Groundwater level and conductivity monitoring in Bist-Doab, Punjab, India

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Abstract

Groundwater, a vital element to sustain life , is highly exploited within India. Particularly in Punjab, the rate of decline of groundwater level is rapid in parts of the Indo-Gangetic plains including the districts of Amritsar, Kapurthala, Jalandhar, Ludhiana, Patiala and Sangrur. The four districts, also known as Bist-Doab region of Punjab, were chosen for a programme of continuous monitoring of water level and conductivity.
In the present study, data loggers were installed for monitoring groundwater level in 6 shallow (<60 m) and deep piezometers (>120 m) at Saroya, Tanda, Bhogpur, Kapurthala, Sultanpur Lodhi and Nakodar during August, 2013 and for monitoring conductivity in 4 shallow piezometers (<60 m) at Saroya, Bhogpur, Kapurthala and Sultanpur Lodhi during December, 2013. Preliminary analysis from the first year of data indicates that in deep piezometers water level starts rising from the month of November and declines from the month of April. In the shallow piezometers, preliminary analysis indicate that the groundwater level at Saroya, Tanda, Bhogpur and Kapurthala declines during the Kharif season (June to October) and groundwater level at Sultanpur Lodhi and Nakodar was almost constant. The conductivity of the groundwater was different in all the shallow aquifers as in Saroya and Sultanpur Lodhi, but almost constant over the period of monitoring.

Keywords: *Groundwater level, conductivity, fluctuations, Bist-Doab, Punjab*

1. Introduction

The Indo-Gangetic basin has the rich and reliable sources of groundwater supplies within the alluvium which has been extensively exploited for meeting the ever increasing demands for industrial, agricultural and urban use. However this is leading to areas with declining groundwater level (Rodell et al. 2009). Such is the case in Punjab, where the rate of decline of groundwater levels has increased during 1980-2005 (Singh 2011), and is now projected to fall by a further 21 meters in 60% of central Punjab during next 2 decades (Sidhu et al. 2010) particularly in the districts of Amritsar, Kapurthala, Jalandhar, Ludhiana, Patiala and Sangrur (Krishan et al. 2014a). These trends have been reported in several other studies carried out in different parts of Punjab and Indo-Gangetic basin where the emphasis is laid on decreasing groundwater level and deteriorating groundwater quality (Chopra 2014a, b; Krishan and Chopra 2015; Krishan et al. 2015a,b; Krishan et al. 2014a-h; 2013a-c; Lapworth et al. 2014 a-b; Lohani et al. 2015; MacDonald et al. 2013, 2014; Rao et al. 2014; Sharma et al. 2014). But in the northeastern part the Kandi region comprising of districts Hoshiarpur and Nawanshahr reported to be high rainfall areas of the state. In the present study, 4 districts viz. Jalandhar, Kapurthala, Hoshiarpur and Nawanshahr also known as Bist-Doab region of Punjab were chosen for continuous monitoring of water level and conductivity.

2. Study area

Punjab State, underlain by Quaternary alluvial deposits of the Indo-Gangetic basin, has an area of 50,362 sq.km. which constitutes 1.57% of total area of country and is drained by 3 major rivers – Beas, Satluj and Ravi. The study was carried out in Beas-Satluj Doab area of Punjab having a total area of 9060 sq. km. 17.6% of total area of Punjab covering Hoshiarpur, Nawanshahr, Jalandhar, Kapurthala districts. The area lies between 30^{0}51’N and 30^{0}04’N latitude and 74^{0}57’ and 76^{0}40’E longitude. It is bounded by Shivaliks in the north-east, the river Beas in the north east-south west and the river Satluj in south east-south west. There is a choe ridden (ravine-ridden) belt in the area bordered by the Shivaliks called the Kandi area. This area is a bhabhar, or a piedmont plain, lying at the foothills of the Shivaliks and formed by the coalescence of various alluvial fans resulting from the deposition of sediments by various choe at the foothills. The economy of the study area is primarily agro based and the farmers shifted the cropping pattern from the Maize-Wheat or Sugarcane-Maize-Wheat to Wheat-Rice cropping pattern (Krishan et al. 2014b; Statistical abstract of Punjab 2013).

The study area has a continental climate. Temperature in summers ranges from 30 to 32°C and maximum can be as high as 45°C. Winters are moderately cold with normal temperatures falling between 10 and 15°C. The area nearest the Shivaliks receives more rainfall (1200mm at Dhar Kalan) than plains that are far away from it. High rainfall and poor vegetation cover are responsible for soil erosion in the Shivalik foot hill zone (Sehgal et al. 1988).

