A Study on Ground Water Fluctuation in Bhiwani District of Haryana

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Abstract- **Groundwater is the major source fresh water available for various human activities worldwide. In the semiarid region of Indian state of Haryana groundwater is primarily used as a source of water supply for drinking and irrigating the agricultural land. Due to rapid growth of population and the intensive agricultural activity and agriculture based industry dependency on groundwater have increased the by manifold. The majority of the aquifers are suffering from stresses because of over drafting of groundwater beyond their maximum safe yield potential, though some other aquifer are being recharged beyond the rainy season by the irrigation canal. Thus, it is imperative to study the groundwater dynamics of such hydrogeological set up. In the present study, an attempt has been made to explore the groundwater dynamics (seasonal and annual) of the Bhiwani district of Haryana. Ground water level data were collected from 24 observation wells uniformly distributed over the entire district for a period of 2005 to 2013. The monthly rainfall data were also collected for the same period and its effect on groundwater level and fluctuation in groundwater level were explored. Results indicate that different degree of fluctuation spatially and seasonally. No strong and definite relationships were observed between ground water level (fluctuation) and rainfall during the study period. It is expected the study may provide some vital clue for proper management of groundwater resource of the region.**

Keywords: Ground water level, monsoon, seasonal variation, rainfall, Bhiwani

I. INTRODUCTION

Groundwater, the largest source of fresh water, is one of the most important vital resources available on this earth. It is widely distributed and readily available fresh water resource for domestic, agricultural and industrial activities [1]. In general, the availability of groundwater depends on rainfall and recharge conditions which in turn depend on geology, hydrologic parameter, soil properties, recharge & discharge and hydraulic characteristic of aquifer of a particular area [2].

The uncontrolled and unscientific explorations of grounwater have depleted this finite fresh water resource in both quantity and quality wise. This phenomenon, further, leads to several socio-economic and environmental consequences in the region in the form of crop failure adverse salt balance, sea water intrusion in costal aquifers and subsidence[3]. The declining groundwater level and associated environmental problems are widespread phenomena even in high rainfall areas which experiences water scarcity in summer months [4]. In general the recharge groundwater resource is directly proportional to amount rainfall though not linearly. However, this problem is highly exaggerated in nature in arid and semi arid regions. Thus, it is imperative to monitor and manage development and usage of groundwater resource of a region [5].

In the present study an attempt has been made to explore the temporal variation in groundwater level (GWL) annual and seasonal. The second objective is to explore the behavior of groundwater fluctuation with respect to rainfall in Bhiwani District of Haryana.

II. STUDY AREA

Bhiwani District, with a geographical area of 5140 km^2, lies in South-Western part of Haryana. It has no perennial river and physiographycally comprises of flat and level plain frequently interrupted by clusters of sand dunes, isolated hillocks and rocky ridges. The climate of Bhiwani district is tropical, semi-arid and dry except during monsoon season. The monsoon season starts from last week of the June to September. The normal annual rainfall of the district is 420 mm of which about 85% occurs in monsoon period. It has a population density of 298/km^2.

Hydrogeologically, the aquifer of the district primarily comprised of alluvium, aeolian sands and underlying jointed and fractured hardrocks formations. The hardrocks comprising of Aravalli group of rocks, Malani suite of volcanic and Alwar Quartzites of Delhi system. The exploratory tubewells at Budhera taps in the depth range of 52 to 100m and yields 946 LPM for 8.4 m. of drawdown with transmissivity of 1130 m^2/day [6].

III. MATERIALS AND METHODS

The study involves two main data i.e. temporal groundwater level data and rainfall data. The groundwater level data of nine years (2005-2013) were collected from Central Groundwater Board [7]. The groundwater level data were collected from 24 observation wells (Table 1) which helped in exploring the spatial variation of groundwater level in Bhiwani District. In order to explore the seasonal effect on ground water level, monthly data have been categorized into seasonal data with respective three distinct seasons i.e. Monsoon (June- September) Post monsoon (October- January) and Premonsoon (February – May) and annual data (Jan-Dec).

