RESEARCH PAPER:

Evaluation of groundwater potential in Najangud taluk of Mysore district, India

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SUMMARY

The overexploitation of population to stress on groundwater resources due to ever-rising density and demands profligate uses as well as overgrowing population of Nanjangud taluk is an issue of great concern. The purpose of this study was to make a qualitative and quantitative estimate of the available groundwater resources in the Nanjangud taluk for efficient utilization and management of groundwater resources. The methodology involved the collection and analysis of existing bore well data. The results indicated that the aquifers were composite and composed of weathered regolith of low permeability to high storage and overlying fissured bedrock of high permeability and low storage. Semi-unconfined aquifers prevailed in major portions, which constituted the principal source of groundwater. The depths of boreholes in the taluk ranged from 17 - 95 m with an average of 75 m.

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Key words :
Groundwater assessment, Water quality, Recharge, Water management, Water resources

Present requirement and changes of life cycle and population growth have increased demands for water resources globally. Thus, the welfare of every society is tied to the sustainable exploitation of water resources. Groundwater continues to serve as a reliable source of water supply to most rural communities in Taluk. Although groundwater is a renewable resource, its availability and use are influenced by many factors such as the lithology of the area, climatic patterns and water quality. Due to these climatic changes, computations based on historical data are sometimes erroneous, therefore, the margin of variation should be factored in and abstraction should be less than recharge by this estimated margin. The largely unseen nature of groundwater has resulted in development initiatives which are unaware of the hydrodynamic limits of the resource and unable to regulate the resulting patterns of abstraction. There is the need for efficient management and utilization of groundwater resources on a sustainable basis to meet the future challenges. As with other renewable resources, demand can exceed supply and therefore some form of control or management of the resource should be in place, to ensure long term access by users. Management does not imply that users are guaranteed to have access to unlimited quantities of the resources at all times, but rather that under normal circumstance, users will be assured of a specified minimum quantity at all times. The Nanjangud Taluk located in a region of varied rainfall conditions and periods of extreme climatic conditions do occur and there may be times when even these minimum standards of supply cannot be met. Due to these climatic changes, computations based on historical data are sometimes erroneous, therefore, the margin of variation should be factored in and abstraction should be less than recharge by this estimated margin. Currently, the Taluk relies mainly on groundwater for its water supply needs. Therefore, the proper management of this resource is a matter of great concern and the most effective and economic means to sustain water supply in the Taluk is through the protection and sustainable management of water resources in the Taluk. There are a number of governmental departments and non-governmental organizations (NGOs) engaged in the exploitation of groundwater and the supply of potable drinking water for the rural communities. During the last 15 years, a large

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number of boreholes and hand dug wells have been constructed in the rural communities across the country. Available records show that about 90 boreholes and 270 hand dug wells exist in the Nanjangud Taluk. Unfortunately, all the borehole and well construction projects were implemented without due attention to the source and amount of replenishment of groundwater in the aquifers being tapped and this has resulted in reduction in yield, culminating in long queues and water quality deterioration. The population of the Taluk is rapidly increasing and it is expected that, new industries will be established as a result of the proposed in private sectors in the Taluk, will lead to further population growth. This development will certainly increase stress on groundwater due to the increase in water demand for various purposes like domestic, industrial and agricultural. There is the tendency of over-exploitation of groundwater resources in the near future, which may have serious repercussions on the environment. This therefore, calls for the assessment of water resource for planning and optimal utilization. The main objective of this paper is to provide information on the potential of groundwater resources and perspective planning necessary for a rational use of the resource in the Taluk.

MATERIALS AND METHODS

The study area is bounded between North latitude 11^0 5´ 30´´ and 12^0 12´30´´ East longitude 76^0 22´30´´to 76^0 56´30´´. Toposheets numbers are 57 D/12 and 57D/16. provides the physiographic coverage of the study area. Total extent of the study area is 981.60 sq. km covering parts or whole of 184 villages falling in Nanjangud Taluk. The state highway connecting Mysore to Coimbatore passes at the South-western corner of the study area for a short distance. Nanjangud-Gundlupet and Nanjangud–Chamarajanagar, the other important roads pass through the area. All the interior villages have a good network of roads with good communication facilities.

