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Groundwater problems studies in the Thar desert, India using isotope techniques

Introduction

The Thar desert extends from the western side of the Aravalli mountain ranges in India upto the limit of Indus valley in Pakistan. It covers 60% of the area of the Rajasthan state in the north western part of the country. With ~ 38% of the state's population with a density of 84 persons/km^2, this is one of the most populated desert regions of the world. The constantly increasing human and livestock population is putting tremendous pressure on the available natural resources (Figure 1).

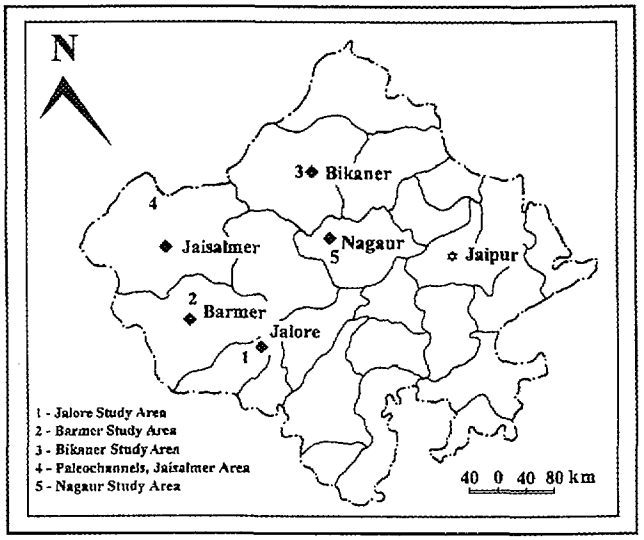

Figure 1 Location map of the study areas

The land is characterised by sand dunes with interdunal plains in the north, west and south, and alluvium in the central and eastern parts. Streams are very few, ephemeral in nature and confined mostly to the rocky parts of the desert, the most prominent being the Luni river in the southwest region. Precipitation is low and erratic with frequent droughts.

The main source of water in the area is groundwater. The region faces acute shortage of potable water and village women have to fetch water from many kms away to meet domestic requirements. In many places the groundwater is brackish or saline. Efforts are being made by the state groundwater department to study known groundwater resources and explore potential ones in the region.

In groundwater management, particularly in arid regions like western Rajasthan, it is important to know the presence of modern recharge and to estimate the recharge rate to avoid over-exploitation of the groundwater resource. Isotopes can help to identify modern recharge and to estimate recharge rate to the aquifer. If modern recharge is absent, groundwater dating using radiocarbon could help to identify old groundwater or paleowaters. A number of isotope studies carried out in arid zones (particularly in the Sahara) have shown that the deep groundwater is generally very old. From these studies it was concluded that episodic large scale recharge corresponding to humid phases or pluvials occurred in these arid areas. The paper reviews our experiences on the application of isotope techniques in understanding groundwater recharge process in arid western Rajasthan.

Groundwater recharge process

The possible groundwater recharge process in arid areas like Rajasthan may be :

a) direct recharge of precipitation through the unsaturated zone
b) indirect recharge through river channels from flash floods or from irrigation canals etc.
c) paleoclimatic recharge during humid episodes in the past which was mentioned above.

Direct recharge of precipitation to the groundwater was studied in Jodhpur and Barmer districts of western Rajasthan using artificial ^{3}H tracer as HTO in the unsaturated zone (Shivanna et al 1994). The results showed that the tracer displacement and hence the groundwater was found to be negligible due to low rainfall (~ 200 to 300 mm) during the study periods of 1982-84 and 1990-92 respectively. Hence for arid areas the artificial tracer method which determines recharge on an annual basis for a short duration may not be useful and may be combined with other methods such as environmental ^{3}H, ^{36}Cl and chloride methods. In these methods results are derived from long term average of recharge. In central Sudan for example (mean annual precipitation = 180 mm) a net annual direct recharge of around 1 mm/a was estimated using the chloride method (Edmunds et al 1990). In a study being carried out under an IAEA/CRP on isotope based assessment of groundwater renewal and related anthropogenic effects, environmental chloride profiles in a site in Barmer district of western Rajasthan (Mean annual rainfall = 241 mm), showed a mean annual recharge of 14 mm. The recharge obtained by the chloride method is being compared with that of the tritium method. Unsaturated zone solute and isotope profile will also be used to provide a record of recharge history as interpreted for profiles from Cyprus and northern Senegal (Cook et al 1992).

