P: ISSN No. 0976-8602 RNI No.UPENG/2012/426228 VOL.-III, ISSUE-IV, October-2014
E: ISSN No. 2349 - 9443

Asian Resonance

Mitigation of Ground Water Level Depletion in Ujjain Sector, Madhya Pradesh, India.

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Abstract

Ujjain Township is located in the Malwa region of Madhya Pradesh. The ground water occurs both under unconfined and confined conditions revealing a fairly good range of seasonal variation of static water levels. The present status of ground water development has been discussed along with remedial measures. It is suggested that the currently increasing, trend of rapidly declining ground water can be controlled by implementation of the proper scheme for the construction of artificial recharge structures such as roof top rainwater harvesting in urban areas and stop dam percolation tanks etc in rural areas.

Keywords: Groundwater, artificial recharge, roof top rainwater harvesting, stop dam, percolation dam.

Introduction

Water is the most vital natural recourse to sustain life. It has been estimated that the extraction of water would be increased to 50 % in developing countries and 18% in developed countries by the year of 2025 owing to current trend of the population explosion, industrialization, urbanization, increased standard of living, and practices in agriculture. This state of water demand is generating immense pressure on ground water resource resulting into rapid depletion of ground water levels, which is causing drought conditions in several parts of the country. To meet this demand, over exploitation has lead to drought conditions. In the recent past Ujjain has experienced acute crisis of sustained water supply. Hence, it is the priority need to generate hydrogeological data in respect of Ujjain area for formulating a strategic plan for adequate development and management of ground water with a view to obtain sustained water supply.

Aim of Study

The main objective of study is to analyze the status of ground water levels of Ujjain area and to discuss the strategy for increasing the ground water levels.

Location of study area

The area under study is located in the western section of Ujjain, and is bounded by latitude 23^0 8' 34" N and 23^0 13'32" N and longitude 75^9 37' E and 75^9 45' E on Survey of India Topgraphy No 46M /12. (Fig.1). The study area is characterized by flat Topography and a few isolated hillocks. The climate is tropical in nature, the temperature rises to 46^0 C in summer season and falls to 7^0C in winter season. The average annual rainfall is 930 mm. Intensive weathering of the basalts has given rise to black cotton soil. It is mainly drained by the Gambhir River.

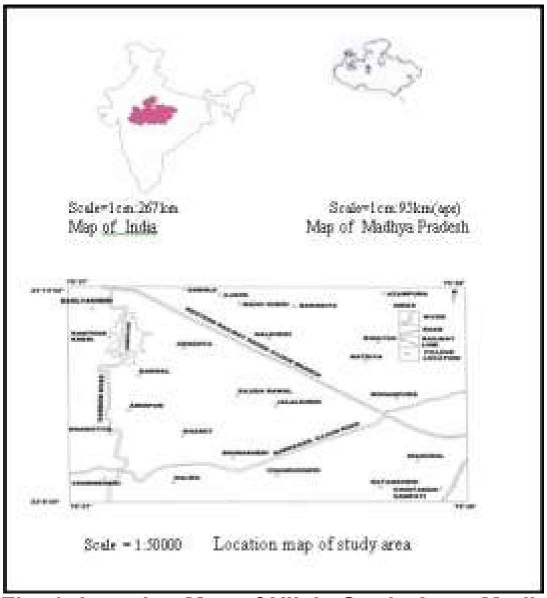

Fig. 1: Location Map of Ujjain Study Area, Madhya Pradesh, India.

Geological and Hydrogeological setting

Ujjain is situated on the Malwa Plateau, which forms the part of Deccan trap province. Geological age of Deccan Traps is late Cretaceous to early Eocene. In Ujjain, six basaltic lava flows has been reported (Hari and Chatterjee, 1990). The types of basalts in the area are vesicular, amygdaloidal, compact/massive, fractured, jointed, highly weathered basalts and red boles (Trachylitic bands). The area is broad and undulating with no marked mountain ranges. The general slope is in the direction of south to north. The climate is tropical in nature, the temperature rises to 46^0 C in summer season and falls to 7^0 C in winter season. The average annual rainfall is 930 mm. Intensive weathering of the basalts have given rise to black cotton soil. In the Deccan Basalts, ground water occurs in confined and unconfined conditions. The ground water in the study area is restricted to the zones of secondary porosity.