Geology:

The calciphyres and granulites are exposure in the Taluk and were examined in detail in view of the reported occurrence in them of a remarkable assemblage of rare minerals. A brief field examination disclosed the absence of Gabbrolimestone contacts previously reported. The calciphyres and calc-granulites occur as layers, lenses and nodules in a group of amphibolites and hornblende granulites. Thin sections of these granulites display cataclastic textures indicative of shearing, and crushing. They are found to be composed of minerals characteristic of high grade marbles, and the absence in them of such minerals as larnite, merwinite and spurrite recorded previously, is consistent with the present field observations.

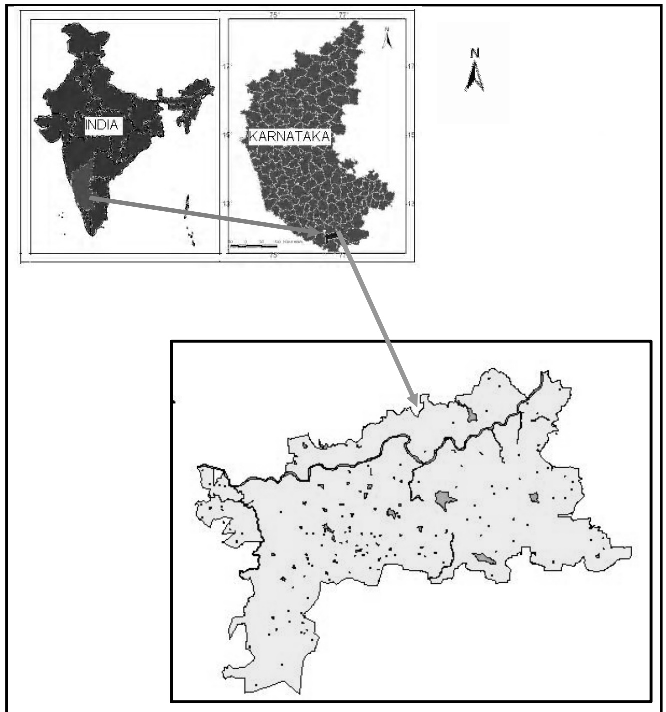

Fig. 1: Location of the study area

Sargur belt:

Sargur belt does not represent a well defined belt of schists but consists of a series of intimately associated enclaves of supracrustal rocks within peninsular gneiss. Besides the main sargur belt, there are several isolated

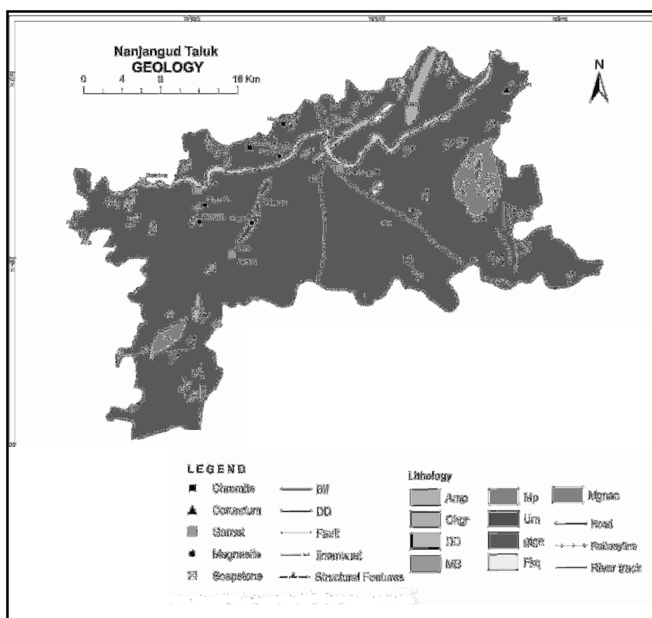

Fig. 2: Geology of the study area

but closely associated schist bands in Mysore district the Wolagere, Amble, Alathur and Nanjangud and as stringers in Gundlupet region. It has now been arranged upon that all the schist belt of south India older than 3,100ma should be grouped as ancient supracrustals of Sargur type. Sargur belt extends from Elwala near Mysore in the north to Shingebetta near the Kerala – Karnataka boundry in the south, with a length of 70km and a maximum width of 10km. This belt extends for a further 140km in Kerala through Sultan bettery, Mananthavady to Iritty with an approximate width of 20-60km. Various enclaves of schists of this belt standout as hillocks amidst, the rolling migmatitic terrain. The southern portion of this belt in Karnataka and a major portion in Kerala are located in the dense forest inhabited by wild life.

