Stable Isotopes and Inland Salinity-Evidences for Mixing and Exchange

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Abstract: For finding the salinity pathways, in this particular study fundamental relationships between $\delta^{18}O$ and δD and salinity have been used. Groundwater samples were collected for pre monsoon, monsoon and post monsoon seasons of year 2018 in highly salinity affected area of Mewat, Haryana. It has been found that the original composition of groundwater intercept GMWL at the point ($\delta^{18}O$ = -8‰ and δD = -60‰). During pre-monsoon, slope of groundwater samples is less around 4.9 with intercept -14.67 showing high evaporation; with onset of monsoon season slope is increased to 5.8 with intercept -9.69 showing mixing. This data provides new insights into the sources of water salinity, mixing and exchange which will be useful for its management and remediation.

Keywords: Groundwater; salinity; Isotopes; Inland aquifer systems; Mixing & exchange

1. Introduction

Salinization of natural water resources, particularly groundwater the most demanding of all, have become a global environmental problem affecting various aspects of human life by degrading water quality thus limiting its use for domestic, agriculture, and industrial applications (Krishan, 2019a). High salinity levels result in high concentrations of sodium, chloride, sulphate, boron, fluoride, selenium, arsenic and high radioactivity. A continuous increase in the salinity of major aquifers containing sweet water is worsening the water quality of coastal as well as inland aquifers of Indian sub-continent (Krishan et al., 2019b). Inflow of saline waters has been observed due to intense exploitation of fresh water aquifers in inland aquifer systems thus limiting supply of potable fresh water. Identifying the saline water origin and its regular monitoring will be useful for its management. However, identifying multiple salinity sources such as natural/primary, anthropogenic or secondary sources are not that easy but environmental stable isotopes can be effectively used for this (Vengosh et al. 2005; Carreira et al. 2014). The main objectives were to determine the major sources of groundwater salinity; investigate evidence for mixing and exchange between these waters. Stable isotopes ($\delta^{18}O$ and δD) of water are recognised as a powerful tool in the determination of salinity sources in groundwater in inland aquifer systems.

2. Materials and Methodology

Mewat district is newly formed district of Haryana state (fig. 1) with a geographical area of 1861 km^2 and population of 10.09 lakhs (Census, 2011). The district comes under semi arid climatic conditions with normal rainfall of 594 mm; depth of water level is 5 – 29 mbgl (CGWB, 2012). Groundwater salinity is increasing and reported to invade the fresh water aquifers (Thomas et al., 2012; Krishan et al, 2017, 2019). Geology of the district is dominated by Quaternary sediments alluvium deposits consisting a sequence of inter layered clay/silt and sand with occasional kankar formations (Malik and Rajeshwari, 2011).

Groundwater in the study area characterized by high hydraulic gradients near aravali hills and with low gradients away form these hills, reflect the flat topography, but regionally it flows from south to eastwards.