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In arid areas, indirect recharge through wadis (river channels) could be an important mechanism for groundwater recharge (Gonfiantini 1974, Darling 1987). Environmental isotopes (^2H, ^{18}O, ^3H) and ^{14}C were employed to identify the recharge process in the Jalore area of western Rajasthan (Navada et al 1993). The isotope results showed that most of the shallow groundwater near the Sukri river course, have δ^2H and $\delta^{18}O$ enriched compared to the shallow groundwater away from the river course and have ^3H values of 15-20 TU, showing that they are possibly recharged from river channels during flash floods. The deep groundwater (>100 m) near the river course also shows some component of recent recharge indicating probable interconnection between the shallow and deep aquifers. The other deep groundwaters away from the river course on the other hand have negligible ^3H and depleted δ^2H and $\delta^{18}O$, indicating recharge during more humid periods in the past.

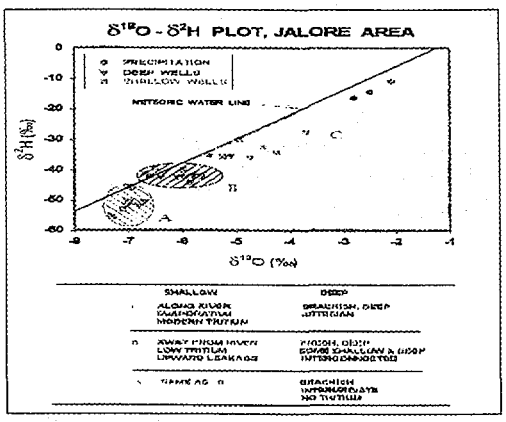

Figure 2 Deuterium and Oxygen-18 relationship of samples from Jalore area

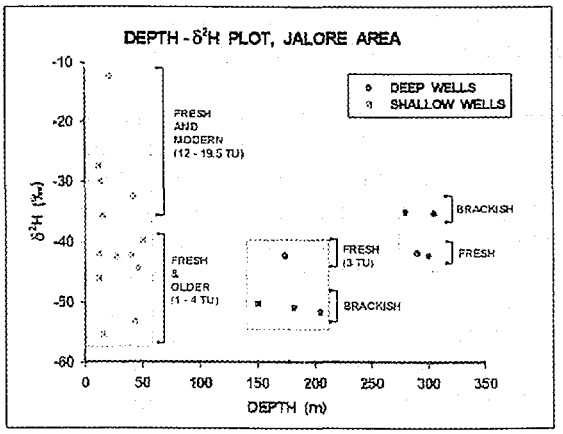

Figure 3 Depth versus Deuterium plot of samples from Jalore area

Buried courses of rivers (paleochannels) are important as they have good groundwater potential. Isotope studies were carried out along a buried river course in Jaisalmer district in western Rajasthan, which was supposed to belong to the legendary Saraswati river of Himalayan origin mentioned in many earlier lite-rary works and known to have existed before 3000 years BP. The shallow groundwaters along the river course have negligible ^3H and low ^{14}C values of 54 to 70 pmc confirming that they are old waters.

An environmental isotope study in the Bhadka-Bheemda area in Barmer district in western Rajasthan (Navada et al 1996) showed that the deep groundwater (depth > 100 m) has depleted δ^2H, $\delta^{18}O$ compared to the shallow groundwater and present day precipitation. They have negligible ^3H and ^{14}C model ages of these groundwaters range from 4000 to 9500 years BP. Hence they are paleowaters recharged in the past.

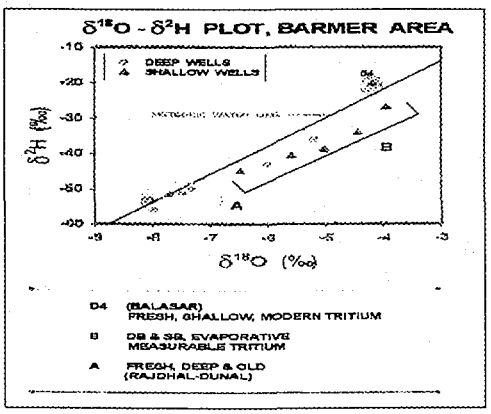

Figure 4 Deuterium and Oxygen-18 relationship of samples from Bhadka-Bemda area

Paleocological studies have proposed the following dry and wet periods in Rajasthan (Bryson and Barreis 1967, Singh et al 1974).

10,000 - 6000 years BP	moderately humid, rain fall greater than present
5000 - 3000 years BP	humid period
3000 - 1100 years BP	low rainfall
1100 - Present	dry conditions

Hence the recharge to these groundwaters occurred during humid periods shown above.