The Malwa region belongs to Deccan Volcanic Province. The ground water occurs in confined and unconfined conditions. The ground water in the study area is restricted to the zones of secondary porosity. The area exhibits presence of fairly good ground water potential zones in the weathered basalts, vesicular basalts with fractures and joints.

Material and Methodology

Systematic survey of shallow hydrogeological regime of the Ujjain study area has been conducted. Prepared base map of the study area for detailed investigation, well inventory and collected geological, hydrogeological data. The well inventory involves the examination and measurements of 25 open dug wells (Table 1). Based on the measurements of the examined wells total of 20 wells have been selected as observation wells to monitor the seasonal fluctuations in the static water levels (SWL). Water table depth in Deccan Traps generally varies with topography and the nature of aquifer (Agrawal, 1987; 1995,Bhatt & Salpekar, 1990, and Adyalkar *et al* 1996).

Table 1: Well inventory data of Ujjain study area.

Well No.	Diameter of well (meters)	Depth to water level(meters)	Pre mosoon SWL(meters)	Post monsoon SWL(meters)	Fluctuation (meters)	Locations
1	6	14.4	14	9	5	Mohanpura
2	3.4	5	Dry	4	-	Ratriya
3	3	5	Dry	3.5	-	----do----
4	3.9	7.6	Dry	4.4	-	Kuta bauri
5	6	22	20	13	7	Dharmmandla
6	6	29	24	17	7	Jalal kheri
7	7	35	33	20	13	Baniya kheri
8	6.7	14.2	Dry	11.4	-	Kuta baudi
9	5.3	15.5	10.7	7.1	3.6	Azampura
10	6.2	11.7	12	8	4	Nai kheri
11	6	13	9.2	5	4.2	Chandu kheri
12	8.2	18	15	9	6	Ambodyia
13	4.8	18	14	9.5	4.5	Mansola
14	4.2	16	15	10	5	Ambodiya
15	4.9	15	10	6.7	3.3	Fazalpura
16	7.2	20	13	7	6	Kanthar kheri
17	4.2	18	10.5	6.9	3.6	Chhan kheri
18	5.7	15	14	10	4	Rawal Siloda
19	6.1	15	10.5	7.9	2.6	Nalwa
20	7	15	12	8.6	3.4	Karotiya
21	5.8	15.5	10.7	7.2	3.5	Barwari
22	8	18	15.5	10.2	5.3	Siloda Rawal
23	4	12	9.2	5.5	3.7	Kharet
24	3.6	8	4.3	dry	-	Siloda Rawal

25	3.3	10	7.4	4.2	3.2	Chintaman

Diameter of the Wells

The recorded diameter of 25 wells existing in the study area indicates that the wells have diameter range of 3 m to 8.2 m, The well at Ratriya has minimum diameter of 3 m and the well located at Ambodiya indicates a maximum diameter of 8.2 m. 7 wells constituting 28% of the total examined wells are within the range of 6 to 7 m, and only 1 well is in the range of 8 to 9 m (4%). The average diameter is 5.46 m (Table 2).

Table 2. Analysis of Diameter of examined wells in the Ujjain study area

S. No.	Diameter of wells (Range) meters	Number of wells	Percentage (%)
1	1-2	0	0
2	2-3	0	0
3	3-4	6	24
4	4-5	4	16
5	5-6	3	12
6	6-7	7	28
7	7-8	4	16
8	8-9	1	4
	Total	25	100%

Table 3. Depth variation of dug wells in the study area.

S.No.	Range of depth to water level (bgl) Meters	No. of wells	Percentage (%)
1	5-10	5	20
2	10-15	5	20
3	15-20	11	44
4	20-25	2	8
5	25-30	1	4
6	30-35	1	4
	Total	25	100%

Depth of wells

The depth of the wells ranges from 5 m.b.g.l. to 35 m. b.g.l. (below ground level), well having minimum depth 5 m.b.g.l. is recorded at Ratriya and the maximum depth of 35 m.b.g.l. at Baniya kheri has been recorded. 11 wells constituting 45 % of the total examined wells are within 15 m.b.g.l. to 20 m.b.g.l. Only 1 well is of 35 m.b.g.l.depth constituting 4 % of total wells (Table 3).