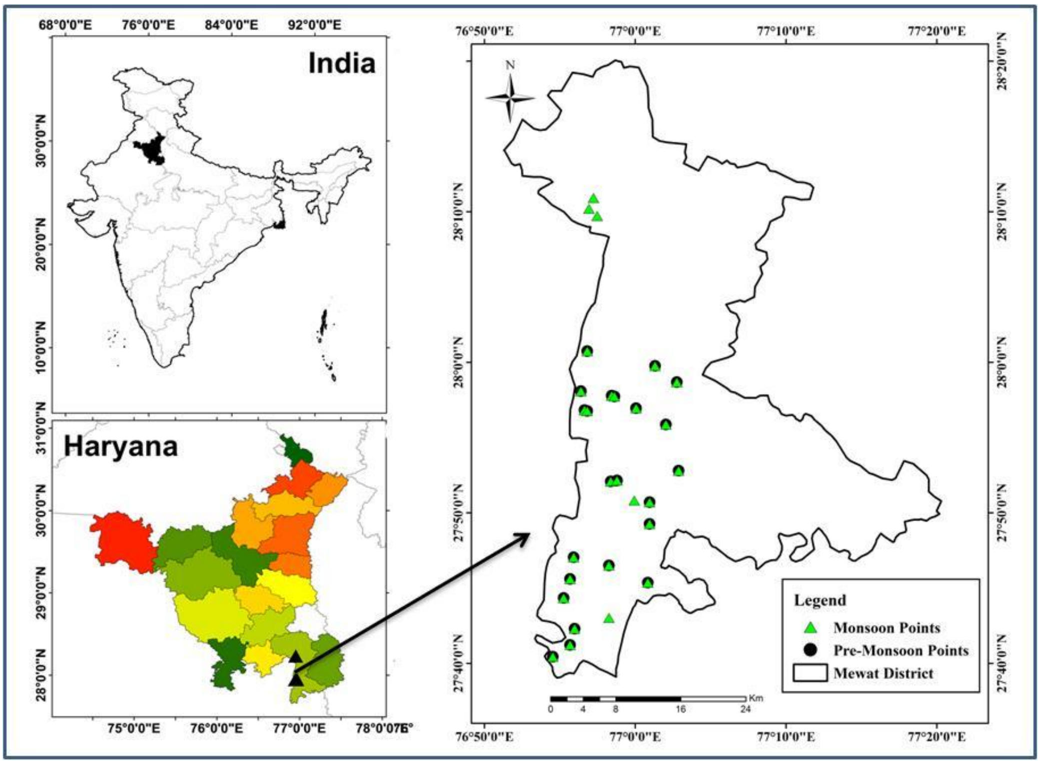

Fig 1: Study area showing sampling locations

Groundwater samples were collected for pre monsoon (24 nos.), monsoon (29 nos.) and post monsoon (29 nos.) seasons of year 2018 in highly salinity affected area of Mewat, Haryana. These samples were collected from open wells, tube wells, hand pumps during pre-monsoon, monsoon and post monsoon seasons from a depth range of 4 to 92m. EC was measured on site using portable hand held EC meter of Hach, HQ30d. Samples have been filtered through 0.45µ membrane filter and analysed for stable isotopes ($\delta^{18}O$ and δD) using instrument Isotope Ratio Mass Spectrometer in the Nuclear Hydrology Laboratory of National Institute of Hydrology, Roorkee.

3. Results

Statistical summary of the analysed data for EC and stable isotopes is given in Table 1. A wide range of Electrical conductivity values ranging from 79 to 55300 µS/cm in pre monsoon; 628 to 51000 µS/cm in monsoon; 462 to 52400 µS/cm in post monsoon and stable isotopic compositions $\delta^{18}O$ from -7.79 to 0.40 ‰ in pre monsoon; -7.88 to 2.33 ‰ in monsoon; -7.59 to 2.39 ‰ in post monsoon; δD from −53.76 to -13.59 ‰ in pre monsoon; −53.97 to -17.16 ‰ in monsoon; −53.63 to -20.63 ‰ in post monsoon were observed in the groundwater. Seasonal spatial variation of $\delta^{18}O$ is shown in fig. 2 majority of groundwater samples have $\delta^{18}O$ values ranging between -5 to -6 ‰. Hydro climatic variability is most likely to be associated with $\delta^{18}O$ variability as evaporation and precipitation affect both $\delta^{18}O$ and salinity (Conroy et al., 2014).

Table 1. Statistical summary of EC values and stable isotopes

	EC (µS/cm)			$\delta^{18}O$ (‰)			δD (‰)		
	PreM	Mon	PoM	PreM	Mon	PoM	PreM	Mon	PoM
Minimum	79	628	462	-7.79	-7.88	-7.59	-53.76	-53.97	-53.63
Maximum	55300	51000	52400	0.40	-2.33	-2.39	-13.59	-17.16	-20.63
Mean	9173	7831	8057	-5.33	-5.63	-5.53	-40.88	-42.35	-43.58
Standard deviation	13711	11469	11888	1.54	1.15	1.06	7.70	6.96	6.46

