ASSESSMENT OF BACKGROUND IONIZING RADIATION LEVEL IN THE CENTRAL PART OF DELTA STATE, NIGERIA

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Abstract: Assessment of background ionizing radiation (BIR) in some oil producing communities in Delta State Nigeria has been conducted using a Geiger Muller counter 320 plus (GMC 320 +). The purpose of this assessment is to obtain a base-line information on this radiation type of the communities, investigate the BIR distribution with respect to location and altitude and verify the radiological safety or otherwise of the members of the public therein. The mean results range from 0.008 to 0.017 mR/hr with an average value of 0.010 mR/hr. This value is in agreement with other research works carry out in Nigeria and lower than the worldwide recommended average of 0.013 mR/hr by the International Commission for Radiation Protection. The calculated mean results for radiation health parameters associated with BIR revealed that the obtained average values were lower compared to their respective global averages. The values obtained in some communities: Ekpan, Jeddo, Ugbokorodo and Kokori were higher than the worldwide average. This is attributable to the oil and gas activities in these areas. However, it indicates that the study areas are not threatened radiologically and the populace is not over exposed. But continuous exposure may be harmful to man in the environment. However there should be a routine check by relevant bodies in charge of radiation protection in the region.

Keywords: Geiger Muller, background radiation, exposure, radiological health status, ionizing

Introduction

The fact that oil and gas activities contribute to the level of background ionizing radiation (BIR) in the environments where they are ongoing is available in Literature (Mokobia *et al*., 2003; Avwiri *et. al.*, 2007; Avwiri and Agbalagba, 2012; Agbalagba *et al*., 2013; United States Environmental Protection Agency (EPA), 2017). Other current anthropogenic activities capable of raising the BIR levels in the environment include solid minerals exploration, rock blasting, road construction, borehole drilling and telecommunication masks (Innocent, 2012).

This oil and gas as well as the identified man-made activities are prevalent in a number of communities in Delta State, Nigeria which is one of the States in the Niger Delta region. The implication is that on a continuous basis the BIR levels of the environments in this region are likely to be on the increase. Literature indicates that radiation health effects for example acute radiation syndrome or varying degrees of skin burns could occur if the radiation levels exceed certain limits (World Health Organization (WHO), 2016) and that even low levels of radiation are capable of increasing the risk of stochastic effects such as cancer. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) had also noted that excessive and prolonged exposure of radiation is a radiological threat to humans. (UNSCEAR, 2000) It is on these premises that this study was carried out to assess the BIR levels in certain selected communities in Delta State where oil and gas activities are ongoing with a view to predicting the current radiological health status of the public in the communities by comparing with potential tolerable limit as recommended by ICRP (2019).

Materials and Methods

In-situ measurements of the BIR levels in 40 selected oil producing communities in Delta State, Nigeria has been determined using Geiger Muller counter 320 plus (GMC 320+). Randomly selected communities comprise of eight Local Government Areas that make up the central part of the State as shown in (Fig. 1). The detector was checked for operation prior to its use (InternetArchieveBot, 2018) and measurements were made between the hours of 13:00 and 16:00 as prescribed by the National Council on Radiation Protection (NCRP, 1987). The detector readings were taken three consecutive times at the required height of 1 meter above the ground at three different triangular points, in each measurement location the mean values thereafter were computed. The obtained mean values were used to estimate the BIR health index using the mathematical models in Mokobia *et al.* (2016) and Ugbede (2018) who relied on earlier models (UNSCEAR, 2008; ICRP, 2007). The locations and the elevations of the communities were determined using a geographical positioning system (GPS). The pattern of the coordinate and elevation of the region as against the BIR are shown in Table 1 and Figs. 6 to 7. The values of the health parameters obtained were compared with their respective worldwide stipulations with the purpose of determining the radiological health effect of the populace in the study areas.

