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INFLUENCE OF SEWARAGE NETWORK ON GROUNDWATER, USING RADIOGENIC ISOTOPE TRITIUM

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ABSTRACT
Radiogenic isotope tritium (^3H) together with chemical compositions of water was used to discriminate ground water age and recharge areas and probable recharge processes respectively in four valleys of Bangalore. Forty seven (47) grounds and twenty (20) surface water samples were collected to assess the TDS, EC, Salinity and ^3H. The groundwater available in four valleys contained high ^3H (>1TU), suggesting recent recharge and belong to 100% modern age. Modern recharge in the aquifer is influenced by the sewerage network and as a consequence groundwater contains higher TDS, EC, salinity and ^3H.

Keywords: Tritium, Salinity, Depth, Sewerage Network, Groundwater age, Recharge and Flow.

INTRODUCTION
During the last two decades environmental isotope techniques have been largely used in the overall domain of water resources development and management (Fritz *et al.,* 1980). In fact, the application of these relatively new techniques has played an important role in solving the envisaged hydrogeological problems that are unsolved by conventional methods alone.

Understanding the relative significance of recharge processes, recharge area, groundwater flow paths and groundwater age is critical for accurate representation of a groundwater flow system. An accurate conceptualization is a prerequisite for realistic simulation of a flow system. To better understand the flow system and translate this understanding to the develop a groundwater model, data's on used radiogenic isotope of ^3H along with groundwater TDS, EC and salinity to distinguish the groundwater age, recharge areas, and possible recharge processes.

MATERIALS AND METHODS

Thirty-four (34) Bore well, 13 Open well, 6 lake and14 sewage samples were collected in pre-acid washed polyethylene bottles from the four valleys, after 10 minutes of initial pumping and transported to laboratory at 10ºC to prevent contamination with heavy metals from the sampling and storage equipments. It was ensured that the samples collected represented those wells located as close as possible to inferred flow paths from the sewarage network in all valleys (Table-1). Driller's well logs were reviewed for information on the lithology, screen interval and relationships of water bearing sections of the lithology above and below the screen in the well. Tritium analysis was done at the Tritium and Radiocarbon laboratory of Bhaba Atomic Research Centre (BARC), Mumbai, using liquid scintillation counting methods. Immediately after sampling, total dissolved solid (TDS), electrical conductivity (EC) were measured in the field by using the PE-138 field Kit (APHA, 1980) and salinity of water was classified according to Handa (1969) (Table-2).

Study Area

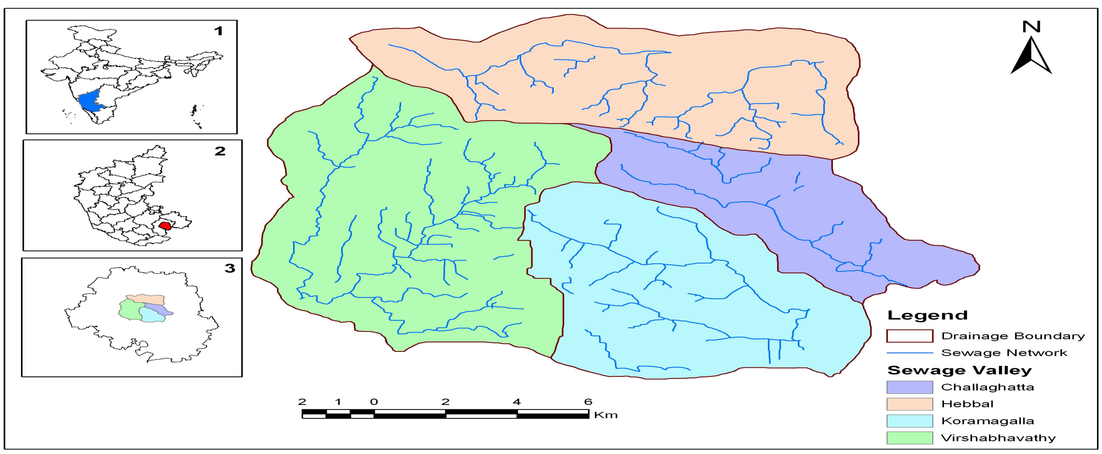

Fig.1: The map of the study area along with sewerage network system is given.

Hydro-geologic setting

A thickly populated settlement area of Vrishabhavathi, Kormangala, Hebbal and Challaghatta valleys basin was selected. The sewerage lines here are interconnected by several tanks. In the study period, the depth of the water table varied between 12ft.-23ft. from the ground level in the open well whereas, in the bore well samples the depth were varied between 25ft.-800ft (Table-1).

