ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 07, pp.33901-33904, July, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A SURVEY OF PO-210 IN DRINKING WATER OF TIRUCHIRAPPALLI CITY

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ARTICLE INFO

Article History:
Received 21st April, 2016
Received in revised form
20th May, 2016
Accepted 04th June, 2016
Published online 16th July, 2016

Key words:

Po-210, Drinking water, Alpha counter, Committed Effective Dose Equivalent (CEDE)

ABSTRACT

The present works deals with internal radiation dose of Po-210 through the consumption of drinking water from Tiruchirappalli city. The concentration of Po-210 was determined in 10 (S1-S10) different drinking water samples. The Po-210 in drinking water ranged from 0.67 mBq/l to1.75 mBq/l. The highest Po-210 activity measured in Thillai nagar (S5) water sample. The Po-210 dose to the individual member of public by consumption of drinking water ranged from 0.70 µSv/y to 1.77 µSv/y.

Citation: Srikanth, G. and Masilamani, V. 2016. "A survey of po-210 in drinking water of Tiruchirappalli city", *International Journal of Current Research*, 8, (07), 33901-33904.

INTRODUCTION

The main source of Po-210 in the environment is Radon-222 gas which diffuse in to the atmosphere from rocks and soil where it ultimately decays to Lead-210, Bismuth- 210 and then to Po-210 in the atmosphere. The Po-210 have been placed in the very hazardous radioactive materials along with Radium-226, Pulutonium-239 and Srotonium-90. Some other sources of Po-210 are mineral industries, fertilizer industries etc. 18% of the average internal dose of the population is due to the ingestion of Po-210 along with the precursor Lead-210 (Pb-210). The dose of radiation received varies significantly between individuals and communities, and depends on locality, lifestyle, diet and type of dwelling. The redistribution of primordial radionuclide by Uranium and Thorium industries lead to significant contact of these materials by plants and animals of the local environment including man. Po-210 and Pb-210 are non-conservative radionuclides in U-238 (Uranium-238) decay series products through the disintegration of Rn-222 (Radon-222). The main source of these nuclides in the environment comes from the earth's crust in U-238 decay series. These radionuclides are also intermediate members of the naturally occurring U-238 decay series and are recognized as tracers for natural processes in the atmosphere. The physical half life of Po-210 is 138.4 days; have a potential utility as tracer for biogeochemical processes such as primary production, geochronology, environmental science and degradation of particles. There are also particle-reactive with varying affinities both in terms of efficiency and type of matter to which they associate. Pb-210 in surface water is coming from the atmospheric deposition and in situ production by decay of Ra-226, whereas the main source of Po-210 is in situ production by Pb-210 decay. These nuclides are deposited into the bottom sediment of river bed or sea bed and Po-210 is more associated with biogenic particles than Pb-210. Mineral waters often originate from very deep aquifers and usually show higher loads of natural radionuclides leached from the surrounding bedrock. The presence of radioactivity in the environment is caused by naturally occurring radionuclides and cosmic radiation but also by artificial radionuclides, which have been incorporated due to fallout from nuclear accidents and nuclear weapons testing. The activity of nuclear power plants also contributes to this back-ground. Artificial radioactivity levels are known and many activities are carried out to monitoring and control their hazardous effects in the environment. Radionuclides, mainly those who are in the atmosphere, can reach the soil and water ways by precipitation. If the atmosphere is contaminated with higher amounts of

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radioactive material, by deposition of radioactive material on the droplets of water, precipitation can become radioactive. In this way, contamination of soil and water- ways, i.e., oceans, rivers, seas, lakes, occur (Marija *et al*., 2012, Joksic and Radenkovic, 2005).

