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Ascertaining the Presence of Natural Radionuclides in Different Sources of Drinking Water in Peri-urban Eco-setting

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Radiological health hazards associated with natural radionuclide and their progenies due to the consumption of ground water has become a global issue. In this study, the presence of natural radionuclide (Radon-222) in artesian well, tube well and public township lake water samples from different sources of peri-urban 10 townships of Yangon Region households and then the level of annual effective dose of natural radionuclide of drinking water sources was calculated. A cross-sectional, community-based descriptive study was carried out from 30 water samples of artesian and tube well from selected 10 townships, Yangon Region. Three water samples were collected from each selected 10 townships of householders. Informed consents were obtained from the householders for water sample collection. Ten water samples were collected from public lake of selected 5 townships. Two water samples were taken from each of these 5 townships. All 40 water samples were collected directly approximately 500 ml of each water sources. Each coded sample was kept in the one experimental can. Solid State Nuclear Track Detector LR115 film, KODAK was used for radionuclide exposure time 90 days at Radiation Toxicology Research Division. In this study, the calculated values of radon concentrations and annual effective dose varied from 0.008±0.00 Bqm^{-3} to 2.18±0.05 Bqm^{-3} and 0.01 μSvy^{-1} to 37.5 μSvy^{-1} in tested water sample, respectively. Among them, only 10 water samples of artesian and tube well and 2 water samples of public lake values were indicated more than the other but lower than the WHO and ICRP recommended values. This study highlighted no risk of radiation exposure from tested 40 water samples to community.

Key words: Radionuclide, Solid State Nuclear Track Detector LR115, Radon concentration, Annual effective dose

INTRODUCTION

Radon is the most prominent source of environmental radioactivity and emits the type of ionizing radiation called alpha-particles. Because radon is inhaled during breathing and alpha-particles do not reach far, it is the lung which obtains most radiation. Thus, lung cancer is the main health risk. Radon is responsible for 6-15% of all lung cancers.[1] The main sources of natural radiation are soil, gas, cosmic ray and natural radioactivity in the body. Naturally occurring radionuclide include isotopes of uranium, radium and thorium and their decay products, such as radon. The U.S. national annual background dose for humans is approximately 360 mrem.[2]

Based on the National Academy of science report, the Environmental Protection Agency (EPA) estimates that radon in drinking water causes about 168 cancer deaths per

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year 89 percent from lung cancer caused by breathing released to the air from water and 11 percent from stomach cancer caused by consuming water containing radon. The drinking water contaminants that have chronic effects are chemicals (such as disinfection by-products solvents, and pesticides), radio-nuclides (such as radium) and minerals (such as arsenic). The decay of radium leads to radon in the environment deposited which contributes the largest fraction of the natural radiation dose to population. The exposure of population to high concentrations of radon and its progeny for a long period leads to pathological effects like lung cancer.[3]

Many countries have adopted the World Health Organization (WHO) recommended guideline activity concentration values of different radionuclide in drinking water. In drinking water on intake of radionuclide, an annual dose equivalent to any single organ or tissue should not exceed 0.1 mSv (WHO, 2004) and then International Commission of Radiological Protection (ICRP) recommended public dose limit of total annual effective dose is lower than the 1mSv per year. People who are exposed to relatively high levels of radionuclide in drinking water for long periods may develop serious health problems, such as cancer, anemia, osteoporosis, cataracts, bone growths, kidney disease, liver disease and impaired immune systems. According to WHO (2011), assessment of distribution of levels of radionuclide in the environment indicated the radiation exposure to the public. Higher levels of radionuclide tend to be found more often in groundwater, such as from wells, than in surface water, such as lakes and streams.[4]

Radionuclides are radioactive isotopes that can occur naturally or result from manmade sources. Since these radionuclides are present in soil and rock, they can also be found in groundwater and surface water. Certain rock types have naturally occurring trace amounts of radioactive elements that may accumulate in drinking water sources at levels of public health concern. Drinking water standards for radionuclide were first set in 1962 and most recently updated by United States Environmental Protection Agency (EPA) in the 2000 Radionuclides Rule. Natural radioactivity in water mainly depends upon geological characteristics of the soil.[2]

