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Determination of Radon Concentration and Annual Effective Dose in Dadin Kowa Dam of Yamaltu-Deba Local Government Area Gombe, Gombe State

S. Shittu, H. Seydou, S. Bullus and I. Justice

Department of Physics Gombe State University, Gombe

Corresponding Author: shittusadeeq@gmail.com

ABSTRACT

The level of Rn-222 concentration for water samples collected from twenty (20) different locations within Dadin Kowa town, Yamaltu Deba Local Government Area (L.G.A) of Gombe State, was estimated. Liquid Scintillation Counter (Model: Tri CarbLSA1000) was used in the analysis. Dam and tap water are the two sources of water utilized. Also, an attempt was made to estimate the Excess Life Cancer Risk and Annual Effective Dose due to Ingestion for different age groups. The mean values of Radon-222 concentrations were found to be 79.90 and 63.41 Bq/L for untreated water samples collected from dam and treated water samples collected from various taps respectively. The mean values of the corresponding Annual Effective Doses as a result of ingestion of Radon-222 in untreated sample (water) for Adult, Children and Infants were 0.58, 0.87 and 1.02mSv/yr respectively. However, for Radon-222 in treated sample (water) for Adults, Children and Infants were 0.49, 0.74 and 0.86 mSv/yr respectively. The mean value for Excess Life Cancer Risk (ELCR) for untreated water sample (dam) were found to be for Adults 2.03×10^{-3}, Children 3.89×10^{-3} and Infants 1.33×10^{-4} while for Excess Life Caner Risk (ELCR) for treated water sample (tap) for Adults 1.74×10^{-3}, Children 3.43×10^{-3} and Infants 4.95×10^{-4}. It can be seen from the result obtained that the mean values were above the World Health Organization 2004 average value of 1.45×10^{-3}. In the present study, the results of radon concentrations as well as the mean values obtained for the two (2) water samples were below the Maximum Contamination Limit (MCL) of 100 Bq/L as approved by the World Health Organization and that of MCL of 11.1 Bq/L as also approved by United States Environmental Protection Agency (USEPA, 1991).

Keywords: Radon-222 concentration, Annual Effective Dose, Excess Life Cancer Risk, Ingestion, Liquid Scintillation Counter.

INTRODUCTION

Radon is a chemical element of atomic number 86 and was discovered by Friedrich Ernest Dorn, a German chemist, in 1900 while studying radium's decay chain. There are 39 known isotopes of radon from Radon-139 to Rn-228 (Audi *et al.*, 2003; Sonzogni, 2008). Studies focused mainly on radon because it is the most stable of all the isotopes that originate from the radioactive decay chain of Radium-226 and Uranium-238 (United States Environmental Protection Agency, USEPA 1990). Radon is a radioactive, colorless, odorless, and tasteless noble gas with a half-life of 3.82 days occurring naturally as an indirect decay product of thorium and uranium. Since uranium is essentially ubiquitous in the earth crust, Radium-226 and Radon-222 are present in almost all rocks, soil, and even water (Giammanco *et al.*, 2009). Radon has been described to be the second most frequent cause of lung cancer after cigarette smoking, causing 21,000 lung cancer deaths per year in the United States. Epidemiological studies have shown a clear link between a high concentration of radon and incidence of lung cancer (BEIR, 1999).

Radon is a naturally occurring element that contributes to radiological contamination of drinking water and poses a health risk. Since the late 1980s, it has been identified as a health concern. Radon is radioactive gas formed when uranium or radium decays. It escapes from the earth's crust through cracks and crevices in the bedrock and either dissolves in ground water or seeps through foundation cracks into the environment/human habitations (Galan *et al*., 2004; Darko *et al*., 2010;). The alpha radiation emitted by radon and its offspring, polonium, is posed a significant health hazard according to the United States Environmental Protection Agency (USEPA). This is because elevated levels of exposure can result to lung cancer. Radon presence on the earth's surface is as a result of continuous diffuses through the bedrock, which lead to the formation of radon in ground water of all the noble gases, radon has the highest solubility in water with a mole fraction of 0.00125 at 37°C and a half-life of 3.8 days, which is 15 times higher than that of helium or neon which causes high accumulation concentration in ground water which poses a greater health risk for people who ingest or inhale it (Garba *et al*., 2010).

