Optimization of Groundwater Monitoring Network in Bist-Doab area, Punjab

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ABSTRACT

The present study was undertaken in the Bist-Doab area of Punjab to monitor the fluctuations in the groundwater level and also to optimize the groundwater monitoring network using cross-correlation. For this purpose, the Automatic Groundwater Level Recorder (Solinist-make) were installed in the shallow (20-60m) Piezometers developed by Punjab Water Resources and Environment Directorate, Chandigarh at Saroya (Nawanshahr), Tanda (Hoshiarpur), Bhogpur and Nakodar (Jalandhar) and Kapurthala & Sultanpur Lodhi (Kapurthala) and the readings for the water level recorders were taken at a fixed interval of 1 hour for a period of August, 2011 to June, 2012.

The statistical cross-correlation was calculated using Metlab software. It was found that the stations Bhogpur and Tanda were highly correlated and the value was 0.91 at 0 lag. It was inferred that these two stations are highly correlated indicating that the groundwater monitoring stations are falling in the homogenous region. Thus instead of two stations only single station data can be used for monitoring the groundwater level. In case of other stations where the correlation has affected at -10 and + 10 lags other hydro-geological parameters are to be investigated in detail.

This will help in managing and monitoring groundwater network and the information derived can be used for establishing the stations at suitable sites. However, in case of stations like Nakodar, Sultanpur Lodhi, Saroya where correlation is not good can be kept for observation as these stations may have different aquifers or other hydro-geological conditions.

1. INTRODUCTION

Groundwater is a vital element to sustain life. The primary resource of groundwater recharge is precipitation and other surface water sources such as canal, pond, drain, also contribute over a time depending upon its transverse in the area of recharge, however decreasing availability of groundwater due to rapid growth of population, urbanization and agricultural activities is increasingly placing stress on both human communities and surrounding environmental system.

The state of Punjab, comprising 1.5% area of the country, has been contributing 40-50% rice and 60-65% wheat to the central pool for the last three decades. The change in cropping pattern in Punjab has increased irrigation water requirement tremendously and the irrigated area has increased from 71 to 95% in the state. Also the number of tubewells has increased from 1.92 to 11.68 lakhs in the last 35 years, resulting in over-exploitation of ground water and rapid decline in water tables (Kaushal et al 2008). During the last decade the average fall of water table in the central Punjab was o.55m/year (Hira et. al 2004). At some places the ground water level declined at the rate of even 0.75 to 1m/year. Facts states that per year we required 43 lakh ha-m of water to grow our crops in Punjab but what we have in our pocket is 30 lakh ha-m. Thus, we draw13 lakh ha-m of excess water from the ground which is a matter of great concern and attention.

The Punjab plains in the past 3-4 decades witnessed a boom in groundwater use and many authors have studied this problem of depleting water quality and fall in water tables (Dhawan 1995; Sondhi et al. 2001; Ambast et al. 2006). Many districts of Punjab show 100% or even greater levels of exploitation and the same is exhibited by a secular decline in pre-monsoon water tables except for extremely wet years.

The Bist-Doab is a triangular region and covers an area of 9060 km^2 comprising of Nawanshahr, Hoshiarpur, Kapurthala, Jalandhar and a part of Ropar districts of Punjab State, India. It is bounded by Siwalik range in the north-east, the river Beas in the north and west sides and the river

Satluj in south and east-south. The area is part of the Indo-Gangetic alluvial plain of the Holocene age and is drained by the Satluj and Beas rivers and their tributaries. The drainage density is high in the NE strip bordering the Siwalik hills, but it is moderate to low in the rest of the area with sub-parallel and sub-dendritic patterns.

