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Presence of Radon in Groundwater in Parts of Bangalore

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Abstract: Presence of high levels of Radon (^{222}Rn) gas was reported from groundwater in Bangalore. To ascertain the ground reality and the nature of the hazards, if any, a study was conducted by the Central Ground Water Board, Bangalore in and around Bangalore city. Groundwater samples from borewells and a dug well were collected and analysed. Available data on Radon gas from both groundwater and surface water sources were also compared. The presence of Radon gas and its concentration in groundwater were examined with respect to geology and well depths. The results are discussed in the paper.

Keywords: Radon in Groundwater, Bangalore, Karnataka.

INTRODUCTION

Bangalore city is mainly dependent on piped surface water supply and to a lesser extent on borewells for drinking purposes. Very high levels of Radon gas in groundwater were reported in Bangalore (Deepa Kozhiserri, 2009). Based on this, the Ministry of Water Resources (GOI) advised Central Ground Water Board, South Western Region, Bangalore to conduct a detailed study to investigate the occurrence of Radon gas, its controlling factors, its depth-wise concentration and relation with local geology.

RADON CHEMISTRY

Radon (^{222}Rn) is essentially chemically inert, but radioactive (www.chemistrydaily.com). It is the heaviest noble gas at room temperature. At standard temperature and pressure radon is colorless. Natural radon concentrations in the Earth's atmosphere are very low, that water in contact with the atmosphere will continually lose radon by volatilization, while groundwater has a higher concentration of ^{222}Rn than surface water. Likewise, the saturated zone of soil frequently has higher radon content than the unsaturated zone due to diffusional losses to the atmosphere.

There are twenty known isotopes of radon. The most stable isotope is radon-222 which is a decay product (daughter product) of radium-226, has a half-life of 3.823 days and emits radioactive alpha particles. Radon-220 is a natural decay product of thorium and is called thoron. It has a half-life of 55.6 seconds and also emits alpha rays. Radon-219 as derived from actinium, is called actinon and is an alpha emitter having a half-life of 3.96 seconds.

The full decay series of uranium-238 which produces natural radon is given in Table 1.

Radon being the daughter product of the uranium is expected in higher levels in rocks containing uranium. The studies indicate the granites, pegmatites and other acidic rocks are generally rich in uranium compared to other rocks types. When groundwater percolates through rocks rich in uranium, it is expected to contain high level of radon gas in ground water. Once the water is exposed to the atmosphere, the radon emanation and escape into the surface is accelerated.

Table 1. Decay series of Uranium-238 (source: www.chemistrydaily.com)

Decay series	Half-lives
Uranium-238	4.5 x 10^9 y
Thorium-234	24.1 d
Protactinium-234	1.18 m
Uranium-234	250,000 y
Thorium-230	75,000 y
Radium-226	1,600 y
Radon-222	3.82 d
Polonium-218	3.1 m
Lead-214	26.8 m
Bismuth-214	19.7 m
Polonium-214	164 micro-s
Lead-210	22.3 y
Bismuth-210	5.01 d
Polonium-210	138 d
Lead-206	stable

PRECAUTIONS

Radon is a carcinogenic gas and is radioactive. It is hazardous to inhale this element, since it emits alpha particles. Radon in water may therefore present dual pathways of exposure for individuals, through drinking water and inhalation of air containing radon released from groundwater (Cross, 1995)

Its solid decay products, and their respective daughter products, tend to form fine dust, which can easily enter the air passage and become permanently stuck to lung tissue, causing heavy localized exposure. Build-up of radon in homes has also been a more recent health concerns and many lung cancer cases are attributed to radon exposure each year. Radon escalates health hazards to smokers. The solid decay products of radon (polonium-218, polonium-214 and lead-210 are the most damaging) present in the atmosphere in dust form can fix themselves on the micro-particles in tobacco smoke, which then enter the lungs. Thus the best mitigation for the adverse effects of radon is simply to give up smoking, as the risk of non-smokers developing radon-related lung cancers is considerably lower (www.chemistry-daily.com).

The occurrence of Radon in the groundwater in bore wells was reported from around Bangalore. The study area