Static Water Levels

The recorded static water levels during post- and pre- monsoon indicate the variations in the depth ranges from 3.5 m .b.g.l. to 20 m. b.g.l. and 7.4 m. b.g.l. to 33 m. b.g.l. respectively. Observations reveal that the water levels in the dug wells decrease during pre-monsoon as compared to post- monsoon (Table 1).

Fluctuation in Ground Water Level

The fluctuations in the groundwater levels have been observed in the observation wells. The minimum seasonal fluctuation of 2.6 m as been recorded at Nalwa and maximum fluctuation of 13 m is observed at Baniya kheri. 10 wells (50 %) are within the fluctuation range of 2 m to 4 m, 7 wells (35 %) belong to range of 4 m to 6 m, 2 wells (10%) are in the range of 6 m to 8 m and only 1 well (5 %) reveals a maximum fluctuation of 13 m.

Ground Water Levels Mitigation and Resource Development

Water resources are developed either to utilize or to control surface /or subsurface water flows (Gupta, 2005). A developmental plan for the proper use of water includes study of the availability and demand of water that can provide sustainable amount of water throughout the year. Groundwater is the manifestation of surface water. Although groundwater is annually recharged by rainfall but this process is very slow. Majority of dug wells bore wells, dug cum bore wells and hand pumps dry out during summer seasons. Deccan Trap rocks are not only poor aquifer formation but also have lesser water holding capacities. The artificial recharge technique is adopted where natural recharge process is inadequate (Gupta, 2005). This rapid depletion of ground water levels should be checked and are usually mitigated by adopting methods of increasing ground water levels by launching artificial recharge schemes.

The main purpose of artificial recharge of groundwater is to :- i) restore supplies from aquifers depleted due to excessive draft, ii) store excess surface water supplies for subsequent use or to alleviate flooding, iii) improve physical and chemical quality of ground water, iv) remove sediment, bacteria and other impurities from sewage and other waste water effluents by taking advantage of filtration characteristics of the vadose zone (Ram Chandra, 1999). Hence, artificial recharge technique is the most appropriate method of ground water level depletion and development of the ground water resource.. The most suitable recharge techniques recommended in the Ujjain region to augment ground water are as follows:-

Stop dam\check dam

The construction of stop dam is most commonly used technique for augmenting recharge from existing streams or ephemeral channels (Pettijohn, 1988). The construction of stop/check dams is favoured in relatively flat nalas characterized by narrow cross section yielding high discharge of fairly long duration (Dev and Singh, 2002).

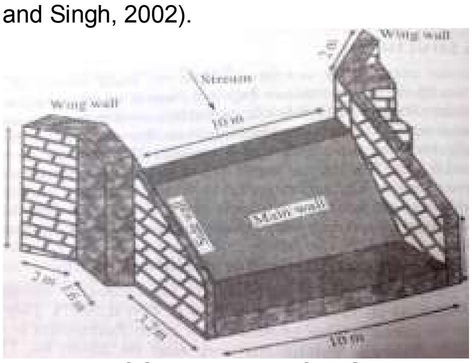

Fig.2 A view of Check Dam (After Chahar, 2015)

Nalla Bunding

Bunding is the most effective method of water harvesting. Bunds are small earthen dams constructed across the local stream, to collect rain water, which are generally 10 to 15 m in length, 2 to 3 m in height and 1 to 3 m in width; constructed in a trapezoidal shape.

Percolation Tank

Percolation tank are recommended in second and third order streams on porous and permeable formations, to overcome the silting problem. Its aim is to collect the surface run off so that the water infiltrates down to recharge the groundwater regime. They are shallow tanks constructed at suitable places in natural or abandoned stream courses.

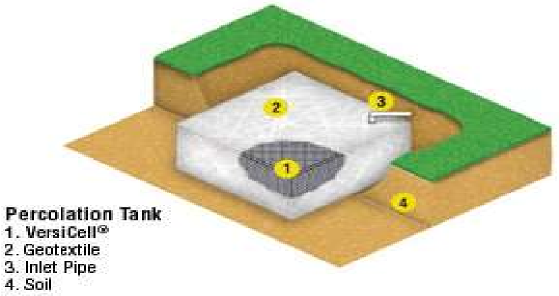

Fig.3 A view of Percolation Tank (www.Google.com)

Gully Plug

Gully plug is advisable at the origin of streams to arrest surface run off. These are smallest conservation structures constructed by means of local stones, sand bags, wood, weathered rocks, soils and other available local materials.

