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Analysis of Water Level Fluctuations and TDS Variations in the Groundwater at Mewat (Nuh) District, Haryana (India)

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ABSTRACT

Groundwater is the major source for fulfilling the water needs of domestic and agricultural sectors in Mewat district, Haryana, India and its continuous use has put an enormous pressure on the groundwater resource, which along with low rainfall and variable geographical conditions lead to the declining water levels. The other problem of this area is high salinity which is reported intruding to the freshwater zone[1]. Taking into account the twin problem of declining water level and high salinity the study was taken up jointly by National Institute of Hydrology, Roorkee; Sehgal Foundation, Gurgaon and Indian Institute of Technology, Roorkee. Groundwater level and TDS (Total dissolved solids) data for pre-monsoon and post-monsoon seasons for the time period of 2011–2015 of 40 monitoring wells developed by Sehgal Foundation, Gurgaon was collected and analysed. It has been found that the groundwater level is decreasing in the area while TDS values show inconsistent trends during 2011-15. Further monitoring of the wells is continued to get the more information on water level and TDS which will help in facilitating the researchers in finding out the applicable solutions for the above problems in the Mewat, Haryana.

Keywords*:* Groundwater Level, TDS, Salinity, Mewat, Haryana.

INTRODUCTION

With an estimated abstraction of around 230 billion cubic meter per year, India is reported as one of the largest groundwater users in the world. Nationally, groundwater accounts for 85% of India's rural domestic water requirements and more than 60% of its irrigation requirements[2]. This excessive use of groundwater has led to its depletion and deterioration of quality in north-west India and across the Gangetic basin which has been reported in many studies[3-18].

It has been reported that 20% of the world's irrigated areas are affected by secondary salinization and India is one among these countries accounting for the most salinized soils to the tune of 9.38 million ha, out of which 3.88 million ha area is covered by alkali soils and 5.5 million ha area is covered by saline soils (IAB, 2000)[19]. Mewat district, Haryana, India is major agricultural land area with deficit of perennial surface water sources[20] and therefore, the main source of irrigation and domestic use is groundwater[20,21]. The natural surface water sources like Kotla and Ujina lakes also remains dry most of the time of the year because of the limited number of rainy days[20]. The major crops grown in this area are wheat, millet and mustard, which requires huge amount of water[22] and result in extraction of large amount of groundwater. The recharge is very less

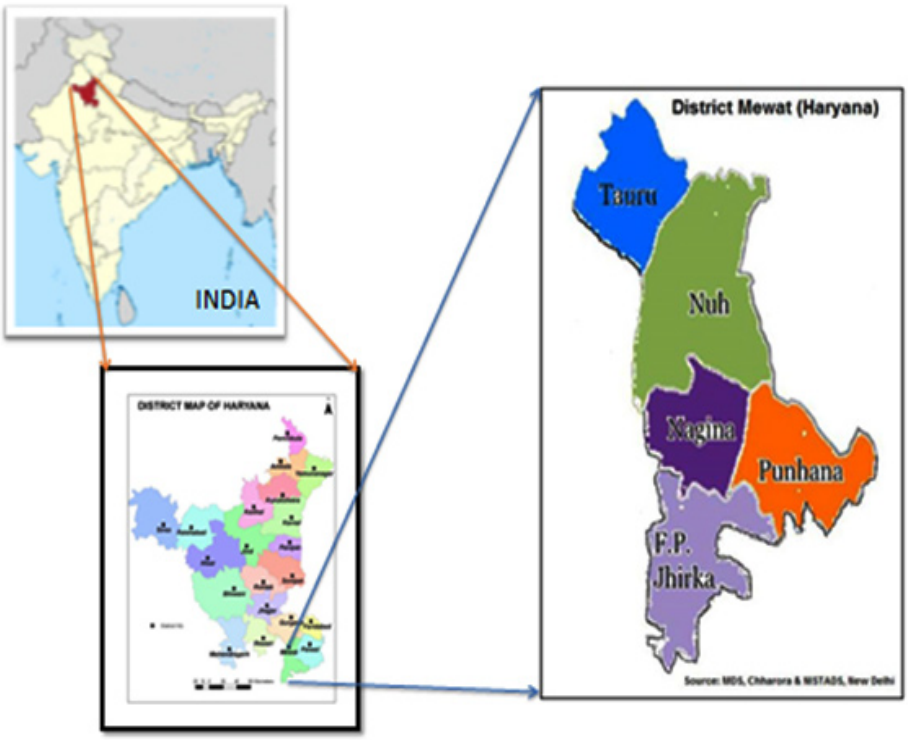
due to the low rainfall being hot and semi-arid zone with the diverse physiography.

