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A STUDY ON GROUNDWATER CONDITIONS IN MEWAT (NUH) DISTRICT, HARYANA, INDIA

Minor Project Thesis

Submitted by

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ENVIRONMENTAL STUDIES AND RESOURCE MANAGEMENT

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Priyanka

DECLARATION

This is to certify that the work that forms the basis of this project "A STUDY ON GROUNDWATER CONDITIONS IN MEWAT (NUH) DISTRICT, HARYANA, INDIA" is an original work carried out by me and has not been submitted anywhere else for the award of any degree.

I certify that all sources of information and data are fully acknowledged in the project thesis.

PRIYANKA

Date: 22 July, 2016

CERTIFICATE

This is to certify that PRIYANKA has carried out her minor project in partial fulfillment of the requirement for the degree of Master of Science in ENVIRONMENTAL STUDIES AND RESOURCE MANAGEMENT on the topic "A STUDY ON GROUNDWATER CONDITIONS IN MEWAT (NUH) DISTRICT, HARYANA, INDIA" during May 2016 to July 2016. The project was carried out at the NATIONAL INSTITUTE OF HYDROLOGY (NIH), ROORKEE.

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ABSTRACT

Mewat district lies in arid and semi-arid climatic conditions and is one of the water starved places, in Haryana state of India where groundwater is the major source for fulfilling the water needs of domestic and agricultural sectors 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. 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 in Mewat has high salinity accompanied by high fluoride contents and declining water level. This also contributes to the problem of non-potable drinking water except the base of the ridges and hillocks area of the district. Keeping in view these points, (i) a survey was conducted as a socio-analytical tool using people's perspective approach to assess the water related issues of the district during the months of March to May, 2016 in 37 villages covering all the 5 blocks, namely Firozpur Jhirka, Nuh, Nagina, Taoru, Punahana of Mewat District. (ii) 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. (iii) 13 random samples were collected represented all the blocks and analysed for water chemistry (pH, EC, ions, isotopes). It has been found that Mewat has limited water resources and most of the available resources are not in useable condition due to high salinity. Also, the groundwater level is decreasing in the area while TDS values show inconsistent trends during 2011-15. There is a need of strengthening soil, water and groundwater institutions along with capacity building, training and education for soil and water management, quality monitoring, and aquifer remediation on a continuous basis. 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, Survey, Mewat.

1. INTRODUCTION

The study was conducted at Mewat district, recently named as Nuh. It 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 (Figure1).

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. It falls under 43R Universal Transverse Mercator (UTM) Zone.

Salinity of a particular area is mainly governed by 2 factors (i) natural- geogenic conditions/regional geomorphology/accumulation of salts in top layer due to evapo-transpiration (ii) anthropogenic activities like excessive use of chemical fertilizers, poor drainage conditions, and excessive uncontrolled irrigation (Saini et al., 2015). Uncontrolled irrigation or excessive pumping of groundwater is also the cause of depleting water level in northwest India (Chopra and Krishan, 2014a,b; Lapworth et al 2014a; Krishan and Chopra, 2014; Krishan et al. 2013, 2014a-d; Rodell et al., 2009; Rao et al. 2014). Similar conditions of salinity and depleting groundwater are also reported in Mewat, district of Haryana (Thomas et al., 2015). The development of groundwater already falls in critical category (around 67%) in the Mewat district (CGWB, 2012; Saini Vikas, 2016) that makes it essential for the development of water potential in the district.

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). The recharge at the district 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 (Chopra and Krishan, 2014a,b; Krishan et al., 2014a-d; Krishan et al., 2015a-c; Lapworth et al., 2014a,b; MacDonald et al., 2013-16; Tanwar and Kruesman, 1985). 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 work, keeping in view these points,

(i) a survey was conducted as a socio-analytical tool using people's perspective approach to assess the water related issues of the district during the months of March to May, 2016 in 37 villages covering all the 5 blocks, namely Firozpur Jhirka, Nuh, Nagina, Taoru, Punahana of Mewat District. This has been done to understand the problems from people's perspective which comprised as a part of on-going study on that area for the development of water resources and rejuvenation of the same wherever possible at the study area. Also, groundwater level and TDS data was collected for the period 2011-15 to analyse the variations for the last 5 years.

(ii) 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.

(iii) 13 random samples were collected represented all the blocks and analysed for water chemistry (pH, EC, ions, isotopes).

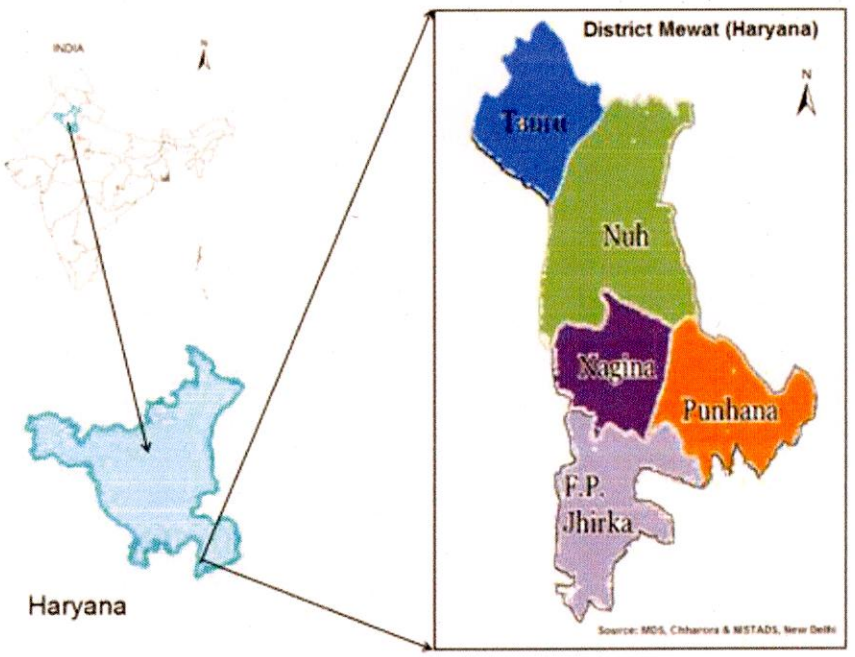

Figure 1: Location map of Study area, Mewat, Haryana (India)

2. LITERATURE REVIEW

Mewat district is the major agricultural land area with deficit of perennial surface water sources[20] and therefore, the main source of irrigation and domestic use is groundwater (Mehra et al., 2012; Rajeshwari, 2011). 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 (Mehra et al., 2012). The major crops grown in this area are wheat, millet and mustard, which requires huge amount of water and result in extraction of large amount of groundwater.

The total population of Mewat is 1,089,263 (Census 2011), 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 (CGWB, 2012). 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 (CRIS, 2016).

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 (World Bank, 2010). 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 (Chopra and Krishan, 2014a,b; Krishan et al., 2014a-d, 2015a-c; Lapworth et al., 2014a,b; MacDonald et al., 2013-16).