Studies have shown that activity concentrations of natural radio nuclides in ground water are connected to presence of uranium, thorium, radium and their decay products in the ground and bedrock. Chemical composition of the water depends on the degree of weathering of the rock, redox conditions and the residence time of groundwater in the soil and bedrock.[5] Ireland has no nuclear industry, however since 2001 all drinking water samples have been measured for this radio-nuclides by liquid scintillation counting.[6]

As part of the national survey to evaluate natural radioactivity in the environment, concentration levels of natural uranium and ^{226}Ra have been analyzed in over 300 drinking water samples (tap water and private wells water) taken from different locations in Argentina. ^{226}Ra concentrations (an annual collective dose of 1.9 manSv, an individual committed effective dose of 0.49 μSvy^{-1}) were measured and they were calculated for the ingestion of both natural radio-nuclides in drinking water.[7]

Concentrations of natural radio-nuclides (^{226}Ra and ^{222}Th) in ground and drinking waters of some areas of Upper Egypt were determined by gamma ray spectrometry. All types of water (drinking and ground water) in some areas of Upper Egypt are below the maximum allowed values for ^{226}Ra. The annual effective dose received as a results of ingestion of the drinking water (tap water) are 0.0072 and 0.0080 mSv and for ground water are 0.0114 and 0.0156 mSv, respectively.[8]

Recently, preliminary studies on groundwater samples from wells in University of Cape Coast and its surroundings in the

Central region of Ghana revealed the average annual effective doses obtained in this study were about 1.7 times higher than WHO guidance levels of 0.1 mSv/yr from intake of radio-nuclides in water but total annual effective dose is lower than the ICRP recommended public dose limit of 1mSv per year.[9] Other study from Penang, Northern Peninsular Malaysia measured ^{222}Rn activity concentration in raw, treated and bottled water samples and found relatively high radon concentrations compared with that from other parts of the world, which still falls below the WHO recommended treatment level of 100Bq l^{-1}.[10]

In 2011 at Department of Medical Research, radionuclides particularly radon particles in rain water samples were analyzed as 0.031 µSv/hr (Yangon), 0.0182 µSv/hr (NayPyiTaw, Dawei, Tanintharyi Region), and 0.032 µSv/hr (Pathein, Ayeyarwaddy Region), 0.011 µSv/hr (Kyaingtone, Eastern Shan State and Pa-an, Kayin State), 0.033 µSv/hr (Mawlamyaing, Mon State), 0.023 µSv/hr (Kayah State) and 0.025 µSv/hr (Taunggyi, Southern Shan State), respectively by using Solid State Nuclear Track Detector. Findings were not exceeded the permissible level of 1mSv/year according to the international standard estimated by IAEA. In 2013 one study at Department of Medical Research, the radon concentration in five kinds of buildings materials (brick, concrete, color cement, lime paint, plastic paint and title) samples and three different floors of newly construction building were tested by using LR115 type 2 Solid State Nuclear Track Detector.

Knowledge of the distribution of radio-nuclide levels in the environment is important for assessing the radiation exposure to the public. In peri-urban areas of Yangon Region, apart from pipe water, households use water from protected or unprotected wells. Naturally occurring radio-nuclides in drinking water usually give radiation doses higher than those provided by artificially produced radio-nuclides and are, therefore, of greater concern. Radiological health hazards associated with natural radionuclides and their progenies due to the consumption of ground water has become a global issue. Detecting radio nuclides in various drinking water sources in peri-urban eco-setting of Yangon Region after Cyclone Nargis and Earthquake have not yet been studied and it is extremely important to know the radon level for safe and healthy environment.

MATERIALS AND METHODS

A cross-sectional, community-based descri-ptive study was carried out from September 2014 to December 2015. Households using (tap water) artesian wells, tube wells and public lakes as their sources of drinking water were selected from peri-urban 10 townships of Yangon Region.

Altogether 40 water samples from artesian wells, tube wells and public lake water were collected. Informed consent (permission) was obtained for householders using 30 water (artesian well and tube well) samples collection from Shwepyithar, Insein, North Dagon, North Okkalapa, South Dagon, Shwepaukkan, Thingangyun, Tharkayta and Tarmway Townships. Each 3 water samples were collected from these townships. Ten water samples took from public lakes from Shwepyithar, North Dagon, North Ohkkalapa, Thingangyun and Tharkayta. Each 2 water samples were collected. All samples were sampled only once. Approxi-mately 500 ml was collected each water sample with quality control procedure.