Commercial bottled water has become one of the main drinking sources, especially in developing countries, but an increasing trend of its consumption is also visible in European countries. As Croatia is rich in natural and mineral water springs many domestic bottled water brands are available on the market, categorized in two types: natural spring and natural mineral water (depending on the mineral content). By the Croatian legislation (Official Gazette, NN 58/98) both natural spring and mineral waters are obtained from underground beds from one or more natural or drilled springs, protected from all kinds of pollution, where the difference between natural spring and mineral waters is in total dissolved solid content (mineral waters contain more than 500 mg /L). Humans are constantly exposed to radiation from external sources as well as from internal sources through inhalation and ingestion by food and water consumption (UNSCEAR, 2000). The main contribution to dose is largely due to the presence of naturally occurring radionuclides of both uranium and thorium decay chains, which are omnipresent in the Earth's crust and leached by surface waters and especially ground waters. For this reason, the geological setting strongly influences the occurrence of natural radionuclides in drinking water. Mineral waters stemming from very deep aquifers usually show higher loads of natural radionuclides compared to surface water and water from shallower wells (Martina Rozmaric *et al*., 2012). The uptake of naturally occurring radionuclides from the uranium- and thorium-decay chains occurs mainly via ingestion of food. Drinking water plays a major role, as it is indispensable and can contain elevated amounts of radionuclides. The source of radionuclides dissolved in the water is the surrounding bedrock. (Gabriele wallner *et al*., 2008)

The new WHO Guidelines for Drinking Water Quality from 2011 (WHO, 2011) in Radiological aspects gave the same recommendations for activity concentrations for a wide range of radionuclides as in 2004, with guidance levels of 0.1 Bq L 1 for Po-210, Ra-228 and Pb-210, 1 Bq L 1 for U-234 and Ra-226, and 10 Bq L 1 for U-238. As the annual consumption of bottled water increases, and due to the fact that more than 98% of total population exposure to radiation comes from natural sources (excluding medical exposure) (UNSCEAR, 2000), estimation of total annual effective dose received from consumption of these products is necessary, along with the assessment of the contribution of particular radionuclides to the total dose. Hence the present study was launched to know the rate of accumulation of Po-210 in drinking water sample of Tiruchirappalli city and dose transfer to the Tiruchirappalli city population through the consumption of these drinking water.

MATERIALS AND METHODS

Sample collection and processing

Drinking water were collected using plastic bucket, previously cleaned with de-ionized water. The samples were filtered through what man 42' filter paper, which had been pre-washed with de-ionized water. For Po-210 estimation, the samples were acidified with concentrated hydrochloric acid. Iron carrier (Ferric chloride) was added to the samples and Po-210 in the filtered water was collected on ferric hydroxide precipitator by slow addition of concentrated ammonia solution. Then the precipitate was separated in a plastic container. This container was labelled and brought to the laboratory for further processing.

Radiochemical determination of Po-210

Analysis of Water

Water sample was filtered through whatman 40 filter paper and acidified with concentrated HCl to pH 1. Iron (ferric) carrier (500 mg) was added to the filtered and acidified sample and the Po-210 in the filtered water was collected on ferric hydroxide precipitate by slow addition of concentrated ammonia solution with rapid stirring until pH reached 9. Two repeat precipitations were carried out to completely carry Po-210 by Fe $(OH)_3$. The complete precipitate carrying Po-210 was dissolved in 6N HCl and finally diluted with distilled water to 0.5 NHC1 and Po-210 was deposited on silver planchette by electro chemical exchange technique and alpha counted following the procedure of Flynn (1968) and Iyengar (1983).

Electrochemical deposition of Po-210

The above mentioned sample solution in 0.5N HCl was placed on a magnetic stirrer with thermostat control at a temperature of 90-95º C. Ascorbic acid (100 mg) was added to reduce ferric ions to ferrous, thus eliminating interference in electrochemical deposition of Po-210. A silver planchette (0.8 mm thickness and 2.5 cm diameter) of predetermined background whose both sides were brightly polished with emery paper was suspended in the sample solution by means of a nylon thread at the end of a glass rod, connected to a stirrer. The solution is stirred for a period of 5-6 hours. Spontaneous deposition of Po-210 on both sides of the silver planchette took place under these conditions. At the end of the plating period, the planchette was taken out, rinsed with alcohol, dried under an infrared lamp for few minutes and counted for activity on both sides in an alpha counter.