Bangalore is the part of Cauvery basin which is situated in the southeast corner of Karnataka (Prakash, 2002). It spans over a geographical area of 713km^2. It is blessed with uneven landscape with intermingling hills and valleys. The western part is rocky and bare rocky out crops raise upto 60-90 meters. The southern and western parts represent rugged topography of granitic gneisses. North of Bangalore is more or less level plateau lying between 839-962 meters above mean sea level. The prominent ridges run parallel towards NNE-SSW direction. The particular physiographic setting of gentle slopes and valleys on either side of this ridge hold better prospects of groundwater utilization and harvesting. The low lying area is marked by a series of tanks and small ponds.

The chief rock types occurring in the Bangalore North granites and gneisses intruded by basic dykes. The granitic ridge running from NNE to SSE governs the drainage pattern of Bangalore North. Towards east the drainage is made up network of canals generally flowing from west to east with storage tanks along the canals, ultimately feeding the South Pinakini River. In the west, the drainage pattern is made up of network of canals generally flowing from east to west with storage tanks along the canals, ultimately feeding the Arakavathi River. The Bangalore south drains were drain towards east direction, into the Pinakini basin and to the west into the Arakavathi. The Vrishabhavathi is a minor river marked with series of tanks.

The western portion of Bangalore is composed of only one type rock that is gneissic granites belonging to Precambrian age. The gneissic granites are exposed as a continuous chain of mounds raising 90-150m above the ground on the western portion constituting the Bennerghatta groups of hills. Inclusions of quartz and pegmatite were occurring in this region.

Groundwater occurs under water table in the weathered mantle of the granitic gneisses and joints, cracks and crevices of basement rocks. The depth of water table is dependent upon the rate of weathering and topographic factors (Singh, 1999). Chief source of groundwater is infiltration and recharge of rainwater. Considering the climatic water balance, soil characteristics account for nearly 70% allowing only 20% rainfall being added again to groundwater pool. Percolation and recharges in the groundwater account for 10% discharge through wells.

Table-1: No. of samples, minimum and maximum values of ^3H, TDS, EC, Depth, Distance and Elevation in the valleys.

		^3H (TU)			TDS (mg/l)		EC (µS/cm)		Depth (ft.)		Distance (ft.)		Elevation (meter)	
Type of samples	**No. of samples**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Sewage	14	3.6	28.79	11.36	186	2502	977	4183					813	943
Lake	6	4.2	10.08	7.66	169	632	338	1568					840	922
Open well	13	3.4	10.32	6.26	842	927	403	1351	12	23	0.5	2	842	927
Bore well	34	1.9	11.19	6.18	256	1077	605	1879	25	800	0.3	2	812	997

Table-2: Classification of waters based on of Electric conductivity (Handa, 1969).

EC (µS/cm)	**water salinity**	**Sewage**	**Lake**	**Open well**	**Bore well**
0-250	Low (excellent quality)	Nil	Nil	Nil	Nil
251-750	Medium (good quality)	Nil	**2**	**5**	**27**
751-2250	High (permissible quality)	**11**	**4**	**8**	**7**
2251-6000	Very high	**3**	Nil	Nil	Nil
6001-10000	Extensively high	Nil	Nil	Nil	Nil
10001-20000	Barines weakly conc.	Nil	Nil	Nil	Nil
20001-50000	Barines moderately conc.	Nil	Nil	Nil	Nil
50001-100000	Barines highly conc.	Nil	Nil	Nil	Nil
<100000	Barines extremely high conc.	Nil	Nil	Nil	Nil

Table-3: Categorization of Groundwater age according to ^{3}HTU values (Zouari *et al.,* 2003).

Groundwater Age			
(<1TU) (Pre-modern) **OLD**	(>=1TU) (Modern) **NEW**		
	(1-8TU) Radioactive decay (Mixture) **OLD +NEW**	(9-18TU) Resent with activities	(19->28TU) Thermonuclear with activities

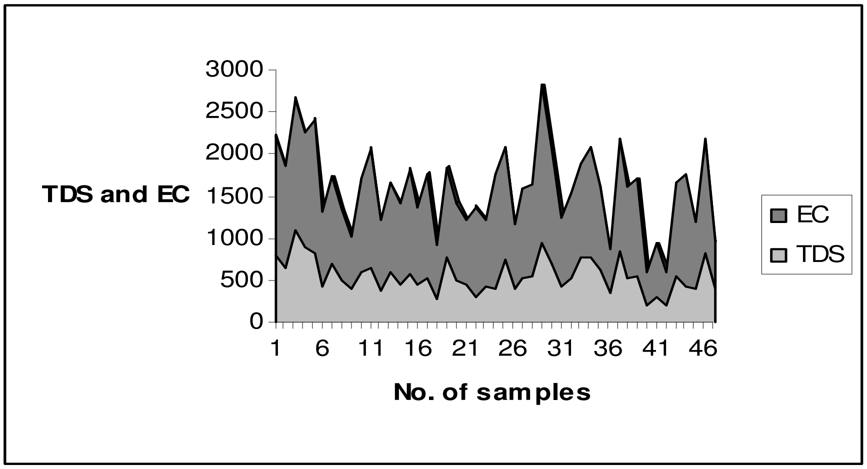

Fig. 2: Variation between TDS and EC values in Open and Bore well samples.