3. Experimental program

In the present study, data loggers were installed for monitoring groundwater level in 6 shallow (<60 m) piezometers of Punjab Water Resources and Environment Directorate (PWRED), Chandigarh and 6 deep piezometers (>120 m) of National Institute of Hydrology (NIH), Roorkee at Saroya, Tanda, Bhogpur, Kapurthala, Sultanpur Lodhi and Nakodar during August, 2013 and for monitoring conductivity, in 4 shallow piezometers (<60 m) of PWRED, Chandigarh at Saroya, Bhogpur, Kapurthala and Sultanpur Lodhi during December, 2013 but the readings were recorded from September, 2014 onwards. The location of the installation of the piezometers in given in fig. 1. Before installing the loggers the age of groundwater was determined at Nuclear Hydrology Laboratory of NIH, Roorkee using tritium tracer technique.

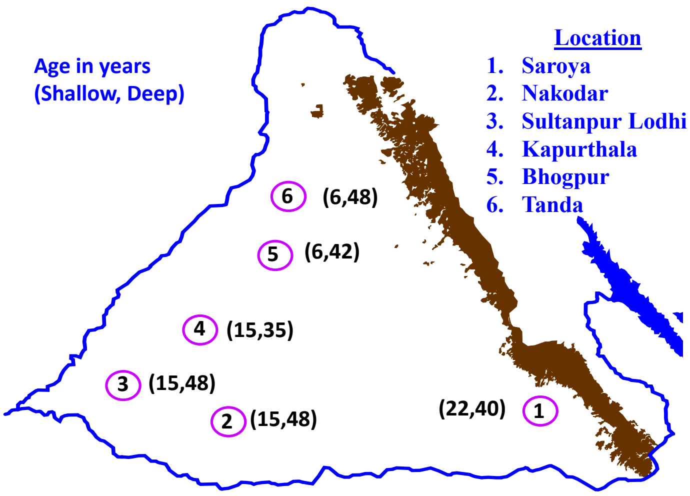

Fig. 1. Locations of paired shallow and deep piezometers where continuous loggers are installed to monitor water levels and conductivity (shallow sites)

4. Results and Discussion

Preliminary analysis of the first year of data indicate that in deep piezometers, it was observed at all the sites the water level starts rising from the month of November and it again starts declining from the month of April (Fig. 2), while in shallow piezometers, it has been observed that the groundwater levels decelined at Saroya, Tanda, Bhogpur and Kapurthala during the Kharif season (June to October) but groundwater level at Sultanpur Lodhi and Nakodar was almost constant (Fig. 3). Similar results were obtained by Krishan et al. (2014c).