The Beas and Satluj, two perennial rivers, rise in the high Himalayas and traverse long distances in the Himalayan and Siwalik zone before entering the state of Punjab. High rainfall and poor vegetation cover are responsible for soil erosion in the Siwalik foothill zone (Sehgal et al. 1988).The climate of the study area is influenced by the Himalayas in the north (Chopra and Sharma, 1993). Bist Doab area is also comprised of Kandi region and central plains. In Kandi region, there are deep groundwater tables, high speed of groundwater flow, uncertain composition of aquifers and some challenges associated with the groundwater use in this area. In these areas, even any moderate development of groundwater results in high levels of exploitation. In the Central Plains of the Bist-Doab, Jalandhar and Kapurthala districts have been categorized in the over-exploited.

Keeping the above points in view, the study was undertaken in the Bist-Doab area of Punjab to monitor the fluctuations in the groundwater level and also to optimize the groundwater monitoring network using cross-correlation.

2. STUDY AREA

The Bist-Doab is a triangular region and covers an area of 9060 km^2**.** The word “Doab” signifies the region between two rivers namely, Satluj and Beas, in the present study. It comprises the Nawanshahr, Hoshiarpur, Kapurthala and Jalandhar districts of Punjab State, India. It is bounded by Siwalik range in the north-east, the river Beas in the north and west sides and the river Satluj in south and east-south. The area lies between 30°51'N and 30"04'N latitude and 74"57' and 76"40'E longitude (Figure 1).

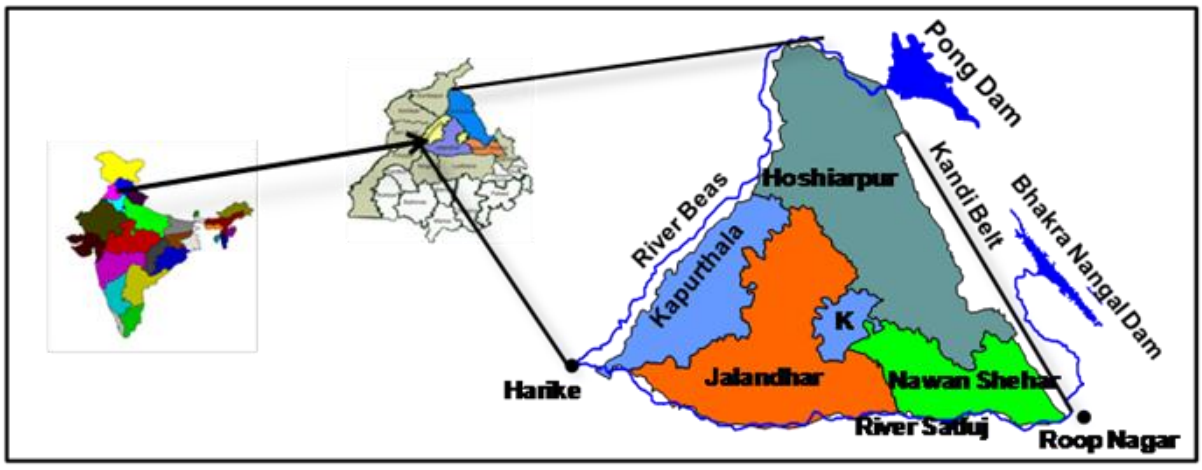

Figure 1. Bist-Doab region

3. METHODOLOGY

The Automatic Groundwater Level Recorder (Solinist-make) were installed in the shallow (20-60m) Piezometers developed by Punjab Water Resources and Environment Directorate, Chandigarh at Saroya (Nawanshahr), Tanda (Hoshiarpur), Bhogpur and Nakodar (Jalandhar) and Kapurthala & Sultanpur Lodhi (Kapurthala) as shown in fig. 2 and the readings for the water level recorders were taken at a fixed interval of 1 hour for a period of August, 2011 to June, 2012. The data processing was done to remove the erroneous data before statistical analysis. The erroneous values were rectified. The statistical cross-correlation was calculated using Metlab software.