3. AIMS AND OBJECTIVES

(a.) To analyze the groundwater level and TDS data for the period 2011-2015.

(b.) To assess spatial variations of the groundwater quality of Mewat District, Haryana using GIS.

4. METHODOLOGY

4.1 Survey data collection:

A survey focusing on the aim and objectives of the study for extraction of the desired social information about the water related issues from the people living in Mewat district was conducted through the questionnaire as a socio-analytical tool using people's perspective approach during the months of March to May, 2016 in 37 villages covering all the 5 blocks, namely Firozpur Jhirka, Nuh, Nagina, Taoru, Punahana of Mewat District. The villages and households were selected randomly.

4.2 Groundwater Level and TDS data collection:

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 (Thomas et al., 2012). 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). 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.

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

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 Sciences.

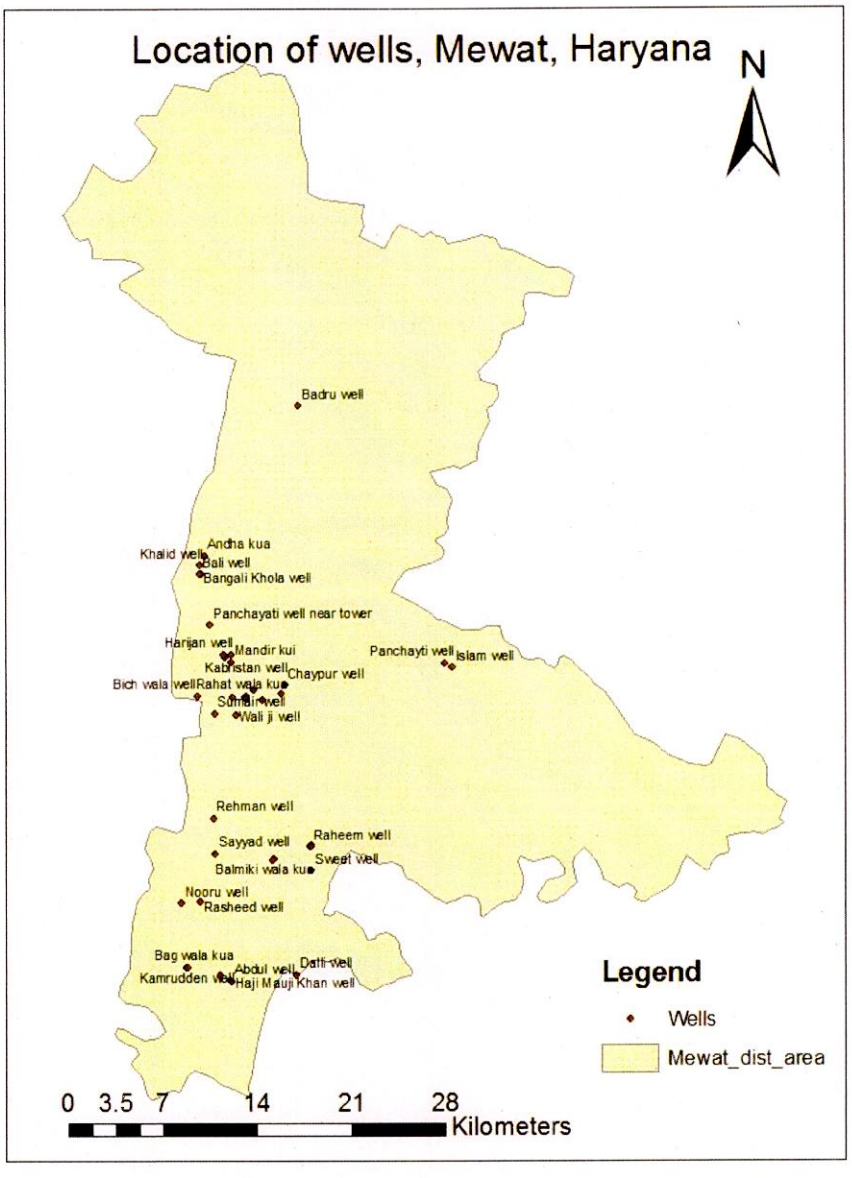

Figure 2: Distribution of wells in Mewat, Haryana (India)

4.3 Water Quality and Isotopes analysis:

In order to investigate the changing groundwater conditions (quality and quantity), water samples were collected randomly from the 13 sites in the month of March, 2016 using the standard procedures. These samples were analysed in the month of May, 2016 for salinity, alkalinity and major anions F, Cl, NO_3 & SO_4 and cations Ca, Mg, Na, K at IIT-Roorkee. Analysis of stable

isotopes (δD) in groundwater was carried out using IRMS at Nuclear Hydrology Laboratory of National Institute of Hydrology, Roorkee.

5. RESULTS AND DISCUSSION

5.1 Survey Results:

The answers/responses received from the villagers are compiled. As per the survey, agriculture is the main occupation (97%) of the inhabitants (Fig. 3a) or we can interpret that majority of the occupants are farmers. The quality of drinking water is mainly saline (57%) at most of the places in Mewat (Fig. 3b). Majority of farmers (45%) has 0-3 acre of land for irrigation, followed by 4-7 acre by 25% and 8-10 acre by 8%. Two types of crops are grown like most of part of northwest India i. Rabi crop (56%) and Kharif crop (44%). Rabi crops include Wheat (27%), Mustard (23%), Lentil (3%) and Gram (3%) and Kharif crops include Millet (22%) and Sorghum (22%).

