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Assessment of Ground Water Potential of Five Villages of Jasra Block of Allahabad District

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Abstract: Natural recharge is a vital parameter to be known for ground water budgeting, management and modelling. Percolation of a portion of the rainfall, through the vadose zone, is the principal source of natural recharge to the aquifer systems in India. The tritium injection method, based on piston flow model, is particularly suitable for quantifying the downward flux of moisture in the vadose zone and for measuring natural recharge in Indian climatic condition, where about 80% of the annual rainfall is received as pulses and occurs during the four monsoon months from June to September. Natural recharge measurements, using the tritium injection method, have been carried out in India during the last 25 years, in several basins and watersheds, located in varying climatic and hydrogeological situations. At present, groundwater contributes 34% of the total annual water supply and is an important fresh water resource. However, over-exploitation has decreased groundwater availability and has led to land subsidence. Assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems.

I. INTRODUCTION

Groundwater is a dynamic system. The total annual replenish able resource is around 43 Mham. Inspite of the national scenario on the availability of groundwater being favourable, there are many areas in the country facing scarcity of water. This is because of the unplanned Groundwater development resulting in fall of water levels, failure of wells, and salinity ingress in coastal areas. Rapid industrial development, urbanisation and increase in agricultural production have led to freshwater shortages in many parts of the world. In view of increasing demand of water for various purposes like agricultural, domestic and industrial etc., a greater emphasis is being laid for a planned and optimal utilisation of water resources. In recent years there has been considerable emphasis on integrated management of surface and groundwater resources in irrigation project areas to augment the canal supplies and to increase agricultural productivities as well as to control groundwater depletion, water logging and soil salinity (Rosegrant and Svendsen, 1993; National Water Policy, 2002).

The country's average annual rainfall is 119.4 cm, which when considered over a geographical area of 320 Mha amounts to total volume of about 400 Mha-m of surface water and 26.5 Mha-m of groundwater (Maghunath, 2000.

Chatterjee and Purohit (1997) studied about the dynamic groundwater of India and estimated groundwater resources estimation. The methodology he used was based on the water-level fluctuation technique and empirical norms for recharge estimation. The groundwater utilization was also estimated.

Due to uneven distribution of rainfall both in time and space, the surface water resources are unevenly distributed. Also, increasing intensities of irrigation from surface water alone may result in alarming rise of water table creating problems of water-logging and Stalinization, affecting crop growth adversely and rendering large areas unproductive. This has resulted in increased emphasis on development of groundwater resources. The simultaneous development of groundwater, specially through dug wells and shallow tube wells, will lower water table, provide vertical drainage and thus can prevent water-logging and salinization. Areas, which are already waterlogged, can also be reclaimed. Singh and Prakash (2002) plotted a groundwater recharge potential map of a sub-watershed from the geology, lineament maps, drainage, slope, and the thickness of the soil covered. Their results show that the well-yield data in India is closely related to the groundwater recharge potential zone.

The basic concept of water balance is:

Input to the system - outflow from the system = change in storage of the system

(Over a period of time)

The general methods of computations of water balance include:

(i) Identification of significant components,

(ii) Evaluating and quantifying individual components, and

(iii) Presentation in the form of water balance equation.

II. MATERIALS AND METHODS

A. Study area

The study was conducted in five villages namely Amreha, Gauhania, Ghurpur, Parsara and Rampur villages of Jasra Block of Allahabad district. The study area lies within the 25°28' North longitude and 81°77' East latitude. The summer seasons are from April to June with the maximum temperatures ranging between 40^0C to 45^0C. Monsoon begins in early July and lasts till September. The winter seasons falls in the month of December, January and February. Temperatures in the cold weather could drop to freezing with maximum at almost 12^0C to 14^0C. The lowest temperature recorded, 2^0C and highest 46^0C in 2012.

B. Ground water balance equation

Considering the various inflow and outflow components, the terms of the ground water balance equation can be written as:

$$R_r + R_c + R_i + R_t + S_i + I_g = E_t + T_p + S_e + O_g + \Delta S \qquad \text{……. (1)}$$

where,

R_r = recharge from rainfall;

R_c= recharge from canal seepage;

R_i = recharge from field irrigation;

R_t = recharge from tanks;

S_i = influent seepage from rivers;

I_g= inflow from other basins;

E_t = evapotranspiration;

T_p = draft from ground water;

S_e = effluent seepage to rivers;

O_g = outflow to other basins; and

ΔS = change in ground water storage.

