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Concentration of uranium levels in groundwater

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ABSTRACT: The uranium isotopes during their course of their disintegration decay into other radioactive elements and eventually decay into stable lead isotopes. The cause of environmental concern is the emanation of beta and gamma radiation during disintegration. The present study tends to estimate uranium in groundwater trapped in granite and gneiss rocks. Besides, the study aims at estimating the radiation during natural disintegration process. The water samples were collected and analyzed following inductively coupled plasma mass spectrometric technique while water sample collection was given to the regions of Kolar District, South India, due to the representation. The significant finding was the observation of very high levels of uranium in groundwater compared to similar assays reported at other nearby districts. Also, the levels were considerable to those compared to groundwater levels of uranium reported by other scientists. On the basis of this study, it was inferred that the origin of uranium was from granite strata and there was a trend of diffusion observed in the course of flow-path of water in the region.

Key words: *Water analysis, granite-gneiss, underground, flow-path, isotope*

INTRODUCTION

The Uranium concentration in groundwater depends on lithology, geomorphology and other geological conditions of the region. In groundwater uranium is present both in dissolved and particulate form due to minerals such as Uranite, Pitchblende and Cornalite or as secondary mineral in the form of complex oxides of silicates phosphates, vanadates, lignite and monazite sands (Mahesh 2001) or as secondary minerals in the form of complex oxides, silicates, phosphates, vanadates, lignite and monazite sands. Natural uranium bymass of isotope proportions are 99.275% for ²³⁸U, 0.72% for ²³⁵U, 0.005% for ²³⁴U. Thus theoretically, the radioactivity of ²³⁵U in water is negligible compared to ²³⁸U (UNSCEAR, 1982). In the last few decades, the behavior of uranium and thorium decay series nuclides in groundwater has contributed to an understanding of the mechanisms of geochemical reactions and transport processes in rock water systems. However,

many uncertainties persist regarding the behavior of these radio-elements in rock water systems, mainly due to the relative importance of nuclear alpha particle recoil and chemical processes, such as ion exchange, sorption and precipitation (Iyengar, 1990). Uranium is the heaviest naturally occurring elements and is found in an average concentration of 0.0003% (3mg/kg) in the earth crust. It is present at a concentration of about 3.0 µg/L in seawater (Lal, 1968; CWC, 2000; Hess, 1985; Hakam, 2001; Bleise, 2003; Almeida, 2004; Guogang Jia, 2005). Uranium isotopes during their disintegration course decay into other radioactive elements and eventually decay to stable lead isotopes in the process emit beta and gamma radiation (Fontes, 1983). The decay products of ²³⁸U (²³⁴Th and ²³⁴Pa) and ²³⁴U (²³¹Th) are responsible for the presence of beta and gamma radiations in purified natural uranium (Bleise, 2003). Uranium isotopes and their specific activity (Bq/g) are represented in Table 2 (UNSCEAR, 1982). ²³⁸U has a half life of 4.47x10⁹ years and its specific activity is 12,455Bq/

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g. The study had dual objectives of estimating uranium as a natural radioactive element in groundwater samples by adopting advanced instrumental techniques as well as delineated the concentration of uranium distributed in the groundwater of Kolar district reflecting the abundance, flow-path through the groundwater current in the region.

MATERIALS AND METHODS

The Kolar district is characterized by the rocks of various geological formations of the Archaean and quaternary periods. The district is rich in mineral deposits like gold, graphite, ochre and kaolin. Three categories of rock, namely granites, gneisses and schists, occur in the region. Granites occupy a major portion of the district. Alluvium is distributed along the stream and river courses. Basic dyke intrude the above formations in some places. They predominantly occur in South-East, South-West and central sections in the district.