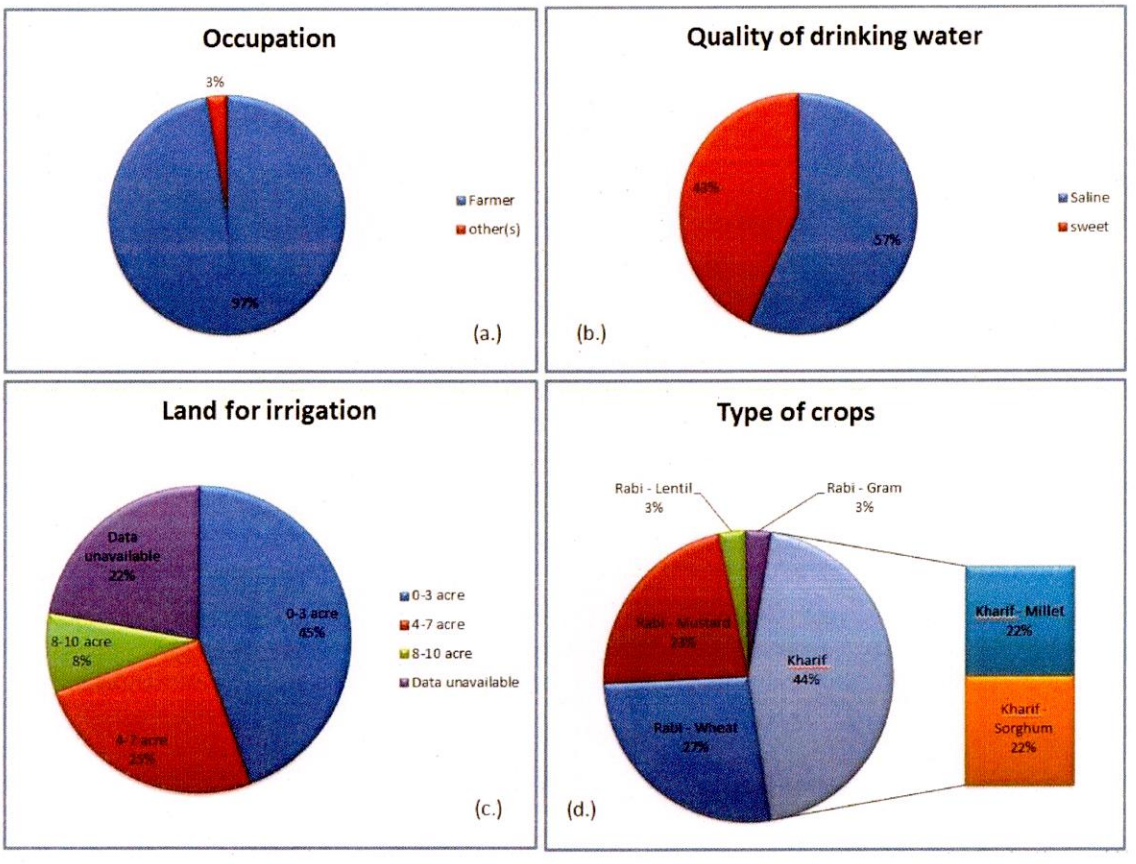

Figure 3: Response of the villagers on occupation (a); quality of drinking water (b); land for irrigation (c); and type of crops (d) in Mewat district, Haryana

The statistics on types of irrigation in Mewat district show that 46% of Mewat inhabitants use bore wells 18% submersible, 11% tube wells and 10% each irrigated from pipelines from canal and diesel engine tube wells (Fig. 4).

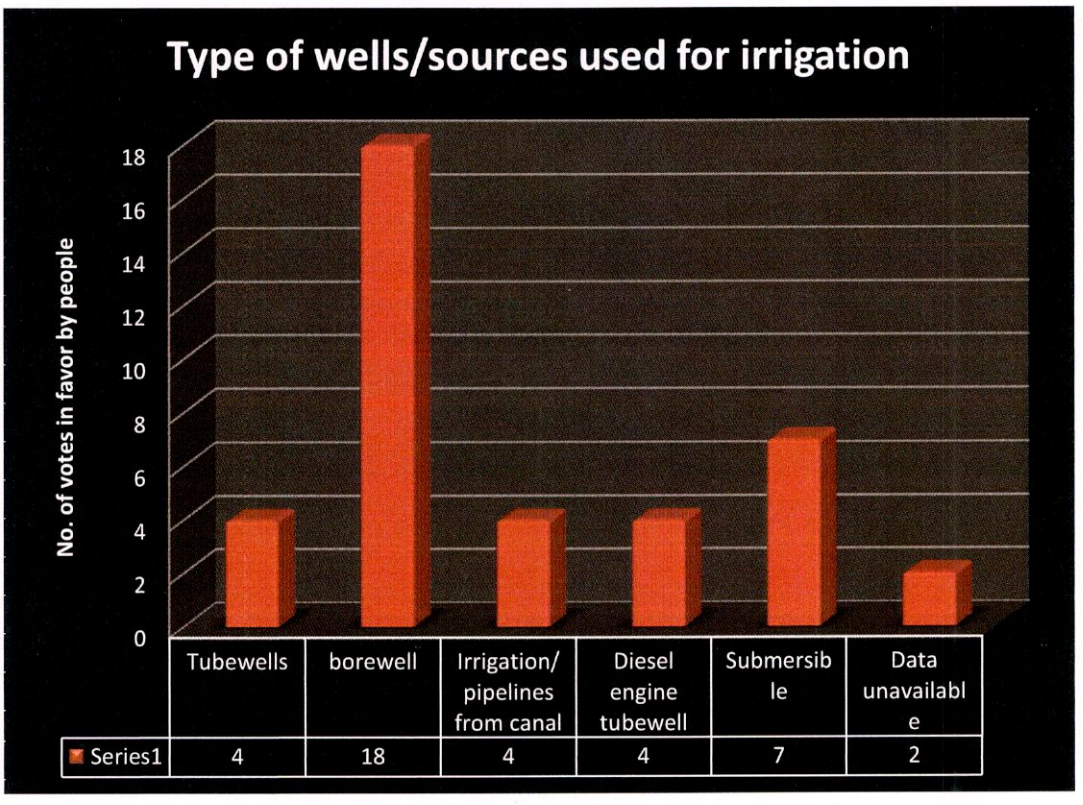

Figure 4: Sources of irrigation in Mewat district, Haryana

From the villagers' point of view, water level below ground ranges between 0-50 feet at 61% places, between 51-100 feet at 17% places, between 301-350 feet at 11% places and between 101-150 feet at 5% places and at 3% places it's between 151-200 feet and above 350 feet (Fig. 5).

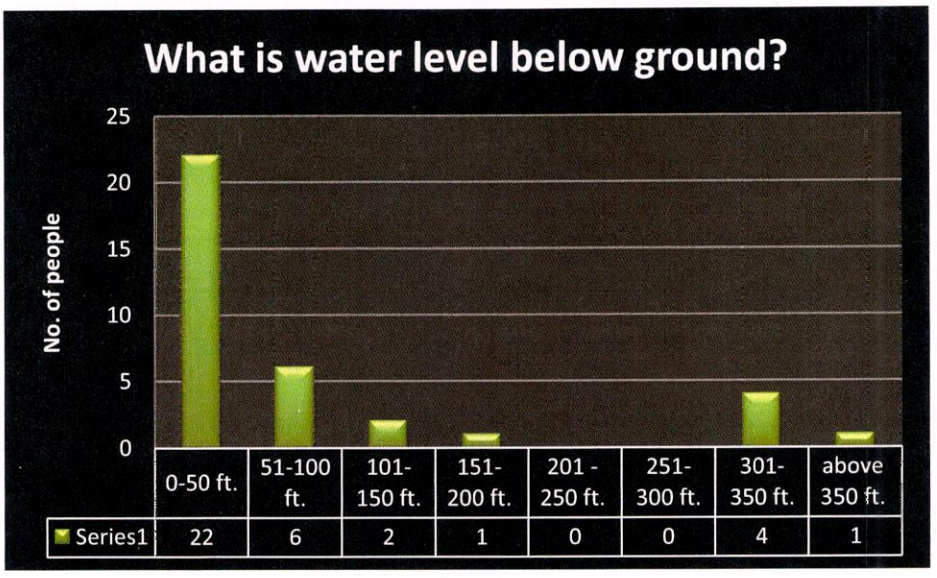

Figure 5: Water level from the villagers' point of view in Mewat district, Haryana

When the villagers were asked about the water related problems in Mewat district, they responded that the main water related problem is groundwater salinity (31%), followed by lack of irrigation facilities (22%), decline water level (11%) and similar in percentage to problems of canal (11%), then comes shortage/lack of water (7%) in Mewat district, Haryana (Fig. 6).