Recharge Shafts

Recharge shaft are constructed mainly at impervious formations are at surface and shallow depth, where porous and impermeable rocks are encountered. Properly designed tube wells also act as recharge shaft, if recharge water is required in deeper aquifer overlain by impervious rocks (CGWB, 2008). In rural areas, dug wells can be constructed along stream beds. Water from fields can be diverted into recharge well through de-siltation chamber and filter media in well through delivery pipe.

Subsurface dykes

Sub surface dykes are water conservation structures constructed at suitable hydrological locations across the riverbeds at end of water shed to check sub surface flow of water along streams beds (CGWB, 2008).The construction of subsurface dykes is an important feature in increasing the groundwater storage. These structures are impervious dykes placed in the subsurface below the stream bed level to arrest the groundwater runoff (Dhokarikar, 1991). These subsurface dykes are useful to conserve groundwater and provide water to the wells existing in the catchment area (Dev and Singh, 2002).

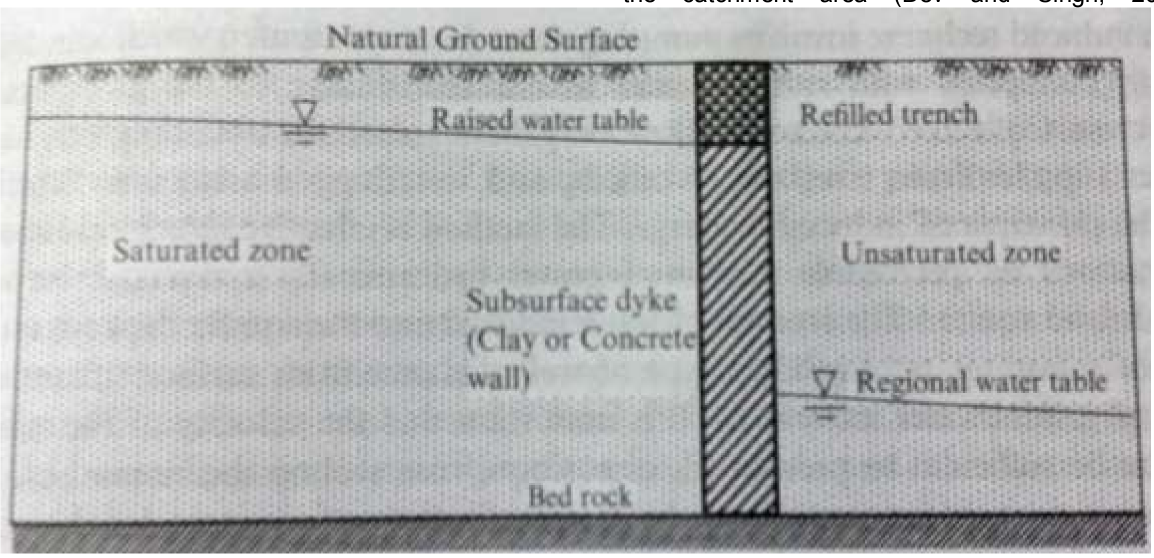

Fig. 4 Diagrammatic Sketch of Dyke (After Chahar, 2015)

Gabison structure

This is a kind of check dam recommended across small streams to conserve water from stream flows, the boulders locally available are stored in a steel mesh wire, which is anchored across the stream sides, the height of these structures is around 0.5 m and is normally used in the streams having width of about 10 to 15 m.

Rainwater Harvesting

In urban areas roof top rainwater harvesting is advisable in urban areas. The roof top water is collected and diverted to the existing structures like tube wells, dug wells hand pump to increase groundwater resources (Parashar, 2002) Silt traps, check dams, bunds and terraces are also important types of water harvesting practices.

Fig. 5 Showing Rainwater harvesting phenomena (www.Google.com)

Conclusion

The paper has discussed the problem of ground water levels depletion. The ground water levels in Ujjain area are rapidly depleting from 2 to 13 m. b.g.l. Based on the analyzed data, it has been considered that the large diameter wells having considerable depth are most feasible for ground water extraction and development. The problem of ground water levels has been discussed and it is resolved that the ground water levels need to be mitigated. It is recommended that the implementation of the scheme for the construction of appropriate artificial recharge structures would provide optimum development of ground water resource in the Ujjain region and also resolve the problem of sustained water supply.

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