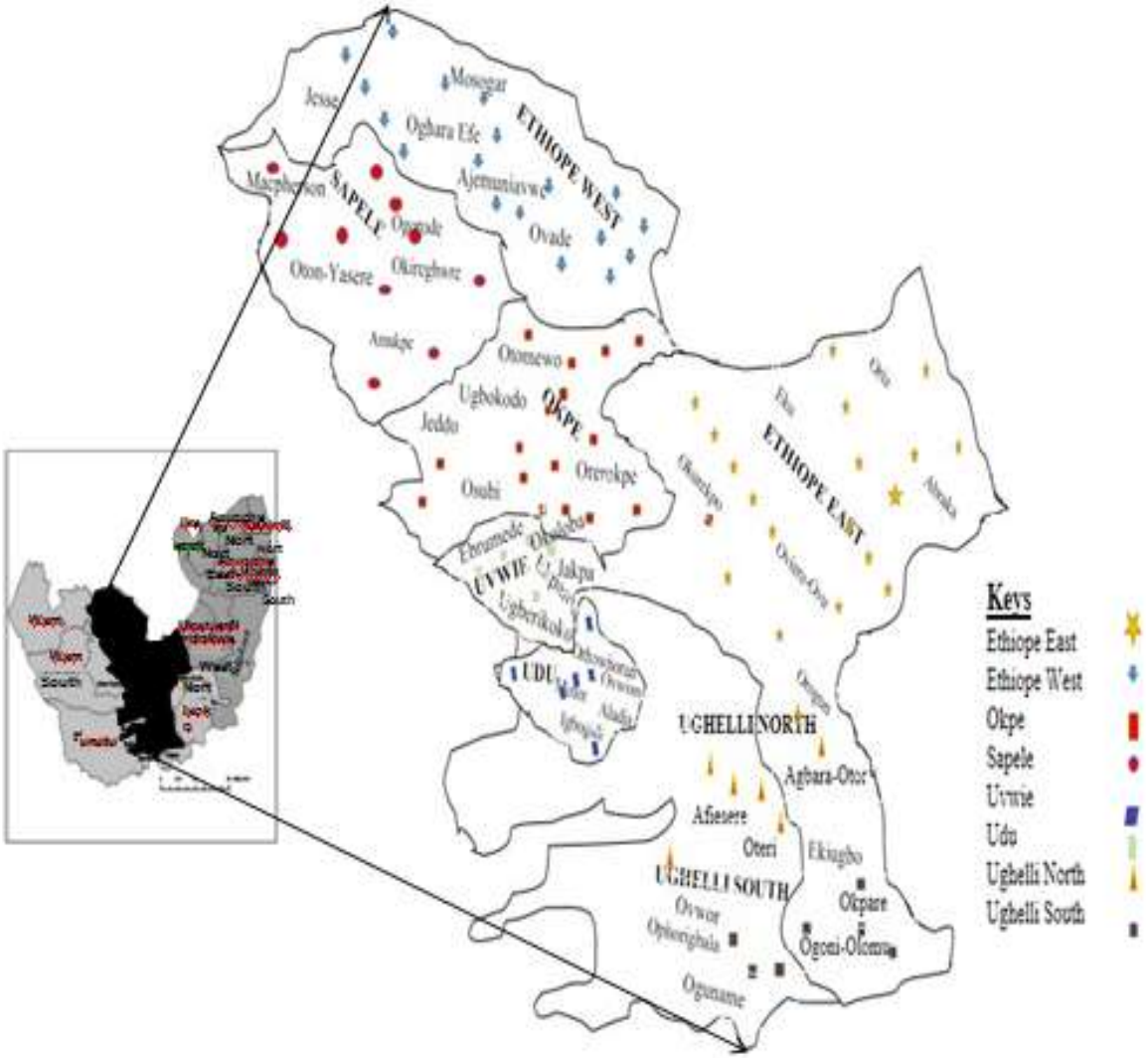

Fig. 1: Map showing the study sites/communities

Results and Discussion

Table 1 shows the measurement of Background Ionizing radiation level in some communities in Delta Central, Delta State. The measurement values for BIR in all the communities varied from 0.008 to 0.017 mRh^{-1}, with an average value of 0.010 mRh^{-1}. The minimum values observed were in Abraka town, Macpherson, Ophorigbala, and Orogun communities, respectively. This may likely be attributed to absence of oil activities and major industries in these areas. Meanwhile the maximum values obtained were evident in Kokori and Ekpan communities. Of course we can infer that due to the oil activities of Warri refinery at Ekpan and the flow station at Erho- Ike (Kokori) has significantly increased the BIR level which may have in turn inflict some hazard effects on the health status of the populace in this environment (Avwiri *et al*., 2007). The geometric mean value results obtained for BIR in each Local Government Areas are: 0.010, 0.010, 0.012, 0.011, 0.010, 0.011 and 0.011 (mRh^{-1}), respectively and have an overall average value of 0.010 mRh^{-1}, respectively. However, Comparing this average value with other studies carried out in Delta State and Nigeria at large, the obtained average value results conformed with other studies Innocent (2012), Mokobia *et al.* (2016), Akpolile and Akpolile (2014) and Nyango (2006). Also, comparing with worldwide (ICRP, 2003) standard limit, the obtained average results are less than the potential limit of 0.013 mRh^{-1} as graphically shown in Fig. 2. Despite the low average value results obtained, some communities like Ekpan,Erho-Ike (Kokori), Ovwor, Jeddo, Ugbokodo, etc. has an upshoot of BIR which is greater than international stipulation. This may be seriously tied to oil and gas activities in the environment. The indication is that the member of the public may not have an immediate effect but continuous exposure is detrimental to health status.