Radon in water is primarily a problem for water supplies that extract water from drill holes in rocks, which have somewhat higher uranium concentrations than the average bedrock. Granites and acid volcanic rocks are examples of rocks that have uranium concentrations greater than 5ppm, which means that wells situated in area with this rocks make contain ground water with radon concentration of 50-500Bq/L or considerably higher (IAEA, 2011).

Most developing nations has as one of its major problems of inadequate potable water, pipe borne water as an example. Majority of the populace rely heavily on untreated ground water sources as their primary source of drinking water as well as for other domestic uses. As a result, it is pertinent to investigate the radiological content of water from such sources. In Nigeria in general, Dadin Kowa in particular, there is no credible or reliable data on radon concentrations in drinking water sources, even though most of the inhabitants of the study area, depend solely on ground water and surface water sources for drinking, domestic and agricultural purposes, this water might contain higher-than-normal concentrations of radon (IAEA, 2011).

Radionuclide’s are isotopes which have the ability to produce radiation. Radiation is produced when an element with unstable atomic structure undergo decay into another element. Radiation is all around us, every minute of every day. Some radiation is essential to life, such as heat and light from the sun. As used in medicine, radiation helps us to diagnose and treat diseases and to save lives (Karr *et al*., 1995). But other radiation such as radon isotopes, and its decay products of uranium and thorium, can be quite harmful to human beings. The radionuclide’s in water are members of three natural radioactive series, which are the uranium series, thorium series, and the actinium series (Karr *et al*., 1995).

The isotopes in the uranium decay series that may pose a health risk because of their presence in water are Radium-226 and Radon-222 (Duenas *et al*., 1997). The human population typically is exposed to radiation from water, both by ingestion and inhalation. Since Radon-222 occurs naturally in soil and rocks, it is virtually omnipresent on earth. It accounts for more than 50% of the total dose from all sources of ionizing radiation absorbed by the population (USEPA, 1999). Since Radon-222 readily dissolves in water under pressure, groundwater is another source of radon. High concentration of Radon-222 may cause concern about its effects on health. Either drinking groundwater or breathing can give rise to exposure of humans to its radiation and may result in cancer deaths (USEPA, 1999).

Inadequate water supply is one of the major problems facing most developing nations especially Africa. Ground water, particularly from areas underlain by granites and similar uranium-bearing rocks, have been reported to contain high radon concentration (Knutsson & Olofsson, 2002; Badhan*et al*., 2010; Oni *et al*., 2014). Therefore, it is necessary to determine the radon concentration, annual effective dose and excess life cancer risk in Dadin Kowa Dam in Yamaltu Deba Local Government Area (L.G.A) of Gombe in Gombe State Northeast Nigeria.

MATERIALS AND METHODS

Study Area

Dadin Kowa Dam is situated in Yamaltu Deba local government area of Gombe in Gombe State Northeast Nigeria (Figure 1). The dam which is located about 35 kilometers to the east of Gombe town, provide drinking water for the inhabitant of the town and its environs. The dam which was built with the goal of providing irrigation and electricity for the planned Gongola sugar plantation project was completed by the Federal Government of Nigeria in 1984. (*https*://en.m.wikipedia.org).

Figure 1: Map of Gombe State showing YamaltuDeba L.G.A and indicating Dadin Kowa Dam (*https*://en.m.wikipedia.org).

Sample and Sample preparation

In this work, twenty (20) samples were collected in all, ten (10) samples for treated water within 12 hours interval and ten (10) samples for untreated water at different sampling point.

During sample collection, plastic bottles of about 1litre volume were used. The containers were rinsed three times with the distill water in order to minimize contamination from the original content of the container. Dilute nitric acid was used to rinse the containers for the second time in order to prevent the absorption of radioactivity by the walls of the sample container. The water samples were collected near the bank of the river where there is less dilution of the washout from the surrounding environment for untreated water samples and the treated water samples were collected at the tap from Dadin Kowa treatment plant. The temperature and conductivity of the water samples were measured using thermometer and conductivity meter respectively, because the temperature affect the equilibrium ratio of radon in air to radon in water. The sample containers were tightly covered with a space of about 1% of the volume left for expansion of water. The samples now were kept in the laboratory until they were analyzed.

