556.3 : 556.51 (282.253.21)

HYDROGEOLOGY OF KASGANJ BLOCK, DISTRICT ETAH IN PARTS OF THE CENTRAL GANGA BASIN : A MICRO-LEVEL APPROACH

1. Kasganj block occupies the northern part of Etah district where the depth to water level varies from 1.85 to 13.69 m b.g.l. and 1.25 to 12.40 m b.g.l. during the pre and post-monsoon periods respectively. The water level fluctuation ranges between 0.36 and 2.80 meters. The regional groundwater flow is due southeast as the water table elevation varies from northwest to southeast from 168 to 157 m a.m.s.l. The fence diagram shows the existence of a single-tier aquifer system, however, at places, the intercalation of thin to thick clay layers mark an appearance of two to three tier aquifer system. The discharge of shallow and deep tubewells ranges from 36 to 90m^3/hr and 118 to 236 m^3/hr respectively at the drawdown of 3 to 10 meters. The hydraulic conductivity of aquifer material ranges from 20 to 70m/day whereas, the specific capacity varies from 11 to 58 m^3/hr per meter drawdown.

The net annual calculated groundwater recharge is 18.69 MCM and groundwater draft is 15.09 MCM thus, leaving a balance of 3.60 MCM as utilizable resource for future development. The analytical results show that the groundwater of the area is hard, alkaline in reaction and alkali-bicarbonate type and suitable for domestic, agricultural and industrial purposes. This study is based upon the detailed hydrogeological investigations during the years 1997 and 1998 in the entire sub-division.

2.1. The Ganga basin constitutes around 38% of the total annual replenish able groundwater resource and is one of the most potential groundwater repositories of the world (Pathak, 1978). A generalized hydrogeological study of the basin has already been carried out but the detailed studies of its smaller parts are simply rare. The micro-level groundwater investigation at the block level will help evolve a uniform hydrogeological frame work of