Data collection method

Raw water samples were collected directly from wells and lakes. Latex gloves were worn during sample collection to avoid sample handling contamination. In this study, Solid State Nuclear Track Detector LR115 Type II film was used. Although there are many techniques to find out the alpha particles for radon in water, Solid State Nuclear Track Detector is one of the most fascinating alpha particles detection techniques, developed to date. It has been found to be equally useful in basic and applied research, particularly for scientists, engineers and technologists in the developping countries. That detector is small in size, flexible, inexpensive, efficient and free from sophisticated electronics and dead time problem. This is more convenient than other detectors.

In this technique a known amount (100 ml) of the samples was placed in experimental can. Solid State Nuclear Track Detector LR115 Type II film (about 1cmx1cm) was fixed inside of the lid of each can with tape, so that, sensitive side of the detector faced the specimen. The cans were tightly closed from the top and sealed. At the end of the exposure time (90 days), SSNTD LR 115 Type II film was removed from the lid of experimental can and subjected to the chemical etching process.

For etching of the LR 115 detectors, 2.5 N NaOH solutions at 60ºC for 80 minutes (temperature was kept constant with an accuracy of ±1ºC and without stirring) were used. The detectors were rinsed, dried and the tracks produced by alpha particles were observed and counted with optical microscope. Then, alpha track density was calculated for each detector.[11]

Data analysis

Data analyses of radionuclide concentrations in mean, standard deviation and median values were done using Microsoft Excel.

Ethical consideration

This study was approved by the Institutional Ethical Review Committee, Department of Medical Research.

Working definitions (defined by WHO)

Becquerel (Bq)

Unit of radioactivity concentration, corresponding to radioactive disintegration per second.

Effective dose

When radiation interacts with body tissues and organs, the radiation dose received is a function of factors such as the type of radiation, the part of the body affected and the exposure pathway. This means that 1Bq of radioactivity will not always deliver the same radiation dose. A unit called 'effective dose' has been developed to take account of the differences between different types of radiation so that their biological impacts can be compared directly. The effective dose is expressed in SI units called Sieverts (Sv).

Annual effective dose

It is used to better describe the biological relevance of a radiation exposure where different tissues/organs receive varying absorbed doses in a year.

RESULTS

Solid State Nuclear Track Detector LR115 Type II film detectors for background were etched under corresponding identical conditions. To reduce the statistical errors, alpha tracks were counted for different fifty views, and the alpha track densities were calculated as follows:

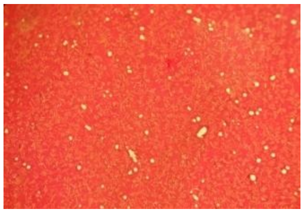

Fig. 1. Photomicrograph of Alpha Tracks in SSNT Detector LR 115 Type II for water sample with 40X objective

Total number of tracks for background=2

Average number of tracks n=2/50=0.04

δ^2=0.9216, $\Sigma\delta^2$=1.08432

$$\sigma = \frac{\sqrt{\Sigma\delta^2}}{N} = 0.018$$

Number of tracks=0.04±0.018

Background number of tracks=0.04±0.018

(Standard Error)=$\sqrt{\Sigma\delta^2} / N$,

where σ is the standard deviation and N is the number of observation (50 fields of view)

The background of the alpha track density for SSNTD LR-115 Type II was 0.04±0.018 tracks.

According to the calculation of the background number of tracks, the net number of track of each samples were calculated by using the average number of tracks equation.

$$\text{Alpha trackdensity (tracks cm}^{-2}\text{ day}^{-1}\text{)} = \frac{\text{Net number of tracks}}{\text{Microscopic view area x Exposure time}}$$

According to the above equation, the alpha track densities of collected 40 water samples were calculated.

To find out the radon concentration in collected water samples (the present study) calibration factor used is

0.05 track cm^{-2} day^{-1}=1 Bqm^{-3} (Muramatsu-1999)

And then, annual effective doses from all these samples were calculated using Publication International Commission on Radiological Protection (ICRP-2007) where 1 Bqm^{-3}=0.0172 $mSvyr^{-1}$.