Dosimetric Study

A survey was carried out at the Tiruchirappalli city population. Based on the International Atomic Energy Agency safety series No.115 and the reported individual dose to members of public from intake of radionuclides, the committed effective dose from the ingestion of Po-210 was assessed. The dose coefficient of Po-210 recommended by the international commission on radiological protection are 1.2×10^{-6} respectively. The annual consumption rate of water assumed is 730 y^{-1} , which was taken from the Guidelines for the Drinking water Quality. Using this value the ingestion dose to the critical population is calculated. Detailed information about the drinking water consumption was known from the local population.

RESULTS AND DISCUSSION

The water sample were collected from 10 different places of Trichirappalli city, namely Periyar EVR College (S1), Khajamalai (S2), Amma mandapam (S3), Palakarai market (S4), ThillaiNagar (S5), Thiruvarambur (S6), Chinthamani (S7), Karumandapam (S8), K.K.Nagar (S9), and Somarasampettai (S10) respectively. From these S1-S10 sampling stations different water samples such as 2 Tap water, 6 Bore well water,1 Branded mineral water, 1 Aqua guard water were collected and analyzed for Po-210 activity. The Po-210 activities of drinking water of the present study are given in Table 1. The Po-210 activity ranged from 0.67 mBq/l to1.75 mBq/l. The bore well water from Thillai nagar (S5) shows maximum Po-210 activity 1.75 mBq/l and minimum Po-210 0.67 mBq/l activity recorded in the bore well water collected from Thiruvarambur station (S6). This value is in reasonable agreement with the value reported by Ideota, *et al.* (2011) for ground water 2.8 mBq/l surface water 7.6 mBq/l and drinking water sample 2.7 mBq/l. The present study shows a very low Po-210 activity compared with the values reported by Katazlberger, (2001) for drinking water sample 4.4 mBq/l, 7.3 mBq/l and 14.0 mBq/l. Skwarzec *et al*. (2001) results revealed that Po-210 in drinking water ranged were 0.23-0.95 Bq/l this values is low with the present study. Rajasekara *et al*. (2011) drinking water river Kali, Sharavathi and Netravathi riveris is Po-210 found in 1.28 Bq/l and 1.30 Bq/l, and 1 Bq/l this slightly compared to our study. Deswyn *et al*. (2010) drinking water sample lowest values Po-210 ranged from (0.04 – 0.61 Bq/l).

Table 1. Po-210 Activity in Drinking water Samples of Trichirappalli City

S.No	Place	Po-210 Activity mBq/L
1	S1	1.14
2	S2	1.14
3	S3	1.10
4	S4	1.14
5	S5	1.75
6	S6	0.67
7	S7	1.10
8	S8	1.21
9	S9	0.82
10	S10	1.0

Table 2. Average consumption and Committed Effective Dose Equivalent (CEDE) to Trichirappalli public due to intake of drinking water

S.No	Place	Average Consumption of Water (mBq/y)	CEDE (µSv/y)
1	Periyar EVR College	0.26	1.12
2	Khajamalai	0.27	1.19
3	Amma mandapam	0.26	1.12
4	Palakarai Market	0.27	1.17
5	Thillai Nagar	0.41	1.77
6	Thiruvarambur	0.16	0.70
7	Chinthamani	0.25	1.09
8	Karumandapam	0.28	1.23
9	K.K Nagar	0.20	0.87
10	Somarasampettai	0.23	1.08