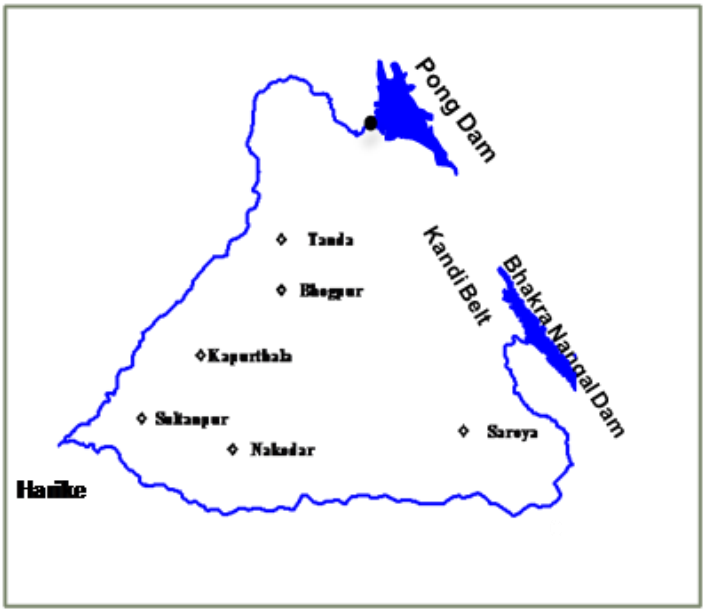

Figure 2. Sampling stations in Bist-Doab region

4. RESULTS & DISCUSSION

The increase in the groundwater level to the tune of 1 m, 2 m & 3.4 m in May, 2012 was observed in Bhogpur, Saroya and Tanda, respectively as compared to the August, 2011. However, the water level increased at all the stations during the period from December, 2011 to March, 2012 and a maximum increase of 31% was observed at Bhogpur which was followed by 24% at Saroya and the least 19% at Sultanpur lodhi. The water level again started decreasing after the month of March, 2012. The difference in change in phreatic water levels may be due to local aquifers or variation in the aquifer structures and availability of groundwater.

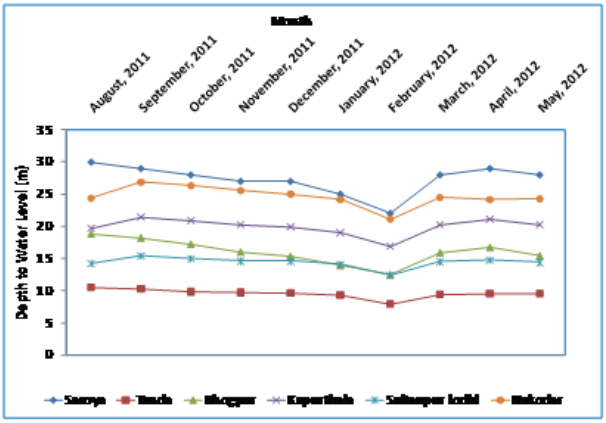

Figure 3. Groundwater level in Bist-Doab region from August, 2011 to May, 2012

As evident from the tables 1-3 and figure-4, Bhogpur station has found a very good cross-correlation (at 0, -10 & +10 lag) ranging from 0.79 to 0.91 with all the stations, closely followed by Tanda where the cross-correlation was found in the range of 0.71 to 0.91. The highest cross-correlation to the tune of 0.91was observed between the Tanda and Bhogpur, followed by 0.84 between Tanda and Sultanpur Lodhi. The good correlation among the stations indicates that the stations are falling in homogeneous regions. Nakodar has recorded lowest (0.53) correlation with Saroya & Sultanpur Lodhi. The poor cross-correlation among these stations may be due to different aquifers or hydro-geological conditions. The cross-correlation of Kapurthala at -10 and +10 lags improved with all the stations except Bhogpur, while the cross-correlation of Sultanpur Lodhi and Nakodar showed a decline from 0.73 at 0 lag to 0.53 &0.54at -10 & +10 lags, respectively. In case of

such stations, where the cross-correlation is improving after -10 & + 10 lags other hydro-geological parameters may be investigated in detail.