PreM – n=24; Mon & PoM- n=29

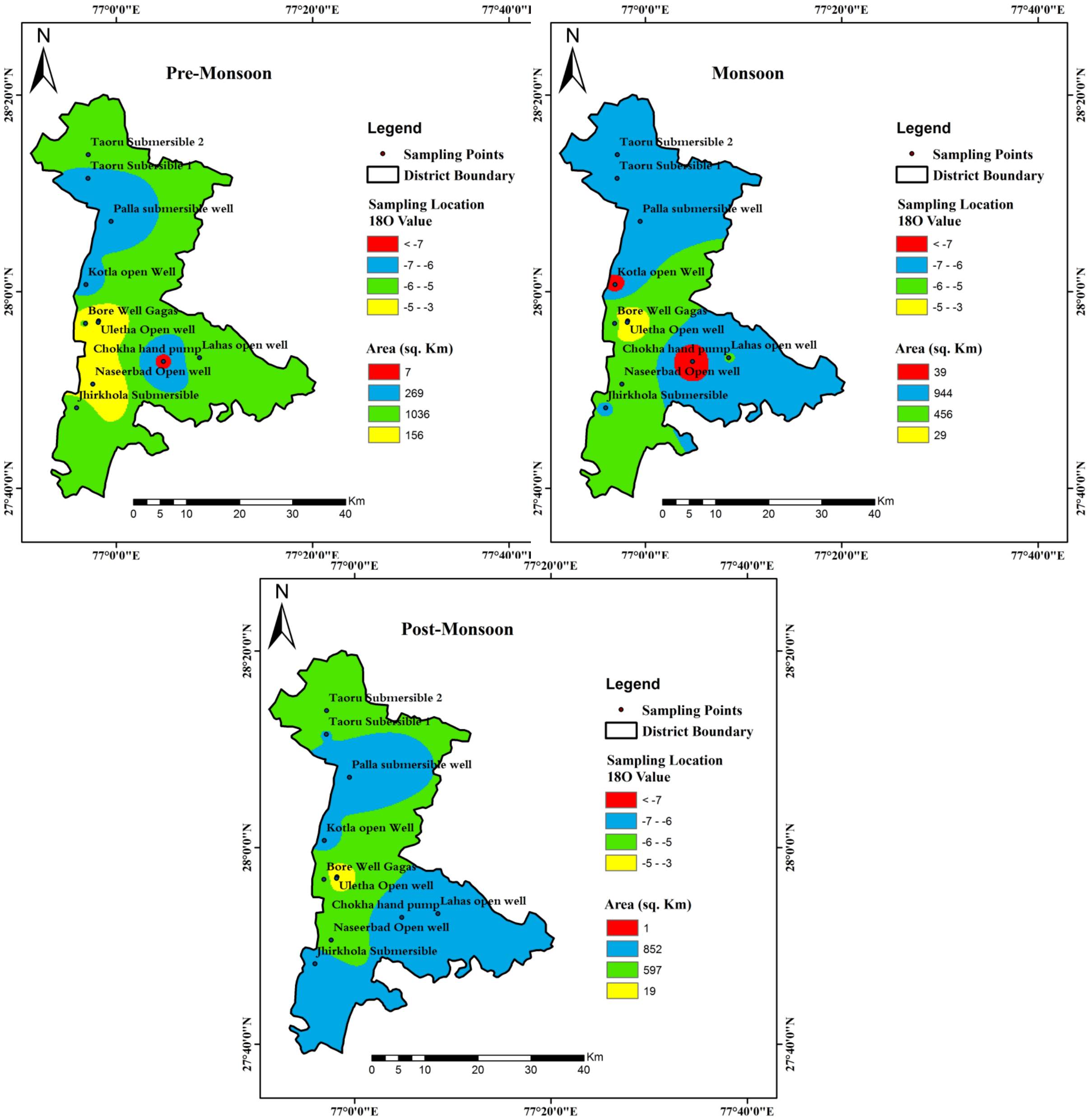

Fig 2: Seasonal spatial variation of $\delta^{18}O$ (‰)

