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Measurement of Vertical Recharge to Groundwater in Haryana State (India) Using Tritium Tracer

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Downward movement of soil moisture due to rainfall and supplemental irrigation in the unsaturated zone has been followed by tagging a layer of soil with tritiated water at a number of sites in the state of Haryana. The activity apparently moves by a piston type flow. The average recharge for 15 sites during the interval July - November, 1973 has been equivalent to 9 cm of water which is 14% of the irrigation plus rainfall. For 18 sites sampled after two monsoons (July 1973 to December 1974) the average recharge is 19 cm and the fractional recharge is 0.15. Wide variations in recharge values are noted. The most significant factor affecting the fractional recharge is the clay content of the soil.

Introduction

Movement of moisture in an unsaturated zone of soil can be monitored with the help of environmental (bomb-produced) (Smith et al. 1970; Allison and Hughes 1972; Anderson and Sevel 1974; Bredenkamp et al. 1974) as well as artificial tritium (Zimmermann et al. 1966; Blume et al. 1967; Zimmermann et al. 1967; Datta et al. 1973). In most studies the tritium profiles show that the downward movement of water through the unsaturated zone takes place by displacement flow, and without overtaking by new water. Infiltration due to precipitation increases the water content in the upper parts of the unsaturated zone. As soon as the field capacity is exceeded, a zone of gravitational water is produced. The front of this zone starts moving downwards in a piston-type flow.

In a recent paper we (Datta et al. 1973) have reported the results of tritium tracer studies on groundwater recharge in Western Uttar Pradesh. In these alluvial plains the moisture movement below the root zone is essentially by displacement flow. In the present paper we report the results of our studies undertaken in the state of Haryana where semi-arid climatic conditions prevail.

Geohydrological Conditions

The state (Fig. 1) traverses mainly plain area ranging in elevation from 198 m to 298 m above mean sea level. There are five physiographic regions, namely, the Siwalik hill tract (average height 500 m from m.s.l.), the dissected rolling plains in the foot-hills (298 m - 373 m), the upland plains or the Ghaggar Yamuna Doab (220 m - 280 m), the flood plains (190 m - 225 m) and the plains with hills and sand dunes. Streams from north flow south and westward while the flow of streams in the southern part is towards north constituting an internal drainage basin. Groundwater occurs in unconfined, semi-confined and confined conditions. Water table depth varies from 3 to 20 m in eastern part to as deep as 55 m in the western part of the state.

The underlying materials consist of alluvial deposits of Quaternary age. The alluvium, at least that of the shallower horizons, is derived from peripherial erosion, essentially all from the highlands in the north east. These deposits are akin to those found generally throughout the Indo-Gangetic plain and consist of a succession of clay, clay with *kanker* (irregular concretions formed due to the segregation of the calcareous material), sandy to silty clay, silt, fine to coarse sand, and sand with *kankar*. Locally, thin beds of gravel and cemented sands are occasionally present with unconsolidated sand.

The slope of the plain in the northern part of the area from west to east is about 0.19 m/km. While that of the south-western part from west to northwest is about 0.75 m/km. The slope in the southeastern part is at about 0.19 m/km. It appears that sand dunes are more or less fixed in southwest to southeast region and support light vegetation in most places.

The long term records of water levels in the fresh water zone show its decline because of the increased rate of pumping. On the contrary a rise in water levels has been observed in various saline or marginal water areas after the introduction of canal irrigation because the withdrawal of groundwater in such areas is very low.

In 1974 the number of wells has increased to 180,000. Out of these about 32,800 are open wells (dug-wells), 145,000 shallow tubewells owned by cultivators, and 2,200 are the heavy capacity deep tubewells run by the State Corporation. These wells are located in an area of 22,000 sq.km. which has groundwater of fresh and marginal quality (E.C. from 300 to 6,000 micro-mhos/cm at 25° C). The total area of the state is 44,222 sq.km.