On the other hand, high salinity adversely affects productivity by deteriorating soil quality and limits the choices of crops for farmers[1,23]. Taking into account the twin problem of declining water level and high salinity the study was taken up jointly by National Institute of Hydrology, Roorkee along with Sehgal Foundation, Gurgaon and Indian Institute of Technology, Roorkee. Sehgal Foundation, Gurgaon has developed 40 monitoring wells in the Mewat district of Haryana where the continuous monitoring is going on.

In the present paper, groundwater level and TDS data was collected for the period 2011-15 to analyse the variations for the last 5 years.

Study area

Recently named as Nuh, Mewat district is newly carved district among the 21 districts of Haryana state. The district lies between 26° and 28° N latitude and 76° and 77° E longitude and comprises of 5 blocks, namely Firozpur Jhirka, Nuh, Nagina, Taoru, Punahana (Figure 1). The total population of Mewat is 1,089,263 (Census 2011)[24], and 88.6% of total population comes under rural population with agriculture as main occupation and has a crop intensity of around 150%. Cultivable area is 1,53,257 ha which is around 74% of total and it depends on two main sources for irrigation- (i) canal, which covers 16432 ha area (21.6%) and (ii) groundwater-tube wells/bore wells/open wells which covers 59527 ha (78.4%) out of the net irrigation area, i.e. 75959 ha. The principle crops (wheat, Millet and Mustard) covers 192000 ha area. Also, non-cultivable area is 108334 ha (around 70%) of land[25].



Source: 'Mewat Development Society' and 'State Election Commission, Haryana'

Fig. 1: Location map of Study area, Mewat, Haryana (India)

The land is extended by ridges of Delhi Quartzite and is majorly covered by alluvial plains. The land proximity to National Capital Region (NCR) of Delhi and also being a part of aravalli range which comprises of rocky area having below average vegetation, gives the district some specific geophysical, topographical and ecological feature values. The elevation of the district is 189 meters in height, equivalent to 620 feet. The normal annual rainfall in the district is 594 mm, out of which maximum contribution (approximate to 75%) takes place during monsoon season. May-June is the driest months of the year highlighting the water issues at that time[25].

Methodology

Groundwater level and TDS were recorded for 40 monitoring wells during the time period 2011-15 (Table 1). These wells are developed by Sehgal foundation, Gurgaon and their distribution and location is shown in Fig. 2. The wells were mainly concentrated in the zones having problems of declining water level and TDS[1]. The groundwater levels are recorded using water level indicator and are measured as 'meter below ground level (m bgl)' and TDS readings were measured in-situ with TDS meter as 'parts per million (ppm)'. The database of five years groundwater level, TDS readings and average rainfall (IMD, New Delhi) has been prepared and analyzed for the changes and trends during the period of observations. The average of the rainfall was taken between December-May (pre-monsoon) and between June-November (Post-monsoon) (Table 2). The pre-monsoon and post-monsoon groundwater levels and TDS were plotted as time-series plots with reference to average rainfall data (Figures 3-4). The data was analyzed statistically (Tables 3-8).

There's a constraint in the analysis of TDS data for 15 wells which was not recorded for post-monsoon season in 2012 (i.e. for Nov, 2012).

