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Ground Water Resource Management Of Shivna River Basin In Mandsaur, Madhya Pradesh, India

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ABSTRACT: *In India, Madhya Pradesh is one of such state, which in spite of a good network of rivers; it is facing shortage of water supply in majority of its district resulting in a state of drought phenomenon. Mandsaur district is one of such area, which is facing the situation of water unavailability during summer season, in spite of Shivna River drainage system. In view of this fact, it has been considered appropriate to undertake the present investigation of a part of Shivna River Basin of Mandsaur Region, Madhya Pradesh. This study is concerned with the concept and planning of ground water resource management by estimation of ground water potential, ground water recharge and ground water balance. The ground water potential has been determined by using rainfall infiltration and hydrodynamic methods. The computation of the ground water recharge (3937.75 x 10^4 m^3) and annual draft (8423.87 x 10^4 m^3) indicates that there is an over draft of ground water by 4486.12 x 10^4 m^3 in 2011-2012 which was 1898.484 x $10^4 m^3$ in year 2007-2008. The over draft of ground water can be assigned to the increasing demand of water supply for the human population. This trend is resulting into rapid depletion of ground water levels causing the severe problem of acute shortage of water supply. As a strategy, appropriate suggestions have been recorded herein for the target of sustained development and management of ground water resource.*

Keywords: *Groundwater potential, Groundwater Recharge, Rainfall infiltration, Annual draft, Aquifers, Water resource estimation, Hydrodynamic method*

I. INTRODUCTION

Ground water plays a vital role throughout the globe. In India, Madhya Pradesh is one of the states, which in spite of a good network of rivers, is facing shortage of water supply in majority of its district resulting in a situation of drought phenomenon. Hence, the present trend of rapidly increasing population growth, development of agriculture, irrigation, urbanization and energy sectors, is developing pressure on the extraction of ground water to meet the requirements of water supply. Mandsaur district is one of such area, which is facing the situation of water unavailability during summer season, in spite of Shivna River drainage system. Realizing the present situation of over-extraction of ground water, it has been considered feasible to undertake a systematic hydrogeological investigation of ground water in Mandsaur area. Recently, Kulshreshtha and Dev (2007) computed ground water potential of Mandsaur Township. This paper deals with the problem of ground water resource management of a part in Mandsaur region.

II. LOCATION OF STUDY AREA

The present investigation has been carried out in and near Mandsaur town (Fig 1), forming a part of Mandsaur district of Malwa region in Madhya Pradesh. The study has been confined to latitude 24°0'N to 24°10'N and longitude 75°0'E to 75°10'E (Survey of India, Toposheet No. 45 P/4).

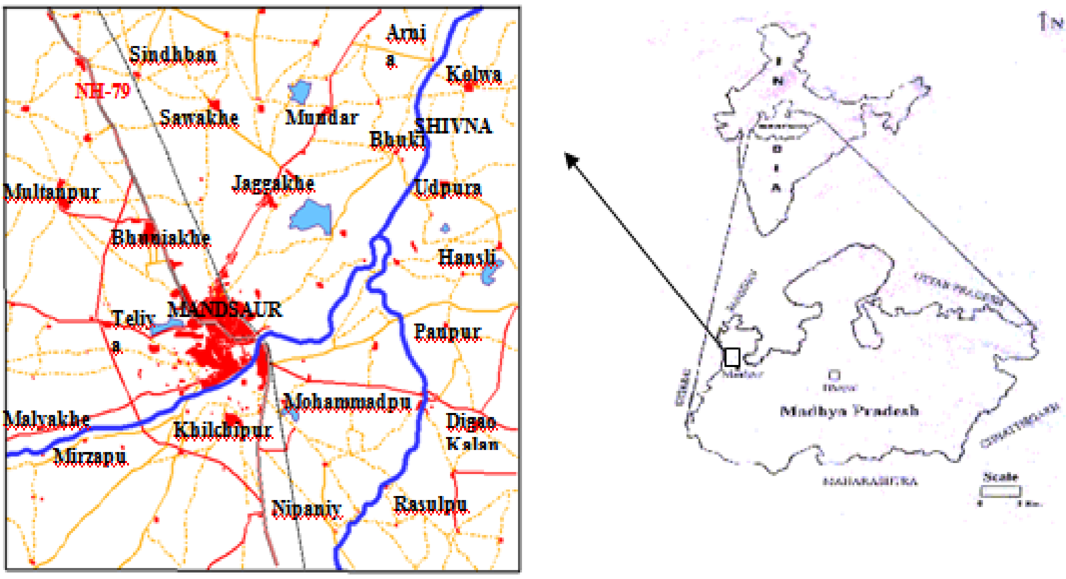

Figure 1: Location Map of Study Area, Mandsaur District (M.P.)