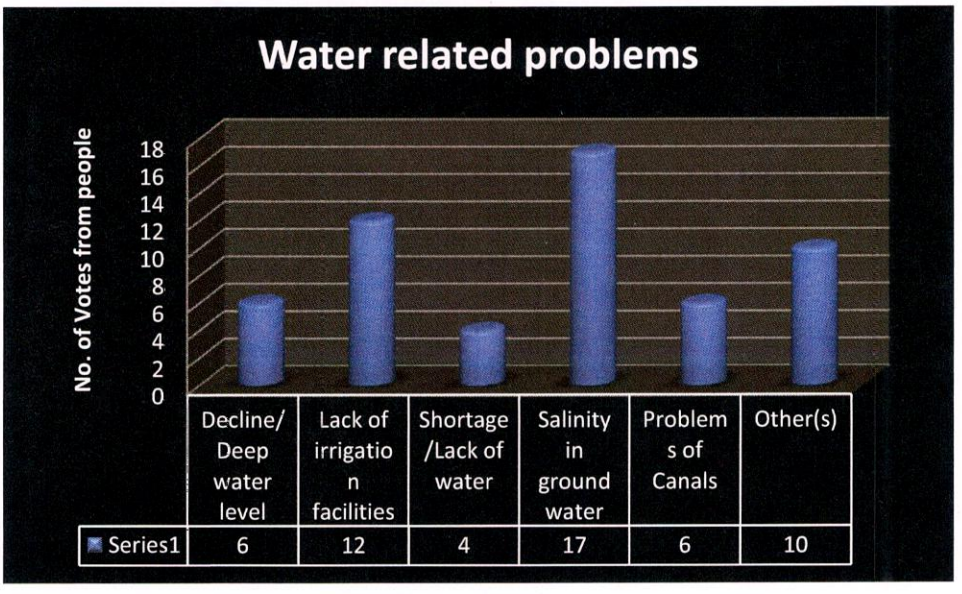

Figure 6: Response of the villagers on types of water related problems in Mewat district, Haryana

Fig. 7: shows the farming related problems in decreasing order of percentages listed as shortage of water/lack of water for proper irrigation and uneven ground surface (37%), lack of good manure, lack of seeds, and shortage of irrigation facilities (29%), termites and white insects affect the crops (10%) and salinity of water(7%).

Fig. 8 shows the suggestion of the villagers on solving of water related problems in the district, the foremost suggestion from the people came as by constructing bore wells, tube wells, ranney wells through government or private (57%), followed by construction of recharge wells and lakes for collection of rain water (18%), then people also pointed that leaving water open or letting it waste by anyway should also be stopped (5%) and electricity bills should be paid on time by the inhabitants and illegal connections should be closed by the government (4%).