Effect of over exploitation of groundwater

The increasing demand of water supply for various purposes has lead to heavy exploitation of groundwater resources in many parts of the world. This is particularly so in arid regions where limited water resources are being exploited with adverse effects of rapid lowering of water table and deterioration of water quality. For example in Bikaner town in Western Rajasthan the aquifers are being extensively used and

the water levels have been declining. An isotope study (Navada et al 1996) showed that the shallow and deep wells have generally similar d^2H, $d^{18}O$ and negligible ^3H. The ^{14}C model ages of the deep wells vary from modern to 9500 years BP. Similar, d^2H, $d^{18}O$ of the shallow and deep groundwater and young groundwater encountered in some deep well samples indicates mixing of the shallow and deep zone waters due to heavy exploitation of groundwater in the area.

In an another example, in a limestone belt which extends from Bilara to Phalodi in Western Rajasthan, groundwaters are being heavily exploited for irrigation and domestic purposes. The isotope results (Nair et al 1993) show that modern recharge is possible in the southern part of the area through the Luni river which is ephemeral. In the central part the groundwaters have negligible ^3H, and ^{14}C indicates an age of ~ 2000 years BP. In Phalodi area in the north, the groundwater contains negligible ^3H and ^{14}C showing a maximum age of 4000 years indicating paleo recharge. Time series analysis of the tritium data of some of the wells showed a decreasing trend. This may be due to over- exploitation of groundwater in the central part leading to influx of older water from the north.

Thus, isotope techniques are useful in understanding groundwater recharge process in arid areas. Absence of modern recharge and over exploitation observed in some of the above studies stress the need for proper management of such scarce groundwater resources.

References :

Bryson R.A., & Berreis D.A. (1967). Bulletin American Meteorological Society Boston, 48, 136.

Cook P.G., Edmund W.M., Gaye C.B.(1992). Water Resources Research 28 (10), 2721.

Darling W.G. Edmunds W.M., Kinniburg D.G.,and Kotoub S. (1987). In : Proceedings of IAEA Symp.,Vienna. Isotope techniques in water Resources Development, 205.

Edmunds W.M., Darling W.G.,and Kinniburg D.G. (1990). In: Groundwater Recharge (e.d. D.N.Lerner, A.S. Issar and I.Simmers) Verlag Heinz Heise, Germany, 257.

Gonfiantini R.Dincer T., and Devekoy A.M. (1974). In : Proc. of IAEA Symp. Vienna. 1, 293

Nair A.R., Sinha U.K, Joseph T.B., and Navada S.V.(1993). Proc. 2nd National symp. on Environment,Jodhpur, 188

Navada S.V., Nair A.R., Rao S.M., Paliwal B.C. and Doshi C.S. (1993). J. Arid Environment 24, 125

Navada S.V., Nair A.R., Rao S.M.,Kulkarni U.P., and Joseph T.B., (1996). In: Isotopes in Water Resources Management Proc.IAEA Symp.Vienna, 451

Shivanna K,. Kulkarni U.P., Sinha U.K., Nair A.R. and Navada S.V. (1994) In : Proc.International workshop on groundwater monitoring and recharge in semi arid areas, Hyderabad , 61

Singh G., Joshi R.D., Chopra S.K., Singh A.B., (1974). Phil. Trans. Royal Soc. London B. Biol. Sciences 267, 889.

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Technical Review

GROUNDWATER RENEWAL IN WATER SCARCE REGIONS

The second Co-ordination Meeting of the Co-ordinated Research Project (CRP) on "Isotope -Based Assessment of Groundwater Renewal and Related Anthropogenic Effects in Water Scarce Regions" was held from 9-13 November 1998 in Sfax, Tunisia.

The CRP involves applied field research for study of the infiltration rate (natural recharge) and/ or diffuse evaporative discharge under natural conditions, through hydrochemical and isotope profiles at selected benchmark representative sites in arid and semi-arid regions. Institutions from fourteen countries (Austria, Bolivia, China, Egypt, India, Jordan, Mexico, Nigeria, Saudi Arabia, Senegal, South Africa, Syria, Tunisia and United Kingdom) are participating in this CRP.

The meeting reviewed the results and achievements of the work undertaken since the last co-ordination meeting held in Vienna on December 1997. In depth discussions were held on various related technical/ scientific issues concerning the results achieved, as well as further required work for successful completion of the CRP in 1999.

Significant progress was reported in most of the country projects. Spatial variability was an important question discussed at some depth. The long-term recharge rates provided by the unsaturated zone Cl profiles and supported by the ^3H, ^2H and ^{18}O data offered by far the best and most robust point source data for large areas of the semi-arid regions of the world. However these need to be integrated on a regional scale. Additional work required and tasks to be accomplished during the last year of the project have been identified.

It was agreed that the overall data and results be compiled in a TECDOC to be published by the Agency after the completion of the CRP.

The Responsible officer of this CRP is Y. Yurtserver.

CRP News