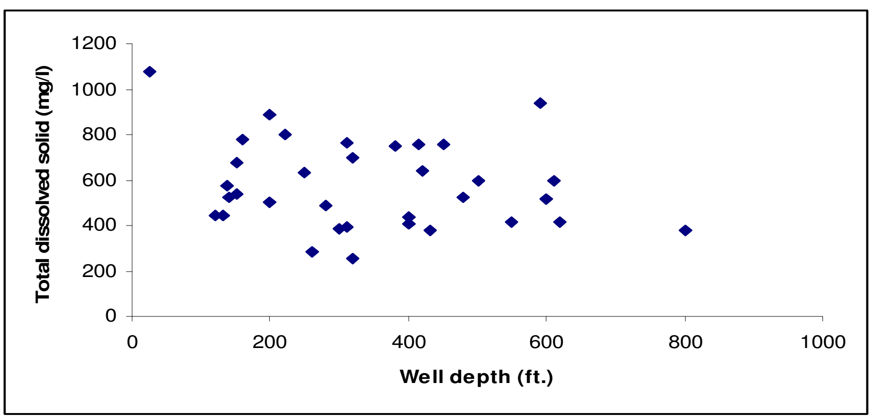

Fig. 3: Plot of TDS vs. Bore well depth showing increase in Salinity at shallow aquifers.

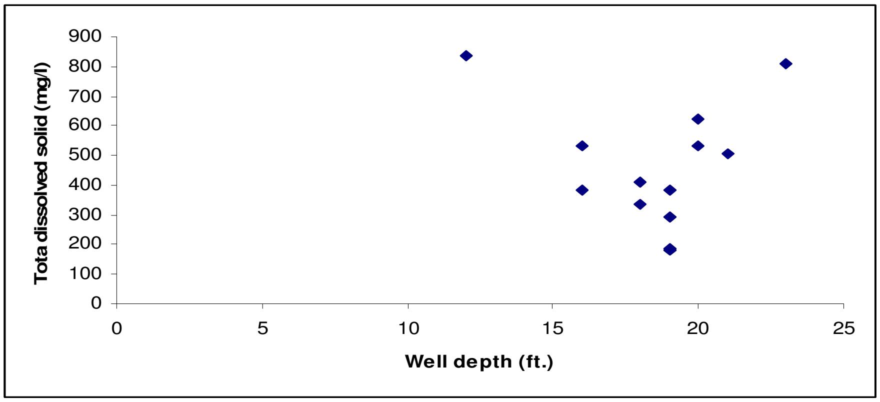

Fig. 4: Plot of TDS vs. Open well depth showing increase in Salinity at shallow aquifers.

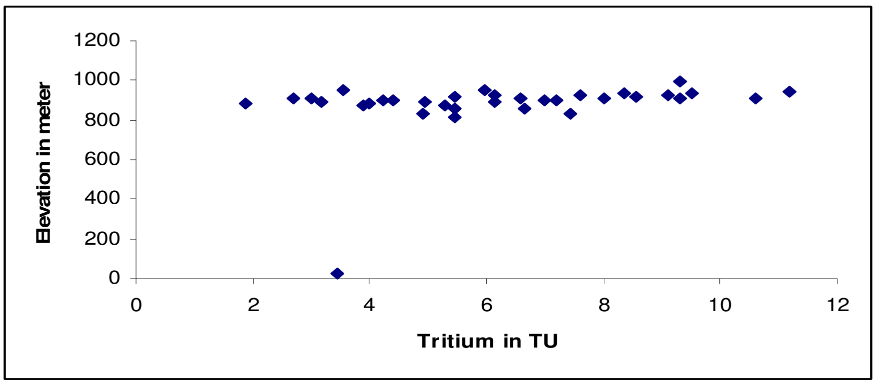

Fig. 5: Scatter diagram of TU vs. Water level elevation of Bore well samples showing higher tritium values with increase in elevation.