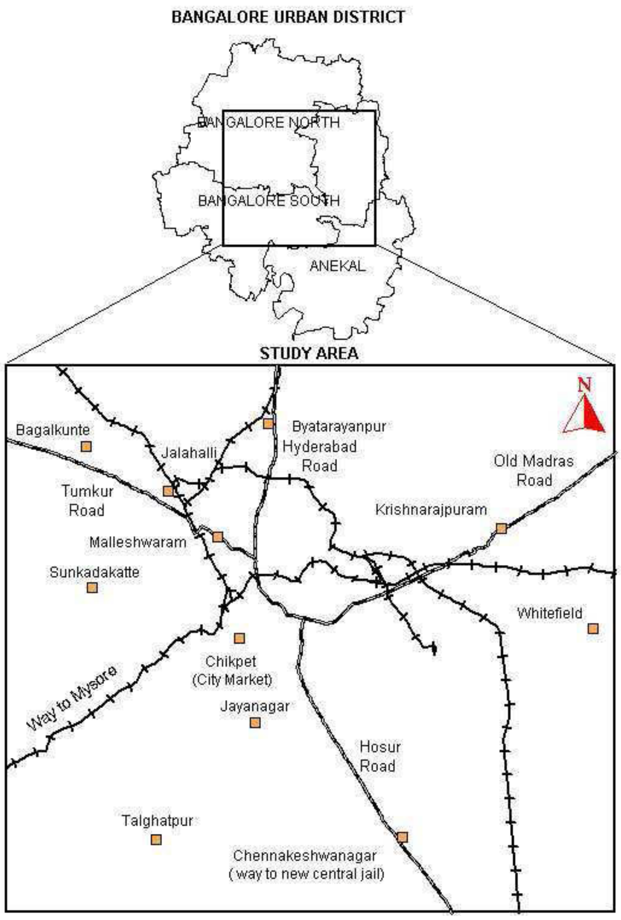

Fig.1. Study area.

lies between North Latitudes 12°50'04" - 13°05'33" and East Longitudes of 77°27'43" - 77°45'30", covering about 1000-sq km area in the urban agglomeration, includes Bangalore north and south taluks and parts of the Anakel taluk of the Bangalore urban district (Fig.1).

SAMPLE COLLECTION AND MEASUREMENTS

Different traverses were taken during the period 02.03.2009 - 09.03.2009 covering almost all parts of the city within the radius of 20km. The groundwater samples were collected from 29 borewells used for domestic purposes and one dug well in various depth ranges (Fig.2).

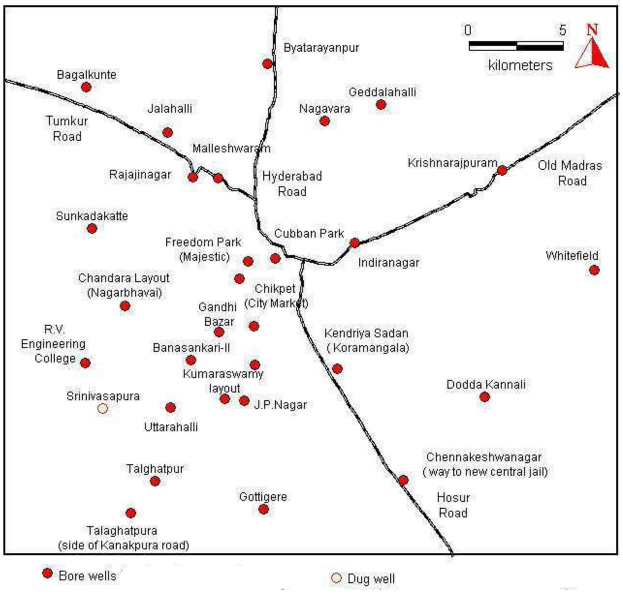

Fig.2. Map showing sample locations in Bangalore, Bangalore urban district.

The bore well was flushed to ensure that the collected water is fresh from the aquifer without chance of gas escape. The water was collected in the sterilised container through the ooze pipe to avoid the exposure of water samples to the atmosphere. Thus collected samples were sent to the laboratory on the same day for analysis.

Depth of the bore well, year of construction and time of sample collection were recorded during the study. The locations of the borewells were digitized in the MapInfo GIS and the maps were generated. The location map is shown in Fig.2. The samples were analysed at Bangalore University using RAD7 Instrument.

GEOLOGY

Geologically, the area is mainly underlain by 95%

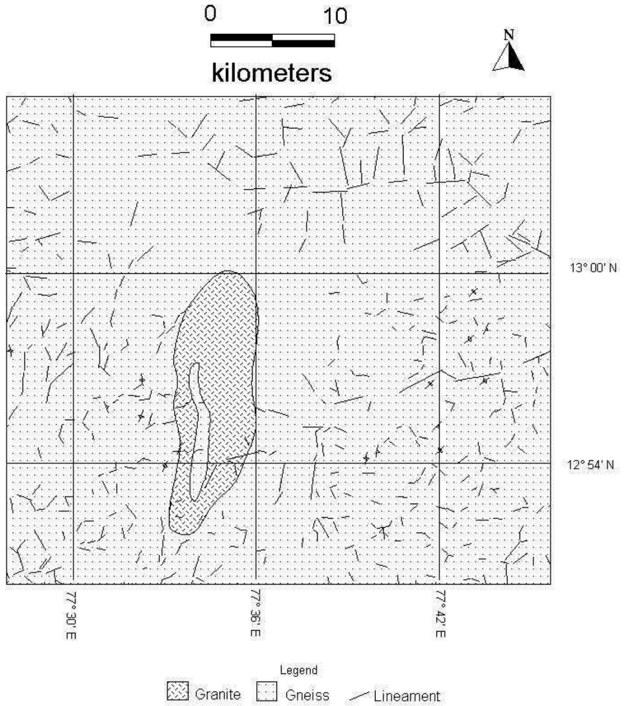

Fig.3. Geology of the study area.