A vail containing 10 ml of base scintillator was added to 10ml of each water sample using hypodermic syringe. Each vial containing the sample and the cocktail were tightly capped and shaken vigorously for three (3) minutes to extract radon-222 in water phase into the organic scintillator. In a similar manner a blank sample for the background was prepared using distilled water that has been kept in a glass bottle for at least 21 days. The prepared samples were allowed to stand undisturbed for at least three (3) hours each in order for 222-Rn and its alpha decay products attain equilibrium before counting.

Sample Analysis

The prepared samples and the blank were each analyzed using the Liquid Scintillation Counter (Tri-Card LSA 1000) at the Center for Energy Research and Training (CERT), Ahmadu Bello University Zaria, Kaduna, Nigeria. Radiation emitted from the samples transferred energy to the organic scintillator which in turn emits light photons. This way each emission result as a pulse of light in form of digit. The activity concentrations of Radon-222 were determined for all the samples using the formula below (Dankawu *et al.*, 2021).

$$C_{Rn}\,(BqL^{-1}) = \frac{100\times(SC\times BC)\,exp(\lambda t)}{60\times CF\ X\ D} \quad (1)$$

C_{Rn} (BqL^{-1})= Concentration of Radon-222 in Becquerel per litre; SC= Sample Count (Count min^{-1}); BC = Background Count ($Countmin^{-1}$) ; t =Time elapsed between sampling to counting (60 mins) ; λ = Decay constant (1.26 $\times10^{-4}min^{-1}$) ; 100 = Conversion factor from per 10ml to per liter; 60 = Conversion factor from minutes to seconds ($secondmunite$); CF = Calibration factor or Number of emissions per count (5) ; D = Fraction of Radon-222 in the cocktail in a 22 ml total capacity vial for 10ml of sample, 10 ml of cocktail and 2 ml of air (0.964).

Data analysis

Annual Effective Dose

The corresponding Annual Effective Doses (mSv/yr) due to ingestion of Radon-222 in water samples taken from Dadin Kowa dam were calculated using equation (2) below by taking into account the dose coefficient in (Sv/Bq), the annual water consumption (L/YR) and the activity concentration of Radon-222 obtained from equation (1) above using equation (2) (Ryan *et al.*, 2003).

$$AED = C_{Rn}\times K\times G\times 1000 \quad (2)$$

AED = the annual effective dose (mSv/y) ; *C* = the 222Rn concentration in water (Bq/L), *G* = the water ingestion rate (182.5 *L/YR*, 547.5 *L/YR* and730 *L/YR*) for infants ,children

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and adults respectively (UNSCEAR, 1993); K = the dose coefficient ($7 \times 10^{-8} Sv/Bq$, $2\times 10^{-8} Sv/Bq$ and$10^{-8} Sv/Bq$ for infants, children and adult (UNSCEAR, 2000) respectively. 1000 is the conversion coefficient from Sv to mSv.

Excess life cancer risk (ELCR)

The Excess life cancer risk (ELCR) due to ingestion for different age categories was calculated from annual effective dose using equation (3) below Adamoh (2021).

$$\boldsymbol{ELCR = AED \times DL \times RF} \quad (3)$$

where AED = Annual Effective Dose mSv/yr ; DL = life expectancy (70 years) ; RF = Fatal Risk factor per Sievert (0.05/Sv).

RESULTS AND DISCUSSION

A total of twenty (20) water samples comprising ten (10) untreated water samples (UTWS) and ten (10) treated water samples (TWS) were collected and analyzed using Liquid Scintillation Counter. The Annual effective dose and Cancer risk as well as the results of the analysis obtained are presented in Table 1:

Table 1: Physical parameters and radon concentration in Untreated Water Samples (UTWS) and Treated Water Samples (TWS)