Table 1: Details of the wells

S. No.	Village Name	Place of Well	S. No.	Village Name	Place of Well
1	Multhan	Panchayati well near tower	21	Agon	Huch tower well
2		Badru Well	22		Abdul well
3	Ulheta	Panchayati Dholposh Kua	23		Haji Mauji Khan well
4	Karhera	Mandir Kui	24	Naharika	Bari masjid well
5		Harijan Well	25		Sweet well
6		Kabristan Well	26		Panchayati Kua (school)
7		Ratti Khan well	27		Raheem well
8	Sathawari	Wali ji well	28	Jali Khori	Johad wala well
9		Sumair well	29		Kamrudden well
10	Nagina	Asthal mandir well	30	Raniyali	Balmiki wala kua
11		Bag wala Kua	31	Nasir bas	Rehman well
12		Badkali wala kua	32	Poll	Rasheed well
13		Bich wala well	33	Thekri	Sayyad well
14		Rahat wala Kua	34	Bhond	Nooru well
15		Masjid bandh bore	35	Satakpuri	Panchayati well
16		Bhoron wala well	36		Islam well
17		Khatikan well	37	Kotla	Bangali Khola well
18		Baldev Saini well	38		Andha Kua
19		Chaypur well	39		Bali well
20	Agon	Dalli well	40		Khalid well

The wells for which data was not recoded are: Dalli well, Huch tower well, Abdul well, Haji Mauji Khan well, Bari masjid well, Sweet well, Panchayati Kua (school), Raheem well, Johad wala well, Kamrudden well, Balmiki wala kua, Rehman well, Rasheed well, Sayyad well, Nooru well.

RESULTS AND DISCUSSIONS

Groundwater Level

The results obtained for groundwater level data of 40 wells in five aforementioned blocks during period of 2011-15 for pre-monsoon and post-monsoon season in Mewat district are given in Tables 3 & 4 and Figure 3.

As evident from the Figure 3, groundwater level in most of wells is almost constant but decline is also observed in some wells. The water level is found to increase after the rainfall events. In pre-monsoon season, the rainfall is very less or negligible except in May 2014, where the level of the groundwater has also raised above due to recharge in aquifers. In post-monsoon season, increase in water level is observed for most of the wells. Rainfall has a direct effect on the water level in the study area. From the Fig. 3, it is clearly visible that, recharge through rain water plays an important role for aquifers at Mewat, as decline water level during the pre-monsoon time was recouped by a rise in water level in post-monsoons.

Table 2. Rainfall Data (2011 - 2015)

Time Period	Pre-Monsoon					Post-Monsoon				
	2010-2011	2011-2012	2012 - 2013	2013-2014	2014-2015	2011	2012	2013	2014	2015
Rainfall (mm)	0	0.2	0	8.3	0	202.6	250.2	356.6	219	509.9

*Source: Customized Rainfall Information System (CRIS), Hydromet Division, India Meteorological Department, Ministry of Earth Sciences26.

Fig. 2: Distribution of wells in Mewat, Haryana (India)

From the tables 3 & 4, it is evident that groundwater level is declining during five years' time period. In the pre-monsoon season, the minimum decline is 1 m and maximum decline of 6.8 m with an average of 2.4 m was observed in Mewat, Haryana. For post-monsoon season, the minimum decline is 1.1 m and maximum decline of 13.3 m with an average of 2.7 m was observed in Mewat, Haryana.

As per the data presented in table 5, it has been found that during May 2011 to November 2015 out of 40 wells the rise in water level was observed in 4 wells while in 36 wells there was fall in water level. Out of 36 declining wells, in 12 wells water level decreased between 0.0-2.0 mbgl; in 19 wells it decreased between 2.1-5.0 mbgl; in 3 wells it

decreased between 5.1-10.0 mbgl and a decline of more than 10.0 mbgl was observed in 1 well during years 2011-2016. In pre-monsoon season, water levelrise was found in 5 wells while 35 wells have shown a decline. Out of these 35 wells, in 8 wells water level decreased between 0.0-2.0 mbgl, in 20 wells it decreased between 2.1-5.0 mbgl and in 5 wells it decreased between 5.1-10.0 mbgl. During the post-monsoon season, groundwater level rise was observed in 4 wells and a fall was observed in 36 wells. Out of these 36, 13 wells shown have decrease of 0.0-2.0 mbgl; 15 wells have shown decrease of 2.1-5.0 mbgl; 5 wells shown decrease of 5.1-10.0 mbgl and more than 10.0 mbgl decrease were observed in 1 well. The rate of decline in shallow well is faster than the deeper wells as decrease of 50% and 84.6% in pre-monsoon and post-monsoon seasons, respectively was found in well having minimum water level and the well having maximum water level has decrease by 26.3% and 53.6% in pre-monsoon and post-monsoon seasons, respectively.