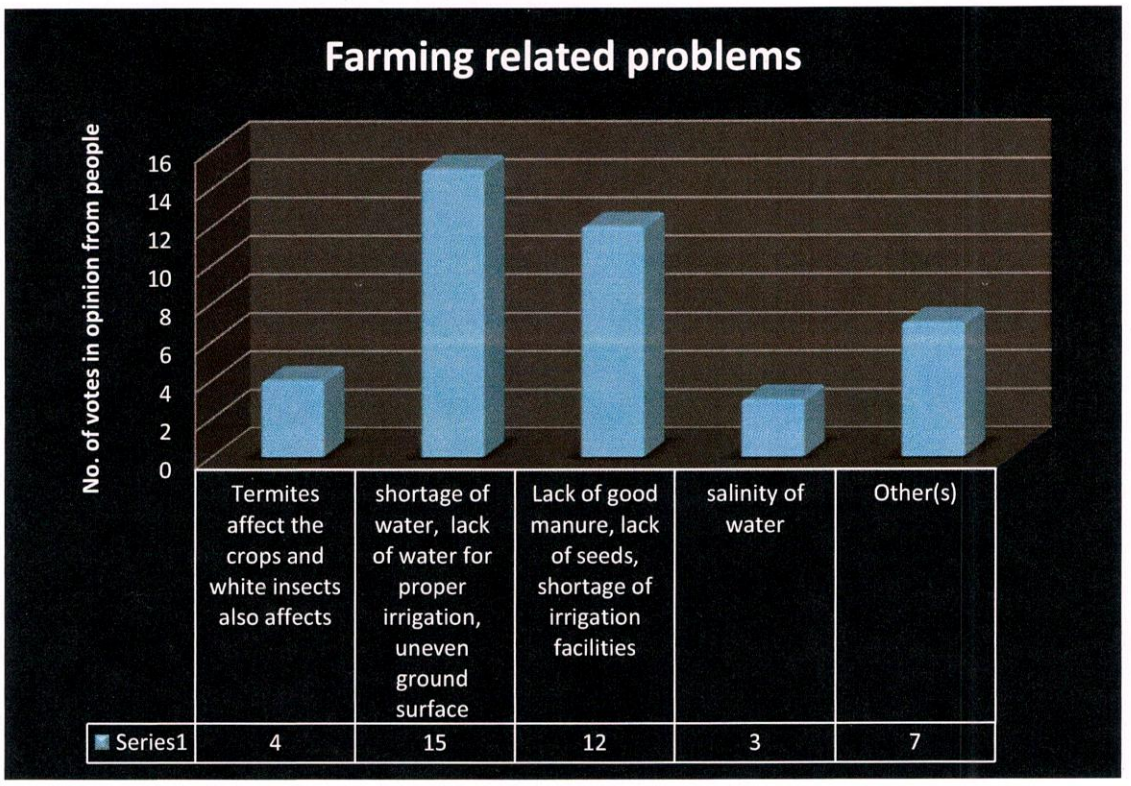

Figure 7: Farming related problems in Mewat district, Haryana

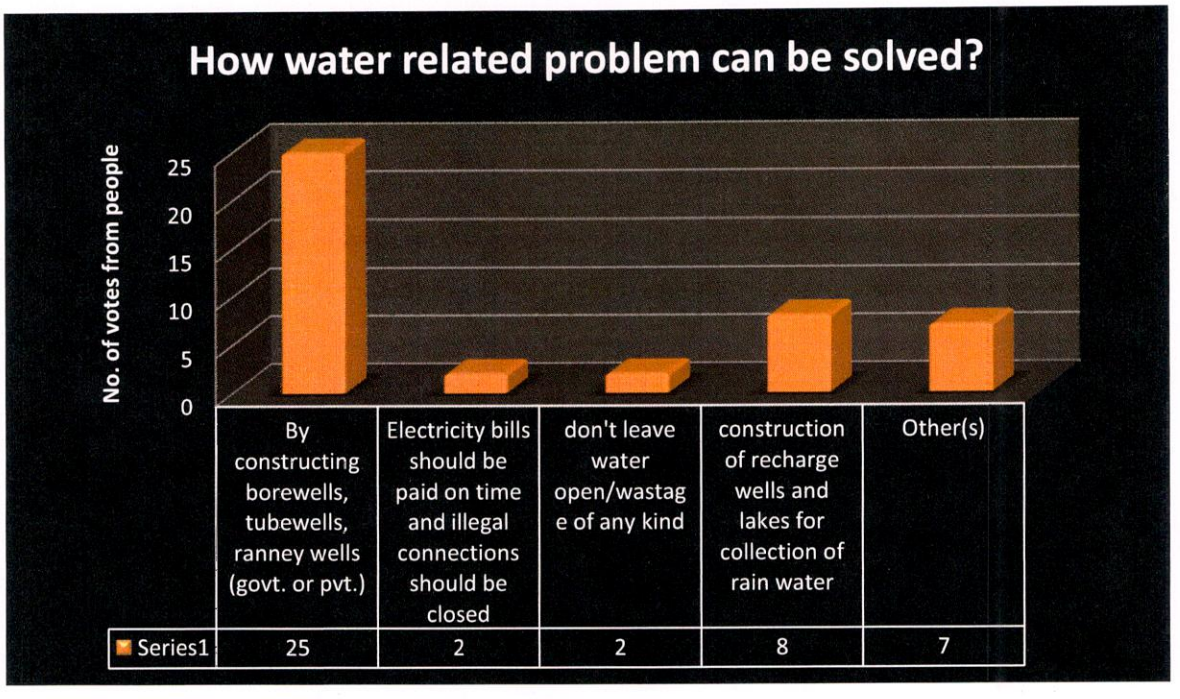

Figure 8: Suggestion of the villagers on solving water related problems in Mewat district, Haryana

5.2 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 9, 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.

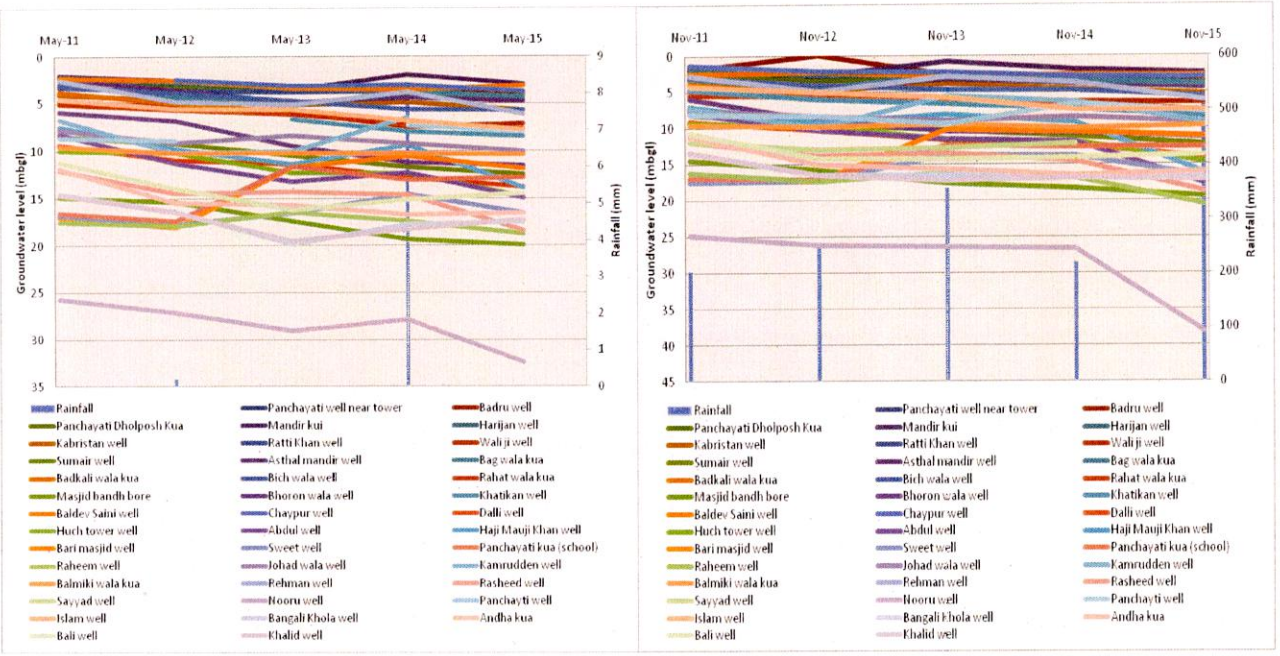

Figure 9: Variations in Groundwater level for pre & post monsoon seasons for the period 2011-15

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.

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 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 level rise 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.

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

5.3 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. 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 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)**