Table 1: Cross-correlation between the sampling stations in Bist-Doab, Punjab

(0 lag)

Station name	Saroya	Tanda	Bhogpur	Nakodar	Kapurthala	Sultanpur Lodhi
Saroya	1	0.84	0.80	0.56	0.75	0.67
Tanda	0.84	1	0.91	0.75	0.71	0.84
Bhogpur	0.80	0.91	1	0.81	0.81	0.83
Nakodar	0.56	0.75	0.81	1	0.67	0.73
Kapurthala	0.75	0.71	0.81	0.67	1	0.75
Sultanpur Lodhi	0.67	0.84	0.83	0.73	0.75	1

(-10 lag)

Station name	Saroya	Tanda	Bhogpur	Nakodar	Kapurthala	Sultanpur Lodhi
Saroya	1	0.80	0.79	0.53	0.81	0.68
Tanda	0.80	1	0.86	0.73	0.86	0.80
Bhogpur	0.79	0.86	1	0.80	0.80	0.86
Nakodar	0.53	0.73	0.80	1	0.86	0.53
Kapurthala	0.81	0.86	0.80	0.86	1	0.81
Sultanpur Lodhi	0.68	0.80	0.86	0.53	0.81	1

(+10 lag)

Station name	Saroya	Tanda	Bhogpur	Nakodar	Kapurthala	Sultanpur Lodhi
Saroya	1	0.78	0.80	0.54	0.82	0.68
Tanda	0.78	1	0.88	0.73	0.88	0.78
Bhogpur	0.80	0.88	1	0.80	0.79	0.88
Nakodar	0.54	0.73	0.80	1	0.88	0.54
Kapurthala	0.82	0.88	0.79	0.88	1	0.82
Sultanpur Lodhi	0.68	0.78	0.88	0.54	0.82	1

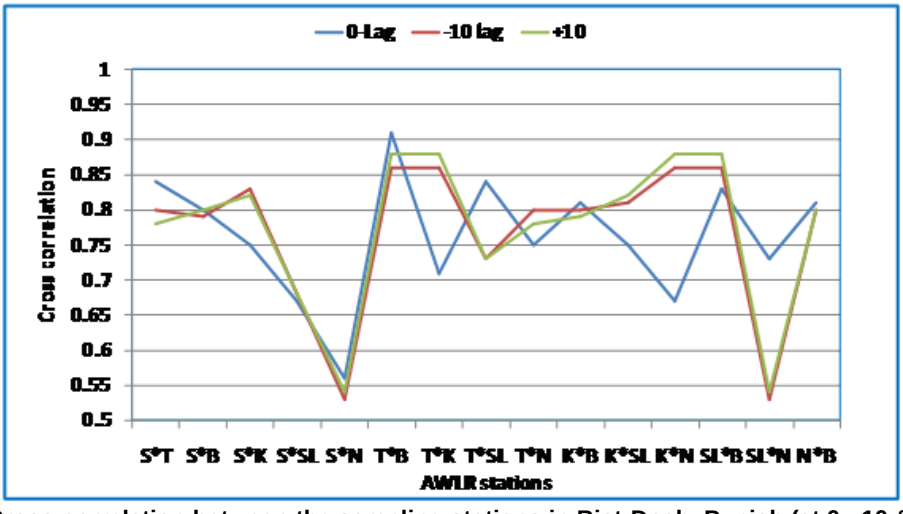

Figure 4: Cross-correlation between the sampling stations in Bist-Doab, Punjab (at 0, -10 & +10 lags)

5. CONCLUSION

It was found that the stations Bhogpur and Tanda were highly correlated and the value was 0.91 at 0 lag. It was inferred that these two stations are highly correlated indicating that the groundwater monitoring stations are falling in the homogenous region. Thus instead of two stations only single station data can be used for monitoring the groundwater level. In case of other stations where the correlation has affected at -10 and + 10 lags other hydro-geological parameters are to be investigated in detail.

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