Table 1: Measured background radiation level in each LGA's in Delta Central, Delta State

S/N	LGA	Location	Lat.	Long.	Elev. (m)	1st Rdg.	2nd Rdg.	3rd Rdg.	Mean (mR/hr)	Dose equivalent ($mSvy^{-1}$)
1	Ughelli South	Ovwor	5.488	5.488	5	0.015	0.015	0.014	0.015	1.267
		Ophorigbala	5.469	6.053	6.2	0.008	0.008	0.009	0.008	0.673
		Oguname	5.466	6.177	5.3	0.009	0.008	0.009	0.009	0.765
		Okpare	5.465	5.902	7	0.009	0.010	0.011	0.010	0.840
		Ogoni–Olomu	5.496	6.022	6	0.011	0.011	0.010	0.011	0.925
		Mean							**0.010**	**0.893**
2	Ughelli North	Agbarha -Otor	5.736	6.050	11	0.013	0.012	0.013	0.013	1.093
		Afiesere	5.571	6.676	8	0.013	0.011	0.012	0.012	1.009
		Orogun	5.591	5.086	38	0.008	0.009	0.008	0.008	0.673
		Ekiugbo	5.546	6.226	9	0.012	0.011	0.010	0.011	0.925
		Oteri	5.606	6.525	7.8	0.008	0.010	0.009	0.009	0.765
		Mean							**0.010**	**0.693**
3	Udu	Mofor	5.589	5.976	12	0.012	0.013	0.013	0.013	1.093
		Igbogidi	5.642	5.867	18	0.009	0.009	0.010	0.009	0.765
		Orhuvworhun	5.626	6.047	20	0.011	0.012	0.010	0.011	0.925
		Aladja	5.589	5.885	19	0.010	0.009	0.011	0.010	0.840
		Owian	5.585	5.896	13	0.011	0.010	0.011	0.011	0.925
		Mean							**0.012**	**0.909**
4	Uvwie	Ebrumede	5.613	5.460	15	0.012	0.012	0.010	0.011	0.925
		Jakpa	5.546	5.688	12	0.011	0.008	0.009	0.009	0.765
		Ekpan	5.685	5.833	10	0.016	0.017	0.018	0.017	1.429
		Ogberikoko	5.583	5.691	11	0.010	0.012	0.011	0.011	0.925
		Okoloba	5.581	5.788	14	0.013	0.011	0.010	0.011	0.925
		Mean							**0.011**	**0.996**
5	Okpe	Otomewo	5.803	5.695	18	0.009	0.008	0.010	0.009	0.765
		Jeddo	5.936	5.866	5	0.014	0.015	0.014	0.014	1.188
		Ugbokodo	5.733	5.964	7	0.015	0.014	0.014	0.014	1.188
		Osubi	5.652	5.972	23	0.012	0.013	0.011	0.012	1.009
		Orerokpe	5.861	6.240	78	0.012	0.010	0.009	0.010	0.840
		Mean							**0.011**	**0.998**
6	Ethiope East	Oviere-Ovu	5.859	6.230	96	0.011	0.010	0.009	0.010	0.840
		Kokori	5.837	6.121	99	0.019	0.015	0.017	0.017	1.429
		Eku	5.832	6.155	28	0.009	0.010	0.008	0.009	0.765
		Oria	5.834	6.151	98	0.009	0.009	0.010	0.009	0.765
		Abraka-town	5.859	6.230	112	0.008	0.007	0.009	0.008	0.673
		Mean							**0.10**	**0.894**
7	Sapele	Amukpe	6.000	5.796	41	0.013	0.011	0.011	0.012	1.009
		Okireghwre	6.047	5.608	38	0.010	0.011	0.009	0.010	0.840
		Ogorode	5.973	5.696	42	0.011	0.010	0.009	0.010	0.840
		Macpherson	6.031	5.819	35	0.009	0.007	0.008	0.008	0.673
		Oton-Yasere	5.232	5.978	28	0.014	0.015	0.016	0.015	1.261
		Mean							**0.011**	**0.924**
8	Ethiope West	Jesse	5.942	5.979	42	0.010	0.010	0.009	0.010	0.840
		Mosogar	5.946	5.973	46	0.011	0.010	0.011	0.011	0.925
		Ovade	5.935	5.972	43	0.012	0.009	0.011	0.011	0.925
		Ajemuniavwe	5.945	5.921	4	0.012	0.011	0.012	0.012	1.009
		Otefe-Oghara	6.098	5.612	44	0.011	0.010	0.013	0.011	0.925
		Mean							**0.011**	**0.924**
	Total Average								**0.010**	**0.813**
	Max								**0.017**	**1.429**
	Min								**0.008**	**0.673**