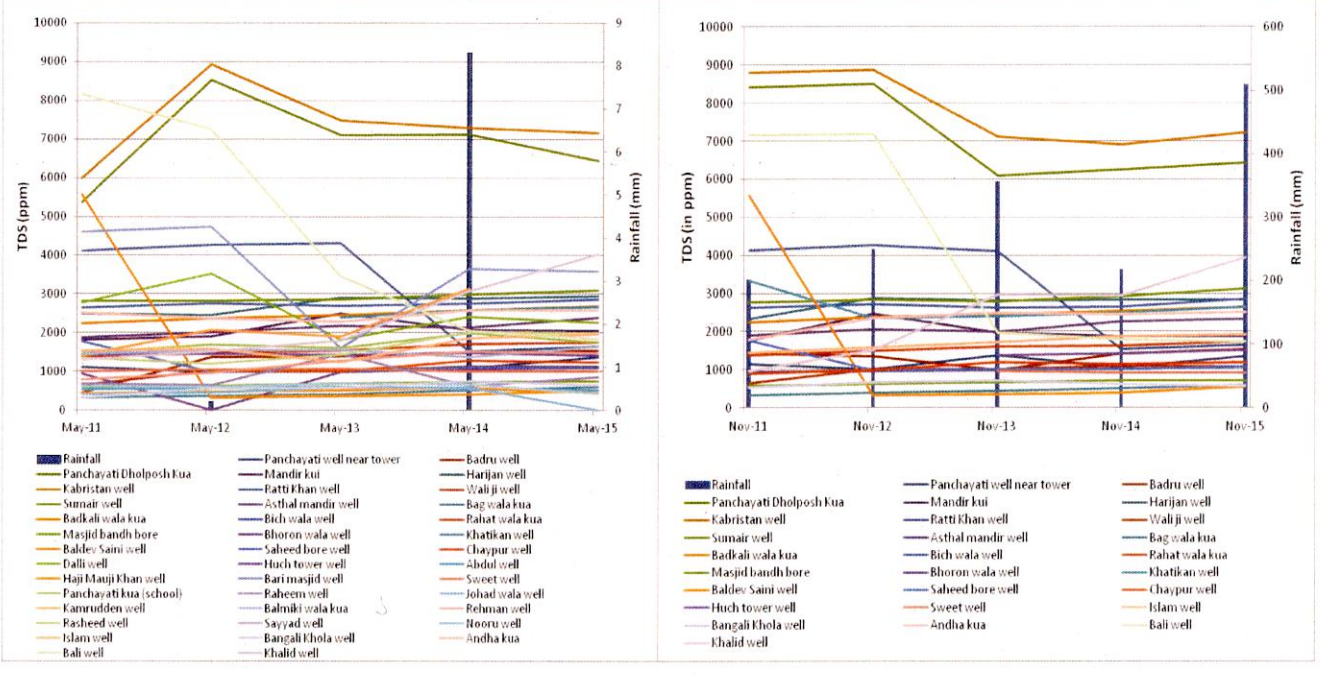

Figure 10: Variations in TDS for pre & post monsoon seasons for the period 2011-15

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 10) 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].

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	14	26	7	14	4	1

	TDS						
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

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 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); which was used by Krishan et al. (2016a-f) and Singh et al. (2015) for evaluating the groundwater quality in some parts of Uttar Pradesh, Gujarat and Punjab.

5.4 Water Quality and Isotopes analysis:

The statistical summary from table 9 shows that pH ranged from 7.3 to 8.5 with an average value of 7.9 and all the samples are within the desirable limit of 6.5-8.5. Total dissolved solids range from 509 to 21641 mg/l with an average value of 4285 mg/l. 77% of the samples fall in the permissible limit of 2000 mg/l while none of the samples fall under the desirable limit of 500 mg/l. High salinity may be due to the geogenic in nature. The anion chemistry of the analysed samples shows that Cl^-, SO_4^{2-}, HCO_3^-, contributed about 99% of total anions and follows the abundance order of $Cl^- > SO_4^{2-} > HCO_3^- > NO_3^- > F^-$ in all the samples.

Table 9: The statistical summary of the water quality parameters

Statistical parameters	pH	TDS	F^-	Cl^-	HCO_3^-	SO_4^{2-}	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Minimum	7.3	509	0.6	200	120	194	0.5	107	94	30	6.2
Maximum	8.5	21641	5.2	10547	600	645	48.8	3980	3953	4850	50.6
Average	7.9	4285	1.8	2041	323	342	11.6	790	887	888	13.9
Standard Deviation	0.4	7375	1.4	3516	118	125	14.3	1401	1388	1756	12.3
D.L.	6.5 8.5	500	1	250	NR	200	45	75	30	NR	NR
P.L.	NR	2000	1.5	1000	NR	400	NR	200	100	200	NR

D.L. = Desirable limit; P.L. = Permissible limit; ISO 10500 (2012): Drinking water

The major cations include Ca, Mg, Na and K. The water chemistry of the Mewat district is dominated by Na, Ca and Mg. On an average Na and Mg constitute 34.4% each and 68.8% of the total cations (TZ+). In general, the cations follow dominance order as Na=Mg>Ca>K water type. The weathering and cation exchange processes normally control the levels of these cations in the water.

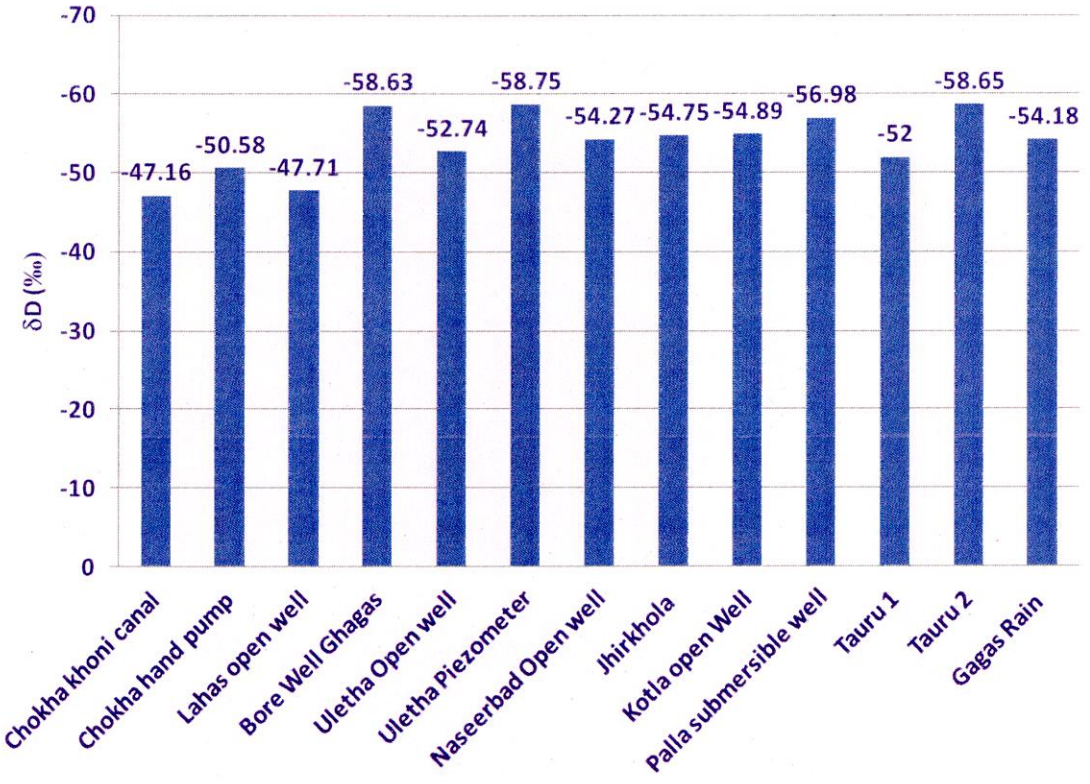

Figure 11: Variation of isotopes in groundwater of Mewat, Haryana

6. CONCLUSION

In the present study, from the survey, in Mewat district it has been observed that the main occupation is farming and majority of farmers have small land holdings (0-3 acre). Groundwater is the main source of irrigation. Mewat district faces mainly 2 water related issues: (i) high groundwater salinity and (ii) declining groundwater levels. Since the majority of villagers are depend on farming therefore, these problems will result in huge loss of crop yield and hence the economy.

As per the recent development that was planned by the Haryana government to recharge the groundwater by making two artificial lakes in the state, the first out of these two is Kotla Lake , which would be created over 178 acres in Mewat by reviving a dried lake bed spread across Haryana and Rajasthan, for the utilisation of the surplus flood water of river Yamuna for irrigation, drinking and recharging of the depleting ground water. This besides recharging the groundwater can also irrigate around 27000 acre of land.

