FINAL REPORT
(March, 2016 to March, 2017)

Baseline data collection and analysis of hydrological and hydro-geological data of Mewat district, Haryana

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Introduction

The water-logging and deteriorating ground water quality of Mewat district, Haryana has affected the Ferozpur Jhirka, Nagina, Nuh, and Punhana blocks severely. The reasons for this are considered to be due to low rate of groundwater withdrawal and salinity of groundwater. The net annual withdrawal is very less as compared to the recharge. These natural as well as anthropogenic factors, therefore, result ponding of water in the depression areas, both on surface and sub surface surface, creating almost water logging conditions. In the areas, where water level is shallow, groundwater brings salts upward by capillary action and these dissolved salts are left at the surface due to evaporation. Such salts affected lands are seen in Nuh block and parts of Punhana block.

The origin of salinity in soils and in groundwater in shallow and deeper aquifers and its growth in space and time is not well understood. Considering this, the present study will be carried out mainly in the Mewat district of Haryana shown in Fig. 1. The district covers an area of 1859.61 sq km and comprises of 5 blocks (Ferozpur Jhirka, Nagina, Nuh, Taoru and Punhana) and out of which 2 blocks namely Ferozpur Jhirka and Taoru are over exploited and Punhana block is critical. The objectives are: (i) to collect baseline hydrological, hydrogeological and water quality data of Mewat district (ii) To analyze and identify the problems and groundwater recharge sources using isotopes

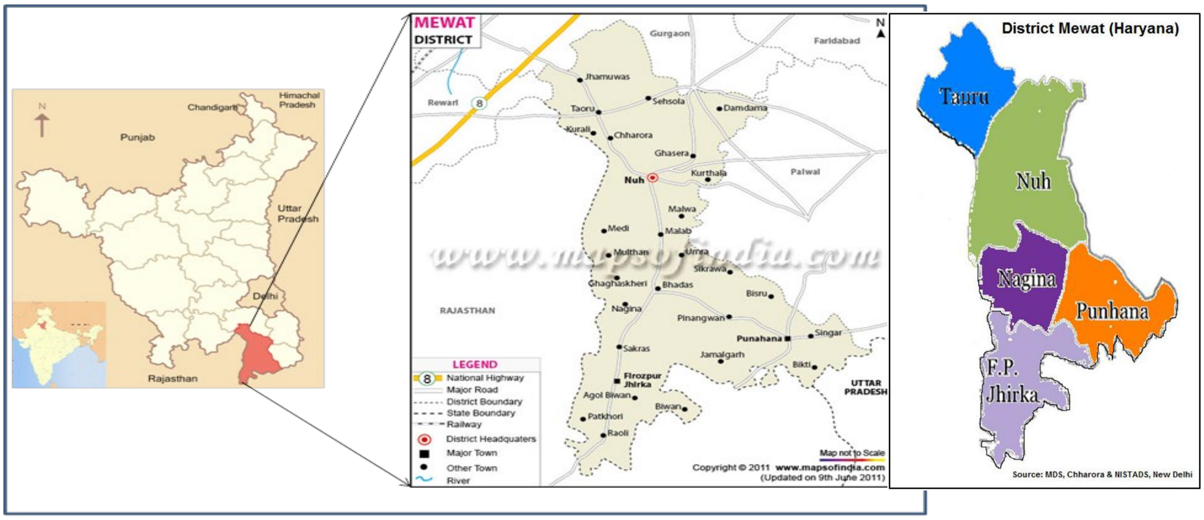

Fig. 1 Map of Mewat district

Study Area

Mewat district lies between latitude 27° 39’ to 28° 20’ N and longitude 76° 51’ - 77° 20’ E. The district has a total population of 1089263 (2011, census). Total area is 1859.61 sq. km out of which cultivable area is 1361 sq. km and forests are covered in 30 sq. km area. The average rainfall is 594 mm. The physiographic unit is flat alluvial plain with major drainages are Kotla, Nuh and Ujina. In Mewat district the gross irrigated area is 236434 ha and out of which 72,000 ha area is irrigated by tube-wells/Borewells and 16,000 ha is irrigated by canals. Long term water level trend in 10 yrs in m /yr fall is –0.12 to –0.04 while rise is found 0.36 to 0.48 m. Pre-monsoon depth to water level is 1.15m-27.35mbgl while post-monsoon depth to water level is 1.05m-27.30mbgl.

Methodology

Field Survey

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. The survey results for salinity and water level were validated with the field based observations.

Long term water level and salinity data

TDS and Groundwater levels were recorded for 40 monitoring wells during the time period 2011-15 (Table 1) (Figure 2). The wells are widely distributed and developed by Sehgal foundation at all the five blocks of Mewat district, Haryana. The groundwater levels were recorded using water level indicator and were measured as ‘meter below ground level (m bgl)’ and TDS readings were taken in-situ which were measured as ‘parts per million (ppm)’. The database of five years groundwater level, TDS readings and average rainfall has been prepared and analyzed for the changes and trends during the period of observations.

Table 1: Location of the wells

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

Fig. 2 Spatial distribution of wells

Water chemistry

In order to investigate the changing groundwater conditions (quality and quantity), water samples were collected (Fig. 3) randomly from the sites given in Fig. 4 in the months of March, May, August and November, 2016 using the standard procedures. These samples were analysed for salinity, alkalinity and major anions F, Cl, NO_3 & SO_4 and cations Ca, Mg, Na, K. Analysis of stable isotopes of groundwater carried out to investigate the groundwater dynamics.

Fig. 3. Water Sampling

Soil analysis

3 representative soil profiles were sampled upto depth of 1.2 m at Ghagas, Karhera and Tauru and shown in fig. 5. The samples were analysed for pH, EC, trace metals (Fe, Mn, Cu, Zn, As, Cd, Ni) at CSSRI-ICAR laboratory, Karnal.