The hydrogeological framework of the Mandsaur area shows that the ground water occurs both under unconfined and confined conditions. The well inventory has covered examination of 65 open dug wells. The dug well data of 35 observation wells have been analyzed to observe variations in the static water levels in these wells during post-monsoon (December-2010) and pre-monsoon (April-2011) periods. The fluctuation range of ground water levels has been recorded from 0.9 to 10.2 m (b.g.l.). The ground water movement has been observed mainly towards Shivna River.

III. CONCEPT OF GROUNDWATER RESOURCE MANAGEMENT

The management of ground water resource of a basin refers to a programme of development and utilization of sub-surface water for some specific social or economic purpose (Burt, 1967). The ground water management means the maximum development of ground water resource for beneficial human use involving planning in term of entire ground water basin. The main objective of ground water resource includes geologic, hydrologic, economic, legal, political and financial consideration. The ground water management involves the extraction of maximum quality of water at minimum cost (Todd, 1980). The management of ground water resource involves four stages of investigation (Amer. Soc. Civil Engr., 1972; vide Todd, 1980). These stages are –(1) Preliminary examination, (2) Reconnaissance, (3) Feasibility, and (4) Define project.

The ground water resource management deals with the augmentation of ground water resource of a particular area. It can be achieved by the conjunctive use, which involves planning of development of both the surface and ground water. The management of conjunctive use requires the physical facilities for water distribution, artificial recharge and pumping (Todd, 1980).

Dhokarikar (1991) remarked that the concept of ground water management is focused around equal demand for ground water supply. It means fulfilling the users need without unnecessary depleting or causing damage to the ground water resource regime. The optimum development planning of ground water resource is receiving special attention on priority to cater the demand of water supply. The sustainable development of ground water resource can be successful only when detailed information is obtained about ground water occurrence, its movement, fluctuation with respect to seasons, withdrawal, mode of exploitation and ground water budget (Jeyaram et al., 1996).

IV. GROUND WATER POTENTIAL ESTIMATION

The area of present investigation forms a part of Deccan Trap province, which is characterized by the occurrence of different basaltic lava flows. The ground water in basaltic terrains occurs in almost horizontal flows and also under certain conditions. The vesicular and weathered zones in basaltic lava flows have proved high potentiality of water bearing horizons. The Deccan basalts serve as moderate aquifers partly due to their vesicular nature and also due to their jointed and fractured character. The flows are horizontally disposed, piled on over the other, and constitutes a layered aquifer system.

The development and management of ground water resource depend on the ground water potential and ground water balance of a particular area. The determinations of ground water recharge and annual draft of the present study area have been made by using common procedure.

V. ESTIMATION OF RECHARGEAND BALANCE OF GROUND WATER

[5.1] ***Ground water Recharge***

The ground water recharge is determined by the use of rainfall infiltration and hydrodynamic methods. The procedure of computation of ground water recharge is described herein.

(5.1.1) Rainfall infiltration method

The ground water recharge of study area has been computed as:
Total area of study = 275.29 sq km. = 275.29 x 10^6 sq. m.
Average annual rainfall of study area = 736.65 mm = 0.73665 m.
Rainfall Infiltration Index of hard rock terrain (R.I.I.) = 10% (assumed value after Charlu and Dutt, 1982)
Ground water Recharge = Area x R.I.I. x Average Annual Rainfall
= 275.29 x 1000000 x 10/100 x 0.73665
= 202.77 x 10^4 m^3

(5.1.2) Hydrodynamic Method

The hydrodynamic method is most appropriate as it provides reliable values of the ground water recharge computation because it involves variation in water levels, which exhibits a real nature of ground water system (C.B.I.P., 1976; Adyalkar and Sruhari Rao, 1979). Ground water recharge of the present drainage basin has been calculated by employing hydrodynamic method as follows:
Total area of study = 275.29 sq. km. = 275.29 x 10^6 m^2
Average annual water level fluctuation = 4.768 m (b.g.l)
Specific yield of hard rock terrain = 3% (assumed value after Charlu and Dutt, 1982)
Ground water recharge = Area x Water level fluctuation x Specific yield
= 275.29 x 10^6 x 4.768 x 3/100
= 3937.75 x 10^4 m^3