Sample ID	pH	Temperature (^oC)	Rn (Bq/L)
UTWS1	5.06	27.00	73.02
UTWS2	5.22	27.50	95.92
UTWS3	5.17	27.60	71.95
UTWS4	5.01	27.90	73.67
UTWS5	5.40	27.80	81.02
UTWS6	5.35	28.10	91.90
UTWS7	5.43	28.30	72.78
UTWS8	5.54	28.40	78.73
UTWS9	5.55	28.50	79.68
UTWS10	5.60	28.60	80.37
Mean	**5.33**	**27.97**	**79.90**
TWS11	10.40	24.60	56.48
TWS12	10.76	25.00	68.87
TWS13	10.11	24.20	69.07
TWS14	10.32	25.20	76.70
TWS15	11.02	24.00	71.78
TWS16	10.90	25.40	67.06
TWS17	12.08	23.10	73.73
TWS18	8.83	25.00	70.05
TWS19	10.47	24.00	67.20
TWS20	9.01	25.20	63.13
Mean	**10.39**	**24.57**	**63.41**

Untreated Water Samples

The results of the analysis of radon concentrations obtained for the ten (10) untreated water samples (UTWS) revealed that the concentrations of Radon-222 varies from 71.95 Bq/L to 95.92 Bq/L with a mean value of 79.90 Bq/L. From the results of the analysis, the maximum concentration was obtained from UTWS2 (95.92) while the minimum concentration was found to be UTWS3 (71.95) as shown in Table 1. All the values obtained from the samples were found to be below the recommended guideline level of 100 Bq/L set by (WHO, 2008).

Treated Water Samples

The concentrations of Radon-222 in treated water samples (TWS) collected from ten (10) different taps were presented in Table 1as shown above were found to be in a range of 56.48 to 76.70 Bq/L, with a mean value of 63.41 Bq/L. TWS14 recorded the maximum radon concentration of 76.70 Bq/L which is below the recommended reference level of 100 Bq/L set by (WHO, 2008). While TWS11 recorded the minimum radon concentration of 56.48 Bq/L as shown in Table 1 above. All values obtained from these samples were found to be below the recommended WHO guideline level as shown above.

Mean Radon Concentrations

The mean concentration of each of the water samples in table 1 were represented on a bar chart in Figure 2, in order to compare the level of Radon-222 in the two categories of water samples i.e untreated water sample (dam) and treated water sample (tap).

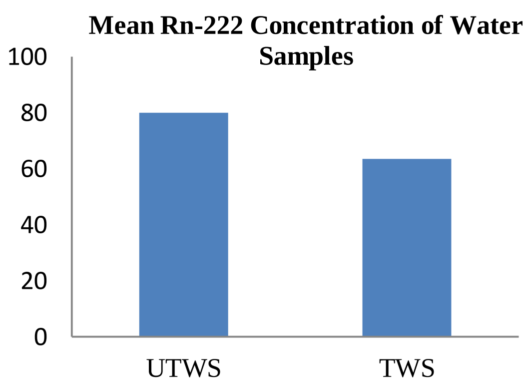

Figure 2: Mean Radon-222 Concentration for the two water samples

From the bar chart in figure two above, the untreated water has the highest mean concentration of 79.90Bq/L while that of treated water samples have the least mean concentration of 63.41Bq/L, because the treated water samples have undergone the two primary methods for removing radon from the treatment plant, these two methods include aeration and granular activated carbon absorption. The lowest mean value of Radon-222 concentration for treated water samples (tap) as compared to the highest mean value of Radon-222 concentration for untreated water samples (dam) could be linked to the fact that water from the dam is exposed to air and since radon is a gas it tends to escape into the atmosphere. Values from the two (2) water samples were found to be below the recommended guideline level of 100 Bq/L set by (WHO, 2008) and the world average value of 10 Bq/L set by WHO (1993).

Annual Effective Dose (AED)

The corresponding Annual Effective Doses were estimated from the same water consumption rate using equation (2) above and was found to be in the range of 0.52-0.70 mSv/yr, 0.78-1.05mSv/yr and 0.91-1.22 mSv/yr for Adult, Children and Infants respectively.

UTWS2 recorded the highest AED of Radon-222. All samples showed dose rates above the recommended reference value of 0.1 mSv/yr intake of radionuclide in water set by WHO (WHO, 2004).

The estimated Annual Effective Dose (A.E.D) of Radon-222 for Treated Water Samples were found to be in the range of 0.41-0.55 mSv/yr, 0.61-0.83 mSv/yr and 0.72-0.97 mSv/yr for Adult, Children and Infants respectively as shown in Table 2.