The survey has helped in understanding the water related issues from the perspective of inhabitants of Mewat more critically and holistically. There is a need of strengthening soil, water and groundwater institutions along with capacity building, training and education for soil and water management, quality monitoring, and aquifer remediation on a continuous basis.

From groundwater level and TDS results, 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 (Thomas et al., 2012). 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 (Acharya et al., 2016). The groundwater in many wells which previously contained freshwater has now salinized.

All the groundwater samples are depleted as compared to canal sample which may be due to the evaporation effect in open system.

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 (Sharma, 2014). 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.

REFERENCES

Acharya, B.N. Summary of a Case Study to Promote Sustainable Groundwater Management in Rural Mewat District, Haryana, India. Institute for Global Environmental Strategies (IGES). http://www.iges.or.jp/en/natural-esource/groundwater/PDF/Groundwater_management_in_Mewat.pdf (assessed on 14-07-2016).

CGWB, Central Ground Water Board (2012) Ground Water Information Booklet, Mewat District, Haryana.

Chopra RPS, Krishan G (2014a) Analysis of aquifer characteristics and groundwater quality in southwest Punjab, India. J Earth Sci Engineer 4(10): 597-604. http://doi: 10.17265/2159-581X/2014. 10. 001

Chopra RPS, Krishan G (2014b) Assessment of groundwater quality in Punjab. J Earth Sci Climate Change 5(10):243. http://dx.doi.org/10.4172/2157-7617.1000243

Customized Rainfall Information System (CRIS), Hydromet Division, India Meteorological Department, Ministry of Earth Sciences (assessed on 14-07-2016).

http://www.census2011.co.in/

IAB. Indian Agriculture in Brief. (27th edition). 2000. Agriculture Statistics Division, Ministry of Agriculture, Govt. of India, New Delhi.

Krishan G, Chopra RPS (2015) Assessment of water logging in south western (SW) parts of Punjab, India-a case study from Muktsar district. NDC-WWC J 4(1): 7-10.

Krishan, Gopal, Singh, Surjeet, Kumar, C.P, Garg, P.K., Gurjar, Suman, Ghosh, N.C. and Chaudhary, Anju. (2016a). Assessment of groundwater quality for drinking purpose using water quality index in Muzaffarnagar and Shamli districts, Uttar Pradesh, India. Hydrology: Current Research, 7:1. http://dx.doi.org/10.4172/2157-7587.1000227. (2016)

Krishan, Gopal, Kumar, C.P, Purandara, B.K., Singh, Surjeet, Ghosh, N.C., Gurjar, Suman and Chachadi, A.G. (2016b). Assessment of variation in water quality index (WQI) in north Goa, India. Current World Environment. 11(1): 39-46. (2016).

Krishan, Gopal, Singh, Surjeet, Kumar, C.P, Gurjar, Suman and Ghosh, N.C. (2016c). Assessment of water quality index (WQI) of groundwater in Rajkot district, Gujarat, India. Earth Science and Climate Change. 7:3, http://dx.doi.org/10.4172/2157-7617.1000341. (2016).

Krishan, Gopal, Rao, M.S. and Singh, Surjeet. (2016d). Water quality index of groundwater in different geomorphological units in Bist-Doab, Punjab, India. The Research Journal. 2(2): 1-4. (2016)

Krishan, Gopal, Singh, Surjeet, Gurjar, Suman, Kumar, C.P, and Ghosh, N.C. (2016e). Water Quality Assessment in Terms of Water Quality Index (WQI) Using GIS in Ballia District, Uttar Pradesh, India. Environmental and Analytical Toxicology. 6:3, http://dx.doi.org/10.4172/2161-0525.1000366 (2016).

Krishan, Gopal, Singh, Surjeet, Sharma, Anupma, Sandhu, C., Grischek, T., Gurjar, Suman, Kumar, Sumant, Singh, R.P., Glorian, H. and Bornick, H. (2016f). Assessment of river quality for river bank filtration along Yamuna River in Agra-Mathura districts of Uttar Pradesh. International Journal of Environmental Sciences. 7(1): 56-67. (2016).

Krishan G, Singh RP, Takshi KS. (2015a). Water Level Fluctuation as the Sum of Environmental and Anthropogenic Activities in Southeast, Punjab (India). Journal of Environmental and Analytical Toxicology 5: 298.

Krishan G, Singh RP, Khanna A, Singh S, Ghosh NC. (2015b). Recent groundwater status of groundwater in Haridwar district, Uttarakhand. In: Proceedings of National Seminar on R & D Perspective for Rejuvenation of River Ganga during 16-17 December, 2015 at NIH, Roorkee, pp: 12-13.

Krishan G, Singh S, Sharma A, Sandhu C, Grischek T, et al. (2015c). Assessment of river quality for river bank filtration along Yamuna River in AgraMathura districts of Uttar Pradesh. In: Proceedings of National conference on Monitoring and Management of Drinking Water Quality (MMDWQ) & XXVIII annual conference of National Environment Science Academy during 21-23 December, 2015 at UCOST, Dehradun, p: 48.

Krishan G, Rao MS, Loyal RS, Lohani AK, Tuli NK, Takshi KS, Kumar CP, Semwal P, Kumar S (2014a) Groundwater level analyses of Punjab-a quantitative approach. Octa J Environ Res 2(3): 221-226.

Krishan G, Lapworth DJ, Rao MS, Kumar CP, Smilovic M, Semwal P (2014b) Natural (baseline) groundwater quality in the Bist-Doab catchment, Punjab, India: a pilot study comparing shallow and deep aquifers. Int J Earth Sc Engg 7: 16--26

Krishan G, Lohani AK, Rao MS, Kumar CP (2014c) Prioritization of groundwater monitoring sites using cross-correlation analysis. NDC-WWC J 3(1): 28-31.

Krishan G, Rao MS, Purushotaman P, Yawat YS, Kumar CP, Gupta S, Bhatia AK, Marwah S, Kaushik YB, Angurala MP, Singh GP (2014d) Groundwater resources in Bist-Doab region, Punjab, India- an overview. NDC-WWC J 3(2): 5-13.

Krishan G, Rao MS, Kumar CP, Semwal P (2013) Identifying salinization using isotopes and ionchemistry in semi-arid region of Punjab, India. J Geol Geosci 2:4, http://dx.doi.org/10.4172/jgg.1000129

Lapworth DJ, MacDonald AM, Krishan G, Rao MS, Gooddy DC, et al. (2015). Groundwater recharge and age-depth profiles of intensively exploited groundwater resources in northwest India. Geophysical Research Letters 42: 7554-7562. (2015)

Lapworth DJ, Krishan G, Macdonald AM, Rao MS, Gooddy DC, et al. (2014a). Using Environmental Tracers to Understand the Response of Groundwater Resources in Nw India to Sustained Abstraction. In: Proceedings of 41st International Conference of International Association of Hydro-geologist (IAH2014) on Groundwater: Challenges and Strategies during Sep. 18-19, 2014. (2014)

Lapworth DJ, Krishan G, Rao MS, MacDonald A (2014b) Intensive Groundwater exploitation in the Punjab – an evaluation of resource and quality trends. Technical Report. NERC Open Research Archive, BGS-UK. Project report Groundwater Science programme, BGS, UK.