Study area: Kolar district falls in the plain regions and is located in the easternmost district of Karnataka, South India. It is situated between 12° 46' and 13° 58' North latitude and 77° 21' and 78° 35' East longitudes. The topography of the district is from undulating to plain land with a number of scattered hill rocks. The central and eastern parts of the district forming the valley of Palar basin are undulating and well cultivated. The average height of the land is 850 MSL. The district can be divided into three river basins, namely Palar, North Pennar and South Pinakini, taking birth in the southwestern part of the district and draining at different parts. The total population of the district is 25.36 lakhs and the population density is 30.7/km (District Statistics Report, 2005). A total of 52 groundwater samples were collected from bore-wells from all the taluks spread over the entire district of Kolar. Groundwater Sample was collected in a 100 mL plastic bottle with cap of inner seal type. The water samples were filtered using Whatman filter paper discs before the acidification to pH around 2 using nitric acids. The samples are then labeled, denoting all the details of time, place and date of sample collection. The samples were transported to laboratory and stored at room temperature to be taken up for uranium analysis later. The concentrations of natural uranium present in the groundwater samples were analyzed by ICPMS (Model VG PQ of M/s. Excel) via the standard run and

with the respective reference uranium standards of 5 ppm, 50 ppm, 100 ppm etc. (APHA. 1995). The results are recorded in ppm and ppb levels.

RESULTS AND DISCUSSION

The groundwater uranium concentration range spanned between 0.3 to 1442.9 µg/L. It is relevant to indicate that the World Health Organization prescribes 30 ppb as a standard for uranium in drinking water. Computing to this prescribed level, 21.8% samples exceeded the permissible limits. The Uranium concentration in the drinking water samples of Chikmangalore area, Karnataka, has been reported to vary from 0.2 to 27.9 µg/L (ppb) (Manjunath, 2002). The reported concentration in China is 0.04-5.1 µg/L (Paziguiang *et al.*, 1988) and 0.9-9.9 µg/L (Padam Singh *et al.*, 1995). The present study shows no agreement with these earlier studies on uranium and is very much on a higher side. Besides, there is a considerable radioactivity in other conventional minerals of commercial importance such as phosphate minerals, appetite, copper, gold lignite, bauxite and such other ores due to the presence of uranium. Mining and processing of these minerals can enhance the radium levels in the environment well above the normal background levels. Exposure to higher levels of uranium is of serious concern for public health (Orloff, 2004) due to its hazardous nature associated with internal exposure (Lawrie, 2000). Uranium concentrations in the water depend on some factors such as uranium content in the host aquifer rock and its chemical constituents, presence of oxygen and its complexion agents, chemical reactions with ions in solution and nature of the contact between Uraniferrous minerals and water (Hess, 1985). The mean levels or uranium distribution in the different taluks of the region is presented in Table 1. The distribution of uranium estimated from water samples collected in different regions does show a trend. Out of a total number of eleven taluks of the Kolar district, maximal concentration found in Chikballapur taluk indicating the presence of uranium due to the rock formation. An interesting finding is that the uranium concentration is higher in samples originating northern regions compared to that from the southern regions of the district. The taluks like Malur and Bangarpet located in the southern regions showed relatively lesser concentration of uranium distributed in the groundwater. It can be inferred from this fact that there is a decreasing trend in the uranium

Table 1: Mean ²³⁸U levels according to taluks in Kolar District

No.	Taluks	No. of samples (n)	Mean ± S.D. µg/L, (Min. – Max.)
1.	Chickballapur	8	291.08, (2.44 – 1443.0)
2.	Gauribidanur	13	14.25, (1.32 – 57.30)
3.	Sidlaghatta	6	5.08, (0.33 – 15.25)
4.	Bagapalli and Gudibanda	3	6.08, (0.77– 13.66)
5.	Kolar	5	23.03, (1.94 -90.0)
6.	Mulbagal	2	4.85, (4.51-5.20)
7.	Bangarpet and Malur	10	15.77, (0.69 – 54.69)
8.	Srinivasapura and Chintamani	5	33.35, (3.85 – 145.53)