Table 1: List of Observation well of the study area

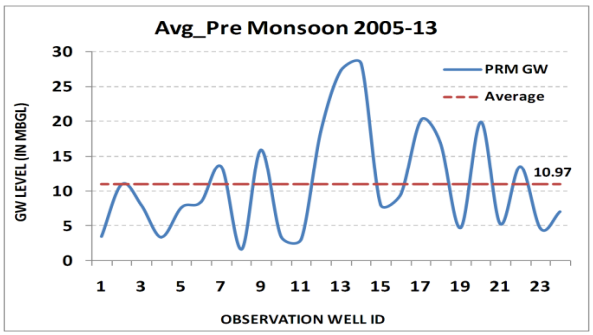
ID	SITE NAME	Long	Lat
1	Badala	28.72234	76.26341
2	Bajina	28.76363	75.98301
3	Bamla	28.80623	76.24463
4	Baundkalan	28.78022	76.33636
5	Bawanikhera	28.94717	76.03114
6	Bohal	28.96148	75.93634
7	Chirya	28.46168	76.26118
8	Dhanana	28.91813	76.17051
9	Gurera	28.91957	75.51105
10	Haluwas	28.73802	76.11432
11	Imlota	28.61905	76.44702
12	Isharwal	28.76348	75.70462
13	Jhumpa	28.77339	75.5289
14	Juikalan	28.63279	75.9424
15	Lachhmanpur	28.80465	75.96196
16	Lohani	28.70629	76.04365
17	Mauhala	28.53634	76.27705
18	Mehrana	28.55676	76.32281
19	Miran	28.84789	75.73819
20	Nayaatela	28.593	76.10245
21	Sanwar	28.71255	76.29088
22	Siwani	28.91171	75.60894
23	Sui	28.8613	76.06141
24	Tosham	28.87316	75.91493

Different graphical presentations of the GWL were used to interpret the temporal variation in GWL in the district. GWL fluctuation was studied by subtracting the GWL in 2005 from GWL in 2013 at a particular well. The monthly rainfall data for the same period was also collected from Indian Meteorological Department (IMD, New Delhi). But the rainfall data was collected from single rain gauge station assuming that there were no significant spatial variations in annual rainfall within the Bhiwani District. A correlation analysis was carried out to explore the relationship of rainfall on GWL or GWL fluctuation during the study period in the Bhiwani district.

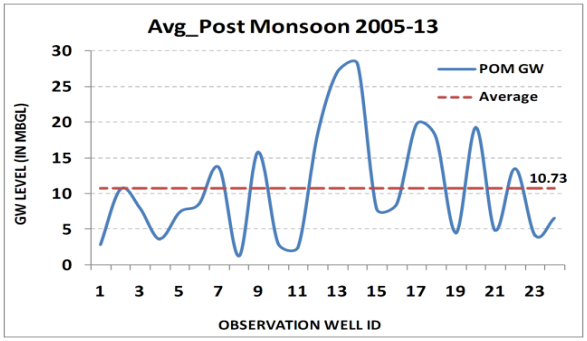
IV. RESULTS AND DISCUSSION

A. Seasonal variation in groundwater level

The depth to water table is closely related to the topography, sub - surface lithology, and also to the irrigation channels and surface water bodies. Thus, different GWL at different observation well can be expected. Moreover, everything being constant, The GWL of the study area fluctuated considerably over the different seasons of a particular year. The smooth lines in the figure 1 present the average (2005 – 2013) GWL of different seasonal and annual time step. The red color dash line indicates the average GWL of the Bhiwani district for the same period. The figures indicate that the relative GWLs at different observation wells follow the same at seasonal and annual time step but the minimum and maximum GWLs at individual observation well and district vary considerably.



