International Journal of Applied Environmental Sciences
ISSN 0973-6077 Volume 11, Number 4 (2016), pp. 847-853

http://www.ripublication.com

Determination of ^{226}Ra and ^{228}Ra in Tap Water Samples from Riyadh City, and Estimation of the Radiation Dose

H.Al-Ghamdi, A.Al-Muqrin, D.Al Oraini and G.Alharshan

Physics Department, College of Science,
Princess Nourah University,P.O.Box 84428, Riyadh11671, Kingdom of Saudi Arabia.
**Corresponding author: Hanan Al-Ghamdi*
Physics Department, College of Science, Princess Nourah University,
P.O.Box 84428, Riyadh11671, Kingdom of Saudi Arabia,

ABSTRACT

In this work, tap water samples were collected from different districts in Riyadh city, KSA, and analyzed for their^{226}Ra and ^{228}Ra content. The two radium isotopes were extracted from four liters samples volume using a strong cation exchange resin and measured by gamma spectrometry.Of all the analyzed samples, 50 % have anactivity concentration of ^{228}Rahigher than 3.5 pCi/L which is considered in violation of the Saudi Arabian Standards Organization (SASO) authorized limit of 2.7 pCi/L.The annual effective dose received by the population as a result of the combined ingestion of ^{226}Ra and ^{228}Ra was estimated. The mean contribution of both ^{226}Ra and ^{228}Ra activities to the annual effective dose from a year's consumption of drinking water in the studied districtswas found to be higher than theWHO recommended level of 0.1 mSv/y for drinking water in five districts in Riyadh city.The values reported in this study constitute a baseline for radium isotopes(^{226}Ra and ^{228}Ra) in tap watersfrom different districts, as no such study has beencarried out before. It can be concluded that the presenceof such activity concentrations of the combined radium isotopesin the five specified districts may not beradiologically safe for consumption in drinking and/or cooking, and it is recommended that uranium isotopes and ^{210}Pb should also be analyzed.

Keywords: ^{226}Ra, ^{228}Ra, tap water, ion exchange chromatography, purolite resin, gamma spectrometry, anuual effective dose.