This equation considers only one aquifer system and thus does not account for the interflows between the aquifers in a multi-aquifer system.

C. Recharge from Rainfall (R_r)

The amount of rainfall recharge depends on various hydrometeorological and topographic factors, soil characteristics and depth to water table. Recharge from rainfall was computed using the empirical formula suggested by **Chandra and Saxena (1975)** was given as follows:

$$R_r = 3.984\,(P - 40.64)^{0.5} \qquad \text{………... (2)}$$

Where,

Rr = Recharge to the groundwater (cms)

P = Monthly precipitation (cms).

In present study, recharge was estimated using the five years monthly rainfall data of different ranging station.

Empirical Methods

1) *Chaturvedi formula*: Based on the water level fluctuations and rainfall amounts in Ganga-Yamuna doab, Chaturvedi in

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1936, derived an empirical relationship to arrive at the recharge as a function of annual precipitation.

$R = 2.0 (P - 15)^{0.4}$ ……..…….(3)

where,

R = net recharge due to precipitation during the year (inches)

P = Annual precipitation (inches)

The Chaturvedi formula has been widely used for preliminary estimations of ground water recharge due to rainfall.

2) *Amritsar formula:* Using regression analysis for certain doabs in Punjab, Sehgal developed a formula in 1973 for Irrigation and Power Research Institute, Punjab.

$R = 2.5 (P - 16)^{0,5}$ ………..(4)

where, R and P both are measured in inches.

3) *Krishna Rao :* He gave the following empirical relationship in 1970 to determine the ground water recharge in limited climatological homogeneous areas :

$R = K (P - X)$ ………..(5)

The following relation is stated to hold good for different parts of Karnataka:

R = 0.20 (P - 400) for areas with annual normal rainfall (P) between 400 and 600 mm

R = 0.25 (P - 400) for areas with P between 600 and 1000 mm

R = 0.35 (P - 600) for areas with P above 2000 mm

where, R and P are expressed in millimeters.

Conditionshave to be examined and established or suitably altered for application to other areas.

4) *Kumar and Seethapathi (2002):* It was observed that as the rainfall increases, the quantity of recharge also increases but the increase is not linearly proportional. The following empirical relationship (similar to Chaturvedi formula) was derived by fitting the estimated values of rainfall recharge and the corresponding values of rainfall in the monsoon season through the non-linear regression technique.

$Rr= 0.63 (P - 15.28)^{0.76}$ …..… (6)

Where,

Rr= Groundwater recharge from rainfall in monsoon season (inch).

P = Mean rainfall in monsoon season (inch).

D. *Recharge from Field Irrigation (R_i)*

Water requirements of crops are met, in parts, by rainfall, contribution of moisture from the soil profile, and applied irrigation water.The recharge from the field due to canal irrigation was considered to the 35% of the total water applied (Baweja, 1979). In case of well irrigation, deep percolation was considered as 30% of water applied from the wells.

E. *Sub-surface inflow — outflow (I,O)* ..……… (7)

Sub-surface inflow-outflow was estimated by pre-monsoon and post-monsoon water table contour maps of the study area and Transmissivity (T).values were taken on the basis of the standard values of the lithological data of the area (Todd 1974). Darcy's law was used for the calculation of sub-surface inflow-outflow.

$Q = T\ i\ L$ ………… (8)

Where,

Q = Flow across the boundary (m^3/day)
T = Transmissivity of the aquifer (m^2/day)
i = Hydraulic gradient
L = Length across which flow takes place (cm).

F. Recharge from Tanks (R_t)

It indicated that seepage from tanks varies from 9 to 20 percent of their live storage capacity. However, as data on live storage capacity of large number of tanks may not beavailable, seepage from the tanks may be taken as 44 to 60 cm per year over the total waterspread, taking into account the agro-climatic conditions in the area. The seepage from percolationtanks is higher and may be taken as 50 percent of its gross storage.