Total Dissolved Solid (TDS)

The results obtained for Total Dissolved solids (TDS) data of 40 wells in Mewat, Haryana during period of 2011-15 for pre-monsoon and post-monsoon season is given in Fig. 4 and Tables 5-8.

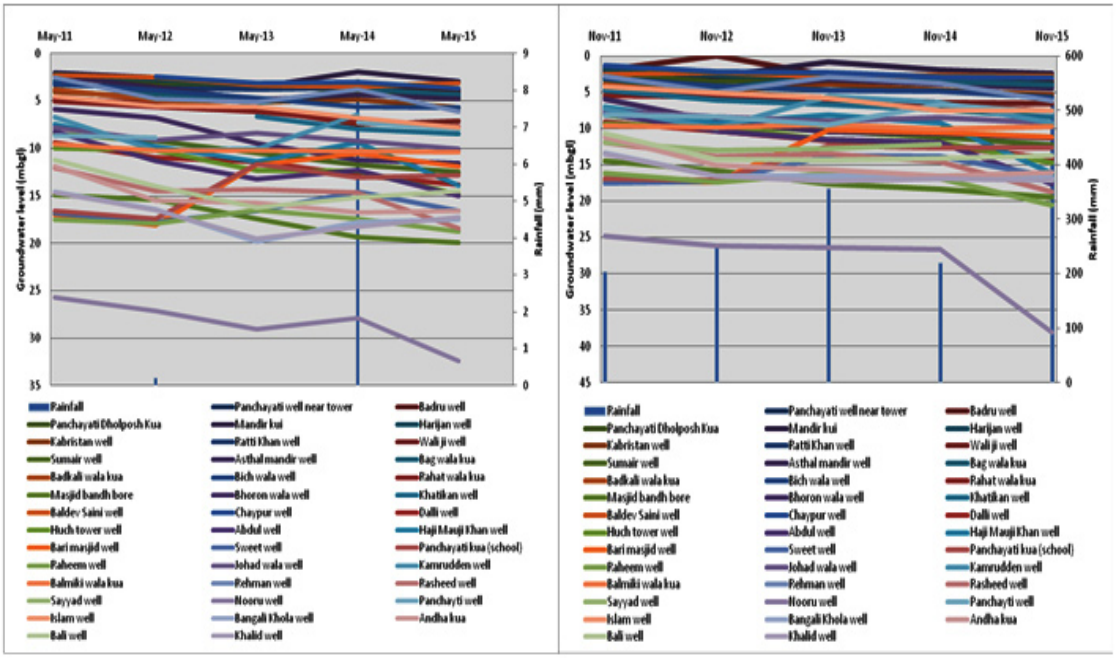


Fig. 3: Variations in Groundwater level for pre & post monsoon seasons for the period 2011-15

Table 3: Statistical summary of groundwater level data (n = 40)

S. No.		Pre - Monsoon					Post - Monsoon				
		May 2011	May 2012	May 2013	May 2014	May 2015	Nov 2011	Nov 2012	Nov 2013	Nov 2014	Nov 2015
1.	Min	2.0	2.5	3.1	2.0	3.0	1.3	2.2	0.9	1.9	2.4
2.	Max	25.7	27.1	29.1	27.9	32.5	24.8	26.1	29.1	26.7	38.1
3.	Average	8.2	9.3	9.7	9.7	10.6	7.9	9.4	8.8	9.2	10.6
4.	Std. Dev	5.8	6.1	6.1	5.8	6.3	5.6	5.9	5.7	5.6	7.1

*readings are in 'meter below ground level' (mbgl).

As evident from the figure 4, TDS in most of wells is almost constant but decline is also observed in some wells. The TDS is found to decrease after the rainfall events. In pre-monsoon season, the rainfall is very less or negligible except in May 2014, where the level of the groundwater has also raised above due to recharge in aquifers. In post-monsoon season, decrease in TDS is observed for most of the wells.