Other several investigator reported that Po-210 concentration were Umadevi *et al*. (2011), 1.29 mBq/l, Avadhani *et al*. (2000) 1.66 mBq/l, Kannan *et al*. (2001) 1.4mBq/l, Khandekar *et al*. (2001) 1.9 mBq/l, Carvalho *et al*. (1988) 0.21 mBq/l and Othman *et al*. (1995) 1.0 mBq/l this study values similiarly in Present study. The average consumption of Po-210 through the drinking water of Trichirappalli city. The concentration of Po-210 in bottled mineral water reported by Skwarzec *et al*. (2003) Po-210 the activity concentration ranged from 0.35 to 3.43 mBq/l. The lowest concentration of Po-210 detected in drinking water of Tiruvarambur station 0.16 Bq/y and the highest concentration of Po-210 observed in the water collected from Thillai nagar 0.27 Bq/y. Swarzec *et al*. (2004) reported that annual intake water consumption 0.240 Bq/y drinking water and Bottled water 0.0048 Bq/y this result obtain slightly higher in this study. The another reported skwarzec *et al*. (2001) low anuual intake in Po-210 0.24 Bq/y. Deswyn *et al*. annual consumption in water 29.2 to 503.7 Bq/y result low dose intake in our study. The polonium isotopes are among the more radiotoxic nuclides and their contribution in drinking water is very important from a biological point of view, more ever Po-210 is the main source from the alpha emitters of the internal dose received by humans. The committed Effective Dose equivalent (CEDE) to public from Po-210 due to consumption of drinking water are presented in Table 2. Among the different stations of drinking water consumed by the public Thillai nagar bore well water recorded higher CEDE from Po-210 (1.77 µSv/y) and the public consuming Thiruvarambur bore well water samples recorded minimum CEDE from Po-210 (0.70 µSv/y).

The data on drinking water take revealed that Po-210 plays a major role in building up of internal radiation dose to man. The committed Effective dose to all the stations estimated to be 11.13µSv/y. Committed effective doses have been evaluated considering the dose convertion factor for ingestion exposure of Po-210 Sv/Bq recommended by the ICPR (1996) and WHO (2006). The dose coefficients are age dependent but for their corresponding available dose coefficients have been considered. The annual mean ingested volume of water consumption by the population has been estimated as 730.L/year according to WHO (2006). The present value was slightly higher than the annual effective doses of Po-210 0.00200 µSv/y Skwarzec *et al*. (2003) of drinking water in Poland, Skwarzec *et al*. (2004) drinking water in 0.288 µSv/y, followed by mineral water in 0.0048 µSv/y, and Skwarzec *et al*. (2001) 0.120 µSv/y. The dose result of the present study suggested that the radionuclide Po-210 contributes lower dose about 1.77 µSv/y to human through the consumption of water which is below the maximum permissible dose (5 µSv/y). The Rajasekara *et al*. study dose transfer level in Kali river, Sharavathi river and Netravathi river followed by 1.28 mSv/y, 1.41 mSv/y and 1.1 mSv/y this values was very higher in present study. Deswyn *et al* (2010) reported in annual effective dose transfer 0.04-0.60 mSv/y.

Conclusion

The present study was carried out to understand the distribution pattern of Po-210 in drinking water samples of Trichirappalli city. The water samples were collected from (S1-S10) different stations of Trichirapplli city. Among the 10 different stations Thillai nagar (S5) bore well water recorded

1.75 mBq/l higher Po-210 activity and Thiruvarambur (S6) recorded 0.67 mBq/l lowest Po-210 activity. To find out the CEDE of public due to consumption of drinking water Dosimetric study was carried out. From the dosimetric study it is understood that public of (S6) consuming bore well water received higher Po-210 than that of other stations. Even though (S6) public receives higher dose (1.77 μSv/y) its lower when compared to annual dose limit of 5 mSv/y recommended by International Atomic Energy Agency (IAEA).

Acknowledgement

The authors would like to thank The Principal Periyar E.V.R.College, Tiruchirappalli-23 Tamil Nadu. This work was financially supported by the UGC, New Delhi. (Major Project: Studies on Polonium-210 in Drinking water and Biota of Tiruchirappalli city, Tamil Nadu).

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