gneisses of Archaean age and 5% of Younger Granites of Proterozoic age. The general strike of the rock formations is NW-SE with steep dip in either direction. The gneisses belong to Peninsular Gneissic Complex, range in composition from granodiorites to tonalites (Fig.3).

The composition of the granite rocks varies from diorite to granite. The granite rock is exposed in the south central part of the study area and is trending in N-S direction.

HYDROGEOLOGY

The occurrence, movement and recharge of groundwater are controlled by the degree of weathering, fracture pattern, geomorphological setup and rainfall. Granites and gneisses of Peninsular gneissic group constitute the major aquifers in the study area. Groundwater occurs under phreatic condition in the weathered zone and under semi-confined to confined condition in fractured and jointed rock formations.

As revealed by groundwater exploration, the depth of the exploratory wells ranged from 119.45 to 264.23 meters below ground level (mbgl). Static water levels ranged from 5.45 to 33.50 m bgl. The weathered zone i.e., shallow aquifers in granites and gneisses, ranges from 2 to 25 m depth. Fractures are generally encountered in the depth ranges of 35-80 m, 100-125 m and also as deeper fractures down to 250 m in the district, revealed by groundwater exploration programme. In general, discharge of the exploratory wells ranged from < 1.0 liters per second (lps) at Hesaraghatta to 8.4 lps at Bangalore University (www.cgwb.gov.in).

RADON CONCENTRATION IN GROUNDWATER

The details of the analytical results of groundwater samples are presented in the Table 2.

Table 2. Analytical Results of borewell water samples for radon

	Location	Depth (m)	^{222}Rn Bq/L	±Error
1	R.V.Engineering College	252	210.94	0.561
2	Srinivasapura (Dugwell)	11	55.96	1..230
3	Uttarahalli	152	564.48	16.5
4	Talghatpur	N/A	136.22	2.25
5	Talaghatpura (side of Kanakpura road)	183	1189.3	22.8
6	Gottigere	152	484.89	8.24
7	J.P.Nagar	122	509.3	24.2
8	Kumaraswamy layout	213	260.34	19
9	Dodda Kannali	171	148.04	7.76
10	Whitefield	152	80.89	6.92
11	Krishnarajpuram	122	127.02	10
12	Geddalahalli	40	160.58	1.7
13	Byatarayanpur	122	568.01	53.3
14	Kendriya Sadan (Koramangala)	137	345.1	12.3
15	Lalbagh	73	887.67	34.1
16	Cubban Park	73	764.05	35.4
17	Malleshwaram	91	245.68	8.53
18	Indiranagar	46	114.18	3.36
19	Chennakeshwanagar (way to new central jail)	183	228.28	11.1
20	Jayanagar	91	405.57	28.8
21	Gandhi Bazar	32	421.03	3.9
22	Chickpet (City Market)	76	341.53	3.27
23	Freedom Park (Majestic)	85	946.69	33.8
24	Chandara Layout (Nagarbhavai)	N/A	97.19	5.74
25	Nagavara	152	781.83	11.1
26	Jalahalli	91	308.75	10.6
27	Bagalkunte	152	111.55	4.84
28	Rajajinagar	244	166.62	8.08
29	Sunkadakatte	207	135.2	7.01
30	Banasankari-II	91	525.37	9.55

Bq/L – Becquerel per liters

CORRELATION BETWEEN BOREWELL DEPTH AND RADON CONCENTRATION

The perusal of the data indicates that the ^{222}Rn concentration varies from 56 to 1189 Becquerel per liters (Bq/l) as against the maximum permissible limit of 11.1 Bq/l in drinking water. The data were analysed to find out correlation between the depths of bore wells and the radon contents. It is observed that generally very shallow wells have low concentration of radon, as reported from dug well water at Srinivaspura having a depth of 11 m bgl with a

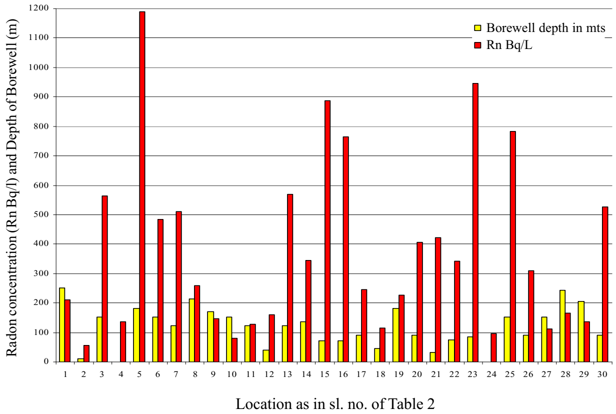

Fig.4. Radon concentration in groundwater vis-s-vis depth of borewells.