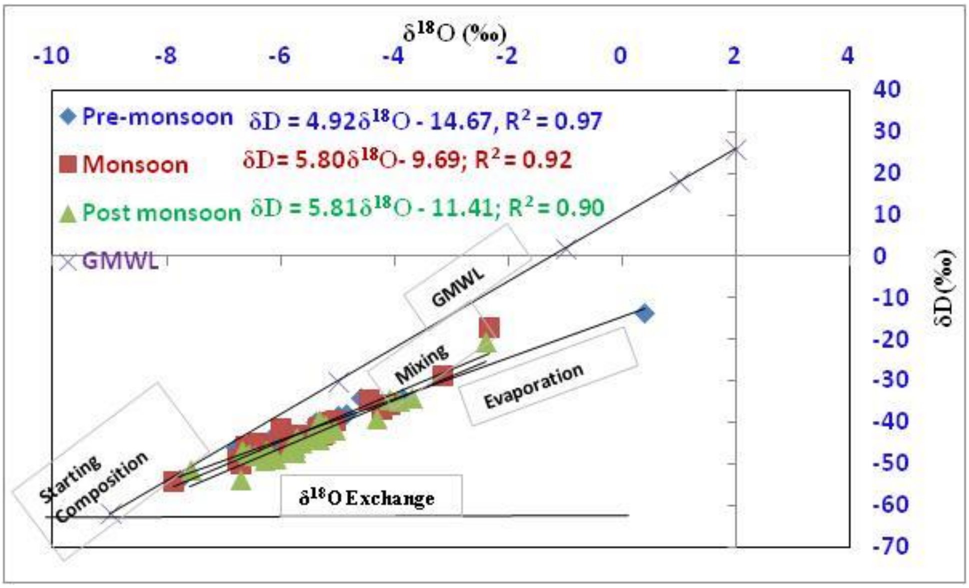

Fig.3. Cross plot between $\delta^{18}O$ and δD

It has been found that the original composition of groundwater intercept GMWL at the point ($\delta^{18}O$ = -8‰ and δD = -60‰). During pre-monsoon, slope of groundwater samples is less around 4.9 with intercept -14.67; in monsoon season slope is increased to 5.8 with intercept -9.69 while in post monsoon slope is almost constant at 5.8 with intercept decreasing to -11.41.

4. Discussion

Combined assessment of the stable isotope and salinity data of groundwater allows marking of the sources of water and solutes in the area and helps in finding processes controlling salinity. Electrical conductivity and isotope data indicated likely movement of saline water towards fresh water areas and useful in qualitative assessment of potential impacts of future hydrological changes that are likely to occur because of increased pumping of groundwater in the vicinity of Aravali hills coming times.

It has been observed that relatively high salinities occur in most of the groundwater in the central part and higher concentration attributed to dissolved cyclic salts generally indications of major evaporative enrichment at groundwater discharge areas or otherwise close to GMWL stable isotope composition but the slope of groundwater is lower demonstrated the relevance of water evaporated from the aquifer system.

Groundwater shows high evaporative values in pre monsoon and there is mixing of rain water with groundwater in monsoon season. The missing effects again decrease in the post monsoon season. This might be due to high salinity in the region which is checking the complete dilution due to the recharging effects of rains in monsoon season.

5. Conclusions

In this study, the isotopic data provides new insights into the sources of water and salinity in the groundwater systems. The stable isotope compositions indicate distinct salinity sources: Accumulation of cyclic salts due to evaporation over the time and affected by water–rock interaction. The alluvial formations along the interface of saline waters in these areas may deposited since long which resulted in higher salinity in this region. There is a need of flushing of the salt content in shallower aquifers and some suitable management measures are required. This study helps in marking of distinct groups of salinity affected groundwater which will be useful for its management and remediation.

Acknowledgements

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