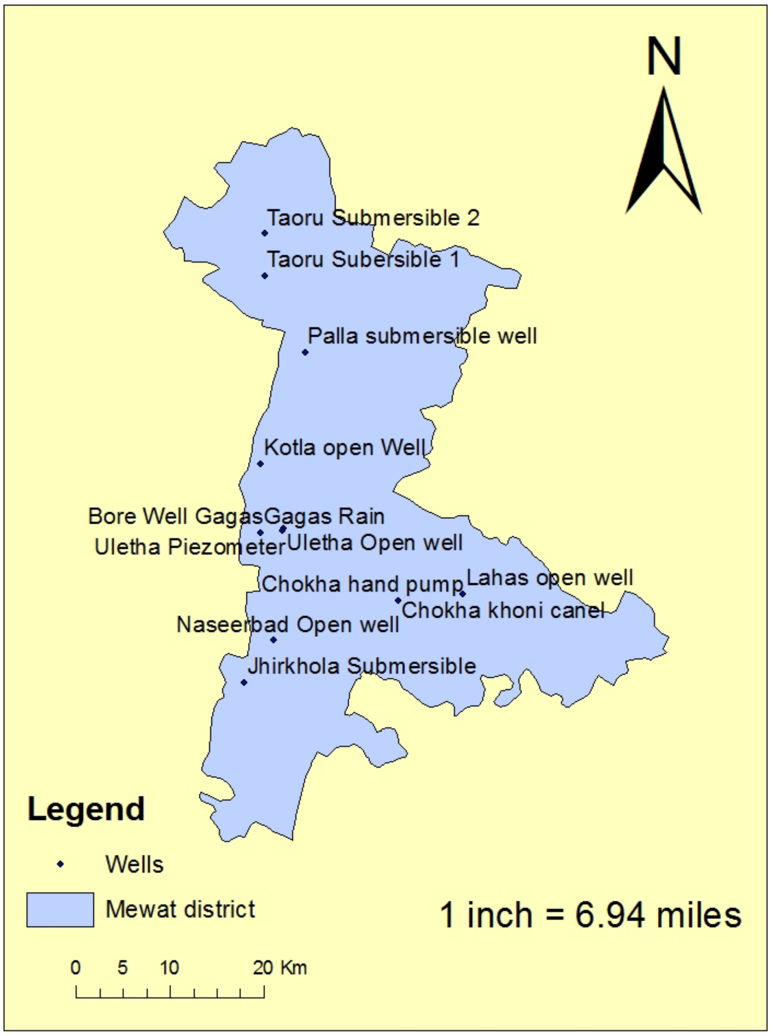

Fig. 4. Sampling sites

Fig. 5. Soil Sampling

Results and Discussion

Survey based results

The answers/responses received from the villagers are compiled. As per the survey, agriculture is the main occupation (97%) of the inhabitants (Fig. 6a) 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. 6b). 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. 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%).

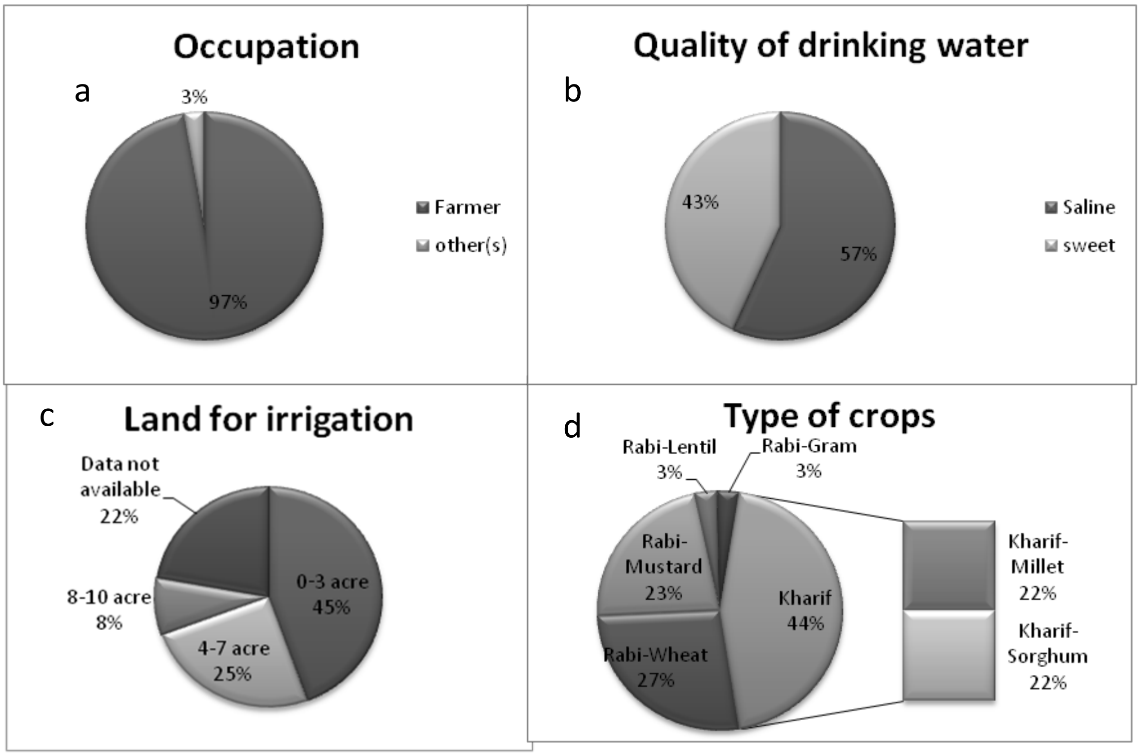

Fig. 6. Response of the villagers on occupation (a); quality of drinking water (b); land for irrigation (c); and, type of crops (d) in Mewat district, Haryana

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. 7).

