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# Isotope Study of Groundwater in Arid Areas of Jaisalmer

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**Abstract** : In order to understand the ground water recharge process in Shahgarh area of arid Jaisalmer district, an environmental isotopic study based on measurement of D, $^{18}O$ and $^{3}H$ contents was carried out on shallow groundwaters. The area is characterized by very low rainfall, sandy terrain and very little vegetation. Water level in the scattered shallow wells and hand pumps varies from 10 to 30 m. Stable isotope analysis of the water samples indicate very high depletion of the heavy isotope contents, i.e., $\delta D \sim -50‰$ and $\delta\ ^{18}O$ -6 to -7‰, and suggest quite old origin of these waters. The $^{3}H$ contents are also very low. A $^{3}H$ tracer injection experiment at Mehrana indicated negligible recharge due to modern precipitation. The ground water is potable to brackish, the TDS ranging from 200 to 1500 mg/l. A higher fluoride content was observed in two wells.

**Key words** : Stable isotopes, groundwater recharge, palaeowater.

Groundwater is a precious resource, especially in the arid regions which receive very low and erratic rainfall and lack adequate surface water resources. Consequently, there is always a need for exploring new sources of groundwater. However, the overexploitation of groundwater may affect the quality and quantity of water, if there is no fresh recharge. Therefore, the recharge characteristics of aquifer need to be studied in detail.

Isotope techniques provide important clues to hydrological processes and in the determination of the age of water. The stable isotopes content of groundwater (i.e., deuterium and oxygen-18) remains unchanged unless it is exposed to atmosphere or some isotopic exchanges take place with rocks in the earth's crust. Therefore, the measurement of deuterium (D) and oxygen-18 ($^{18}O$) contents in groundwater gives an indirect information regarding the period of recharge. The old groundwaters generally have depleted heavy isotope values and very low tritium content, which indicates recharges during palaeoclimatic period. The variations in stable isotope ratio of water is caused mainly by phase transition, climatic variation and transport processes in the atmosphere (Dincer, 1974; Ramesh *et al.*, 1993). Bhattacharya *et al.* (1985) carried out a survey of oxygen and hydrogen isotopic ratios in groundwaters, as well as in water of rivers, lakes and hot springs from various parts of India.

The most depleted heavy isotope content was found in high altitude precipitation in the Himalayas. The shallow groundwaters display a continental effect where the heavy isotope content decreases with distance from the coast. The D/H and $^{18}O/^{16}O$ of these fresh waters are linearly related and show the effect of enrichment due to evaporation and transpiration from soils. Bahadur (1979) studied the stable isotope abundance in some groundwaters of Gujarat and Rajasthan. It revealed that the rainwater which recharges the aquifer is evaporated more in Rajasthan than in Gujarat. This was related to increase in aridity in Rajasthan. Navada *et al.* (1993) used environmental isotopes $^{3}H$, $^{14}C$, D and $^{18}O$, and also injected tracers to study the

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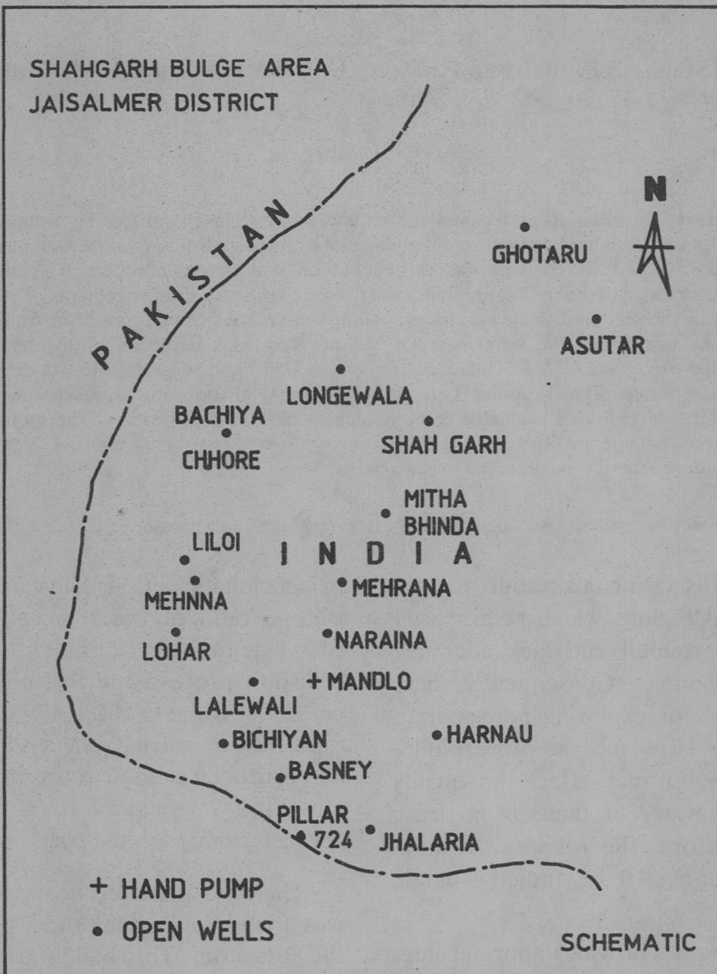


