DYNAMICS OF THE AQUIFER SYSTEM IN PARTS OF GREATER NOIDA USING AQUIFER MODELING FOR DIFFERENT LAND USE PATTERN

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ABSTRACT

The study area lies in parts of Greater Noida where the various land use have been superimposed through the master plan such as residential, commercial, recreational, industrial and forest along with the agriculture land. Ground water availability with the rain water harvesting potential is examined. Various parameters such as specific yield of the soil, water level fluctuation and rain water harvesting potential of the shallow aquifer and deep aquifer are studied. It is observed that the specific yield has got the great variations from forest land use to agriculture, village, residential, commercial and finally institutional. The minimum specific yield is recorded in the agriculture area while the maximum specific yield is recorded in the institutional zone. Similarly, the minimum water level fluctuation occurs in village area where as maximum is recorded in the institutional zone. This study is prepared to superimpose the land use master plan in totality.

Key words: Aquifer modelling, water level fluctuation, rain water harvesting potential, specific yield of the soil.


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1. INTRODUCTION

Water is the most important species on the planet to support life. Ground water has unique features which render it particularly suitable for public water supply. It has excellent natural quality, usually free from pathogens, color and turbidity and can be consumed directly without treatment. Ground water is widely distributed and can be frequently developed incrementally at points near the water demand, thus avoiding the need for large water storage, treatment and distribution system. However, the availability of ground water is neither unlimited, nor protected from deterioration. Generally, the withdrawal of unnecessary amount of ground water has resulted in desiccation of wells, broken ecosystems, land subsidence, salt water intrusion and exhaustion of the resources. Ground water quality is becoming more and more vulnerable through agriculture, urban and industrial wastes, which are percolated into essential aquifers [1-8]. It has been noticed that once pollution assimilates the subsurface environment, it may remain concealed for several years, becoming dispersed over wide areas of ground water aquifer and rendering ground water supplies unsuitable for consumption and other uses. The rate of depletion of ground water levels and deterioration of ground water quality is of concern in major cities and towns of the country. Greater Noida is facing multifaceted problems regarding water availability, and quality. The population growth and rapid urbanization in and around it has led to immense pressure on basic emanate such as water supply. Deepak Khare et al. (2004) [9] have assessed the impact of RWH on groundwater quality at Indore and Dewas in India using the data from existing tube wells. The rooftop rainwater was put through sand filter leading to a reduction in the concentration of pollutants in groundwater.

Saleem and Athar [10] have examined in their study in Greater Noida region that 90% water samples have good quality and 10% water samples comes under moderately poor group. The water quality index ranges falls between 16.49 to 64.65. Hence, there is a requirement of some treatment before usage and also need to protect the area from contamination. Sharma and Jain (1997) [11] conducted an experiment in Nagpur city where 80,000 liters of water, Collected from the roof top of 100 m2 area was recharged. The rise in water level up to 1 m was recorded in the recharge well and adjoining dug wells. Groundwater quality is bound to improve because of nitrate concentrations got diluted reasonably to the permissible limit. Vijaya Kumar (2005) [12] has evaluated the ground water potential by groundwater estimation committee (GEC 1997) norms. Venkateswara Rao (1996) [13] has reviewed the importance of artificial recharge of rainfall for Hyderabad city water supply.

A simulation based model is created by Srivastava (2001) [14] to make a system which determines the catchment to command area ratio, size of tank, desirable command area of a single tank and the feasibility to economics of lining a tank. F. and Shareef (2009) [15] studied the research to determine the potential for water quality with the help of rainwater in residential sectors of the Jordan. It has provided suggestions regarding the improvement of both quality and quantity of harvested rainwater. Sazaklia et al (2007) [16] examined the quality of rainwater, which is used for drinking and domestic purposes in the northern area of Kefalonia Island in Greece.