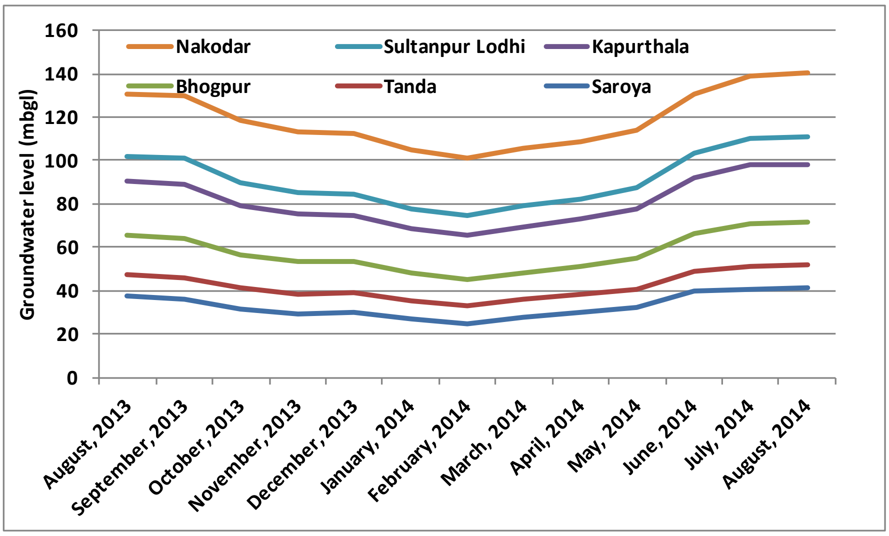

Fig. 2: Water level Variation in Deep Piezometers Bist-Doab, Punjab

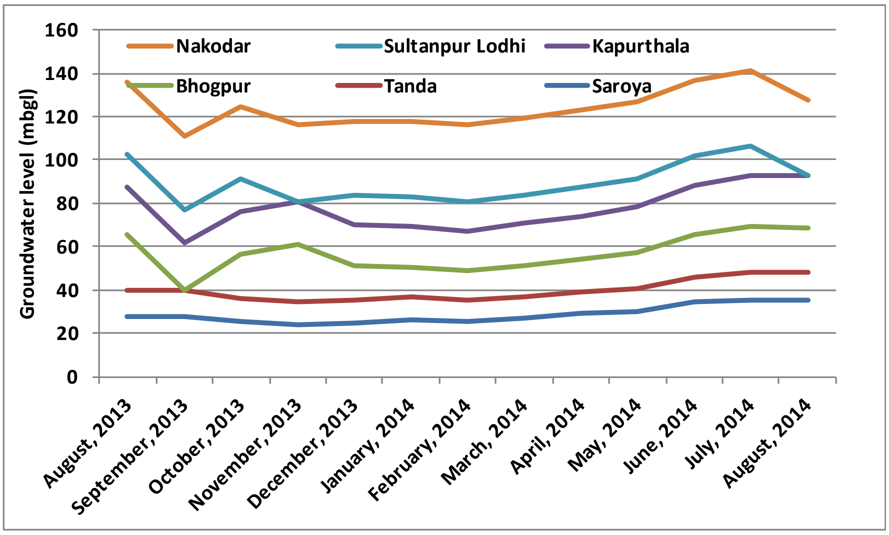

Fig. 3: Water level Variation in Shallow Piezometers Bist-Doab, Punjab

The conductivity of the groundwater behaved differently in all the shallow aquifers. In Sultanpur Lodhi, it decreased from September, 2014 to October, 2014 and then it was almost constant. In other stations Saroya, Bhogpur and Kapurthala a small increase in conductivity was observed from February, 2015.

The north-east portions of Hoshiapur and Nawanshehar, there are deeper groundwater tables, due to the change in topography, and this region considered the recharge area for the deeper plain aquifer system. The transition from the Kandi belt to the plains and sudden change in slope results in a dense network of drainage that recharges the plain aquifers. This area has higher rainfall (900 mm/y) and higher areal and surface water recharge, middle portion has lower rainfall (700 mm/y) and recharge from irrigation and seepage from canals and southwest prtion has lower rainfall (600 mm/y), shallow groundwater and limited recharge potential. Some parts of Nawanshahr and Jalandhar districts are irrigated using canals from the R. Satluj, however, most of the study area is irrigated using shallow (0-50 m) groundwater (>90%). The groundwater table is shallow in the confluence area with associated water logging and salinity issues (Lapworth et al., 2014a,b).

The study carried out for mean residence time by Lapworth et al (2014a) on the basis of results obtained using chlorofluorocarbon (CFC-12) groundwater age tracers show that median shallow groundwater mean residence times (MRTs) of 25 years and 30 years under post-monsoon and pre-monsoon conditions. Deep groundwater (>100 mbgl) had median MRTs of 45 years irrespective of recharge conditions. Deep groundwater MRTs are much younger than would be expected under natural groundwater flow regimes, where groundwater residence times of the order of ca.102-103 years or more might be expected in the deeper plains aquifers, some 50 km down-gradient of the recharge zone.

The variations in water level and conductivity can be understood by the research work carried out by Lapworth et al (2015) where it was reported that the widespread occurrence of modern tracers (Choroflurocarbons (CFCs), noble gases) in deep groundwater in >10 numbers of sites out of 16 sites had >10% modern recharge which suggests that there is low aquifer anisotropy. The deep aquifers are recharged by a significant component of modern recharge via vertical leakage. The contrasting isotope signatures of precipitation and surface waters in this area clearly demonstrate that both shallow and deep groundwater recharge is dominated by meteoric sources, rather than surface water sources including canal irrigation water. Stable isotope and noble gas results at all depths conform to modern meteoric and annual average temperature conditions, with no evidence of a significant regional component of recharge from canal leakage. They further reported that the depleted water isotope signatures in the deep groundwater relative to the shallow groundwater can be explained by recharge sources from the deep groundwater having a component of groundwater recharged some distance up gradient from the sampling point at a higher elevation. Alternatively, this may be a signature of modern groundwater irrigation and the recycling of groundwater over the last four decades leading to a small enrichment in the shallow aquifer system. Even at a depth of 160 m groundwater isotope signatures are consistent with modern meteoric sources.

5. Conclusions

The results have shown fluctuation in water level and conductivity during different time period of the year due to variation in source of recharge and usage of the bore wells. The deep aquifers are recharged by a significant component of modern recharge via vertical leakage. The contrasting isotope signatures of precipitation and surface waters in this area clearly demonstrate that both shallow and deep groundwater recharge is dominated by meteoric sources. The groundwater is used more for irrigating the Kharif crops and hence the groundwater level is found low in this season due to more extraction. Further long term monitoring is required for assessing the variations.

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