Radon concentration of 56 Bq/l. The bore well at Whitefield having a depth of 152 m has radon content of 81 Bq/l, while at Geddalahalli the bore well having a depth of only 40 m is having a concentration of 161 Bq/l. The highest concentration of 1189 Bq/l was reported in Talghatpura bore well, 183m deep, while the deepest borewell at R.V. Engineering College (252 m) is having radon content of 211 Bq/l. The radon concentration vis-à-vis bore well depth is presented in Fig. 4.

CORRELATION BETWEEN LITHOLOGY AND RADON CONCENTRATION

There is a correlation between the lithology of hard rocks and the concentration of radon in groundwater. Figure 5 depicts spatial concentrations of radon in groundwater. It is observed that the concentration is high along the granitic rock exposures in the N-S direction. The high concentration zone is not only restricted to the granitic body but also to the fringe area of the granitic body, thereby suggesting the control of granitic body on radon occurrence. Similar observation of high values of radon is reported in sheared gneisses compared to phyllites and schists (Choubey and Ramola, 1997).

DISCUSSION

Even though the radon concentration is reported to be 100 times more than the permissible limits in the groundwater in parts of Bangalore, it may not be a cause of worry. The high concentrations are reported from the wells after thorough flushing. In actual practice water from the bore wells are not used for drinking purposes immediately after pumping. Generally, the pumped water is stored in overhead tanks and exposed to the atmosphere with the radon

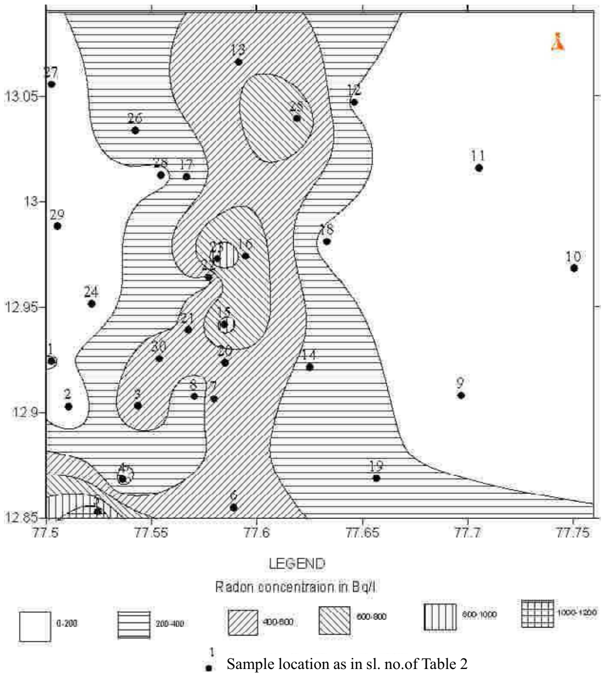

Fig.5. Spatial distribution of Radon concentration in groundwater in Bangalore.

gas escaping in to the atmosphere drastically reducing its concentration, thus making it safe for drinking. Further the half life of radon is 3.8 days only. The analytical results of 27 surface water samples from the area, as reported by the Central Water Commission indicates that the radon concentration is less than 0.5 Bq/l in 24 samples and only 3 samples have indicated the presence of radon in the range of 1.2 to 2.8 Bq/l, which is well within the permissible limits (Central Water Commission, 2009).

CONCLUSION

The analytical results of all the 30 groundwater samples collected from the gneissic and granitic rocks shows Radon concentration is above the permissible limit of 11.83 Bq/l and at places the concentration is as high as hundred times. The radon gas is occurring in the groundwater of the area ranging from 55.96 Bq/l to 1189.30 Bq/l plus or minus error values. There is no relation between the radon concentration and the depth of bore wells. However it is observed that the formation waters from very shallow aquifers are having the least concentration of Radon due to its easy loss to the atmosphere. Surface water samples are having negligible quantity of radon, which is well within the safe limits. It is observed that there is a good correlation between the presence of high Radon content and the presence of granitic rocks. The peripheral areas of granites also have higher concentration of Radon. The presence of high radon need not be a cause of worry as it is reported in borewell samples only after flushing for 15-20 minutes and not in stored water in the wells. However, detailed studies are essential for further confirming the health hazards of radon in groundwater in the area.

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