G. Groundwater draft (T_p)

The details of the Number groundwater extraction structures and its discharge etc, i.e. hand pumps (HTW), pump dug wells (PDW), shallow tube wells (STW) and deep wells (DTW) were collected. Annual groundwater draft alas estimated using the number of groundwater extraction structures and average number of operating hours per year.

H. Evaporation losses from groundwater (E_{tg})

The average depth of groundwater in the study area varies between 46-50 cm the capillary movement and evaporation from the groundwater was assumed negligible.

I. Groundwater storage change (W_s)

Change in groundwater storage was estimated by the following relationship.

$$\Delta S = \Delta H.\ A.\ Y \qquad \text{……….. (9)}$$

Where,

ΔS = Change in groundwater storage.
ΔH = Water table fluctuation.
A = area under consideration.
Y = specific yield of the formation.

III. RESULTS AND DISCUSSION

A. Recharge from rainfall (R_r)

This component of the water balance equation is the major part of the groundwater inflow in the study area. The any annual rainfall of the study area was collected and the recharges from rainfall in five villages were calculated using equation. The results are given in Table 1. The table clearly indicates that the more recharge (2298700 $m^{3)}$ was observed in Ghurpur village because of the largest cultivated area in this village.

Table: 1 Recharge from rainfall in five villages of Jasra block of Allahabad district.

Name of village	**Recharge from rainfall, R_r (m^3)**
Amreha	637120
Ghauhania	1542120
Ghurpur	2298700
Parsara	792780
Rampur	181000

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Table:2 Annual components of ground water balance (m^3) in five villages of Jasra Block of Allahabad district.

Groundwater balance components	**Amreha**	**Gauhania**	**Ghurpur**	**Parsara**	**Rampur**
Recharge from rainfall (m^3)	637120	1542120	2298700	792780	181000
Recharge from well irrigation (m^3)	71232	66825	133488	113488	30240
Recharge from canal/surface irrigation (m^3)	-	-	-	-	-
Seepage from canal/streams (m^3)	-	-	-	-	-
Sub-surface inflow (m^3)	297.554	215.71	139.33	215.80	220.61
Total input (m^3)	**806725**	**1613771**	**2432327**	**906483**	**282020**
Sub-surface outflow (m^3)	246848	164745	321132	266602	70560
Evaporation from groundwater (m^3)	-	-	-	-	-
Total natural output (m^3)	**246848**	**164745**	**321132**	**267412**	**70560**
Groundwater balance (m^3)	289280	235350	458760	380860	100800
Usable groundwater 80% of balance) (m^3)	231424	188280	367008	304688	80640

In view of increasing demand of groundwater, systematic assessment of the additional sources of groundwater needs to be carried out. In the shallow water- table areas where in spite regular groundwater extraction, the water level does not decline, the sustainable yield of the aquifers needs to be determined.

B. Recharge due to well irrigation

The results of recharge due to well irrigation are given in Table 4.4. This component was estimated based on the assumption that only 80% water discharge through the well are being used for irrigation and 30% of the well irrigation is causing there recharge due to deep percolation while irrigation.

Table: 3 Lithology of the water bearing strata and depth of groundwater level in five Villages of Jasra block.

Name of village	**Depth of water bearing strata (m^3)**	**Average transmissivity (m^2/day)**	**Pre monsoon ground water table (m)**	**Post monsoon ground water table (m)**
Amreha	14.18-47.85	2.438	08.56	07.05
Gauhania	14.18-47.85	2.438	12.45	10.50
Ghurpur	14.18-47.85	2.438	14.60	13.35
Parsara	14.18-47.85	2.438	09.70	08.75
Rampur	14.18-47.85	2.438	17.35	15.90

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V. CONCLUSION

Following conclusion was drawn for the study.

A. The maximum inflow was observed in village Ghurpur (2432327 m^3), because of higher cultivable command area irrigated by lesser number of shallow wells and deep wells.

B. The maximum outflow was estimated for Gauhania village due to maximum number of deep tube wells (11) used for irrigation and no area irrigated by canal system.