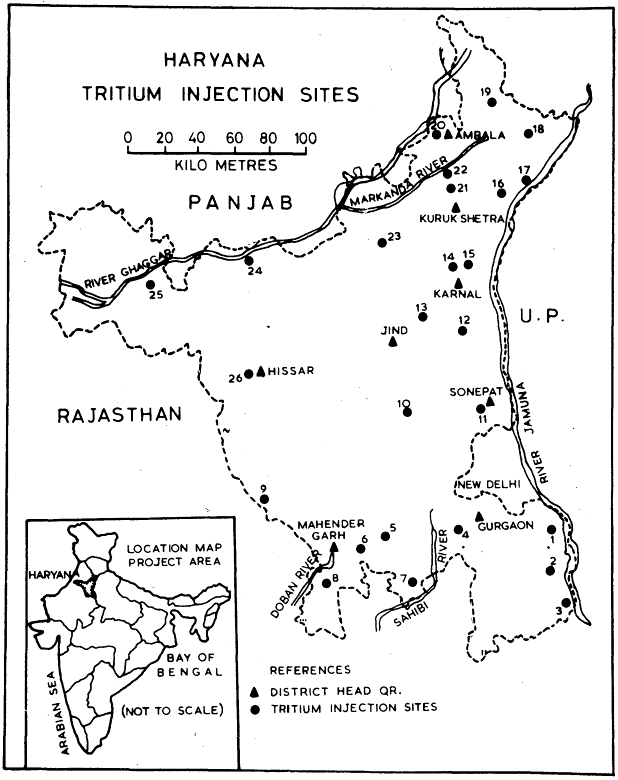


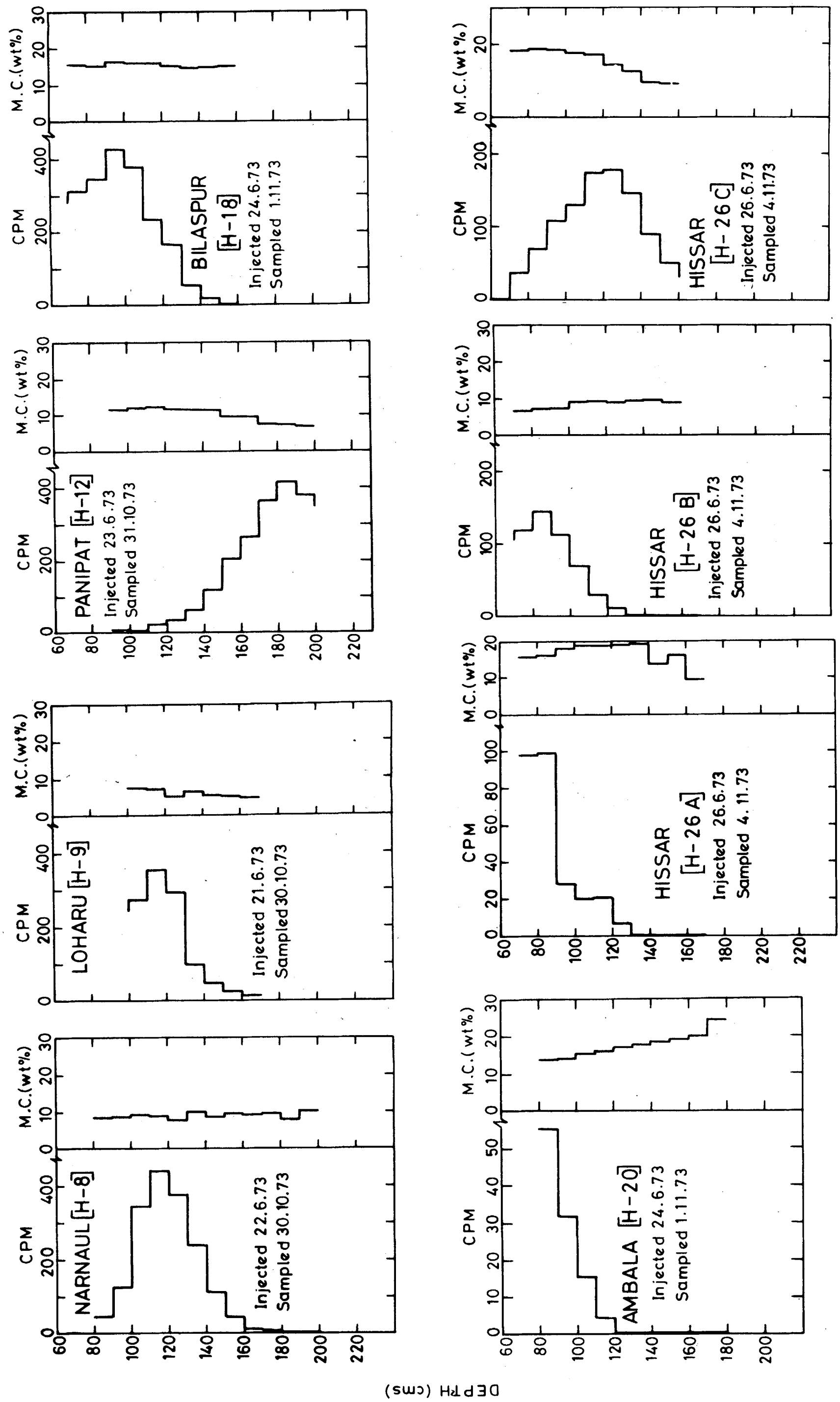
Fig. 1. Index map of Haryana state.

The normal annual rainfall increases from 30 cm in the western part of the state to 100 cm in the extreme north. The normal rainfall in the central part of the region is of the order of 50 cm. The climatic conditions are tropical. A continuous heavy development of groundwater basins is needed. This is possible only if there is adequate groundwater recharge from all sources. It is, therefore, very desirable to determine the amount of vertical recharge in this state.

Experimental

A total of 26 sites spread over the entire state were chosen for tritium injection. Broadly these covered geohydrologically representative areas. The location of injection sites is shown in Fig. 1. In Table 1 some geohydrological information about each site is given.

A soil moisture layer below the root zone (70 cm deep) was tagged with tritiated water (10 μCi/ ml) before the onset of monsoon rains. Our experience from the U.P.



Figs. 3-5. Activity and moisture profiles at some sites sampled after one monsoon.