Saleem and Athar presented (2016) [17] hydrogeochemical assessment of groundwater in shallow aquifers of Greater Noida region. Therefore various physio-chemical parameters such as pH, TDS, EC, TH and major ions i.e. Cl⁻, SO₄²⁻, NO₃⁻, Na⁺, K⁺, Ca²⁺, Fe²⁺, Mg²⁺, CO₃²⁻ and HCO₃⁻ have been analyzed in the present study using standard procedures. The results of major constituents were compared with the water quality standards prescribed by WHO. From the analyzed samples, different indices such as soluble sodium percentage (SSP), sodium
adsorption ratio (SAR), residual sodium carbonate (RSC), magnesium adsorption ratio (MAR), Kelley’s ratio (KR) and permeability index (PI) were characterized in the study. Results delineate that the ground water is suitable for drinking and irrigational use.

In this paper, the authors have examined ground water availability with the rain water harvesting potential. Various parameters such as specific yield of the soil, water level fluctuation and rain water harvesting potential of the shallow aquifer and deep aquifer are studied. This study is prepared to superimpose the land use master plan in totality.

2. STUDY SITE AND DATA AVAILABILITY
Greater Noida is one of the most crucial region for residential and commercial purpose adjacent to Delhi. It lies in the Gautam Buddha Nagar district of the state Uttar Pradesh (India). It is located at a latitude of 28.47 44° N and longitude of 77.50 40° E. It comprises of 124 villages with a population of 107,676 (till March 2014). The area of Greater Noida is about 40000 hectares broadly bounded by national highway NH- 24 in the North West [18-30]. The city comes under NCR (National capital Territory) region of Delhi and River Hindon flows in the western side of the city. During the last decade the number of various industries in Greater Noida has grown more than 10 times (Greater Noida Master Plan, 2001). Summer season starts from March and remains till July. During this period the climate remains hot and average temperature ranges between 23°C to 45°C.

During mid–June to mid-September the monsoon season gains with an average rainfall of 93.2 cm (36.7 inches) , average temperature falls substantially down to as lower 3 to 4° C at the apex of winter. The total land use cover is 13570.00 hectares with 30.0 hectares of commercial area and 1970.03 hectares of the total institutional area. The water supply in the area congregates through overhead tanks, tube wells, trunks and other supply lines. At present nearly 460 km length of sewerage network, 500 km length of drainage and nearly 500 km length of water supply lines subsists in the area. Generally, groundwater is found in shallow aquifers which decline to the depth of 100 mbgl in intermediate and its occurs in deeper aquifers under confined to semi-confined conditions. Groundwater monitoring wells have been established in the district to monitor the nature of water level and four times water table are being monitored in a year. Depth to water level of the study area can be divided into various zones on the basis of depth to water ranges. Water level varies from 3.35 to 14.40 mbgl in phreatic aquifer whereas it exceeds greater than 9 mbgl in most of the non-command areas of the study area. The general inclination of the area is from eastern side towards river Hindon in the west as shown in figure 1. (Wikipedia Greater Noida) [31-38].

![Figure 1 Map of District Gautam Buddha Nagar](image-url)
3. HYDROGEOLOGY

3.1. Water Bearing Formation
The thick unconsolidated sediments occur up to the explored depth of 350.0m in the area. The underlying basement comprising Delhi Quartzite has been reported to be encountered at 116.4m depth at Bilaspur Exploratory borehole, 327.0 m depth at Dankaur boreholes in Greater Noida district. Delhi Quartzite deposits take place in Ganga - Yamuna Doab area consist an aquifer system which makes good repository of ground water. It occurs in granular zones made of coarse sand and occasional gravel. Solid clay beds inter lying with sand performed as confining layers and separate the aquifers. The thickness of the unconsolidated sediments gradually increases towards east [39-44].

3.2. Occurrence of Ground Water
Ground water is found under substantial conditions in shallow aquifers which is down to the depth of 100 mbgl, in intermediate. The deeper aquifer is found under confined to semi-confined conditions.