Table 4: Percent seasonal change in groundwater level during 2011-15 in Mewat (n = 40)

S.No.		Pre-monsoon		Post-monsoon	
		Difference in water level during 2011-15	% decrease in water level	Difference in water level during 2011-15	% decrease in water level
1.	Min	1.0	50.0	1.1	84.6
2.	Max	6.8	26.3	13.3	53.6
3.	Average	2.4	29.0	2.7	35.2

*readings are in 'meter below ground level' (mbgl).

Table 5: Quantification of groundwater level data (n = 40)

S. No.		No. of wells showing increased GW level	No. of wells showing decreased GW level	No. of wells under different declining limits (mbgl)			
				0.0-2.0	2.1-5.0	5.1-10	> 10
1	Overall Status of wells	4	36	12	19	3	1
2	Pre-Monsoon decrease in groundwater level	5	35	8	20	5	0
3	Post-Monsoon decrease in groundwater level	4	36	13	15	5	1
4	Pre-Monsoon annual rate of decrease in groundwater level	5	35	35	0	0	0
5	Post-Monsoon annual decrease in groundwater level	4	36	36	0	0	0

Table 6: Statistical summary of TDS data (n = 40)

S.No.		Pre - Monsoon					Post - Monsoon				
		May 2011	May 2012	May 2013	May 2014	May 2015	Nov 2011	Nov 2012	Nov 2013	Nov 2014	Nov 2015
1.	Min	321	326	376	409	440	298	326	357	390	470
2.	Max	8170	8930	7480	7290	7170	8800	8880	7120	6920	7220
3.	Average	2019	2080	1875	1923	1952	2291	2470	1872	1835	1933
4.	Std. Dev	1820	2111	1550	1508	1476	2305	2363	1448	1408	1461

*readings are in 'parts per million' (ppm)

It is clearly indicated from figure 4 that during pre-monsoon season TDS is high but it comes down during the post-monsoon season. In 2014, TDS for all the wells was found near or below 3000 ppm, except 4 wells namely, Panchayati Dholposh Kua, kabristan well, Khalid well and Bari masjid well. In Kabristan well and Panchayati Dolposh Kua TDS is recorded more than 6000 ppm (Figure 4) in spite of high rains. Table 5 indicated that the minimum values of TDS for pre-monsoon and post-monsoon seasons which shown an increase of 37.7 and 57.7, respectively but the maximum and average values of TDS in groundwater has actually decreased. This may be due to the reason that the saline zone is increasing and intruding into fresh water zone[1].

As per the data presented in Table 8, overall decrease in TDS during years May, 2011 to November, 2015 found in 11 wells and an increase is observed in other 29 wells. Out of which these 29, 7 wells have shown an increase of 0-200 ppm in TDS; 14 wells have shown increase of 201-500 ppm, 3 wells have shown increase on 501-1000 ppm and more than 1000 ppm increase was observed in 5 wells. In pre-monsoon season, 12 wells have a decreased TDS in 2015 as compared to year