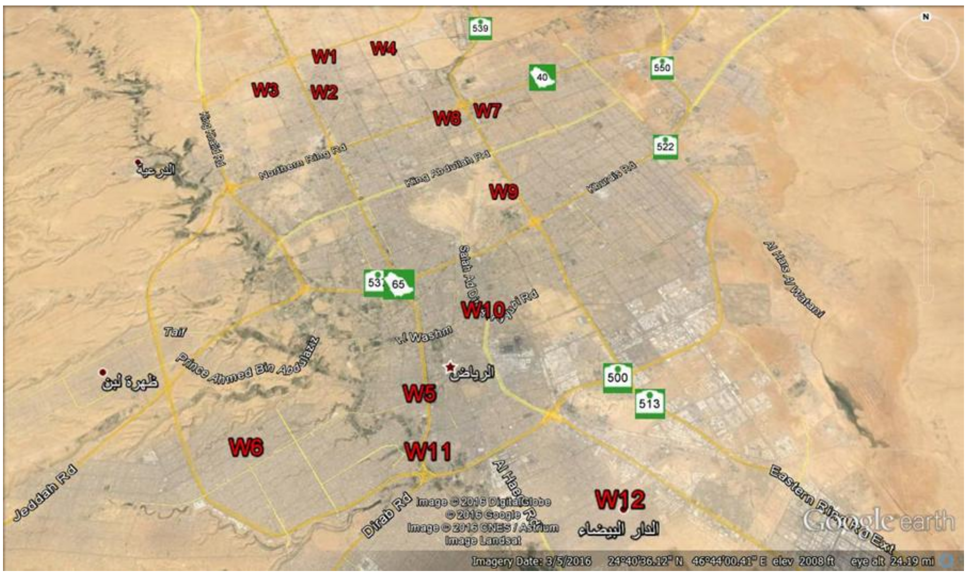
INTRODUCTION

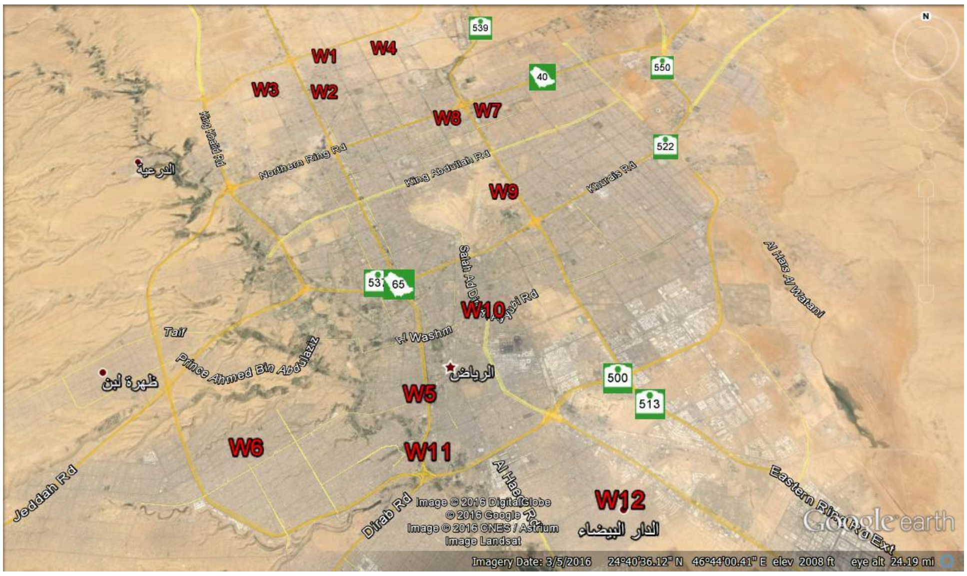
Due to the importance of drinking water for human life, their quality must be carefully and systematically controlled. The recommended control of radioactivity levels in drinking water can be achieved by the determination of the activity levels in all types of drinking water, in order to guarantee an exposure lower than 0.1 mSv/y, recommended by the WHO (WorldHealth Organization) [1].The knowledge of radium activity concentrations in drinking water is important because radium is deposited in bones, and gives a contribution to the internal dose [2].In many districts in Riyadh, the capital city of the Kingdom of Saudi Arabia, there is a tendency in population to use tapwater of satisfactory quality for human consumption in drinking and cooking purposes. Several studies have been reported for the radioactivity levels in drinking water in Saudi Arabia, but these studies were presenting radon and radium activity concentrations in groundwater and bottled water collected from various regions in KSA [3, 4, 5, 6], and no data were available for radioactivity in tap waters in Riyadh city. Therefore, it was necessary to ascertainwhether the level of radium isotopes (^{226}Ra and ^{228}Ra) in Riyadh city tap waters could pose anysignificant health hazard to the population.In this study, we have carried out a survey of ^{226}Ra and ^{228}Raactivity concentrations in tap waters from different districts in Riyadh city to draw a general picture of radium activity levels in the investigated districts, to assess the annual effective dose received by public due to the consumption of these waters in drinking and cooking and to compare these dose values with the Saudi Arabian Standards Organization (SASO) and WHO drinking water standards.

METHODOLOGY

Sampling

The collection of tap water samples was carried out from different districts in Riyadh, as shown in map 2-1.





Map 2-1: locations of tap water samples in Riyadh city

The locations of the sites were precisely recorded using global positioning system (GPS). The water was allowed to run in a continuous flow,and five liters of each tap water sample were collected in polyethylene containers and immediatelyacidified with 11 M HCl at the rate of 10 ml per liter of sample to avoid the adsorption of radionuclides on the walls of the container and the growth of micro-organisms.

Materials and Apparatus

Radium extractions from water samples were carried out using a strong cation exchange resin, Purolite C-100 Na form, supplied by Veolia Water Co. (Riyadh, Saudi Arabia). Reference solution of ^{226}Ra and ^{228}Ra were supplied by the National Institute of Standards and Technology (NIST), (SRM 4967A, SRM 4339B). The ^{133}Ba standard solution was supplied by North American Technical Services (NATS) (EZ-83879-767). The cation exchange resin was used in a column mode with BioRad Glass Econo columns of 0.9 cm diameter, together with polypropylene funnels and Teflon end fittings connected with plastic taps. All gamma radioactivity measurements were carried out using a Canberra HPGe coaxial detector (Model GC4020) with relative photo-peak efficiencies of 40%. The germanium detector was connected to a Digital Spectrum Analysis model DSA-1000.

RADIOANALYSIS

The radium isotopes were determined in the tap water samples by extraction from 4 liters samples with a strong acid cation exchange resin (Purolite) and measured by gamma spectrometry, and the calculations of the specific activity were performed using a comparison method with a standard resin prepared by adding a known amount of the radionuclides of interest to DDW at similar conditions (resin volume, flow rate, detector, counting time, measuring container) [7]. The calculations of the activity concentration of ^{226}Ra was based on the gamma energy transitions of 295.1, 352.0, 609.3 keV and 1764.5 keV. For ^{228}Ra, the gamma energy lines 338.4 and 911.2 keV were used.