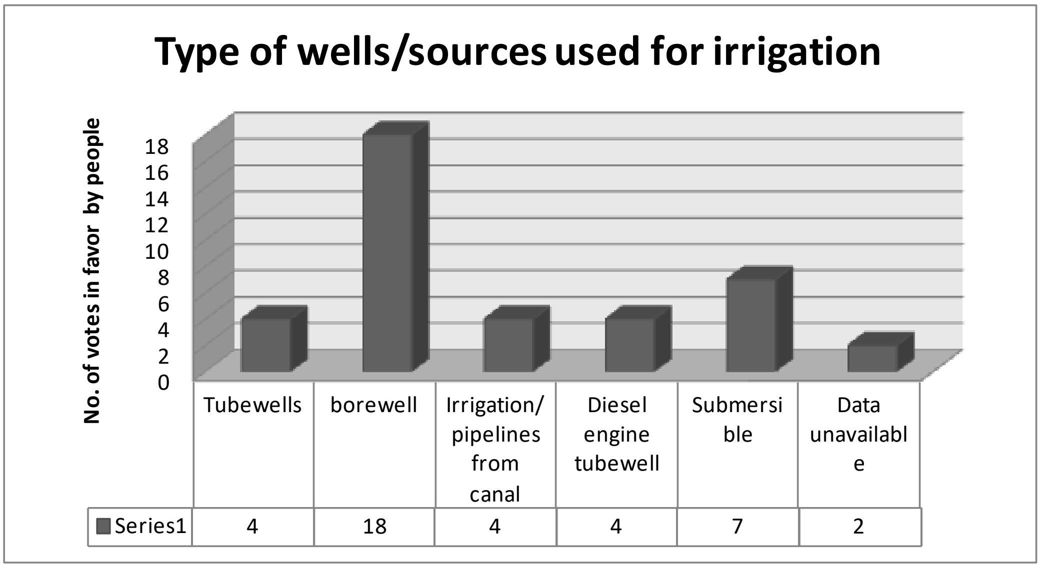

Fig. 7. Sources of irrigation in Mewat district, Haryana

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. 8).

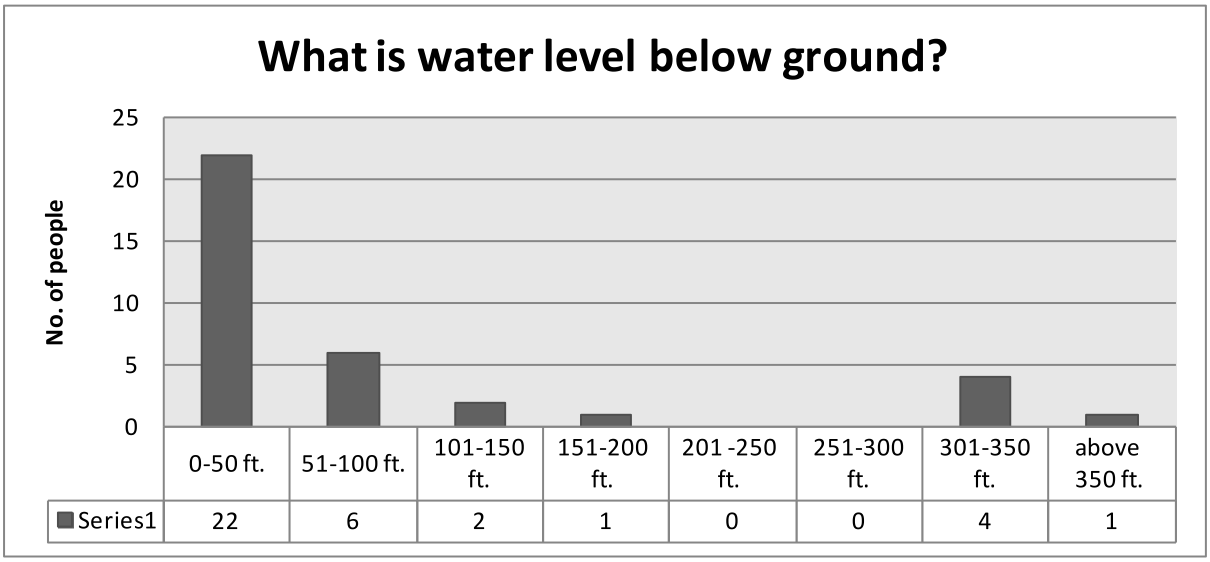

Fig. 8. Water level from the villagers' point of view in Mewat district, Haryana

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. 9).

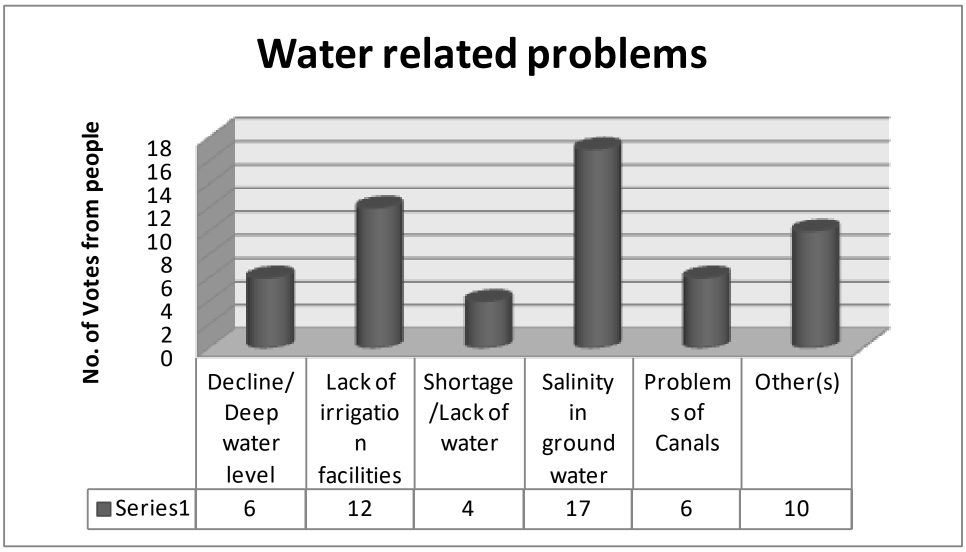

Fig. 9. Response of the villagers on types of water related problems in Mewat district, Haryana

Fig. 10 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. 11 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%).