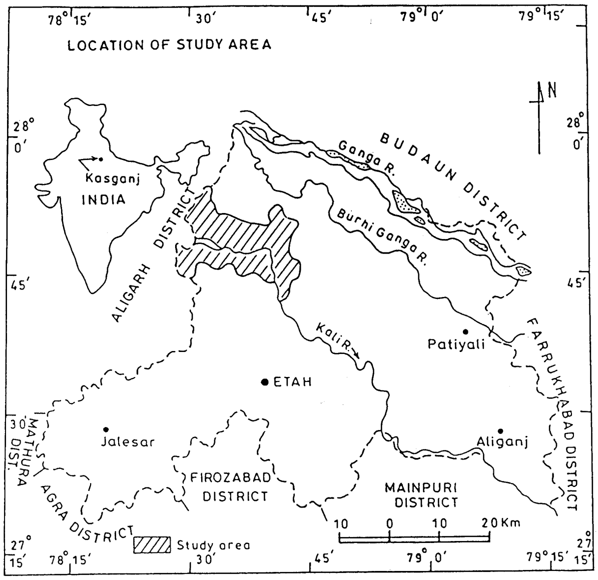


Fig. 1. Location map of the study area

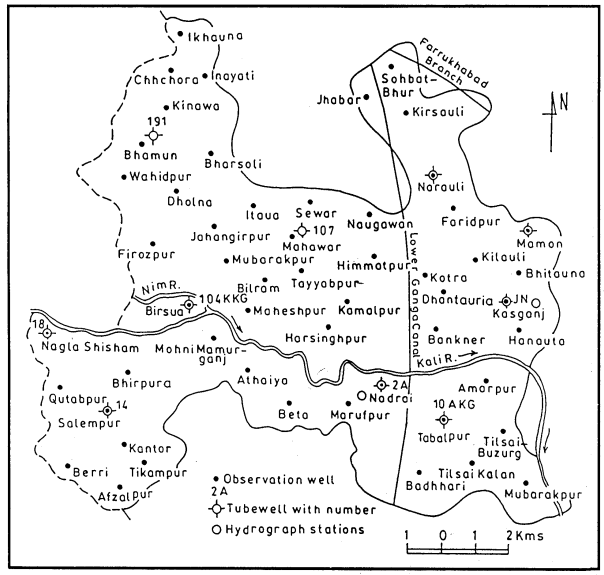


Fig. 3. Location of dugwells and tubewells

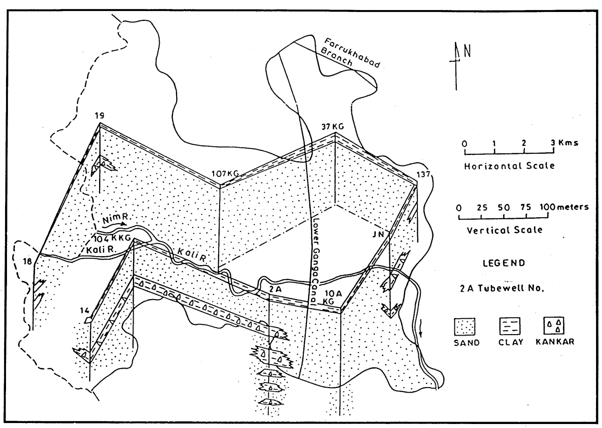


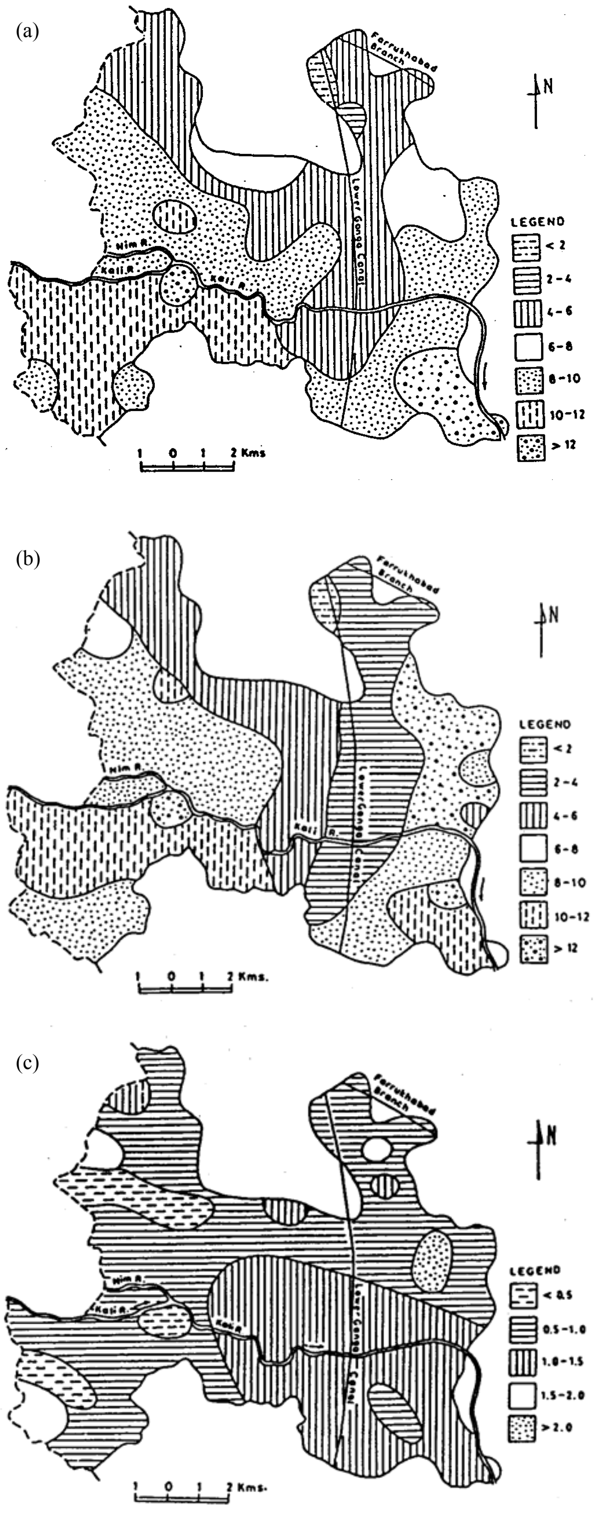
Fig. 2. Fence diagram showing the aquifer geometry

the aquifer systems of the entire Ganga basin or similar basins on the globe. With this backdrop, an attempt has been made to generate a detailed quantitative and qualitative database at block level considering it the smallest unit of the physical boundaries of the district. The population explosion, rapid urbanization, industrialization and fast agricultural extensions have together generated the high profile water demands and consequently, accelerated the pace of groundwater development (Hasan, 1999). To meet these relentless increased demands for water for various purposes it is necessary to get the water resource development holistic through the comprehensive and integrated river basin planning and management (Karanth, 1995 and Sivanappan, 1997).