[5.2] Ground water Balance

The ground water balance of the study area has been determined as -
Area under investigation = 275.29 sq km. = 275.29 x 10^6 sq m
Decrease in water level from post to pre monsoon period = 10.2 m
Specific yield = 3% (assumed value after Charlu and Dutt, 1982)
Annual draft = Area x Decrease in water level from post-monsoon to pre-monsoon x Specific Yield
Annual draft = 275.29 x 10^6 x 10.2 x 3/100
= 8423.87 x 10^4 m^3
The computed values of ground water recharge (3937.75 x 10^4 m^3) and annual draft (8423.87 x 10^4 m^3) indicate that there is an over draft of ground water by 4486.12 x 10^4 m^3. The over draft is causing the problem of rapidly depleting trend of the ground water levels that is resulting into scarcity of water supply to the inhabitants of Mandsaur Township and surrounding area of the district.

VI. DEVELOPMENT AND MANAGEMENT OF GROUND WATER RESOURCE

The ground water resource development is commonly achieved by using methods of artificial recharge as one of the strategic tool for water resource management. The 'artificial recharge' is a common term used for the planning of augmentation of water into the ground water reservoir system by suitable recharge techniques that can be beneficial for reducing overdraft, conserving surface runoff and increasing available ground water supplies. The Artificial recharge has been defined as "Augmenting the natural movement of surface water into underground formations by some methods of construction by spreading of water, or by artificially charging natural condition." (Todd, 1980).

Charlu and Dutt (1982) considered that the artificial recharge is "Replenishment of ground water brought about by man's action. This replenishment, however, could be a result of planned activity like construction of wells or pits." The artificial recharge practices are valuable to conserve water for future application. The main sources of recharge to ground water storage system are (1) Precipitation, (2) Surface inflow, and (3) Subsurface outflow.

Karanth (2003) suggested that for assessment of ground water development potential of an aquifer, the following information is required: (1) geometry of the reservoir defining dimensions and boundaries, (2) conditions at the boundaries, in particular the source of recharge, (3) lithology and aquifer characteristics, (4) hydrodynamic conditions – whether phreatic, confined or semi confined, (5) order of magnitude of reserves, (6) average natural recharge and discharge and (7) quality of water.
There are several techniques of augmenting ground water reservoir. The artificial methods of ground water recharge include – (a) Basin methods, (b) Recharging through pits and wells, and (c) Pumping to induce recharge from surface water bodies.

VII. SUGGESTIONS FOR GROUND WATER MANAGEMENT

Present stage is limited to quantitative analysis for the hydrogeological investigations which carried out in the Mandsaur area. Based on the analysis and results it is being suggested that a plan to increase the recharge phenomena of ground water reservoir is essential for implementation in the study area. This can be achieved by using techniques of construction of artificial recharge structures.

It is visualized that the strategy of development of artificial recharge structures will be of considerable value in the augmentation of ground water resource in Mandsaur area, which is rapidly approaching towards drought condition. Besides the other steps may include afforestation, which will accelerate the amount of rainfall over the area and, inturn, it would contribute to increase the rate of infiltration of rainwater to ground water reservoir. The other most important point is social awareness towards this problem and its remedies.

The observation and analysis of different data pertaining to shallow ground water regime of study area indicate that there is a serious problem of acute shortage of regular water supply to the inhabitants. The groundwater levels are rapidly depleting and current trends is resulting into further depletion of ground water levels causing the present water crises. At this stage of investigation, it is suggested herein that development plan of ground water resource is the necessity to provide remedy to inadequate water supply. It is suggested herein that the suitable areas for location of additional new sites for exploitation of ground water resource through open dug wells may be selected in catchment zones of Shivna River basin.

The development plan of rainwater harvesting structures such as construction of (1) Pits and trenches (2) Stop dams (3) Nala bunds 4) Percolation tanks and (5) Subsurface dykes would significantly contribute to the augmentation of ground water recharge phenomena.

VIII. CONCLUSION

This investigation is concerned with the concept and planning of ground water resource management. The computation of the ground water recharge (3937.75 x 10^4 m^3) and annual draft (8423.87 x 10^4 m^3) indicates that there is an over draft of ground water by 4486.12 x 10^4 m^3 in 2011-2012 which was 1898.484 x $10^4 m^3$ in 2007-2008. The overdraft of ground water can be assigned to the increasing demand of water supply for the human population. This trend is resulting into rapid depletion of ground water levels causing the severe problem of acute shortage of water supply. As a strategy, appropriate suggestions have been recorded herein for the target of sustained development and management of ground water resource.

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