3.3. Depth to Water Level
To analyse the nature of water level and its nature, ground water monitoring well is installed in the district and supposed to monitor four times per year. Pre-monsoon and post-monsoon water level data are collected during May and November months respectively. Depth to water level for pre-monsoon and post monsoon periods have identified that the whole area can be separated into various zones on the basis of depth to water ranges. A large area has shallow to moderate depth to water conditions. Water level in phreatic aquifer ranges from 3.35 to 14.40 m bgl during pre-monsoon period whereas it ranges from 2.00m to 13.95 mbgl during post monsoon period. Water levels greater than 9m bgl occur in most of the non-command areas of the district. Few isolated patches deeper water levels arise in east of Jhajhar (Dankaur Block) and Dadri area. Deeper water levels (> 9 mbgl) [45-50].

3.4. Seasonal Water Level Fluctuation
Water level fluctuation occurs due to the amount of rainfall received by the area. Generally, water level elevates during post monsoon period. Moreover many other factors viz. seepage from canal, base flow of rivers, evaporation losses etc. and also control the outflow and inflow of ground water. It indicates that such areas have moderate to low recharge over the ground water draft during the period. Water level fluctuation is found maximum 3.2 and minimum 2.8m during the period 2017 post monsoon in Greater Noida region [2].

Figure 2 Hydrogeological map of Gautam Buddha Nagar, U.P
4. ANALYSIS AND DISCUSSION

The aquifer parameters such as specific yield, water level fluctuation, Groundwater potential, Rain water potential are analyzed for Greater Noida region. Table 1 depicts different aquifer parameter values along with their land use. It is observed that there are large variations in all the parameters for the different land use in the study area which are analyzed as follows:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Forest</th>
<th>Institutional</th>
<th>Commercial</th>
<th>Village</th>
<th>Residential</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Yield (%)</td>
<td>14</td>
<td>20</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Water Level Fluctuation (m)</td>
<td>2.8</td>
<td>4.0</td>
<td>2.8</td>
<td>3.2</td>
<td>3.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Area (Km²) %</td>
<td>18</td>
<td>14</td>
<td>21</td>
<td>8</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Ground Water Potential $10^6$ (m³)</td>
<td>18.4</td>
<td>28.8</td>
<td>21.2</td>
<td>9.8</td>
<td>42.8</td>
<td>9.3</td>
</tr>
<tr>
<td>Rain Water Potential $10^6$ (m³)</td>
<td>9.8</td>
<td>13.2</td>
<td>21.4</td>
<td>4.6</td>
<td>25.6</td>
<td>5.8</td>
</tr>
</tbody>
</table>

4.1. Land use v/s Specific Yield

![Land use v/s Specific Yield](image)

The specific yield of a soil is the ratio of the volume of water that, after saturation, can be drained by gravity to its own volume. Values of specific yield depend on grain size, shape, and distribution of pores, compaction of the stratum and time of drainage.

The specific yield is recorded in different land use which has been shown in the figure 3 as well as in the table 1. The maximum specific yield is recorded in institutional areas whereas the minimum specific yield is recorded in agriculture area. However, the specific yield is recorded same as 14 for forest area and commercial area. The specific yields in village

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area is 16 and 18 for the residential areas which clearly show that the coarse sand formation has occurred in institutional area and sandy clay formation has occurred in agriculture areas.

4.2. Land use v/s Water level fluctuation

![Land Use v/s Water Level Fluctuation](image)

Figure 4 Land use v/s Water Level Fluctuation

Rise in water table elevation is considered in shallow aquifer. It is found due to the accumulation of recharge water across the water table. The Water level fluctuation is recorded in different land use which has been shown in the figure 4. The maximum Water level fluctuation is recorded in institutional areas whereas the minimum water level fluctuation is recorded in agriculture area. However, water level fluctuation in the forest area is recorded as 2.8 m, commercial area is 2.8 m and village area is 3.2 m along with residential areas 3.6 m which clearly show that the heavy withdrawal has occurred in institutional area and less withdrawal has occurred in agriculture areas.