Kasganj block extends from 27° 43' to 27° 54' north latitudes and 78° 27' to 78° 41' east longitudes, occupies an area of 232 sq. km and falls under the Survey of India toposheet no. 57 I/5, I/9 and I/11(Fig. 1). The block experiences the sub-tropical climate, where the monsoon breaks in the second week of June and remains in action by the end of September every year (District Gazetteer, 1988). The precipitation forms the principal source of groundwater recharge besides, the seepage from the canals and the irrigation return flow are the minor components of groundwater recharge. The mean annual rainfall in the area is 755 mm. Geologically, the Bundelkhand Granite forms the basement, which is unconformably overlain by the upper Vindhyan rocks of upper Proterozoic age which is further overlain by 260 m thick Neogene sediments which unconformably overlain by lower Bhander limestone encountered at a depth of 620 m b.g.l. and finally overlain by 360 m thick Quaternary alluvium comprising alternate beds of sand and clay (Pramanik *et al.*, 1996).

2.2. For the purpose of study, a network of 54 observation wells was established and their pre and post monsoon water levels were measured followed by the collection of water samples. Aquifer parameters were determined by using the hydrogeological data of state tubewells spread over the area.

Hydrogeologically, the aquifer geometry as depicted from the fence diagram (Fig. 2) reveals a single aquifer system down to the drilled depth of 147 m below the ground level (b.g.l.) which, at places, is interleaved with



Figs. 4 (a-c). (a) Pre-monsoon depth to water level map (June, 1997), (b) Post-monsoon depth to water level map (November, 1997) and (c) Water level fluctuation map (1997)

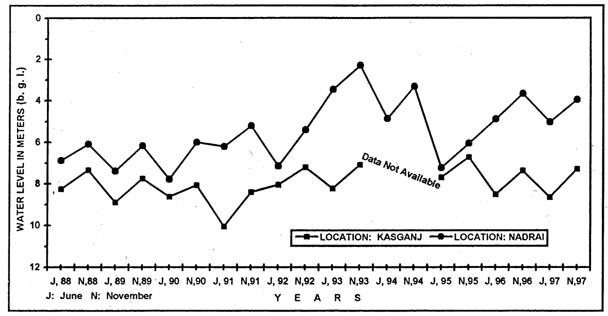


Fig. 5. Hydrograph of permanent network stations (from 1988 to 1997)

thin to thick lenticular clay lenses giving rise an appearance of two to three tier aquifer system. These aquifers are very thick, regionally extensive and have large groundwater potentials. The aquifer comprises fine through medium to coarse sand often mixed with gravels and intercalated by clay beds occasionally with calcareous concretions. The yield of shallow and deep tubewells spread over the entire region, ranges from 36 to 90 m^3/hr and 108 to 230 m^3/hr respectively, at the drawdown of 3 to 10 meters. The specific capacity of these wells ranges from 11m^3/hr to 58m^3/hr per meter draw down. The hydraulic conductivity of the aquifer material varies from 20 to 70 meter per day. Fig. 3 shows the location of dugwells and tubewells inventoried in the area under review.

2.3. The pre and post-monsoon water levels in the area varies from 1.85 to 13.69 m b.g.l. and 1.25 to 12.40 m b.g.l. respectively. The depth to water level maps [Figs. 4 (a&b)] reveal that the water level is shallow along the canal network and deeper where there is no alternate source of groundwater recharge. The characteristic feature of the block is the post monsoon swampy conditions in the low valley of the Ganga due to the poor drainage and permanent water logging all along the lower Ganga feeder canal. It has been observed that, in general, the water level follows the surface topography. The seasonal water level fluctuation in the area ranges from 0.36 to 2.80 meters. The water level fluctuation map [Fig. 4(c)] shows a wide variation spread over the entire region. The study shows that this variation is mainly due to the change in the nature of litho-units and their hydrogeological properties in addition to other factors. The large fluctuations are seen in the sandy horizons while; the small fluctuations are in the areas where the aquifer material is in alternation with the clay beds.