TWS14 recorded the highest AED of Radon-222. All samples does rate were above the recommended reference value of 0.1 mSv/yr as set by (WHO, 2004) for intake of radionuclides in water. These higher values of annual effective doses shows that most of the water sample from the study area could be a threat to the health of the inhabitant of the area if taken directly without further purification.

Mean Annual Effective Dose

The mean Annual Effective Doses due to ingestion of Radon-222 from the two (2) water samples were calculated for Adults, Children and Infants and were found to be 0.58, 0.87 and 1.02 mSv/yr respectively are shown in Figure 3 below.

Table 2: Annual Effective Dose for Untreated Water Samples (UTWS) and Treated Water Samples (TWS)

Sample ID	Adult(mSv/y)	Children (mSv/y)	Infant (mSv/y)
UTWS1	0.53	0.79	0.93
UTWS2	0.70	1.05	1.22
UTWS3	0.52	0.78	0.91
UTWS4	0.54	0.80	0.94
UTWS5	0.59	0.88	1.03
UTWS6	0.67	1.00	1.17
UTWS7	0.53	0.79	0.92
UTWS8	0.57	0.86	1.00
UTWS9	0.58	0.87	1.01
UTWS10	0.59	0.88	1.02
Mean	**0.58**	**0.87**	**1.02**
TWS11	0.41	0.61	0.72
TWS12	0.50	0.75	0.87
TWS13	0.50	0.75	0.88
TWS14	0.55	0.83	0.97
TWS15	0.52	0.78	0.91
TWS16	0.48	0.73	0.85
TWS17	0..53	0.80	0.94
TWS18	0.51	0.76	0.89
TWS19	0.49	0.73	0.85
TWS20	0.46	0.69	0.80
Mean	**0.49**	**0.74**	**0.86**

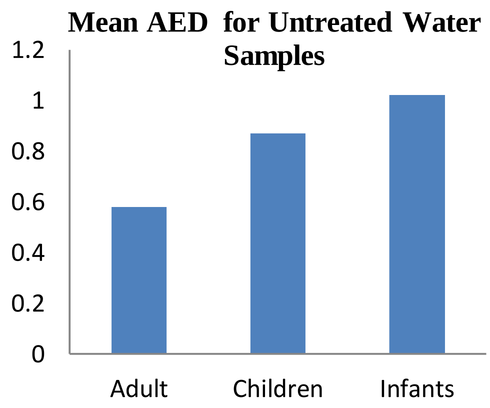

Figure 3: Mean Annual Effective Dose for Untreated Water Samples

From figure 3 above, the mean annual effective doses were found to be above World Health Organization recommended reference level of 0.1 mSv/yr for ingestion of radionuclide in water (WHO, 2004). These results revealed that infants have a higher risk of exposure to cancer compare to children and adults with lower values of the mean annual effective doses for the three (3) categories of people for the same water consumption rate from untreated water samples. This is because the infants have fast dividing cells compare to that of children likewise adults. The mean annual effective doses due to ingestion of Radon-222 in untreated water samples were

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found to be 0.49, 0.74 and 0.86 mSv/yr for Adult, Children and Infants respectively as shown in the Figure 4 below.

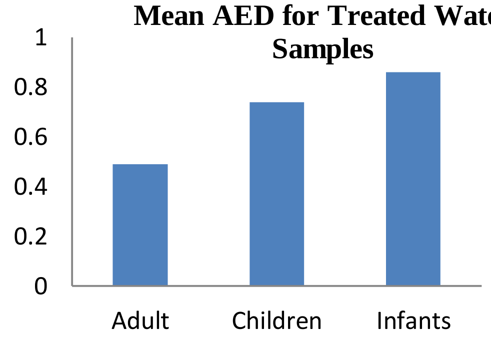

Figure 4: Mean Annual Effective Dose for Treated Water Samples

From figure 4 above, the mean annual effective doses were found to be above World Health Organization recommended reference level of 0.1 mSv/yr for ingestion of radionuclide in water (WHO, 2004). These results revealed that Infants, for the same water consumption rate receive significantly higher doses hence have higher risk to cancer compared to Children and Adult with lower values of the mean annual effective doses for the three (3) categories of people coming from Treated Water Samples. These results have shown that the mean values of Radon-222 concentration were below the World Health Organization recommended value of 100 Bq/L (WHO, 1993) and the mean Annual Effective Doses of the two water samples were found to be above the World Health Organization recommended value of 0.1 mSv/y set (WHO, 2004).