(a)



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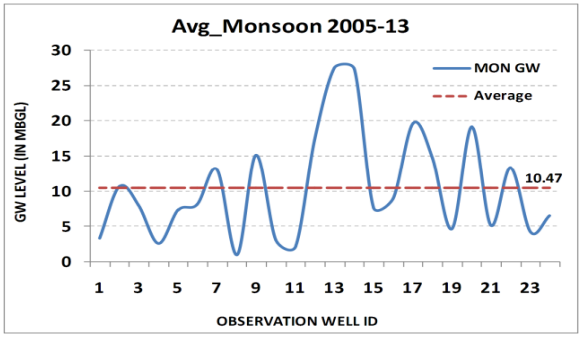

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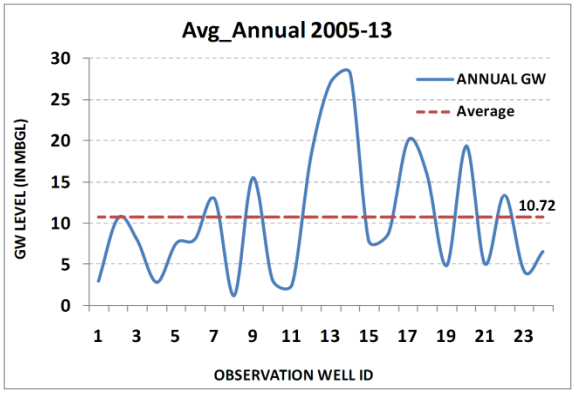


(d)

Figure 1: Average GWL at different observation well (a) premonsoon, (b) monsoon, (c) postmonsoon, (d) annual

The annual averages (1-d) depth to groundwater at different wells range from 2.00 mbgl to 29 mbgl. It is shallow and between 3m to 10 m in the Northern, Northeastern and Eastern (Tosham Bhiwani khera Dadri-l and Bhiwani blocks) and 10 to 20 m.bgl in the Southern and Northwestern parts of the district (Badra, Dadri-ll and Siwani). Ground water levels are deeper in the Western and some patches in the Central part at a depth of more than 20 mbgl (Loharu and Siwani blocks). The depth of groundwater level depends upon the qualities of water recharge and discharge which in turn depend on the rainfall overlying geology and intensity of water demand from different sectors of human activities.

Groundwater level in the region also shows a seasonal pattern. The average depths of GW in Bhiwani district were found to be 10.97m, 10.47m and 10.73m during premonsoon, monsoon and post monsoon season respectively. In the study area, groundwater abstractions take place in the dry months (late winter to premonsoon seasons) starting from January and continues up to May also June. During this period the recharge is either almost nil, the rate of evapotranspiration (ETP) is relatively high. Because of the above reasons, the water table decline sharply and reaches to maximum depth in the month of May (premonsoon season). In mid June, with the onset on southwest monsoon rain events occurs frequently causing recharge of aquifer which gradually increases the water level. Moreover, during the monsoon period the major artificial abstraction (irrigation) and natural abstraction (ETP) are less due to high moisture content in soil and air. All these cause replenishment of aquifer which appears as gradual increase in ground water level.

B. Groundwater fluctuation

Fluctuation of groundwater level provides crucial information on the dynamics of recharge-discharge in short duration and aquifer conditions (in terms of ground potential/depletion) in long term. The long-term (10 years) average water level trend indicates that the water level decline ranges from 0.03m/yr to 1.12 m/yr. during premonsoon and 0.001 m/yr to 1.38 m/yr during post-monsoon. Maximum decline has been noticed in Southwestern part of the district (Loharu block) and the minimum decline in Central part of the district. Water level rise is seen in the Northern part of the district, covering Bhawani Khera, Tosham and Bhiwani blocks.

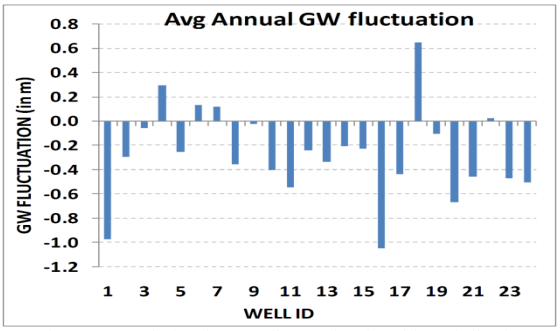


Figure 2: Variation in GW fluctuation in Bhiwani district

The water table elevation map shows the general slope of the water table towards Northwest from Southeast.