Table 2: Characteristics of uranium isotopes in natural uranium

Isotope	Half life (years)	Relative (%)	Specific activity (Bq/g)
²³⁸ U	4.47x10 ⁹	99.3	12,455
²³⁵ U	7.04x10 ⁸	0.72	80,011
²³⁴ U	2.46x10 ⁵	0.006	231x10 ⁶

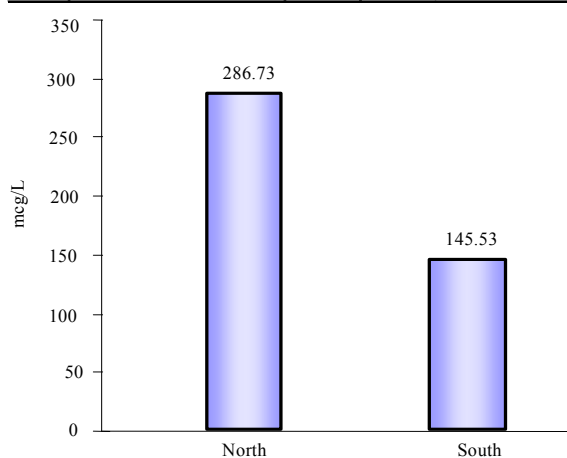


Fig. 1: Uranium levels in groundwater according to the north and south regions

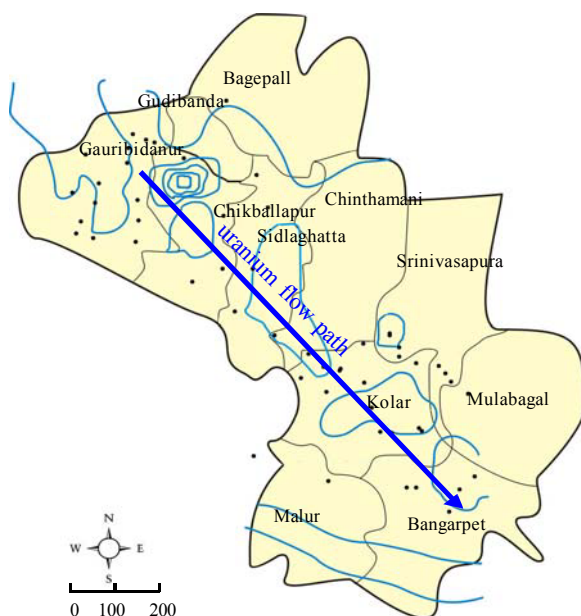


Fig. 2: Isoconcentric distribution of Uranium concentrations and spread pattern

concentrations along the groundwater flow. The Kolar district can be divided into two regions, namely northern and southern regions based on the levels or uranium levels in ground water observed in the present study. The northern comprises of taluks, namely Chickballapur, Gauribidanur, Sidlaghatta, Bagepalli and Gudibanda form the north region. The water samples were collected from the cusp-region of Bagepalli and Gudibanda and hence they are clubbed together for computing the mean levels. This region clearly shows an upward trend and distinctly appears to differ from the southern region of the district. The southern region comprises of Kolar, Mulbagal, Bangarpet, Malur, Srinivasapur and Chintamani taluks. Bangarpet with Malur and Srinivasapur with Chintamani are clubbed, since the collected water samples merged with each other in these regions. This finding urges to hypothecate that there is a certain flow path from northern to southern direction with respect to the uranium distribution in geological strata (Athavale, 1992). The recharge area is located in the north and the discharge area is in the south of the district. This indicates that there could be higher uranium concentrations in the granite rocks of the northern part which could be a source for ground water. Since groundwater flows from north to south, it exhibits a diffusion gradient running from the north to the south direction. The study revealed that the uranium is concentrated at some locations at Chickballapur taluk and gradually spread downwards as shown in Fig. 2.

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