Mean pH of the Two Water Samples

The pH of Untreated Water Samples indicate that the water samples were acidic with the mean average of 5.33 while that of the Treated Water Samples indicate that water sample were base and can be consumable with the mean average value of 10.39 as shown in Figure 5.

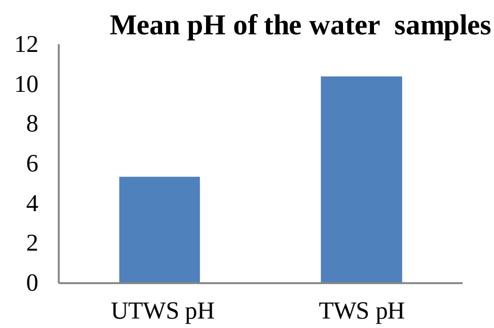

Figure 5: Mean pH of the water samples

Excess Life Cancer Risk (ELCR)

Excess Life Cancer Risk from annual effective dose from ingestion for Adult, Children and Infant were estimated for both untreated water sample and treated water samples. The mean value for Excess Life Cancer Risk (ELCR) for Untreated Water Samples (dam) was found to be 2.03×10^{-3}, 3.89×10^{-3} and 1.33×10^{-2} for Adult, Children and Infants respectively, All the mean values were above the world health organization (WHO, 2004) average value of 1.45×10^{-3} as shown in Table 3 below.

Excess life cancer risk (ELCR) by ingestion for different age categories (Adult, children and infant) from the corresponding annual effective dose for Untreated Water Samples varies from 1.82×10^{-3} to 2.45×10^{-3}, 3.50×10^{-3} to 4.90×10^{-3} and 1.14×10^{-2} to 1.72×10^{-2} for Adult, Children and Infant respectively as shown in Table 3.The Excess Life Cancer Risk from annual effective dose from ingestion for Adult, Children and Infant were estimated for Treated Water Samples. The mean value for Excess Life Cancer Risk (ELCR) for Treated Water Samples (tap) is found to be 1.74×10^{-3}, 3.43×10^{-3} and 4.95×10^{-4} for Adult, Children and Infants respectively,

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All the mean value were above the world average value of 1.45×10^{-3} (WHO, 2004).

Excess Life Cancer Risk (ELCR) by ingestion for different age categories (Adult, children and infant) from the corresponding annual effective dose for Treated Water Sample varies from 1.44×10^{-3} to 1.93×10^{-3}, 2.87×10^{-3} to 3.85×10^{-3} and 9.80×10^{-3} to1.37×10^{-2} for Adult, Children and Infant respectively.

Table 3: Excess Life Cancer Risk (ELCR) Dose for Untreated Water Samples (UTWS) and Treated Water Samples (TWS)

Sample ID	Adult	Children	Infant
UTWS1	1.86×10^{-3}	3.50×10^{-3}	1.29×10^{-2}
UTWS2	2.45×10^{-3}	4.90×10^{-3}	1.72×10^{-2}
UTWS3	1.82×10^{-3}	3.50×10^{-3}	1.26×10^{-2}
UTWS4	1.86×10^{-3}	3.50×10^{-3}	1.29×10^{-2}
UTWS5	2.07×10^{-3}	3.85×10^{-3}	1.44×10^{-2}
UTWS6	2.35×10^{-3}	4.55×10^{-3}	1.61×10^{-2}
UTWS7	1.86×10^{-3}	3.50×10^{-3}	1.29×10^{-2}
UTWS8	1.99×10^{-3}	3.85×10^{-3}	1.14×10^{-2}
UTWS9	2.03×10^{-3}	3.85×10^{-3}	1.14×10^{-2}
UTWS10	2.03×10^{-3}	3.85×10^{-3}	1.14×10^{-2}
Mean	$\mathbf{2.03\times10^{-3}}$	$\mathbf{3.89\times10^{-3}}$	$\mathbf{1.33\times10^{-2}}$
TWS11	1.44×10^{-3}	2.87×10^{-3}	9.80×10^{-3}
TWS12	1.75×10^{-3}	3.50×10^{-3}	1.23×10^{-2}
TWS13	1.75×10^{-3}	3.50×10^{-3}	1.23×10^{-2}
TWS14	1.93×10^{-3}	3.85×10^{-3}	1.37×10^{-2}
TWS15	1.82×10^{-3}	3.50×10^{-3}	1.26×10^{-2}
TWS16	1.68×10^{-3}	3.39×10^{-3}	1.19×10^{-2}
TWS17	1.86×10^{-3}	3.50×10^{-3}	1.29×10^{-2}
TWS18	1.79×10^{-3}	3.50×10^{-3}	1.23×10^{-2}
TWS19	1.72×10^{-3}	3.43×10^{-3}	1.19×10^{-2}
TWS20	1.61×10^{-3}	3.22×10^{-3}	1.12×10^{-2}
Mean	$\mathbf{1.74\times10^{-3}}$	$\mathbf{3.43\times10^{-3}}$	$\mathbf{1.21\times10^{-2}}$