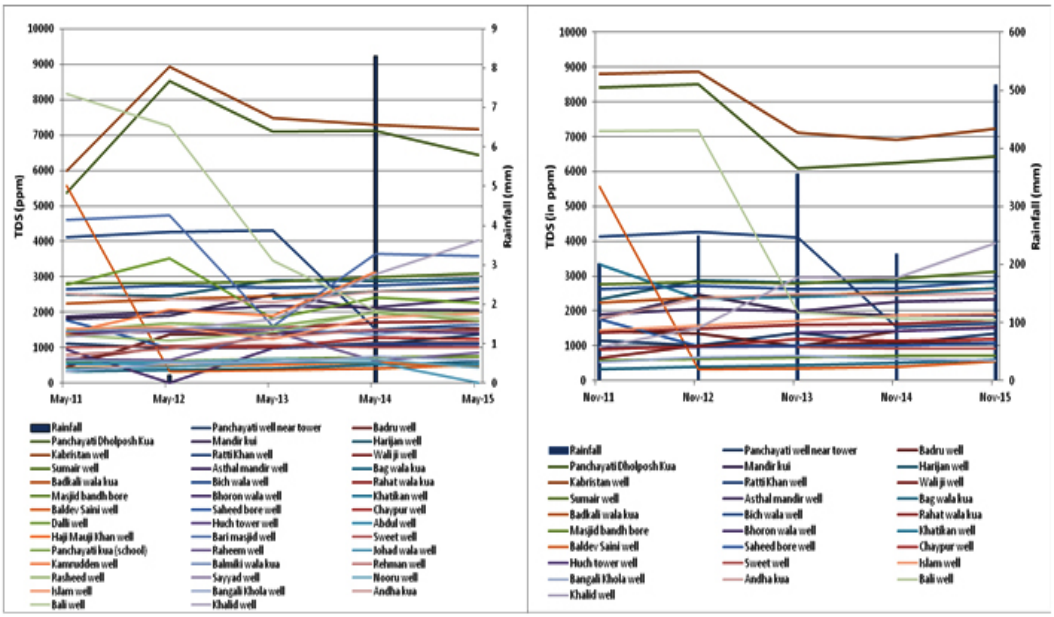


Fig. 4: Variations in TDS for pre & post monsoon seasons for the period 2011-15

Table 7: Percent seasonal change in TDS during 2011-15 in Mewat (n = 40)

S. No.		Pre-monsoon		Post-monsoon	
		Difference in TDS between 2011-15	% increase/ decrease in TDS	Difference in TDS between 2011-15	% increase/ decrease in TDS
1.	Min	119	37.1	172	57.7
2.	Max	-1000	-12.2	-1580	-18.0
3.	Average	-67	-3.3	-358	-15.6

*readings are in 'parts per million' (ppm).

Table 8: Quantification of TDS data (n = 40)

S. No.		No. of wells showing decrease in TDS	No. of wells showing increase in TDS	No. of wells under different increment limits (ppm)			
				(0–200)	(201-500)	(501-1000)	> 1000
1	Overall Status of wells	11	29	7	14	3	5
2	Pre-Monsoon decrease in TDS	12	28	6	16	2	4
3	Post-Monsoon decrease in TDS	14	26	7	14	4	1
4	Pre-Monsoon annual rate of decrease in TDS	12	28	22	4	1	0
5	Post-Monsoon annual rate of decrease in TDS	14	26	25	0	1	0

2011, while 28 wells have shown an increase in TDS in 2015 as compared to 2011. In 6 wells, TDS have increased between 0-200 ppm, in 16 wells it increased between 201-500 ppm, in 2 wells it increased between 501-1000 ppm and in 4 wells it increased more than 1000 ppm. In post-monsoon season, TDS decreased in 14 wells and it increased in remaining 26 wells. Increased TDS values have between 0-200 ppm found in 7 wells, between 201-500 ppm in 14 wells between 501-1000 ppm in 4 wells have and more than 1000 ppm in 1 well. Increase in salinity during the years 2011-2015 in about 12% of wells in not good for the groundwater quality. Detailed study may be carried out in this areas to find out the water quality index as developed by Singh et al. (2015)[27]; which was used by Krishan et al.[28-33] for evaluating the groundwater quality in some parts of Uttar Pradesh, Gujarat and Punjab.

CONCLUSION

In the present study, it has been observed that the groundwater is declining in some wells due to high extraction, low rainfall, and variable geographical conditions as fresh water sources are mostly situated along the steeper Aravalli hills. High salinity is found in some areas and is reported to intrude the fresh water zones[1]. Over-exploitation is resulting in the intrusion of saline groundwater towards the fresh groundwater, speeding up the depletion fast by 300-500 mm every year[34]. The groundwater in many wells which previously contained freshwater has now salinized. The new innovative technique of creating a pool of fresh groundwater within a saline aquifer is developed by the Sehgal foundation at a school and they are further planning to replicate the model for expansion and utilizing benefit of the same[35]. This will require groundwater level and TDS data for estimation of physio-chemical parameters at Mewat district which lacks freshwater aquifers and few which are slowly moving towards turning saline. Since, the problems due to water scarcity and salinity in groundwater are more visible in the district; this study is fundamentally very useful for further investigations and research towards finding solutions of water issues at Mewat.

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