C. In all the five villages of Jasra block of Allahabad district there is sufficient amount of water in the villages of Gauhania and Ghurpur. More 20%-30% of water can be used from the villages of Amreha, Parsara and Rampur.

D. There are no pump dug wells in the respective villages of Jasra block of Allahabad district therefore in view of increasing water for use, pump dug wells should be situated.

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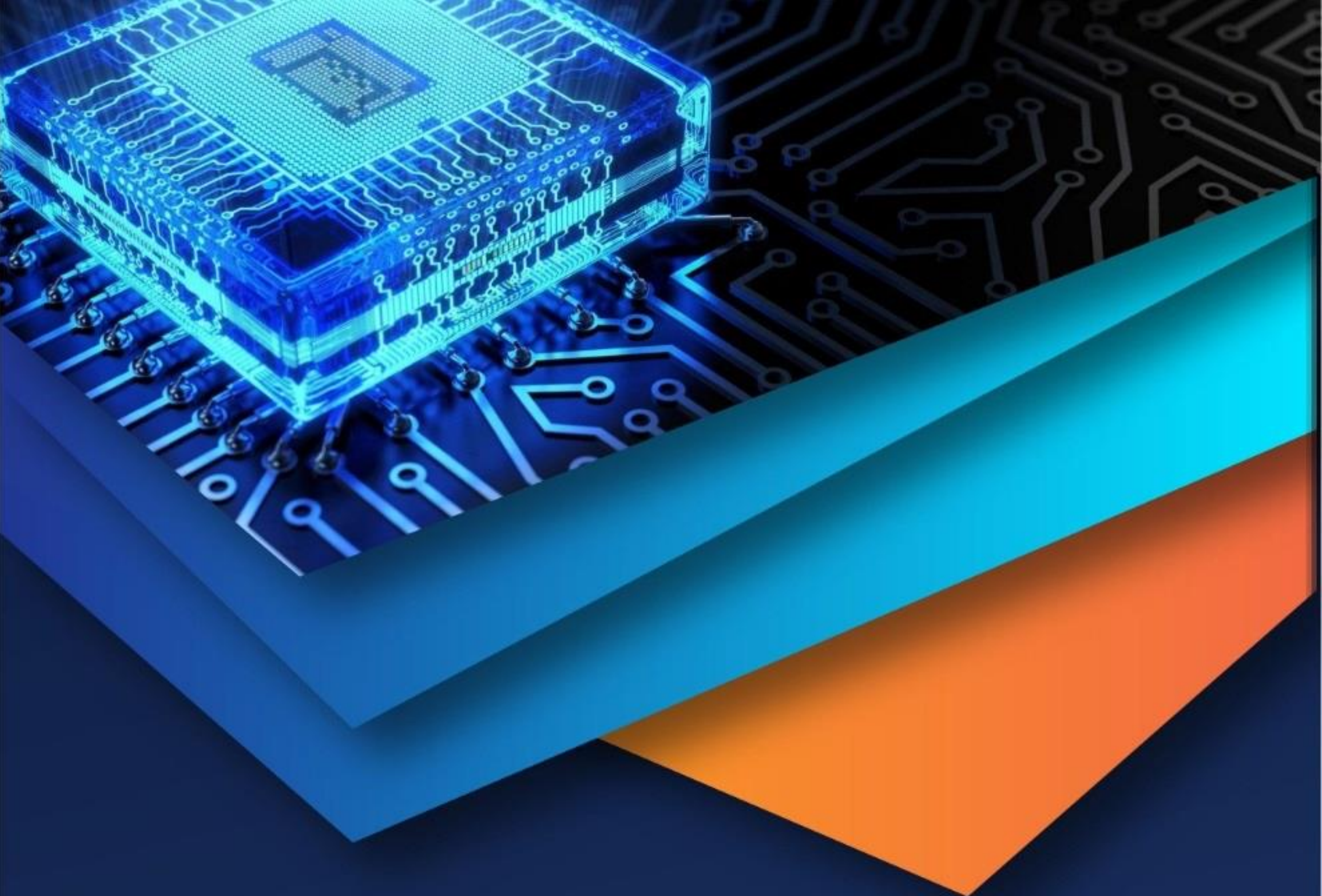

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