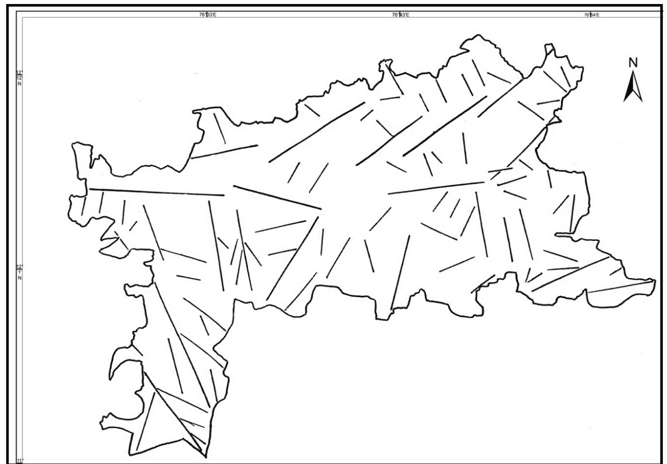

Fig. 3: Lineament of the study area

Lithology:

High grade supracrustal rocks occurring as huge enclaves within gneisses of different ages, which include quartzite-pelite-carbonate association along with banded iron formations, manganiferous horizons and amphibolites (having dip 60^0 and stike $N65^0E$). The components of ultramafic and basic rocks were emplaced into the supracrustals and were invaded by large scale acid igneous rock. Nanjangud band is 8km long, half km wide NE trending linear band extending from 3km NNW of Nanjangud. Lithologically the belt consists of garnet pyribolites with lenses of calcyphire and crystalline limestone.

Gneiss:

Peninsular gneiss generally consists of light coloured course grained, well-foliated biotite migmatite gneiss are the prominent rock types in the area generally termed as peninsular gneiss. Many schistose rocks occur as enclaves within the peninsular gneiss. Gneisses are divided into three major components namely, (1) The macro-layered trimodal gneiss, with alternating amphibolites and ultramafics, (2) Migmatites of various structural types, and (3) Homophonous granitoids. The gneiss of the Nanjangud Taluk fits into type one of Ramakrishnan. These rocks have a strike of $N65^0E$ with varying easterly dips of 60^0. These have variable colours (grey, dark); fine to medium and foliated. The grey gneisses noticed in the valley region are highly weathered, fractured. Where as the dark gneisses are massive and do not show much tectonic disturbances.

The methodology includes collection and analysis of existing borehole data, analysis and determination of the saturated zone (groundwater). Thirty rainwater samples were collected from 10 rain gauges and 100 groundwater samples were collected from boreholes between 2005 and 2009. Additionally, ten 0.3 m based, 0.1 deep plastic containers were placed on selected roof tops for dry fallout collection. All the samples were taken to the laboratory for Cl- determination using standard methods (APHA, 1998). Recharge estimation, estimating the rate of aquifer replenishment is probably the most difficult of all measures in the evaluation of groundwater resources. Hence, two methods of estimation (the chloride balance and the water balance equations) were used. The measured Cl- concentration from rainwater, dry fall out and groundwater in addition to the median values of 30 years rainfall data for the area obtained from the Meteorological Department were used in chloride mass balance method (Equation 1) for the estimation of recharge.

$$GWR = \frac{PT_P + D}{T_R}$$

where,

GWR = recharge (mm); P = precipitation (mm); T_R = groundwater tracer concentration (mg/1); T_P = precipitation tracer concentration (mg/1); D = dry fall out.

This method however is based on the following assumptions:

– That there is a steady input of the tracer at the surface.

– That the water and tracer are transported at the same rate.

– That there is no input of the tracer from rock minerals or anthropogenic sources.

– Since the study area is remote from the sea and covered with thick vegetation, dry fallout is very significant compared with the precipitation flux and thus cannot be neglected.

Water balance equation:

Assuming the surface water divide coincides with the groundwater divide in the watershed and there is no external inflow or outflow of groundwater, then the water balance equation would be given by the expression in equation 2 (Freeze and Cherry, 1979).

$$P = R + E + D + \Delta S_S + \Delta S_G \quad 2$$

where, P = Precipitation; R = Runoff; E = Evapotranspiration; D =Annual average recharge/ discharge; S_S = Change in surface water storage; DS_G = Change in groundwater storage (both saturated and unsaturated).

Averaging over several years, $\Delta Ss \approx \Delta S_G \approx 0$. Equation (2) then becomes:

$$P = R + E + D \quad 3$$

Making D the subject of the formula, equation (3) becomes

$$D = P - R - E \quad 4$$

Hydrometeorological data analysis:

Hydrometeorological data, such as rainfall, temperature between 1980 and 2009, for the study area were used in the analysis.