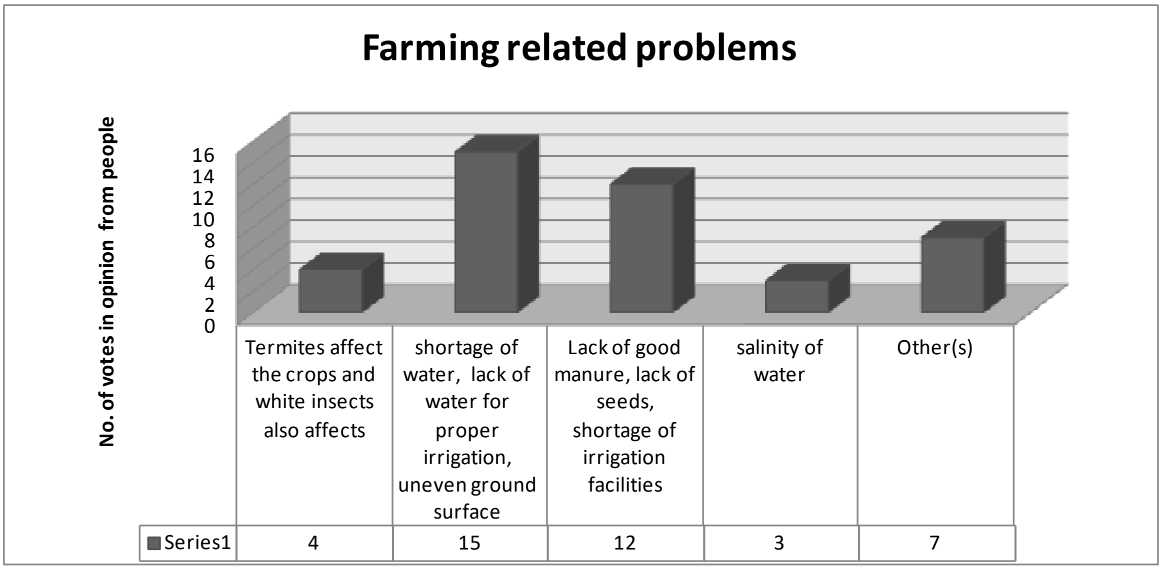

Fig. 10. Farming related problems in Mewat district, Haryana

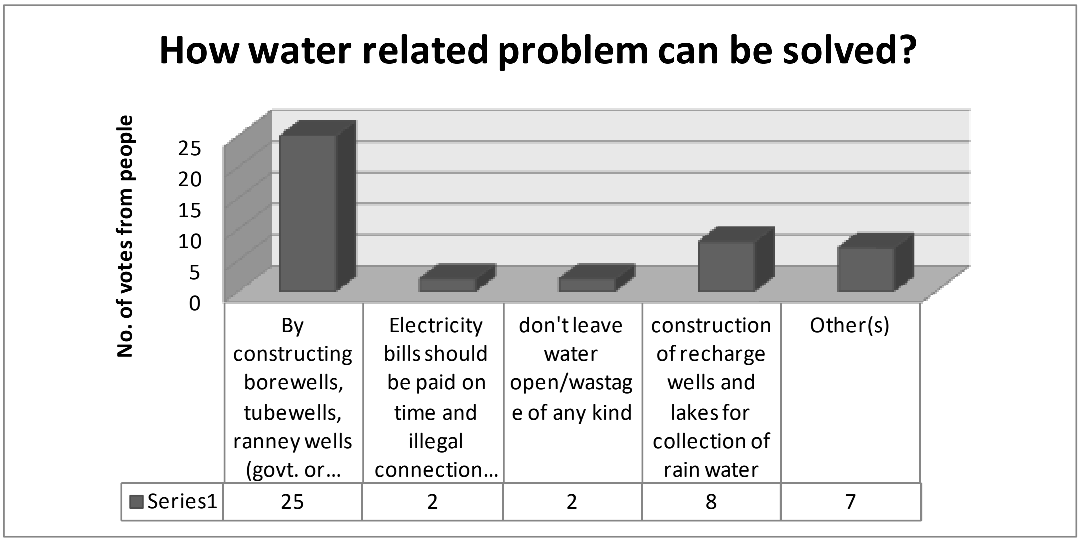

Fig. 11. Suggestion of the villagers on solving water related problems in Mewat district, Haryana

Long term water level and salinity data

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 2, 3 & 4:

Table 2: 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).

Table 3: Percentage changes of groundwater level data by using above statistics (n = 40)

S.No.		Pre-monsoon			Post-monsoon	
		Difference in water level between 2011-15	%age inc./dec. in water level		Difference in water level between 2011-15	%age inc./dec. in water level
1.	Min	0.95	47.5		1.1	84.61
2.	Max	6.75	26.26		13.3	53.63
3.	Average	2.39	29.03		2.77	35.23

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

From the above calculations (minimum, maximum and average values), it is visible that decline in groundwater level is very much during five years’ time period for pre-monsoon season. The decline in minimum, maximum and average groundwater level is 47.5%, 26.26% and 29.03% respectively. For post-monsoon season, the decline in groundwater level is 84.61%, 53.63% and 35.23% for minimum, maximum and average values respectively.