Quality Assurance

For quality assurance and validation purpose, reference water samples were determined using the same analysis and measurement protocol, and were compared against their certified values to test the closeness of the measured samples to its reference values. Also, intercomparison tests were carried out with the International Atomic Energy Agency (IAEA-CU-2010, IAEA-TEL-2011-03, IAEA-TEL-2014-03). Errors were propagated due to nuclear counting statistics, tracer and volume.

RESULTS AND DISCUSSION

Radioactivity in TAP Water Samples

The activity concentrations of ^{226}Ra and ^{228}Ra in the tap water samples are presented in table 3-1. The values are given in pCi/L, with 1σ uncertainties.

Table 3-1: Results of ^{226}Ra and ^{228}Ra in water samples ± 1σ uncertainties.

DISTRICT	CODE	Ra-226	±	Ra-228	±
Yasmin	W1	4.2*	-	4.7	0.3
Sahafa	W2	6.3	0.5	2.0*	-
Malqa	W3	4.2	-	2.0	-
Narges	W4	4.2	-	2.0	-
Shemacy	W5	4.8	0.4	3.6	0.4
West Eraja	W6	4.2	-	5.5	0.3
Shohada	W7	5.2	0.6	7.4	0.7
Ezdihar	W8	4.2	-	2.0	-
King Abdalla	W9	4.2	-	2.0	-
Malaz	W10	8.6	0.6	6.1	0.4
Ateeqa	W11	4.2	-	5.0	0.4
Dar Baydaa	W12	4.2	-	2.0	-

** Within low limit of detection of the instrument (Ra-226 : 4.2 pCi/L, Ra-228 : 2.0 pCi/L)*

The results of radium levels in the water samples showed that the activity concentrations of^{226}Ra ranged from 4.2 to 8.6pCi/L, which are lower than the guideline levels recommended by both, the Saudi Arabian Standards Organization (SASO) and the WHO [1]. For ^{228}Ra, 50% of the analyzed tap water samples exhibited relatively high activity concentrations, as shown in fig 3-1.

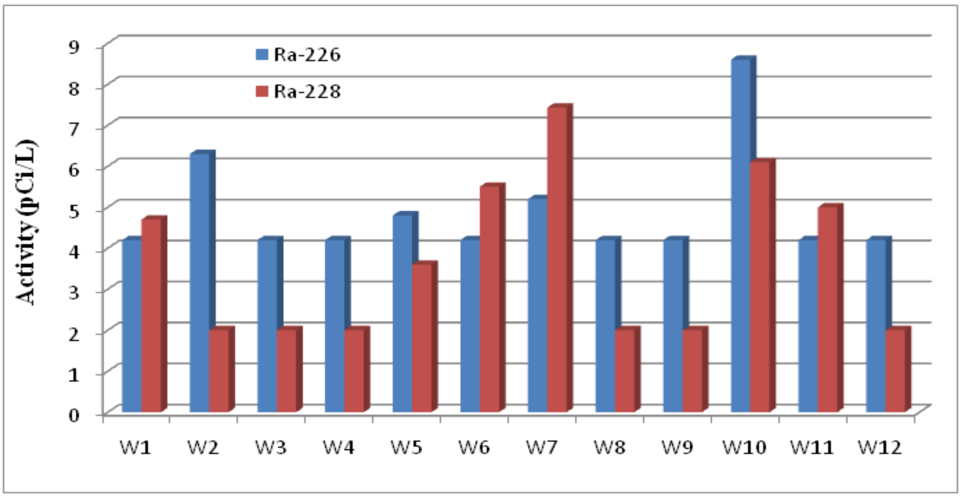


Figure 3-1: the activity concentrations of ^{226}Ra and ^{228}Ra in the tap water samples

Six samples (Yasmin, Shemacy, West Eraja, Shohada, Malaz and Ateeqa) exceeded the national guidance level of 2.7 pCi/L for ^{228}Ra set by SASO and the World Health Organization in drinking water.

Assessment of Radiation Hazards

The assessment of the potential exposure of an individual to the radium present in the tap water samples has been carried out utilizing the determination of annual effective dose rate from the ingestion of the combined radium isotopes (^{226}Ra and ^{228}Ra) in water. Assuming an annual consumption of 730 L/year, according to the WHO Guidelines for Drinking Water Quality for adult, and the dose coefficients of the relevant radionuclides ^{226}Ra and ^{228}Ra (2.8×10-7 and 6.9×10-7 Sv/Bq respectively) [2, 8], the annual effective dose was determined, as shown in fig. 3-2.