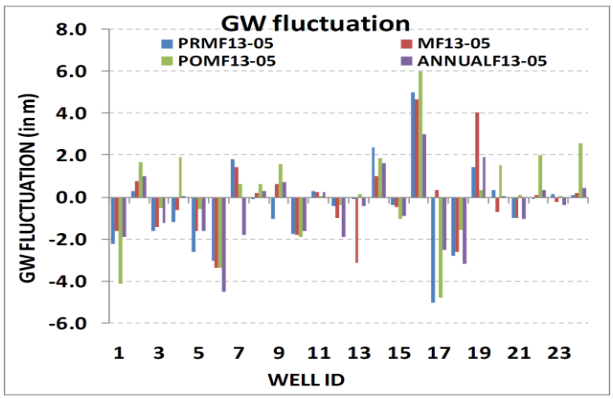


Figure 3: Variation of seasonal GW fluctuations in Bhiwani district

Ground water level fluctuation of different region of different seasons is shown in figure 3. It is obvious from the figure 3 that the fluctuation are most prominent during premonsoon with large depletion of water level in almost all observation wells of the study area and fluctuations are least during monsoon season. at all the wells. It might be due to heavy extract of GW for irrigation purpose for ravi crop and due to increased demand for water supply will almost remain the same. Another possible reason could be negligible to no recharge of aquifer during this period either due to no rainfall or increase evaporation and other initial losses from rainfall and/or surface water bodies.

C. Rainfall in groundwater level and its fluctuation

The study area receives rainfall under the influence of south-west monsoon. The monthly rainfall data collected for only rain gauge station at Bhiwani summed up for annual as well as for the three distinct seasons is presented in Table 2.

Table 2: Annual and season rainfall of Bhiwani district

Year	Rainfall (mm)			
	Annual	PRM	MON	POM
2005	489.8	104.1	373.6	12.1
2006	364.1	72.9	277.3	13.9
2007	381.3	101.7	279.6	0
2008	762.5	141.6	610.5	10.4
2009	227.8	32.4	188.4	7
2010	441.1	9.2	414	17.9
2011	328.9	65.7	263	0.2
2012	335.7	25.4	301.7	8.6
2013	292.9	53.7	212.4	26.8

The normal rainfall of the district was 402.7 mm and around 81% of rainfall occurred during the monsoon season. Figure 4 presents scatter plot of annual rainfall rainfall vs annual average GWL fluctuation of Bhiwani district.

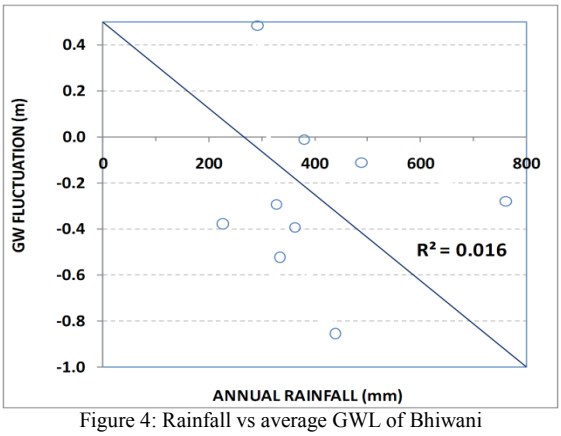
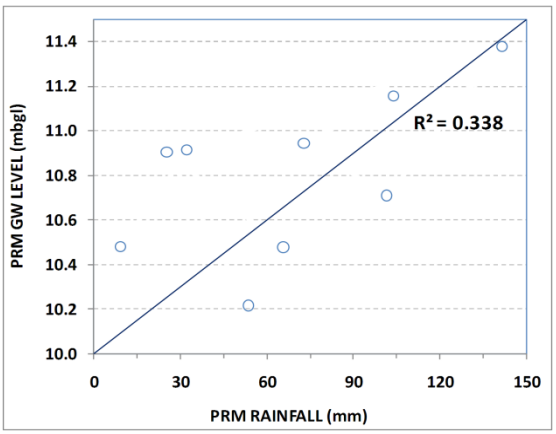
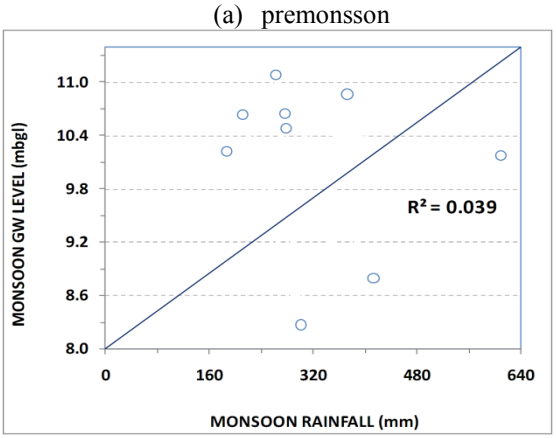