Table 4: Allotment of number of wells under different ranges of groundwater level data (n = 40)

	No. of wells have increased	No. of wells have decreased	No. of wells under different decrement limits

	GW level	GW level	(0.0-2.0) mbgl	(2.1-5.0) mbgl	(5.1-10.0) mbgl	More than 10.0 mbgl
Overall Increment/Decrement in groundwater level	4	36	12	19	3	1
Pre-Monsoon Increment/Decrement in groundwater level	5	35	8	20	5	0
Post-Monsoon Increment/Decrement in groundwater level	4	36	13	15	5	1
Pre-Monsoon annual Increment/Decrement in groundwater level	5	35	35	0	0	0
Post-Monsoon annual Increment/Decrement in groundwater level	4	36	36	0	0	0

The overall increment (from May 2011 to November 2015) in groundwater level is observed in 4 wells and decrement is observed in 36, out of which 12 wells have decreased between 0.0-2.0 mbgl, 19 wells decreased between 2.1-5.0 mbgl, 3 wells decreased between 5.1-10.0 mbgl and more than 10.0 mbgl decrease was observed in 1 well.

The pre-monsoon total increment (May 2011-May 2015) in groundwater level is observed in 5 wells and decrement is observed in 35 wells. 8 wells have decreased between 0.0-2.0 mbgl, 20 wells have decreased between 2.1-5.0 mbgl and 5 wells have decreased between 5.1-10.0 mbgl.

The post-monsoon total increment (November 2011-November 2015) in groundwater level is observed in 4 wells and decrement is observed in 36 wells. 13 wells have decreased between 0.0-2.0 mbgl, 15 wells have decreased between 2.1-5.0 mbgl, 5 wells have decreased between 5.1-10.0 mbgl and more than 10.0 mbgl decrease was observed in 1 well.

Pre-monsoon annual increment for each year during 2011-2015 in groundwater level is observed in 5 wells and decrement in 35 wells. All these 35 wells have decreased between 0.0-2.0 mbgl per year.

Post-monsoon annual increment for each year during 2011-2015 in groundwater level is observed in 4 wells and decrement in 36 wells and all these 36 wells have decreased between 0.0-2.0 mbgl per year.

Groundwater salinity:

The results obtained for Total Dissolved solids (TDS) 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 5,6 & 7:

Table 5: 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).

Table 6: Percentage changes of TDS data by using above statistics (n = 40)

S.No.	Pre-monsoon				Post-monsoon	
		Difference in TDS between 2011-15	%age inc./dec. in TDS		Difference in TDS between 2011-15	%age inc./dec. 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).

Also, here from the above table for minimum values; both, pre-monsoon and post-monsoon season data shows that groundwater TDS has increased but maximum and average values of TDS in groundwater has actually decreased.

Table 7: Allotment of number of wells under different ranges of groundwater level data (n = 40)

	No. of wells have decreased GW TDS	No. of wells have increased GW TDS	No. of wells under different increment limits			
			(0–200) ppm	(201-500) ppm	(501-1000) ppm	More than 1000 ppm

Overall Increment/Decrement in groundwater TDS	11	29	7	14	3	5
Pre-Monsoon Increment/Decrement in groundwater TDS	12	28	6	16	2	4
Post-Monsoon Increment/Decrement in groundwater TDS	14	26	7	14	4	1
Pre-Monsoon annual Increment/Decrement in groundwater TDS	12	28	22	4	1	0
Post-Monsoon annual Increment/Decrement in groundwater TDS	14	26	25	0	1	0

The overall decrement (from May 2011 to November 2015) in groundwater TDS is observed in 11 wells and increment is observed in 29, out of which 7 wells have increased TDS between 0-200 ppm, 14 wells increased between 201-500 ppm, 3 wells increased between 501-1000 ppm and more than 1000 ppm increase was observed in 5 well.

The pre-monsoon total decrement (May 2011-May 2015) in TDS is observed in 12 wells and increment is observed in 28 wells. 6 wells have increased TDS between 0-200 ppm, 16 wells have increased between 201-500 ppm, 2 wells have increased between 501-1000 ppm and more than 1000 ppm increase was observed in 4 wells.

The post-monsoon total decrement (November 2011-November 2015) in TDS is observed in 14 wells and increment is observed in 26 wells. 7 wells have increased between 0-200 ppm, 14 wells have increased between 201-500 ppm, 4 wells have increased between 501-1000 ppm and more than 1000 ppm increase was observed in 1 well.

Pre-monsoon annual decrement for each year during 2011-2015 in groundwater TDS is observed in 12 wells and increment in 28 wells. Out of these 28, 22 wells have increased TDS between 0-200 ppm, 4 wells have increased between 201-500 ppm and 1 well has increased between 501-1000 ppm.

Post-monsoon annual decrement for each year during 2011-2015 in groundwater TDS is observed in 14 wells and increment in 26 wells. Out of these 26, 25 wells have increased TDS between 0-200 ppm and 1 well has increased TDS between 501-1000 ppm.

Soil analysis

Soil analysis show that the sandy loam and loamy sand are the major soil types prevailing in the area. The moisture content ranged from 6 to 36%. Bulk density found to range from 1.49 g/cm^3 to 1.84 g/cm^3. Nitrogen and potassium were found low, phosphorus was in medium range. In most of soil samples- Arsenic, cadmium and nickel were found above permissible limits and very high copper, iron, zinc and manganese content.

