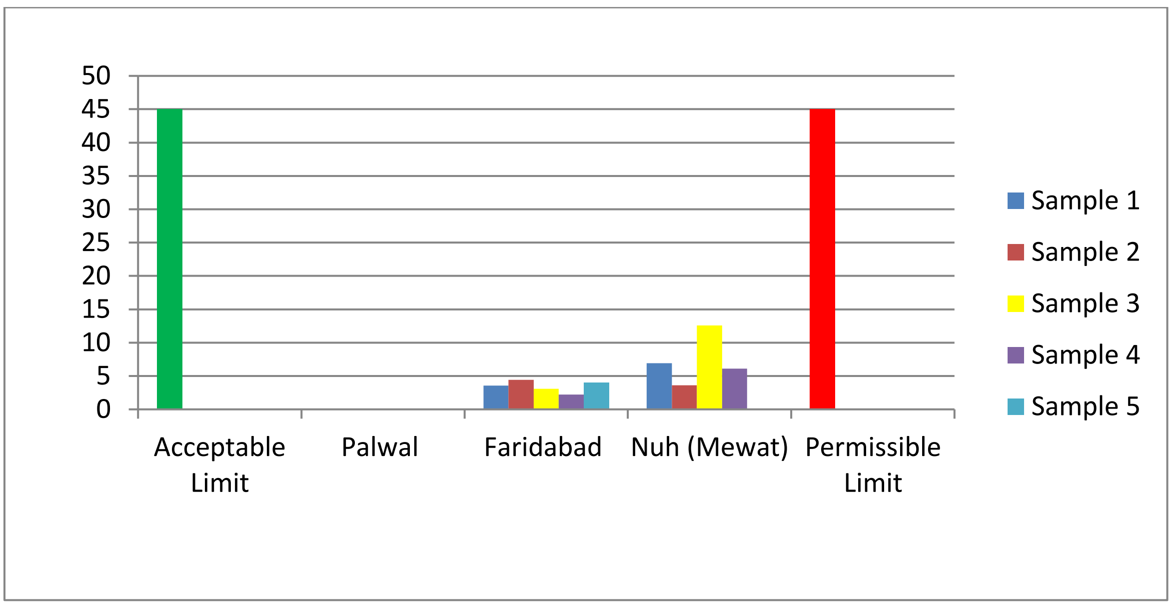

Fig. 11: Nitrate as NO_3 (mg/ltr.)