*Fig. 1. Shahgarh bulge area, Jaisalmer district.*

recharge process in parts of western Rajasthan. It was found that most of the deep wells have palaeowaters which were recharged during wetter and cooler climates than at present.

We carried out environmental isotopic and hydrochemical studies of the groundwater in some border areas of Jaisalmer district and attempted to correlate the data with the origin of these waters. The deuterium, oxygen-18 and tritium measurements were used for the present study. A $^3H$ tracer injection method was employed at Mehrana to study the rainfall recharge.

## Characteristics of the Study Area

Jaisalmer district lies between 26°4′ and 28°8′ north latitudes, and between 69°30′ and 72°20′ east longitudes. The district lies in the very arid part of the Thar desert (Porwal and Mathur, 1993). The average annual rainfall

*Table 1. Isotopic results of water samples collected from Shahgarh Bulge Area of Jaisalmer District*

| Location | Water level bgl (m) | $\delta D$(‰) | d $^{18}O$ (‰) | $^{3}H$ (± 0.5) (TR) |
|---|---|---|---|---|
| Asutar TW | 69.00 | -48 | -7.2 | 1.8 |
| Shahgarh OW | 31.20 | -46 | -6.0 | 4.5 |
| Mitha Bhinda | 25.00 | -52 | -6.7 | 1.8 |
| Mehrana OW | 9.80 | -50 | -6.7 | 4.3 |
| Naraina OW | 8.85 | -46 | -6.0 | 1.5 |
| Mandlo H.P. | 7.00 | -50 | -6.6 | 2.3 |
| Pillar No. 724 FF | – | -48 | -6.2 | 2.2 |
| Jhalaria OW | – | – | -6.9 | – |

TW = Tube Well, OW = Open Well, HP = Hand Pump, FF = Free Flow, bgl = below ground level.

at Jaisalmer is 165 mm. The study area lies in the western part of the district and extends from Asutar to Pillar No. 724 on the international border (Fig. 1). It is known as Shahgarh Bulge area and is strategically important because of its location along the international border. The area is covered with sand dunes which are either bare, or have scrubby vegetation. Since there is no source of surface water, only open wells and some hand pumps of shallow depth are used for drinking water. The hydrogeological formation is alluvium. Near the pillar 724 along international border, a free flow of water was observed.

## Material and Methods

The water samples for environmental isotopic and chemical analyses were collected with the help of Border Security Force (BSF). For stable isotopic analysis, the samples were collected in 100 ml glass/plastic bottles and were tightly sealed to avoid contact with atmosphere after collection from the source. About one litre of each sample was collected for natural tritium and chemical analysis.

The stable isotopic analyses of deuterium and oxygen 18 were done with V.G. Mass Spectrometers, Micromass 602E and 903E, respectively. The isotopic ratios D/H and $^{18}O/^{16}O$ were measured and the results were expressed in the form of $\delta$ values defined as :

$$\delta\ (‰) = ((R_s - R_r)/R_r) \times 1000$$

where, $R_s$ and $R_r$ represent ratio D/H or $^{18}O/^{16}O$ in sample and reference, respectively.

The results are expressed in $\delta$(‰) (permil) with respect to the IAEA standard V-SMOW. The tritium contents were determined at BARC, Mumbai, and the results are expressed

*Table 2. Chemical quality of water resources in Shahgarh Bulge Area*

| Location | pH | EC | TDS | $Na^+$ | $K^+$ | $Ca^{++}$ | $Mg^{++}$ | $Cl^-$ | $HCO_3^-$ | $F^-$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Asutar TW | 7.4 | 2010 | 1450 | 460 | 8 | 40 | 24 | 403 | 140 | 1.6 |
| Shahgarh OW | 8.1 | 950 | 594 | 140 | 33 | 20 | 10 | 71 | 183 | 0.4 |
| Mitha Bhinda | 7.9 | 4040 | 2640 | 200 | – | – | – | – | – | – |
| Mehrana OW | 8.0 | 350 | 224 | 20 | 10 | 20 | 17 | 71 | 85 | 0.8 |
| Naraina OW | 7.9 | 1040 | 639 | 29 | <1 | 2 | 10 | 25 | 247 | 3.1 |
| Mandlo H.P. | 7.8 | 950 | – | 53 | 8 | 10 | 6 | 100 | 104 | 3.1 |