The hydrographs (Fig. 5) of the permanent network stations show a mixed rising and falling trend over a period of ten years from 1988 to 1997. The rise in water levels may be attributed to the sufficient amount of

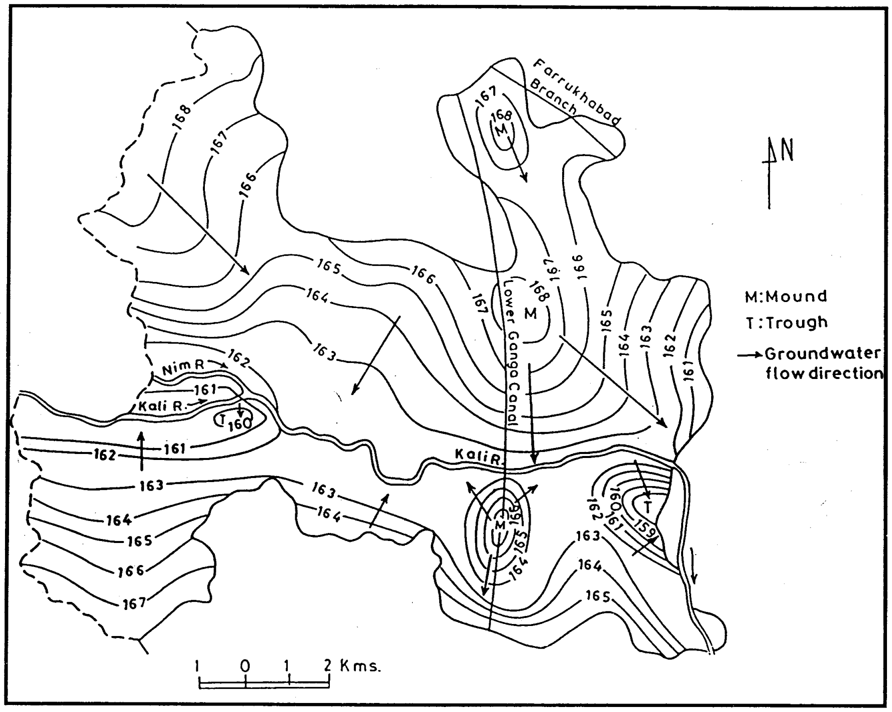


Fig. 6. Water table contour map (June, 1997)

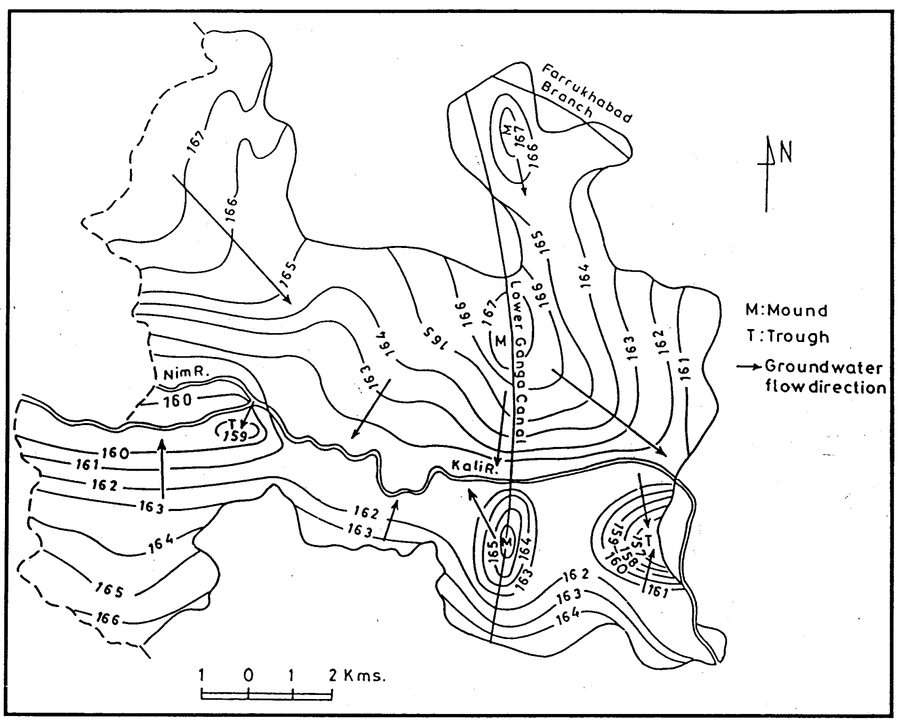


Fig. 7. Water table contour map (November, 1997)

groundwater recharge whereas, the falling trend leads to the insufficient groundwater recharge in addition with the fact that the quantum of the average annual recharge is exceeded by the groundwater development.