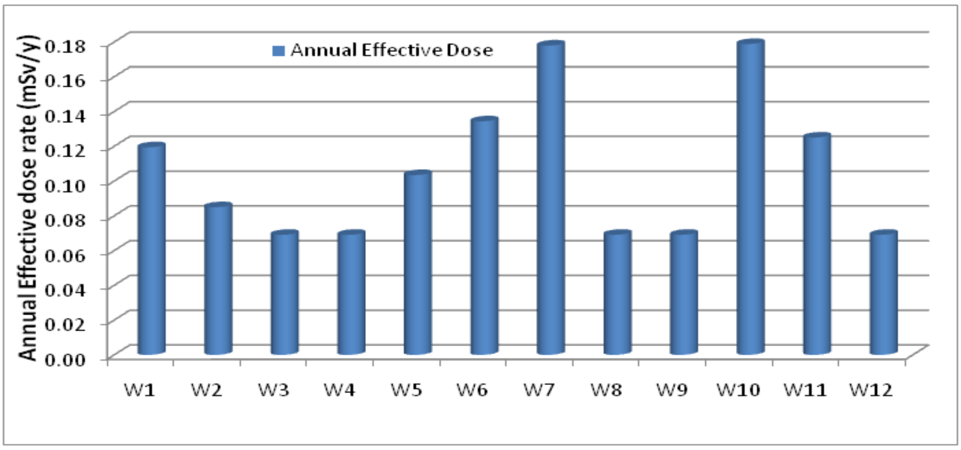


Figure 3-2: the annual effective dose rate from the consumption ^{226}Ra and ^{228}Ra in water

As presented in fig.3-2, The contribution of both radium isotopes to the annual effective dose varies among the selected districts. Samples collected from five districts (Yasmin, West Eraja, Shohada, Malaz and Ateeqa) which give rise to the relatively higher activities added significantly to the annual dose received by people exceeding the recommended limit of 0.1 mSv/year.

CONCLUSION

The present work was a pilot study where radium isotopes (^{226}Ra and ^{228}Ra) were analyzed in tap water samples collected from different districts in Riyadh city. The radium isotopes were measured by gamma spectrometry using high purity germanium detector, after radiochemical separation of the isotopes with ion-exchange chromatography using a strong cation exchange resin. The activity concentrations of^{226}Ra ranged from 4.2 to 8.6pCi/L, while for ^{228}Ra, the activity concentrations ranged from 2.0 to 7.4 pCi/L. The activity concentrations of ^{228}Ra in sixtap water samples were found to be higher than both, the Saudi Arabian Standards Organization authorized limit and the WHO's recommended limit of 2.7 pCi/L. The annual effective dose rate was estimated, and the contribution of the combined ^{226}Ra and ^{228}Ra activities to the effective dose from a year's consumption of these waters in five districts(Yasmin, West Eraja, Shohada, Malaz and Ateeqa) was found to be higher than the 0.1 mSv/y limit allowed by WHO in drinking water.The data generated in this study provide the radiological characterisation ofthe radium activity levels in tap water from different districts in Riyadh city. Therefore, it can be concluded that the presenceof such activity concentrations of the combined radium isotopesin the five specified districts may not beradiologically safe for consumption in drinking and/or cooking, and it is recommended that uranium isotopes and ^{210}Pb should also be analyzed.

REFERENCES

[1] WHO Recommendations. (1993). "Guidelines for drinking water quality vol. 1". World Health Organization, Geneva.

[2] UNSCEAR :(2005). " Sources and Effects of Ionizing Radiation". United Nations Scientific Committee on the Effects of Atomic Radiation. Report to the General Assembly, with annexes.

[3] A.I.Alabdulaaly,(1999). Occurrence of radon in the central region groundwater of Saudi Arabia,Journal of Enironmental Radioactivity, Vol. 44, pp:85-95.

[4] M.Ibrahim, O.Shalabiea, H.Diab, (2014). Measurement of some radioactive elementa in drinking water in Arar city, Saudi Arabia, American Journal of Life Sciences,Vol.2,pp:24-28.

[5] A.H. Al-Ghamd.(2014). Activity Concentrations in Bottled Drinking Water in Saudi Arabia and Consequent Dose Estimates. Life Science Journal, Vol.11(9)

[6] K. A. Aleissa, A. S. Alghamdi,F. I. Almasoud and Md. S. Islam,(2012). MEASUREMENT OF RADON LEVELS IN GROUNDWATER SUPPLIES OF RIYADH WITH LIQUID SCINTILLATION COUNTER AND THE ASSOCIATED RADIATION DOSE, Radiation protection Dosimetry 154(1).

[7] El-Sharkawy, A., Ebaid Y.Y., W.C.Burnett W. C. &AlDaihan, S.K.(2013).A rapid and inexpensive method for 226Ra and 228Ra measurements of high TDS groundwaters.Appl.Radiat.Isot. Vol.77:89-93.

[8] International Commission on Radiological Protection ICRP. (1994).“Exposure of the population in the united states and Canada from natural background radiation”. National Council on Radiation Protection and measurements. Report No.94.