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Estimation of Groundwater Recharge from Irrigated Fields Using Analytical Approach

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ABSTRACT

This study was designed to assess the recharge contribution to groundwater from irrigated field. The Watertable Fluctuation Method was used to quantify the recharge. It was found that the recharge contribution to groundwater from the rainfall and irrigated fields was at the rate of 0.502 mm/day. The recharge to the groundwater from rainfall alone was about 20% of total rainfall, which was 0.225 mm/day. Consequently, the groundwater recharge contribution on an average was found to be 0.277 mm/day from the irrigated fields.

Key Words: Groundwater; Irrigated fields; Recharge; Watertable

INTRODUCTION

Pakistan was once a water abundant country (5300 m^3/capita) during 1950s, which has turned into a water deficit country, with water availability of 1050 m^3/capita in 2002 (Ahmad, 2002). The irrigation system in the Indus Basin (Pakistan) is facing a number of operational problems resulting in very high degree of water losses during conveyance as well as during the application of irrigation to crops. The aquifer is recharged through natural precipitation, river flow, continued seepage from the canal system and application losses from the irrigated fields. Historically, recharged groundwater has been recovered through public and private pumping systems.

In Pakistan, the water availability for crop use in the field has been estimated to be about 50 bcm giving an overall system irrigation efficiency of 40% (Bakhsh & Awan, 2002). The conveyance and application losses have made the canal water supplies insufficient and inadequate for irrigation purposes.

Groundwater is of prime importance to meet rapidly expanding urban, industrial and agricultural water demands, particularly in arid and semi arid areas of Pakistan. The density and growth rate of tubewells confirms the significant role of groundwater usage in the irrigated agriculture of Punjab. The area irrigated from tubewells in Punjab increased from 9.4 mha in 1996-97 to 9.92 mha in 1999-2000, when compared with other provinces where it remained constant (PSY, 2001). Because of this development, the share of groundwater in meeting the crop water requirements at the farm level has gone well above the 50 percent. In fact, this share during the drought period (Rabi of 2001-02) was as high as 80%. This huge application of groundwater induces secondary salinization effects when about 70% of the tubewells are pumping saline/sodic water with high residual sodium carbonate (Shafique *et al*., 2002). The use of groundwater, however, needs very careful analysis before its application.

Groundwater recharge is critical hydrological parameter that depending on the applications may need to be estimated at a variety of spatial and temporal scales. Quantification of water fluxes from the atmosphere to underlying aquifers is important for global water budgets. Aquifer recharge estimates from irrigated field are essential for water management and critical to assess groundwater contamination from non point sources. Therefore, the present study was designed to assess the recharge contribution to groundwater from irrigated fields.

MATERIALS AND METHODS

The Watertable Fluctuation Method (Meinzer, 1923; Gerhart, 1986; Hall *et al.,* 1993; Richard, 2002) was used for estimating recharge based on the assumption that the rise in groundwater levels in unconfined aquifers was due to recharging water arriving at the watertable. Recharge was therefore, calculated using following equation.

$$R = S_y \frac{dh}{dt} = S_y \frac{\Delta h}{\Delta t} \qquad (1)$$

Where,

R = Recharge (mm/day).
S_y = Specific yield.
dh or Δh = change in watertable height (mm).
dt or Δt = Time interval (day).

To observe the watertable fluctuation, a set of six piezometers were installed in the command of watercourse 28000/R of Ghourdour Distributary of Upper Gogera Branch canal system. All the six piezometers were installed along a line with an incremental distance of 2.5, 2.5, 2.5, 2.5, 5.0 and 15.0 m between them. These piezometers were 9.15 m (30 ft) deep containing 6.10 m (20 ft) blind PVC pipe and 3.05 m (10 ft) perforated PVC pipe. The perforated pipe was covered with a thin parachute cloth to prevent the entry of clay particles into the piezometers. After installation, the perforated filters of the piezometers were packed with gravel materials to improve the hydraulic characteristics of piezometers. The watertable elevations were observed over a period of one year (Feb. 10, 2003 to Jan. 31, 2004) on alternate days.

RESULTS AND DISCUSSION

The temporal fluctuation of average watertable based on all the piezometers is given in Fig. 1. It is evident from Fig. 1 that during the early days (February, 2003) when there was no water in the watercourse, the watertable elevation was lower but as the water started to flow in the watercourse, the watertable moved upward and kept on rising up to the first week of May 2003. From the second week of May to the end of July 2003, watertable dropped drastically due to high evapotranspiration during May and June, 2003. From the last week of July, the watertable elevation started rising until the end of first week of February 2004, probably because of additional recharge contribution from rainfall. Observed rainfall shows an average precipitation of 33.7 mm/month during July 2003 to February 2004. The water levels were the highest (199.48 m) on February 8, 2004 and lowest (199.07 m) on July 21, 2003 over the observation period. Using equation 1 and the watertable fluctuation given above with specific yield as 0.25, the recharge contribution from the irrigated fields and rainfall is given in Table 1.

Table I shows that recharge contribution to groundwater from the rainfall and irrigated fields was at a rate of 0.502mm/day. According to Maaslands's method, the estimated recharge varied from 17 to 22% of the total annual rainfall (Ahmad & Chaudhry, 1988). Based on this assumption, the recharge to the groundwater from rainfall in the study area was considered 20% of total rainfall. Recharge from rainfall as 20% of the total rainfall was 0.225 mm/day. Consequently, the recharge contribution on an average was found to be 0.277 mm/day from the irrigated fields.

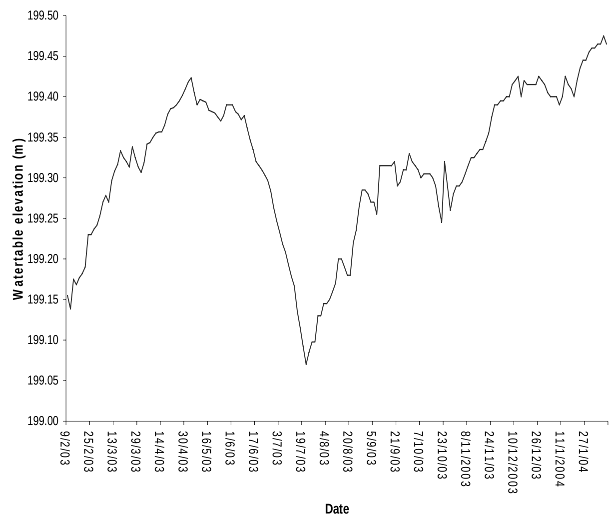
CONCLUSION

It was concluded that the recharge contribution to groundwater from the rainfall and irrigated fields was at a rate of 0.502 mm/day. The recharge from rainfall as 20% of the total rainfall was 0.225 mm/day. Consequently, the recharge contribution as an average was found 0.277 mm/day from the irrigated fields

Table I. Recharge assessment by watertable fluctuation method

Parameter	Lowest	Highest	Difference	Recharge from rainfall and watercourse (mm/day)
Date	21-7-03	10-2-04		0.502
Watertable (m)	199.07	199.48	0.41	
Days	_	_	204	

Fig. 1. Temporal fluctuation of average watertable elevation based on all the piezometers



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