Table 4: Comparison of Annual Effective Dose from Ingestion and Inhalation from Dadin Kowa Community with Other Related Research

Locations	Adults (*mSv/yr*)	Children (*mSv/yr*)	Infants (*mSv/yr*)	Sources
Sokoto	0.25	0.37	0.43	(Abba *et al.*, 2020)
Dutsin Ma	0.47	0.94	3.30	(Adams, 2017)
Dutse	0.69	1.03	1.20	(Dankawu*et al.*, 2021)
Dadin Kowa (UTWS)	**0.58**	**0.87**	**1.02**	**(Current Study, 2023)**
Dadin Kowa (TWS)	**0.49**	**0.74**	**0.86**	**(Current Study,2023)**

In Table 4, previous studies from Sokoto, Dutsin-ma and Dutse shows that the infants have the high AED compare to children and adult because the infant has fast dividing cell. Same applies to the current study even due the AED is higher in Untreated water consumed by infant because the treated water has undergone the two primary methods for removing radon from water, these two methods includes: aeration and granular activated carbon absorption.

CONCLUSION

Environmental pollution has been a great threat to humanity since the beginning of life on earth. Therefore, it is natural for the public to be active and sensitive against all the pollutants causing threats to our lives. In this current study, the results obtained from the analysis of the activity concentrations of Radon-222 in treated and untreated water samples collected in Dadin kowa Dam of Yamaltu Deba Local Government Area (L.G.A) of Gombe State are as follows, the mean values of Radon-222 concentrations were found to be 79.90 and 63.41 Bq/L for untreated water sample (dam) and treated water sample (tap) respectively. The mean values of the corresponding Annual Effective Doses due to ingestion of Radon-222 in untreated water sample were found to be 0.58, 0.87 and 1.02 mSv/yr for Adult, Children and Infant respectively, while that of Radon-222 in treated water sample were found to be 0.49, 0.74 and 0.86 mSv/yr for Adult, Children and Infant respectively. The pH of Untreated Water Samples indicate that the water samples were acidic with the mean average of 5.33 while that of the Treated Water Samples indicate that water sample were base and can be consumable with the mean average value of 10.39. The mean value for Excess Life Cancer Risk (ELCR) for untreated water sample (dam) were found to be 2.03×10^{-3}, 3.89×10^{-3} and 1.33×10^{-4} for Adult, Children and Infant respectively, while that of Excess Life Caner Risk (ELCR) for treated water sample (tap) was found to be 1.74×10^{-3}, 3.43×10^{-3} and 4.95×10^{-4} for Adult, Children and Infant respectively. All the mean values for Excess Life Cancer Risk were below the world health organization average value of 1.45×10^{-3}.

The recorded values of radon concentrations in the present study were below the Maximum Contamination Level (MCL) of 100 Bq/L as set by World Health Organization and the MCL of 11.1 Bq/L as set by United States Environmental Protection Agency for the two (2) water samples. Therefore, these water sources pose a threat to the health of the inhabitant of Dadin Kowa community if continually ingested but it's advisable to be boiled or properly treated before drinking so as to keep their exposure to ingestion of radon-222 as low as reasonably level.

Infants and children are prone to health risk (stomach or lung cancer) than adults as a result of exposure to radon in untreated water. However, the estimated AED were found to be above the WHO reference limit of 0.1mSv/yr for intake of radionuclide.

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