4.3. Land use v/s Area

![Area(Sq Km)(%)](image)

Figure 5 Land use v/s Area

The area is measured in different land use which has been shown in the figure 5 as well as in the table 1. The maximum area is measured as a residential area whereas the minimum area
is measured as a village area. However, forest area is measured as 18%, commercial is 21% and village area is 8% along with residential areas 26%.

4.4. Land use v/s Ground water potential

Groundwater potential is not static. It is part of a dynamic flow system. It moves into and through aquifers from areas of high water level elevation to areas of low water level elevation. Groundwater level fluctuations due to aquifers storage changes involve either the addition or extraction of water from the aquifer, both through natural means and human involvement.

The groundwater potential is recorded in different land use which has been shown in the figure 6 as well as in the table 1. The maximum ground water potential is recorded in residential areas whereas the minimum ground water potential in agriculture area. However in forest area the ground water potential is recorded as $18.4 \times 10^6 \text{ m}^3$, commercial area is $21.2 \times 10^6 \text{ m}^3$ and village area is $9.8 \times 10^6 \text{ m}^3$ along with institutional areas $28.8 \times 10^6 \text{ m}^3$. It clearly shows that the high groundwater potential has occurred in residential area whereas low groundwater potential in agriculture area.

4.5. Land use v/s Rain water potential

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The total rain fall collected over an area is called the rainwater endowment of that area. The amount of water which can be effectively harvested is known as the rain water potential.

The Rain water potential is recorded in different land use which has been shown in the figure 7 as well as in the table 1. The maximum Rain water potential is recorded in residential areas whereas the minimum in village area. However, the rain water potential in forest area is recorded as 9.8*10^6 m^3, commercial area 21.4*10^6 m^3 and village area is 4.6*10^6 m^3 along with institutional areas 13.2*10^6 m^3. It clearly show that high rainwater potential indicates the maximum rain whereas low rain water potential indicates the minimum rain.

4.6. Land Use v/s Aquifer Parameters
It is found that there are large variations in all the parameters for the different land use in the study area which may be analyzed as follows. Different parameters like specific yield, water level fluctuation, area, ground water potential and rain water potential are evaluated for different land use areas. It can be seen evidently that the maximum specific yield is recorded in institutional areas whereas the minimum specific yield is recorded in agriculture area. However, the specific yield is recorded same for forest area and commercial area as 14. In village area, it is recorded as 16 along with residential areas 18. It clearly shows that the coarse sand formation has occurred in institutional area and sandy clay formation has occurred in agriculture areas.

![Figure 8 Land Use v/s Aquifer Parameters](image)

5. CONCLUSION & RECOMMENDATIONS
The land use master plan of the area clearly indicates the variation in different parameters which has been explained. It is found that the institutional area has got the maximum specific yield as 20 and minimum specific yield as 12 at agriculture. The maximum water level fluctuation is measured as 4m at institutional area and minimum as 2.4 m at agriculture. The maximum area is measured as 26% at residential and minimum as 8% at village. High groundwater potential is observed 42.8*10^6 m^3 at residential and low groundwater potential is 9.3*10^6 m^3 at agriculture. High rainwater potential is observed as 25.6*10^6 m^3 at residential and low groundwater potential 4.6*10^6 m^3 at village.
It is concluded on the basis of our study that the scientific parameters have not been followed for preparation of land use master plan because the values of groundwater potential and rainwater potential does not superimposed properly in the land use adopted.

REFERENCES

Dynamics of the Aquifer System in Parts of Greater Noida Using Aquifer Modeling for Different Land Use Pattern


[26] CGWB (Central Ground Water Board) (2010), annual report, ministry of water resources, government of India.