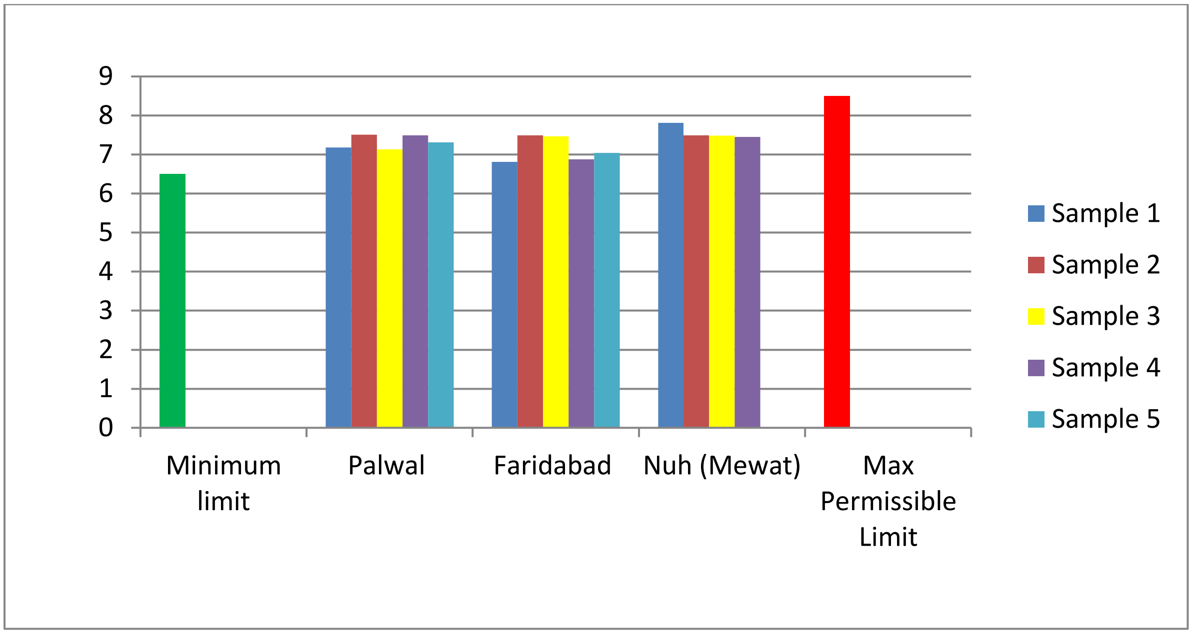

Fig. 12: p^H Value @ 25° c

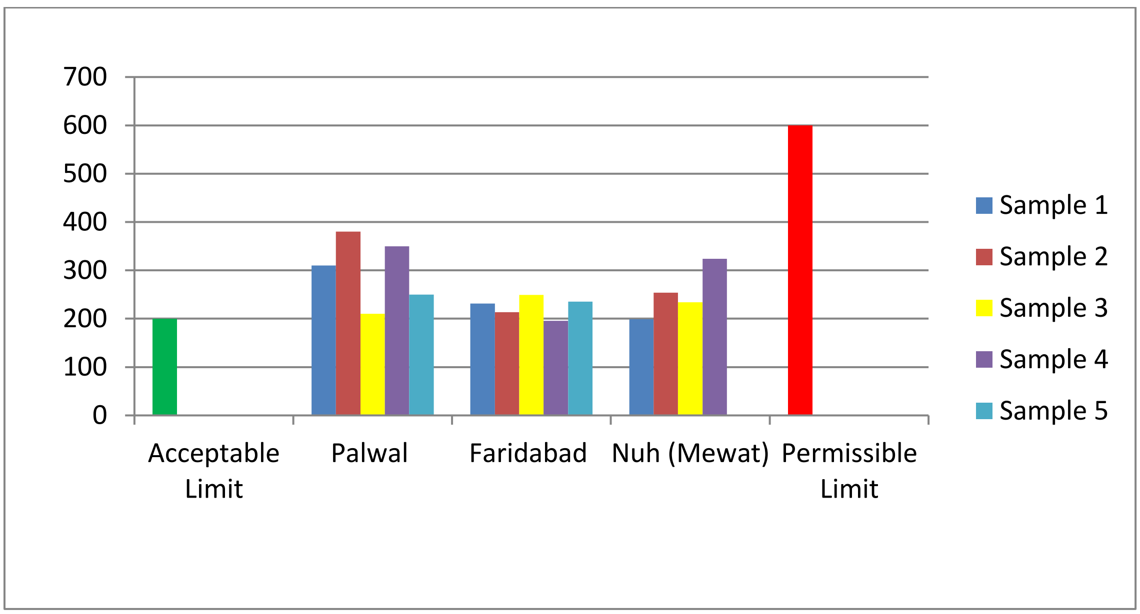

Fig. 13: Total Alkalinity (mg/ltr.)

Conclusion

Groundwater resources in East Haryana cities are under severe stress due to over-extraction, contamination, and reduced natural recharge. The study underscores the importance of integrated monitoring systems that combine hydrogeological, geospatial, and chemical data for effective resource management. There is a pressing need for sustainable practices, such as artificial recharge, improved waste treatment, and stricter regulatory frameworks to address the growing water insecurity. Future research should focus on developing predictive models incorporating socio-economic and climate variables to guide groundwater management in the NCR region.

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