Total and recoverable groundwater storage:

The total groundwater storage in an area can be determined using Equation 5 (Schoeller, 1967).

$$Q_t = \alpha \theta \ HA \quad 5$$

The recoverable or usable storage capacity is the amount of groundwater that can be economically withdrawn from a basin as a source of long term annual supply. It was typically computed using Equation 6.

$$Q_r = \alpha \gamma \ HA \quad 6$$

where, Q_t = total groundwater storage, m_3; Q_r = recoverable groundwater storage;

α= percentage of study area underlain by groundwater zone; γ = specific yield; θ = porosity, H = mean thickness of the saturated zone, m; A = hydrogeological basin ~ extent of the study area, m_2

RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below:

Hydrogeological parameters:

The rock types are different, they are all crystalline in nature and behave similarly under weathering and groundwater conditions. Thus, the lithologies consist of weatherd gneiss and granitic gneiss with silty clay layers (aquitards) of thickness ranging from 1 - 27 m are present in the granites and gneiss extending from Southeastern through eastern to the Northern part of the study area. Weathered and/or fractured granite, calc-granulites are present beneath these aquitards, which are underlain by the second aquitard (that is, fresh bed rock). Thus, groundwater in this area exists under confined conditions which are justified by the fact that water levels in the boreholes rise several meters above the levels at which water was struck (Table 1). Transmissivity values calculated from the well pumping test resulted in the study area, which varied between 0.16 and 61.25 m^2/day, which confirm the conditions stated above. Transmissivity expressed in m2/s defined confine aquifers when the values are within the orders of x 10-3 and x 10-5 (Driscol, 1986). The depth to the confined aquifers increased towards the eastern boundary (*i.e.* from north-western part of the Taluk) and its thickness varied between 8-22m. At the western part of the study area, however, the clay layers were missing which suggest a possible recharge area for these confined aquifers. Such subsurface conditions suggest that unconfined aquifer is present in this area. The saturated thickness of the unconfined aquifer ranged from 9-28 m in this region. The yield of a well is an important hydrogeological parameter which can be used with other factors to determine the groundwater recharge potential of an area.

Table1: Summary of transmissivity values and static water levels in the study area

Formation	No. of borehole (analysed)	Static water level (m)		Transmissivity (m_2/day)	
		Range	Mean	Range	Mean
Granites	30	2.2-28	10.3	0.55-32.0	14.6
Gneiss	20	2.9-33	12.9	0.75-38.0	18.9
Granulites	10	3.1-36	16.8	1.10-46.2	22.4

Table 2: Summary of borehole depths and yields in the study area

Formation	No. of borehole (analysed)	Depth (m)		Borehole yield (1/min)	
		Range	Mean	Range	Mean
Granites	30	14.85-78.0	39.81	14-150	45.63
Gneiss	20	38.0-65.0	27.54	10-140	34.59
Granulites	10	32.0-55.0	19.76	12.-110	28.71

It is clear from Table 2 that the gneiss rocks have the highest yielding wells ranging from 12 to 190 l/min this was followed by the granites which had discharges ranging from 8 to 130 l/min. It was found that there were poor correlations between yield and depth of the boreholes in the sargur group of rocks. Further more, it was observed in the relationship between depth and yield with regards to boreholes in the granites was poor. This was consistent with the fact that both the gneiss and granites were crystalline and behaved similarly under weathering and groundwater conditions.

Permanent and recoverable groundwater reserves:

The total and recoverable quantities of the groundwater storage in the Taluk basin were determined from the borehole data. Measurements of average values of the levels from ground surface to well water surface (static water level) and from well water surface to weathering front were taken from boreholes in the Taluk. The presence of groundwater zone at a sample site is regarded as a success (if yield is greater than 9 l/min) and a failure (unsuccessful) based on the drilled boreholes. Borehole parameters, such as unsaturated thickness and saturated thickness of the weathered zone were determined from the borehole logs of the Taluk. Adopting the relative-frequency definition of probability, the probability that a randomly selected site in the study area was underlain by groundwater zone was computed by dividing the number of borehole sample sites underlain by saturated zone by the total number of borehole sample sites (Owolabi and Adegoke-Anony, 1988). Using the values for porosity and specific yield to be 5 and 2%, respectively (Asomaning, 1993; Ogunkoya, 1987) and information from borehole logs in the study area, the values of the permanent reserves Qt and the recoverable quantity of the groundwater storage Qr were determined. The latter value representing the magnitude of groundwater reserve in the basin regolith of the taluk is that which can be abstracted by wells, becomes baseflow component of stream flow and seep out or flow out as spring where the local topography is favorable.