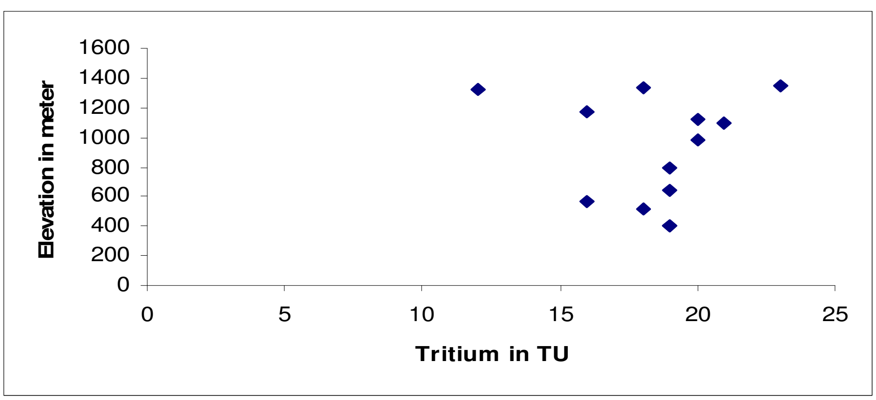

Fig. 6: Scatter diagram of TU vs. Water level elevation of Open well samples showing higher tritium values with increase in elevation.

RESULT AND DISCUSSION

Relative dating of groundwater age has been carried out via the analysis of tritium content as new (>1TU) and old (<1TU) groundwater. The bore well water from the basins had a mean tritium value of 6.2TU ranging between of 1.9 and 11.2TU, 0pen well exhibited a mean tritium value of 6.3TU and a range of 3.4 to 10.3TU, lake water a mean tritium value of 7.7TU and a range of 4.2 to 10.1TU and the sewage water mean tritium value is 11.4TU and ranging between of 3.6 and 28.8TU (Table-1). The apparent age of groundwater is considered to be the amount of time determined from an age-dating tracer that has elapsed since the water was last in contact with the atmosphere.

Tritium is a short-lived radioactive isotope of hydrogen with a half-life of 12.32 years. Tritium forms naturally as cosmic radiation interacts with the upper atmosphere, and all precipitation that falls to Earth has small amounts of tritium. During the 1950s and early 1960s, global atmospheric testing of nuclear weapons raised the atmospheric concentrations of tritium hundreds of times above the normal background concentration (Plummer *et al.,* 1993). After the early 1960s, when the Nuclear Test Ban Treaty (NTBT) was signed and atmospheric testing of nuclear weapons ceased, tritium concentrations in the atmosphere have decreased and are approaching natural levels. Tritium concentration alone generally cannot be used to quantitatively date groundwater, but can be used to qualitatively determine whether groundwater is **modern** (less than about 50 years in age) or **pre-modern** (older than about 50 years in age) (Clark *et al.,* 1997). From table-3, Tritium concentrations below 1 TU were considered to indicate that groundwater is at least 50 years old (pre-modern) and tritium concentrations equal to or greater than 1 TU were considered as modern groundwater. Again modern age is classified depending on ^3H values where in the ^3H values ranging from 1-8TU could be attributed as an admixture of recent water with old groundwater and groundwater having been subjected to radioactive decay. Recent water with activities between 9 and 18TU and thermonuclear water with activities between 19 and 28TU. So, the groundwater samples from basins had 60% of mixture, 30% of recent water, as well as, 10% thermonuclear water from sewage. According to ^3H values of all samples lay beyond the 1TU, indicative of modern water (Table-1). Modern groundwater generally is more susceptible to contamination than old because of the many anthropogenic contaminants introduced during the 20th century (Plummer *et al.,* 1999).

The trend in tritium values [Sewage (11.4TU)>Lake (7.7TU)>Open well (6.3TU)>Bore well (6.2TU)], suggested that the contaminants of ^3H in groundwater is recharged from sewage and lakes. In addition, the presence of high ^3H in groundwater samples along the sewerage network supports the view that the sewage acts as a hydraulic move(?) to groundwater flow. The tritium values are directly proportional to the water level elevation in both bore and open wells (Fig.5 and 6).

High TDS is accounted by the presence of HCO_3, SO_4, Cl, CaH, MgH, and Na (Nawlakhe *et al.,* 1995). The causes of higher TDS and EC may be the combined effect and lithologic variations, industrial effluents and chemical fertilizer contamination as reported by Chebotarebv (1985), Rambabu *et al.,* (1986), Joseph (2001) and Mohapatra *et al.,* (2001), have also expressed similar opinion and concurs that slightly alkaline condition favors higher TDS concentration in groundwater. The TDS and EC values of bore well water samples varied from 256-1077mg/l and 605-1879mg/l respectively and open well water samples varied from 183-839mg/l and 403-1351m/l respectively (Table-1). The Variation between TDS and EC values of Bore and Open well with concomitant variations in Salinity (Fig. 2) confirmed the earlier findings. The depth of wells is inversely proportional to salinity, confirming the source of recharge on (Fig. 3 & 4) sewerage network (Table-2).

CONCLUSIONS

The use of environmental isotopes to study groundwater recharge sources and mixing in the four basins has been demonstrated as a useful technique. Based on the TDS, EC, salinity and ^{3}H, it has been possible to distinguish various types of water and mixing processes in the system.

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