Table 1. The comparison of alpha track density, Radon concentration and annual effective doses of tested 40 water samples

Township	Code No.	Alpha track density(tracks cm^{-2} day^{-1})	Radon concentration (Bqm^{-3})	Annual effective dose ($\mu Svyr^{-1}$)
Shwepyithar	SA1	0.015±0.500	0.3±0.014	**5.16**
	SA2	0.004±0.002	0.008±0.00	0.14
	SB1	0.047±0.002	0.94±0.04	**16.17**
	SB2	0.008±0.003	0.156±0.06	2.68
	SB3	**0.109±0.003**	**2.18±0.05**	**37.50**
North Dagon	NA1	0.004±0.002	0.008±0.00	0.14
	NA2	0.004±0.002	0.008±0.00	0.14
	NB1	0.032±0.002	0.644±0.04	**11.08**
	NB2	0.004±0.002	0.088±0.004	1.51
	NB3	0.025±0.001	0.496±0.024	**8.53**
North Okkalapa	NOA1	0.007±0.003	0.134±0.006	2.30
	NOA2	0.004±0.002	0.008±0.00	0.14
	NOB1	0.004±0.002	0.008±0.00	0.14
	NOB2	0.004±0.002	0.008±0.00	0.14
	NOB3	0.004±0.002	0.008±0.00	0.14
Thingangyun	TGA1	0.004±0.002	0.088±0.004	1.51
	TGA2	0.008±0.003	0.164±0.006	2.82
	TGB1	**0.076±0.003**	**1.528±0.058**	**26.28**
	TGB2	0.009±0.004	0.178±0.008	3.06
	TGB3	0.004±0.002	0.008±0.00	0.14
Thakayta	TA1	0.004±0.002	0.008±0.00	0.14
	TA2	0.018±0.008	0.356±0.016	**6.12**
	TB1	0.019±0.018	0.38±0.036	**6.5**
	TB2	0.004±0.002	0.008±0.00	0.14
	TB3	0.007±0.003	0.134±0.006	2.30
Insein	IB1	0.033±0.011	0.66±0.02	**11.35**
	IB2	0.006±0.001	0.012±0.002	0.20
	IB3	0.024±0.002	0.48±0.04	**8.26**
South Okkalapa	SOB1	0.056±0.003	1.12±0.06	**19.26**
	SOB2	0.006±0.001	0.012±0.002	0.20
	SOB3	0.00±0.00	0.012±0.002	0.20
Shwepaukkan	SPB1	0.006±0.001	0.012±0.002	0.20
	SPB2	0.045±0.004	0.9±0.08	**15.48**
	SPB3	0.006±0.001	0.012±0.002	0.20
South Dagon	SDB1	0.00±0.0001	0.012±0.002	0.20
	SDB2	0.006±0.001	0.012±0.002	0.20
	SDB3	0.006±0.001	0.012±0.002	0.20
Tarmway	TMB1	0.007±0.003	0.134±0.006	2.30
	TMB2	0.004±0.002	0.088±0.004	1.51
	TMB3	0.006±0.001	0.012±0.002	0.20

DISCUSSION

By using the LR115 Type II film detector, the minimum alpha track density (0.04± 0.018 track cm^{-2} day^{-1}) and the maximum alpha track density (0.109±0.008 track cm^{-2} day^{-1}) were found in 40 water samples. The maximum alpha track density was found in artesian well water sample as shown in Table 1.

In this study, the calculated values of radon concentrations and annual effective dose varied from 0.008±0.00 Bqm^{-3} to 2.18± 0.05 Bqm^{-3} and 0.01 μSvy^{-1} to 37.5 μSvy^{-1} in tested water samples, respectively. Fig. 2 shows that comparison of mean annual effective dose between the water sources of tube & artesian well results were indicated more than the public lake from collected water samples but lower than the WHO and ICRP recommended values. Fig. 3 indicated the comparison of the mean annual effective Dose between water sources by townships.

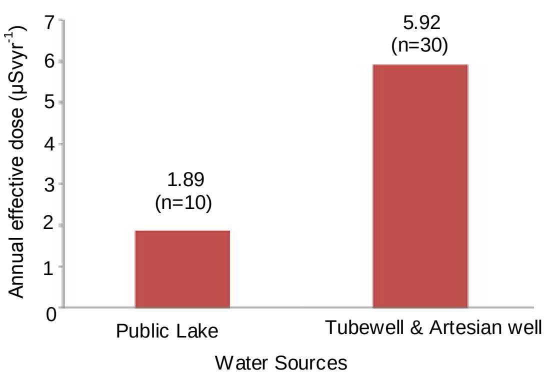

Fig. 2. Comparison of mean annual effective dose between water sources (p=0.17)

Shallow tube well water samples from Shwepyithar result had the highest content and other collected 12 water samples were ascertaining the radon in water. Therefore, removal method is needed for this water sources. Filtration method is the simple, cheap and useful way which is important for reduction of radon in water. Householders usually use the sample filter to get the safe water.