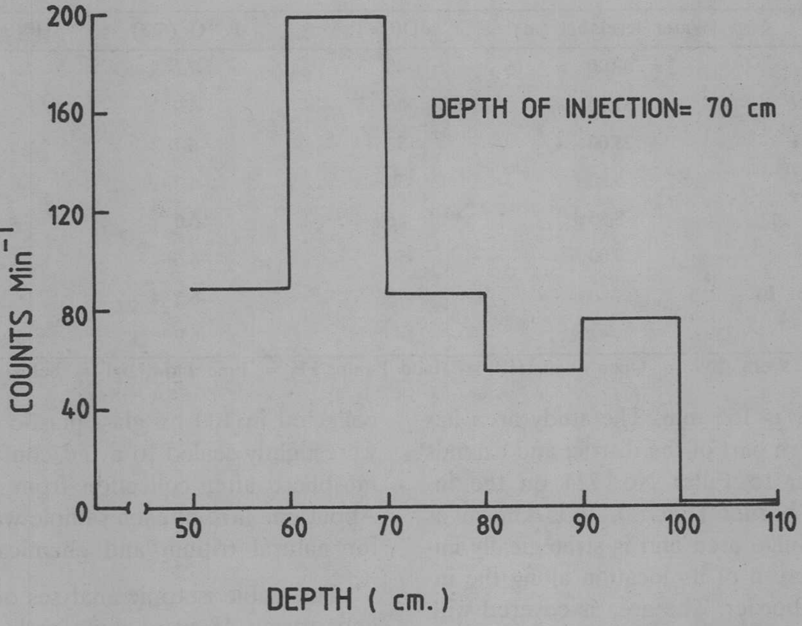


*Fig. 2. Histogram of $^3H$ tracer activity at Mehrana.*

in TR or tritium ratio (one TR is equivalent to one atom of tritium out of 18 atoms of hydrogen). The chemical analyses of samples were done by standard methods.

A radiotracer injection experiment was conducted at Mehrana to study the soil moisture movement due to rainfall. A suitable site with nearly level surface was selected near the BSF post with proper markings. The tracer was injected at 5 points in a circle and at a depth of 70 cm. The movement of tracer was monitored after two rainy seasons. The soil samples were collected and the moisture extracted by vacuum distillation. The radioactivity of the extracted samples was counted using an ECIL liquid scintillation counter.

**Results and Discussion**

The results of isotopic analysis, i.e.. D, $^{18}O$ and $^3H$ values, alongwith the water level of wells, are given in Table 1. The stable isotopic analysis yielded depleted heavy isotope contents, $\delta$ D about -50‰ and $\delta$ $^{18}O$ between -6 and -7‰ measured against V-SMOW. The tritium content of a few well samples were also very low (2-4 TR), thus supporting the stable isotope data.The depleted D and $^{18}O$ contents, as well as the low $^3H$ values, suggest quite old origin of these waters when more wetter and cooler climatic conditions prevailed in this desert area. The total dissolved salts varied from 200 to 1500 mg/l, except in the well at Mitha Bhinda which has a salinity of 2640 mg/litre. The wells at Naraina and Mandlo recorded higher fluoride contents than the permissible limit (Table 2).

The tritium injection result suggests that the centre of gravity of the activity has not moved downward from the point of injection, i.e., 70 cm below ground level. The maximum moisture content of the extracted soil sample was found to be 1% only, which suggests high evaporation from the soil due to arid climate. The total annual rainfall at Ramgarh, the nearest rainguage station, was 175 mm in 1995. This study, therefore, suggests that there was practically no recharge due to rainfall in this area during the period of the study.

The study confirms the earlier findings of Kar (1986, 1993) that water exists at shallow depth in the border areas of Jaisalmer district. The waters are very old and were recharged during more wetter and cooler climate than at present. The present-day rainfall in the area is negligible and can not recharge the water. This has been confirmed by $^{3}H$ injection study carried out at Mehrana. The $^{14}C$ dating of these groundwaters is likely to provide more meaningful information regarding the age of the waters and the period of recharge. The area lies on the courses of the buried palaeochannels of the Saraswati river, as deciphered through remote sensing by Ghose *et al.* (1979) and Kar (1986).

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