The water table configuration (Figs. 6 and 7) shows that the Nim and Kali rivers are effluent in nature throughout their course in the area. Moreover, the development of two troughs close to the river Kali shows

TABLE 1

Range of concentration of major ions and trace elements in shallow and deep groundwater and the comparison with BIS (1991) and WHO (1984)

Constituents	BIS (1991)		WHO (1984)		Study area groundwater			
					Dugwells		Deep tubewells	
	HDL	MPL	HDL	MPL	Min.	Max.	Min.	Max.
pH	6.5-8.5	8.5-9.2	7.0-8.5	6.5-9.2	7.24	8.94	8.38	8.86
TDS	500	1500	500	1500	144.00	1094.00	174.00	467.00
TH	300	200	100	500	108.00	340.00	114.00	200.00
Calcium	75	100	75	200	6.00	73.00	19.00	44.00
Magnesium	30	1000	30	150	11.00	67.00	15.00	28.00
Chloride	250	1.5	200	600	15.00	272.00	18.00	53.00
Fluoride	0.60-1.20	1.5	1.0	1.5	0.22	0.85	0.34	0.71
Sulphate	150	400	200	400	12.00	205.00	29.00	62.00
Nitrate	45	NR	45	45	5.00	22.00	8.00	12.00
Copper	0.05	1.5	0.05	1.00	0.008	0.063	0.014	0.063
Iron	0.30	1.0	0.10	1.00	0.015	0.083	0.015	0.057
Manganese	0.10	0.5	0.05	0.50	0.017	0.112	0.023	0.041
Cadmium	0.01	NR	-	0.01	0.010	0.028	0.018	0.031
Lead	0.10	NR	-	0.10	0.011	0.068	0.011	0.059
Zinc	5.0	15	-	5	0.036	0.091	0.040	0.079

(All concentrations are expressed in mg/l except pH) Abbreviations : HDL : Highest Desirable Limit; MPL : Maximum Permissible Limit; Min.: Minimum; Max.; Maximum; TDS : Total Dissolved Solids; TH : Total Hardness as $CaCO_3$ mg/l

its influent behaviour at these two points, which may be attributed to the heavy withdrawal of groundwater through number of ill-spaced shallow tubewells. However, the mounds developed close to the lower Ganga canal, show the excessive seepage from this feeder canal. The wide and close spacing of contours, over the entire region, show high and low to medium permeability horizons with flat to steep hydraulic gradient respectively. The regional flow of groundwater is from northwest to southeast. However, there are some local variations, which may be attributed to the topographic highs from where the groundwater moves towards the Nim and Kali rivers respectively.

2.4. The groundwater recharge and draft have been calculated by using the water level-specific yield method as this represents the natural groundwater system response (GREC, 1997). The net annual calculated groundwater recharge is 18.69 MCM whereas; the groundwater draft through various abstraction structures is 15.09 MCM thus, leaving a balance of 3.60 MCM as the utilizable resource for future development. The stage of groundwater development in the area is 86%. According to the norms established by the Agricultural Refinance and Development Corporation (1979), the Kasganj block falls under the 'dark' or critical category owing to the fact that the quantum of the average annual recharge through various means, exceeds the annual draft.

All the collected water samples were analyzed as per the standard methods (APHA, 1992). The analytical results (Table 1) show that the concentration of major ions as well as heavy toxic elements are within their permissible limits as prescribed by the Bureau of Indian Standards (1991) and World Health Organization (1984). However, the groundwater of the area is potable, marginally mineralized, hard, alkaline in reaction, and falls under the alkali-bicarbonate type composition category and is almost suitable for domestic, agricultural and industrial purposes.

3. The deep water levels all along the river Kali especially, the southern side need the continuous monitoring *vis-à-vis* sustainable arrangements to recharge the depleting aquifers. Though, the surplus of 3.60 MCM of groundwater is available for future development, the relationship between the withdrawal and its impact on the regional water table is to be strictly monitored as the groundwater development exceeds 80% of the available resources. Qualitatively, the groundwater has been found fit for almost all the purposes but it is recommended that at least, for drinking purpose, the deeper aquifers may be tapped. Finally, the study shows that the micro-level investigation at block level serves as the most reliable source of quantitative and qualitative assessment of groundwater resource of an area.

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