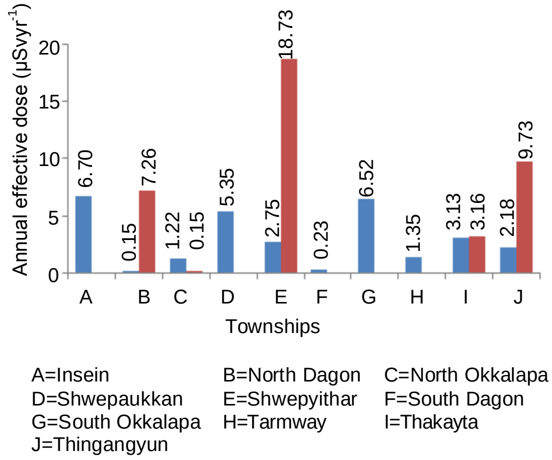

Fig. 3. Histogram of comparison of mean annual effective dose between water sources by selected Townships (n=40)

Conclusion

This study highlighted the no risk of radiation exposure from tested 40 water samples to community. Collected water samples of selected townships contained lower radon concentration in selected area of Yangon and annual effective dose levels than that of public safe limit level. Despite the reported radiological risk associated with the exposure to radon and its progenies, the level of awareness of the presence of this carcinogenic radionuclide in drinking water from selected townships of Yangon region was low. WHO-2009 and International Commission on Radiological Protection (ICRP-2009) have recommended for the public safe limit: Radon Concentration is 100 Bqm^{-3} and Annual Effective Dose is 1 $mSvy^{-1}$ (100 μSvy^{-1}) received from radon and its progency, above which it can be health hazard. Knowledge of the distribution of radionuclide levels is important to the public safety and it is also necessary to know simple knowledge such as well filter for removing radon content in water.

United Nations set the goals of halving the proportion of people without sustainable access to safe drinking water and of reducing under-five mortality by two thirds by 2015 under the Millennium Development Goals (MGD) (UNICEF-WHO, 2009).

The present study will link to ongoing radiological studies on the same area providing information on natural radio-nuclide level of drinking water in the study population and assist in developing inter-vention programs for household different drinking water sources and storage strategies.

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REFERENCES

1. WHO, Recommendations, Guidelines for Drinking Water Quality 2nd ed. 2004; Vol. 1, Available from: URL: http://www.who.int/ water- sanitation-health.
2. EPA, US Environmental Protection Agency, Available from: URL: http://www.epa.gov/ radiation /dose.
3. EPA's Safe Drinking Water Hotline 1(800) 426-4791, Available from: URL: http://www. epa. gov/safewater.
4. WHO, Recommendations, Guidelines for Drinking Water Quality. 4th ed, 2011; Vol. 1, Available from: URL: http:// www.who.int/ water-sanitation-health.
5. Vesterbacka, P. Natural uranium in drinking water in Finland. *Boreal Environment Research* 2007; 12: 11-16.
6. Technical Report, Articles 35, Radiological Protection Institute of Ireland. 2007; IE-07/03, Available from: URL: http://www.ripp.ie.
7. Bomben AM & Palacios MA. Natural radionuclides in drinking water in Argentina 10th International Congress of the International Radiation Association *(*IRPA), Japan 2000; 186-195.
8. Ahmed NK. Natural radioactivity of ground and drinking water in some areas of upper Egypt. *Turkish Journal of Engineering and Environ-mental Sciences* 2001; 28:345-354.
9. Faanu A, *et al.* Determination of radionuclides in underground water sources within the environments of University of Cape Coast. *Research Journal of Environmental and Earth Sciences* 2011; 3(3): 269-274.
10. Muhammad BG, *et al.* Measurements of ^{222}Rn activity concentration in domestic water sources in Northern Peninsular Malaysia. *Radiat Proectiont Dosimetry* 2011; 149(3):340-346.
11. DOSIRAD, KODAK LR115 Films. Available from: URL: http://www.pagespro-orange. fr/ dos irad/Notice%20LR115-A.htm.