Water chemistry

The statistical summary of the measured parameters is given in Table 1.

	pH	TDS	F^-	Cl^-	HCO_3^-	SO_4^{2-}	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	Zn	Fe	Mn	Cu
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l
Min	7.3	509	0.6	200	120	194	0.5	107	94	30	6.2	8.3	164.4	0.2	0.5
Max	8.5	21641	5.2	10547	600	645	48.8	3980	3953	4850	50.6	425.4	727.1	89.7	51.5
Avg	7.9	4285	1.8	2041	323	342	11.6	790	887	888	13.9	51.8	417.1	15.0	8.5
S.D.	0.4	7375	1.4	3516	118	125	14.3	1401	1388	1756	12.3	118.0	207.2	27.8	14.8
D.L.	6.5 8.5	500	1	250	NR	200	45	75	30	NR	NR	5000	300	100	50
P.L.	NR	2000	1.5	1000	NR	400	NR	200	100	200	NR	15000	NR	300	1500

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

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.

Anions (F^-, Cl^-, HCO_3^-, SO_4^{2-} and NO_3^-)

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.

Fluoride range from 0.6 mg/l to 5.2 mg/l with an average value of 1.8 mg/l where about 50% of the samples are found above the permissible limit of 1.5 mg/l and 38% samples are below the desirable limit of 1 mg/l. On an average fluoride is contributing <0.1% of the total anionic balance (Fig. 4). Fluoride (F-) ions have dual significance in water supply. High concentration of fluoride causes dental flurosis (disfigurement of the teeth). The formation of fluoride complex may be important in solublizing beryllium, aluminium, tin and iron in natural water and are also contribute to aquatic fluoride. The fluoride in water may be derived from the weathering of rocks and phosphatic fertilizers used in agricultural field. Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite minerals etc in nature. Among the factors, which control the concentration of fluoride includes climate of the area and the presence of accessory minerals in the rock mineral assemblage through which the groundwater is circulating.

Chloride range from 200 to 10547 mg/l with an average of 2041 mg/l and 77% of the samples fall in the permissible limit of 1000 mg/l while only one sample fall under the desirable limit of 250 mg/l. On an average chloride is contributing 75.1% of the total anionic balance. Chloride is present in lower concentrations in common rock types, than any of the other major constituents of natural water and it is assumed that bulk of the chloride in ground water is primarily either from atmospheric source, sea water contamination or from anthropogenic sources. Abnormal concentration of chloride may result from pollution by sewage wastes. The large lateral variation in the chloride concentration and observed high concentration in some subsurface water indicate local recharge and may be attributed to the contamination by untreated industrial and domestic waste effluents from nearby area.

Bicarbonates ranged from 120 to 600 mg/l with an average value of 323 mg/l. Bicarbonates contributes 11.9% to the total anions (TZ-) in equivalent unit (Fig. 4). The bicarbonates are derived mainly from the soil zone CO_2 and at the time of weathering of parent minerals. The soil zone in the subsurface environment contains elevated CO_2 pressure (produce as result of decay of organic matter and root respiration), which in turn combines with rainwater to form bicarbonate. Bicarbonate may also be derived from the dissolution of carbonates and/or silicate minerals by the carbonic acid.

Sulphates range from 194 mg/l to 645 mg/l with an average value of 342 mg/l where 77% of the samples are found above the permissible limit of 400 mg/l and 2 samples are below the desirable limit of 200 mg/l. Sulphates are contributing 12.6% to the total anions (TZ-). The sulphate is usually derived from the oxidative weathering of sulphide bearing minerals like pyrite, gypsum or anhydrite. Apart from these natural sources, sulphate may be introduced through the application of sulphatic soil conditioners and fertilizers. The observed high concentration of SO_4 in some samples indicates the effects of industrial and anthropogenic activities in the area.

Nitrates range from 0.5 mg/l to 48.8 mg/l with an average value of 11.6 mg/l where only 1 sample is found above the desirable limit of 45 mg/l. In the groundwater of Mewat it contributed about 0.4 % of the total anions (TZ-). Nitrate and nitrite are highly soluble in water. Nitrate and nitrite are likely to remain in water until consumed by plant or other organism. Nitrate and nitrite are form of the element nitrogen which makes up about 80% of the air breath. The chief sources of the nitrate are atmosphere sources, legumes, plant, debris, animal, excrement. Nitrogen is recycled continually by plant and animal and is found in the cells of all living things. Organic nitrogen (Nitrogen combined with carbon) is found in protein and other compound. In organic nitrogen may exist in the free state of a gas, as ammonia. There are three major sources of nitrogen in the water - biological fixation, precipitation, and the application of fertilizers. Human activities have also influenced the nitrogen load considerably. The anthropogenic sources of nitrogen include (i) point source including industrial sewage, refuse dumps etc. discharged directly in to the surface water, (ii) diffuse source including runoff and leaching from rural and urban land and (iii) precipitation.

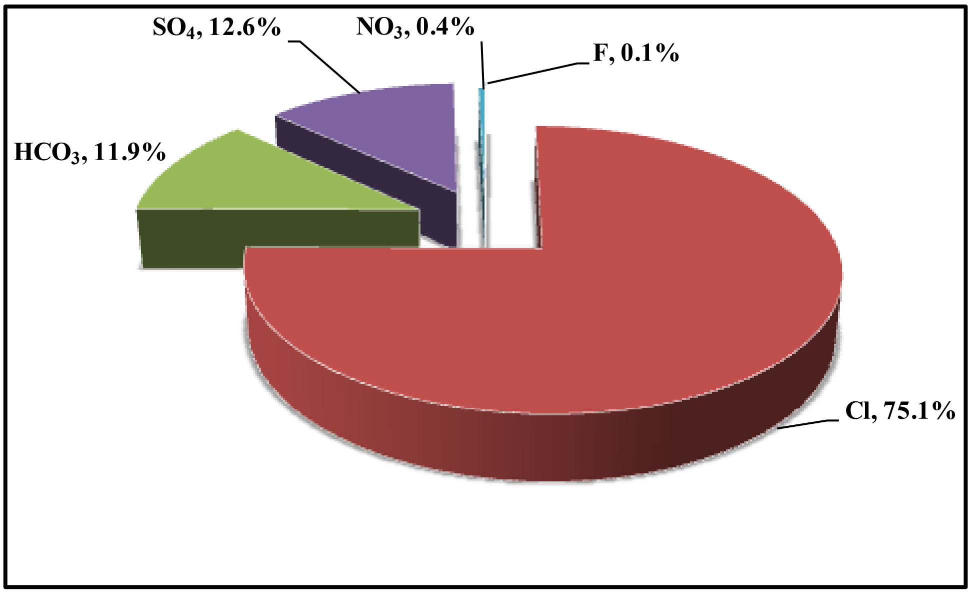

Fig. 4. Contribution of anions towards the total anionic charge balance (TZ-)

Cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+})

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+) (Fig. 5). In general, the cations follow dominance order as Na=Mg>Ca>K water type (Fig. 5). The weathering and cation exchange processes normally control the levels of these cations in the water.

Calcium range from 107 mg/l to 3980 mg/l with an average value of 790 mg/l where about 50% of the samples are found above the desirable and permissible limits of 75 mg/l and 200 mg/l, respectively. Calcium (Ca+) ion and calcium salt are among the most commonly encountered substances in water. Calcium in water arising mostly from dissolution of Ca bearing minerals of the aquifer formation and often it is the most abundant cation in aquatic water. Weathering and dissolution of calcium carbonate (limestone and dolomite) and calc-silicate minerals (amphiboles, pyroxenes, olivine, biotite etc) are the most common source of calcium is aquatic system.

Magnesium range from 94 mg/l to 3953 mg/l with an average value of 887 mg/l where only 1 sample is found below the permissible limit of 100 mg/l. Magnesium (Mg2+) is abundant in earth crust and is a common constituent of natural water. The presence of calcium and magnesium make the water hard. Olivine, clay minerals, dolomite, pyroxenes are the common source minerals for magnesium in the waters. The carbonate, chlorides, hydroxides, oxides and sulphate of the magnesium are used in the production of magnesium metal, refractories, fertilizers, ceramics, and explosives and medicinal. Magnesium compounds are more soluble than their counterparts. As a result, large amount of magnesium are rarely precipitated. Magnesium carbonate and hydroxide precipitate at pH>10. Magnesium concentration can be extremely high in certain closed saline lakes. Natural sources contribute more magnesium to the environment than all anthropogenic sources. The principle source of magnesium in natural water is ferromagnesian mineral in igneous rock and magnesium carbonate in sedimentary rock. The sulphate and chloride of magnesium are very soluble.

Sodium range from 30 mg/l to 4850 mg/l with an average value of 888 mg/l where about 31% of the samples are found above the permissible limit of 200 mg/l. Sodium is exceeding calcium and magnesium concentration in majority of samples of the area. The salts of Na are highly soluble in water and impart softness in food. The sodium in the aquatic system is derived from the atmospheric deposition, evaporate dissolution and silicate weathering. The evaporate encrustation’s of sodium/potassium salts may also be developed due to cyclic wetting and drying periods causes the formation of alkaline/saline soils, which may also serve as a source of sodium and potassium. The weathering of Na and K silicate minerals like albite, anorthite, orthoclase and microcline are the major source of the Na and K in the aquatic system.

Potassium range from 6.2 mg/l to 50.6 mg/l with an average value of 13.9. Although potassium (K+) is nearly as abundant as sodium in igneous rocks and metamorphic rocks, its concentration in these samples is very low in comparison to sodium. Parity in concentration of sodium and potassium is found only in waters with low mineral contents. Two factors are responsible for the scarcity of potassium in groundwater, one being the resistance of potassium minerals to decomposition by weathering and the other the fixation of potassium in clay minerals formed due to weathering.

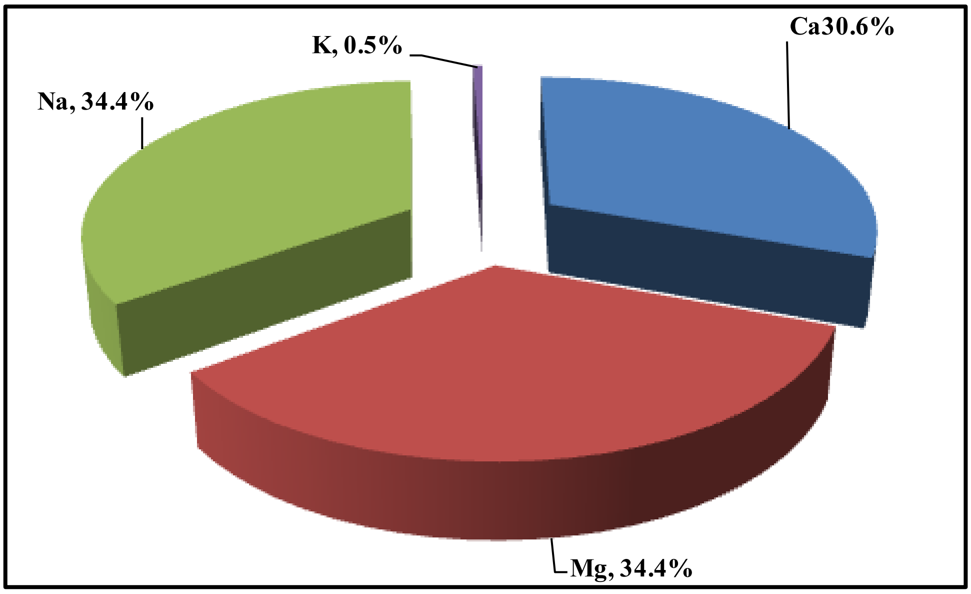

Fig. 5. Contribution of cations towards the total cationic charge balance (TZ+)

Water Type and Hydrochemical Facies

The Piper plot is very useful in determining relationships of different dissolved constituents and classification of water on the basis of its chemical characters. The triangular cationic field of Piper diagram reveals that the groundwater samples fall into Na+Mg and no dominant class, whereas in anionic triangle majority of the samples fall into chloride field (Fig. 6). The plot of chemical data on diamond shaped central field, which relates the cation and anion triangles revealed that the dominant water type in the studied locations were Mg-Ca-Na-Cl.