Table 3: Chemical analysis results of water samples from Najangud Taluk

Selected well no.s	pH	EC	Total hardness	Total dissolved solids	HCO_3	Cl	SO_4	NO_3	Ca	Mg	Na	K	F	Fe
150801D	6.34	1281.00	416.00	713.00	519.00	98.00	49.00	32.00	83.00	52.00	98.00	5.00	0.95	0.10
150802D	6.23	982.00	312.00	574.00	343.00	59.00	38.00	82.00	69.00	35.00	36.00	55.00	0.80	
150803D	6.50	1347.00	650.00	687.00	412.00	126.00	61.00	63.00	84.00	110.00	3.00	4.00	0.10	0.26
150804D	6.03	1130.00	369.00	697.00	319.00	126.00	69.00	74.00	122.00	15.00	67.00	41.00	0.25	0.08
150805D	6.23	877.00	300.00	483.00	480.00	20.00	12.00	7.00	74.00	29.00	66.00	3.00	0.30	0.08
150807D	6.70	730.00	350.00	454.00	270.00	42.00	35.00	66.00	80.00	13.00	48.00	10.00	0.26	0.00
150808D	6.36	3316.00	480.00	2100.00	674.00	476.00	125.00	375.00	164.00	18.00	529.00	16.00	0.00	1.68
150809D	6.95	632.00	264.00	360.00	231.00	53.00	27.00	32.00	29.00	48.00	16.00	10.00	0.00	0.00
150810D	6.95	2074.00	780.00	1150.00	524.00	329.00	97.00	52.00	168.00	90.00	112.00	4.00	0.55	0.18
150811D	7.00	943.00	244.00	555.00	338.00	62.00	70.00	44.00	30.00	42.00	99.00	8.00	0.25	0.00
150812D	7.01	757.00	300.00	427.00	289.00	56.00	36.00	31.00	50.00	44.00	27.00	10.00	0.20	0.00
150813D	6.88	3848.00	1180.00	2290.00	534.00	742.00	150.00	352.00	276.00	122.00	326.00	20.00	0.20	0.26
150814D	7.01	1358.00	540.00	756.00	515.00	98.00	70.00	57.00	109.00	67.00	58.00	2.00	0.50	0.10
150815D	6.90	829.00	348.00	471.00	0.00	186.00	95.00	63.00	66.00	24.00	72.00	26.00	2.00	0.00
150816D	6.52	1398.00	472.00	0.00	0.00	0.00	162.00	0.00	176.00	0.00	0.00	0.00	0.00	1.00

Water quality:

The summary statistics of the physico-chemical and bacteriological constituents and parameters of groundwater within the steady area presented in Table 3. The water quality standard adopted for this project is WHO (2004) guidelines limits. The results from water quality analysis showed that the values for most of the parameters and constituents analysed were within WHO (2004) guidelines limits for drinking water. However, about 20% of the wells had iron values above the acceptable limit of 0.3 mg/l and approximately 4% had manganese values above the acceptable limit of 0.5 mg/l. The groundwater sources in the Taluk can be said to be quite aggressive and may corrode reactive metal fixtures as water from over 58% of the wells sampled in the taluk had pH values below 7.0 pH units. The results of bacteriologicalm parameters (*E. coli*; faecal andtotal coliform) analyses of groundwater in the Taluk indicated satisfactory water quality thus the groundwater was bacteriologically safe for human consumption.

Conclusion:

Recharge is mainly by direct infiltration of rainwater through out crops of the crystalline rocks that have underlain the Taluk. The annual groundwater recharge rate in the Taluk estimated from the water balance equations have been found to be 131 mm/year . The total permanent groundwater storage and recoverable groundwater storage of the Taluk were found to be approximately 326.1 x 106 m^3 and 130.4 x 106 m^3, respectively. The quality of groundwater in the taluk was generally good as most of the physico-chemical parameters analysed fell within the WHO (2004) guideline limits for drinking water. However, there are localities where iron and manganese may pose water quality problem. It is envisaged that the utilization of adequate exploitation methods and development techniques will be employed to achieve optimum yield.

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