Figure 4: Rainfall vs average GWL of Bhiwani

Figure 4 indicates that there are negative correlation between amount of annual rainfall and average GWL fluctuation in the district. But the correlation is very weak ($R^2 = 0.016$). It is because rainfall describes only recharge pattern but GWL fluctuation actually depends on discharge pattern (GW extraction for various human activities) also. Thus, in the next step the relationship of GWL with rainfall is directly explored (Figure 5)



(a) premonsson



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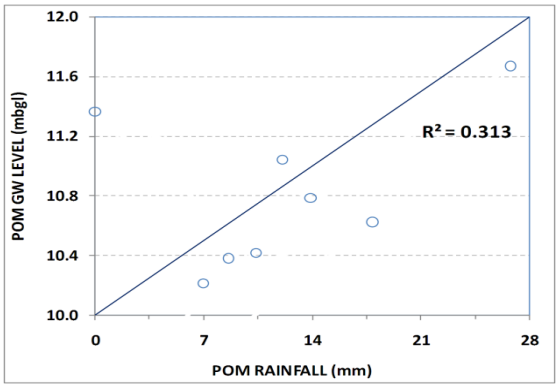

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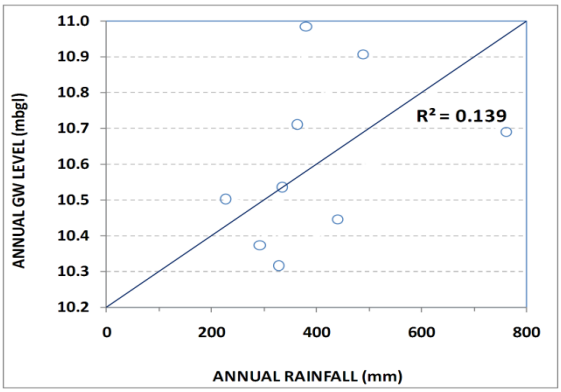

(d) annual

Figure 5: Annual Rainfall vs average GWL fluctuation of Bhiwani

Figure 5 presents the correlation of annual and seasonal rainfall data with annual and seasonal average GWL for Bhiwani district fro the study duration (2005-2013). It is apparent from figure 5 that GWL has good correlation with annual rainfall during dry period and worst for monsoon season. The R2 value is highest during premonsoon season followed by post monsoon and annual average GWL. The least correlation during mosoon season could be attributed to fact that GWL data is averaged over all the 24 observation wells with great variation in their GWL and also may be due to different amount of recharge rate at different observation well.

V. CONCLUSION

Groundwater level and its fluctuation has been studied for Bhiwani district for a period of nine years (2005-2013). The study has profound significance as groundwater is major source of drinking as well as irrigation water. Due to increased population accompanied by unprecedented growth in economic activities has been imparted severe negative impact on the groundwater resource of the District in the form of decline on GW quality and quantity. The majority of observation wells across the district suffer varied degree of declination in GWL while some wells found to have increased GWL during the study period. Results also indicate poor relationship between GWL fluctuation and annual average rainfall of the district. However, effect of rainfall on GWL is relatively better understood in the study.

In order to arrest the declining trend of water levels in the district, the rooftop rainwater harvesting technology should be adopted and recharge structures may also be constructed in depression areas where water gets accumulated during rainy season. This will help in enhancing the recharge to ground water reservoir. Moreover, government should plan new canal or implement efficient irrigation scheduling with increased frequency to reduce the dependency on groundwater for irrigation purpose.

VI. REFERENCES

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