MacDonald, Alan, Bonsor, Helen , Ahmed, Kazi, Burgess, William, Basharat, Muhammad, Calow, Roger, Dixit, Ajaya, Foster, Stephen, Krishan, Gopal , Lapworth, Daniel , Lark, Murray, Moench, Marcus, Mukherjee, Abhijit, Rao, M.S., Shamsudduha, Mohammad, Smith, Linda, Taylor, Richard, Tucker, Josephine, Steenbergen Frank van, Yadav, Shobha. (2016). Groundwater depletion and quality in the Indo-Gangetic Basin from in situ observations. Nature Geosciences.

MacDonald AM, Bonsor HC, Taylor R, Shamsudduha M, Burgess WG, et al. (2015). Groundwater Resources in the Indo-Gangetic basin- Resilience to climate change and abstraction. British Geological Survey Open Report, p: 51.

Macdonald AM, Bonsor HC, Krishan G, Rao MS, Ahmed KM, et al. (2014). Groundwater in the Indo-Gangetic Basin: Evolution of Groundwater Typologies. In: Proceedings of 41st International Conference of International Association of Hydro-geologist (IAH-2014) on Groundwater: Challenges and Strategies during Sep. 18-19, 2014.

Macdonald AM, Bonsor HC, Rao MS, Krishan G, Steenburgen FV, et al. (2013). Groundwater Topologies in the Indo Gangetic Basin. In: Proceedings of International Conference on Advances in Water Resources Development & Management held at PU, Chandigarh.

Mehra. M., Sharma. D., Kathuria. P. (2012). Groundwater use dynamics: Analyzing performance of Micro-irrigation system – A case study of Mewat district, Haryana, India." International Journal of Environmental Sciences, 3, 471-480.

Rao MS, Purushothaman P, Krishan G, Rawat YS, Kumar CP (2014) Hydrochemical and isotopic investigation of groundwater regime in Jalandhar and Kapurthala districts, Punjab, India. Int J Earth Sc Engg 7 (01): 06-15.

Rodell M, Velicogna I, Famiglietti JS (2009) Satellite-based estimates of groundwater depletion in India. Nature 460: 999-1003

Saini R, Krishan G, Tuli NK, Kaur G (2015) Assessment of water logging and salinity in Punjab: Causes and management. In: Proceedings of National conference on "Water logging and soil salinity in irrigated agriculture" during 3-4 September at Chandigarh. p 75-83.

Saini, Vikas. (2016). Spatial hydro-chemical characterization of groundwater in Mewat district, Haryana. M.Tech thesis work carried out at National Institute of Hydrology, Roorkee and submitted at KU, Kurukshetra.

Sharma. L.M. (2014). Innovation for Making Potable Water Available in Saline Ground water Areas. Journal of Water Resource and Protection, 6, 1284-1289.

Singh, Surjeet, Ghosh, N.C., Krishan Gopal, Galkate Ravi, Thomas T. and Jaiswal R.K. (2015). Development of an Overall Water Quality Index (OWQI) for Surface Water in Indian Context. Current World Environment. 10(3): 813-822.

Sitender, Rajeshwari. (2011). Delineation of groundwater potential zones in Mewat District, Haryana, India. International Journal of Geomatics and Geosciences, 2, 270-281.

Tanwar, B.S. and Kruseman, G.P. (1985). Saline Ground Water Management in Haryana State, India. Hydrogeology in the Service of Man. Mémoires of the 18th Congress of the International Association of Hydrogeologists, Cambridge, 24-30.

Thomas N, Sheler R, Reith B, Plenner S, Sharma LM, Saiphy S, Basu N, Muste MM. (2015). Rapid Assessment of the Fresh-Saline Groundwater Interaction. in the Semi-arid Mewat District (India). http://www.iihr.uiowa.edu/intl-perspectives2011-12/home/outcomes/%E2%80%A (assessed on 04-07-2016).

World Bank. Deep Well and Prudence: Towards Pragmatic Actions for Addressing Groundwater Overexploitation in India. The World Bank. (2010).

ANNEXURE

Table 1: The Questionnaire survey carried at Mewat district, Haryana, India

S. No.	Particulars	Details				
1.	Name	Zuhuru	Shitban	Dr. Prem Chand	Ramzaan	Aasu
2.	Name of Father	Firoza	Ram Singh	Jagdish	Chandra	Chittar
3.	Address	Village khedla kala,Tehsil Firozpur Jhirka, District Mewat (Nuh), Haryana-122108	Village Papda, Tehsil Punahana, District Mewat (Nuh), Haryana-122108	Village Maroda, Tehsil Nagina, District Nuh, Haryana-122108	Village Mehlaka, Tehsil Firozpur Jhirka, District Mewat (Nuh), Haryana - 122108	Village Sabras, Tehsil Taoru, District Mewat, Haryana-122108
4.	Occupation	Farmer	Farmer	Farmer	Farmer	Farmer
5.	Quality of drinking water	Sweet water	Saline water	Saline water	Sweet water	Saline water
6.	Land for Irrigation	4 acre	2 acre	2 acre	3 acre	6 acre
7.	Water related problems	Drying of borewells and tubewells due to decline in water level, due to lack of water only rabi and kharif crops are grown	Water depth is more, it's saline, less suitable for irrigation	Saline water is there which is not suitable for drinking	Saline and deep water	Water level is low which results in high costs for taking water
8.	How water problems can be solved?	By constructing canal and by using sprinkle irrigation system	Drinking water should be joined with ranney well, Rain water should be collected somewhere (may be recharge well)	Arrangement for canal and availiability of water for irrigation should be there	Through contruction of canals, Ranney wells for drinking water and rain water collection	Electricity should come regularly for which all the farmers should have legal connections
9.	What is the water level below ground?	80-100 ft.	500 ft.	20 ft.	100 ft.	100 ft.
10.	Farming related problems	Lack of water and uneven ground surface	Good manure, lack of seeds, lack of water for proper irrigation	No other crop grows except Wheat	Manure and seeds are not of good quality, Water for irrigation is not available in required quantity	Due to lack of water and electricity on time, insects gets into the crops
11.	Types of crops	Wheat, Mustard, Millet, Sorghum	Mustard, wheat, Millet, Sorghum	Sarso, wheat, Millet, Sorghum	Sarso,Wheat, Millet, Sorghum, Cotton	rabi (wheat, sarso), Kharif (Jawar, Bajara, dhaincha)
12.	Types of tube wells for Irrigation	Through submersible borewell	Borewell, Pipeline from canal	Diesel engine tubewell	Borewell	Submersible
13.	Contact number	9671913598		9813463656	9812251308	9813275330
14.	Date	29.03.2016	30.04.2016	05.05.2016	07.05.2016	