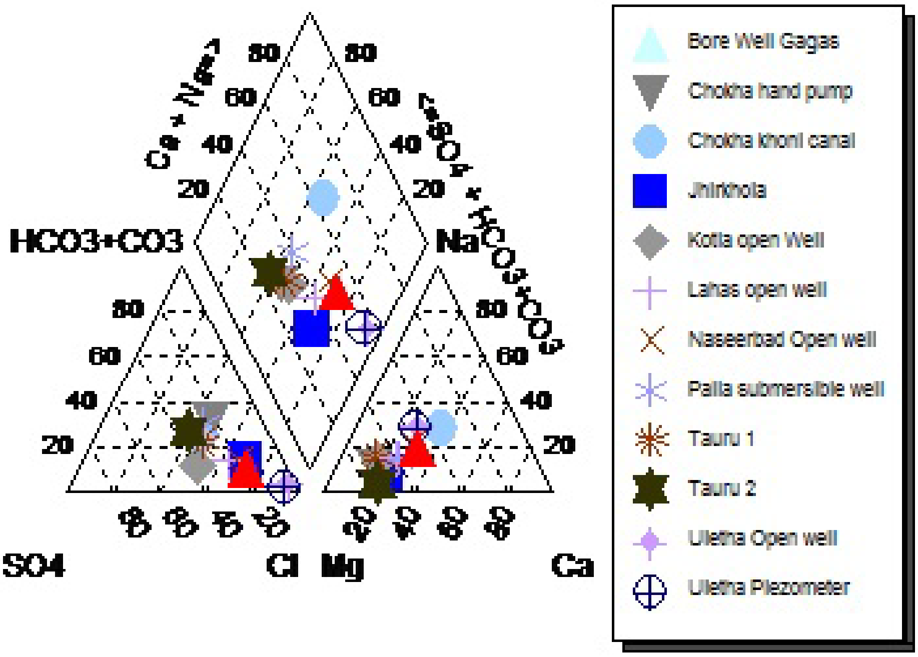

Fig. 6: Piper plot showing water type and hydrochemical facies

Trace Metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper and zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.

Zinc range from 8.3 μg/l to 425.4 μg/l with an average value of 51.4 μg/l where all the samples are found below the desirable limit of 5000 μg/l. Iron range from 164.4 μg/l to 727.1 μg/l with an average value of 417.1 μg/l where about 62% of the samples are found above the desirable limit of 300 μg/l. Manganese range from 0.2 μg/l to 89.7 μg/l with an average value of 15 μg/l where all the samples are found below the desirable limit of 100 μg/l. Copper range from 0.5 μg/l to 51.5 μg/l with an average value of 8.5 μg/l where only 1 sample is found above the desirable limit of 50 μg/l.

CONCLUSIONS

Groundwater is the main source of irrigation. Mewat district faces mainly 2 water related issues: (i) high groundwater salinity and (ii) declining groundwater levels. 5 years (2011-2016) data of TDS shows that the values of TDS at some sites decreased with the time. 5 years (2011-2016) data of water level shows that water level is declining. The groundwater level is declining in the (87.5 – 90) % of wells due to high extraction, low rainfall, and variable geographical conditions as fresh water sources are mostly situated along the steeper Aravalli hills. The groundwater in many wells which previously contained freshwater has now salinized. Electrical conductivity (EC) ranged from 759 to 32300 µS/cm at 25^0C. Around 73% of the district area has been found to have EC value more than 1000 µS/cm at 25^oC out of which 86% of the district area is having EC value more than 2000 µS/cm at 25^oC. A strong positive correlation ($R = 0.9975$) is observed between EC and Chloride concentration. The P-Value is < 0.00001. The result is significant at $p < 0.01$; $p < 0.05$; $p < 0.10$.

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. 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 further joint studies by NIH, Roorkee, IIT-R and Sehgal Foundation are going on to check the salinity ingression in the area.

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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References

Krishan Gopal, Rao, M.S., Loyal, R.S., Lohani, A.K., Tuli, N.K., Takshi, K.S., Kumar, C.P., Semwal, P. and Kumar, Sandeep. 2014a. Groundwater level analyses of Punjab-a quantitative approach. Octa Journal of Environmental Research. 2(3): 221-226.

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

Mitchell, T.D., Jones, P.D. 2005. An improved method of constructing a database of monthly climate observations and associated highresolution grids. International Journal of Climatology 25:693-712.

Rodell M., Velicogna I,.Famiglietti, J.S. 2009. Satellite-based estimates of groundwater depletion in India. Nature, 460, 999-1003

Sidhu, R. S., Vatta, K. and Dhaliwal, H. S., 2010. Conservation agriculture in Punjab – economic implications of technologies and practices. Ind. J. Agric. Econ. 65: 413–427.

Singh, K., 2011. Groundwater depletion in Punjab: measurement and countering strategies. Ind. J. Agric. Econ. 66: 583–589.

Statistical Abstract of Punjab, 2013. Economic & Statistical Organisation, Government of Punjab.

Vijay Kumar, Jain, S.K., Singh, Y. 2010. Annual and Seasonal Rainfall trend over different districts of Punjab. In: Rao, M.S. et al (Eds.) Water Availability and Management in Punjab, National Institute of Hydrology, 223- 233.