LGA = Local government area; **Lat.** = Latitude; **Long.** = Longitude; **Rdg.** = Reading; **Elev.** = Elevation

Moreso, the corresponding mean values for the obtained results for dose equivalent are 0.893, 0.0693, 0.909, 0.996, 0.998, 0.894, 0.924 and 0.924 $mSvy^{-1}$ respectively, with weighted average value of 0.813 $mSvy^{-1}$. The minimum and maximum values are recorded at Ophorigbala, Orogun, Abraka, Macpherson and Ekpan Kokori, respectively. The high values, observed may be blamed on oil and gas activities at Warri refinery Ekpan and Erho-Ike flow station situated at Kokori. This equally confirmed the high value of BIR in some communities.

Table 2 present the computed mean values for radiation health parameters in each local government areas. The estimate dose rate ranges from 0.762 to 0.914 (nGy^{-1}) with an average values of 0.819 (nGy^{-1}). The Ethiope East, Ughelli North and South have the lowest value an Udu highest. For the annual effective dose equivalent range from 0.426 to 0.514 ($mSvyr^{-1}$) with an average values of 0.5 II $mSvy^{-1}$. While excess lifetime cancer risk varies from 0.011 x 10^{-3} to 0.014 x 10^{-3} having an average of 0.091 x 10^{-3} to 0.014 x 10^{-3}, respectively. These averages value result compare very-well with previously existing literatures (Avwiri and Agbalagba, 2012; Agbalagba *et al.*, 2013; Akpolile and Akpolile, 2014) and less than their respective worldwide permissible limit as shown in Figs. 3 to 5. This again is another clear indication that the study environment is safe and the member of public are not threatened with radiation hazards.

Table 2: Radiation health parameter associated with BIR Levels in study areas in Delta Central of Delta State

S/N	LGA	Mean (mR/hr)	DoseRate (mGy^{-1})	AEDE ($mSvy^{-1}$)	ELCR ($x10^{-3}$)
1	Ughelli S.	0.010	0.762	0.426	0.011
2	Ughelli N.	0.010	0.762	0.426	0.011
3	Udu	0.012	0.914	0.514	0.014
4	Uvwie	0.011	0.838	0.469	0.012
5	Okpe	0.011	0.838	0.469	0.011
6	Ethiope E.	0.010	0.762	0.426	0.011
7	Sapele	0.011	0.838	0.469	0.012
8	Ethiope W.	0.011	0.838	0.469	0.012
	Mean	0.010	0.819	0.511	0.091

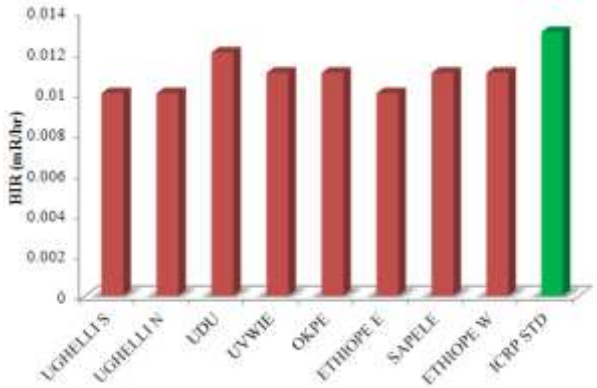

Fig. 2: Inter comparison of measured BIR values in study areas against ICRP standard

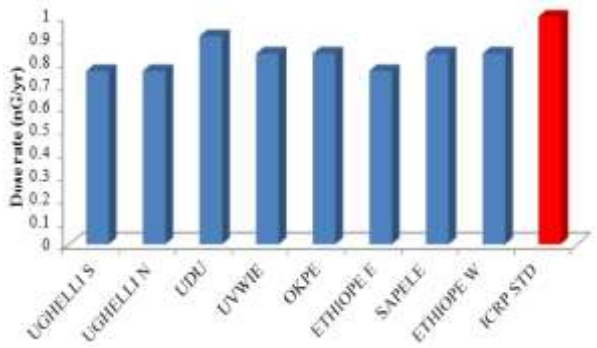

Fig. 3: Inter comparison of dose rate values in each study areas against ICRP standard

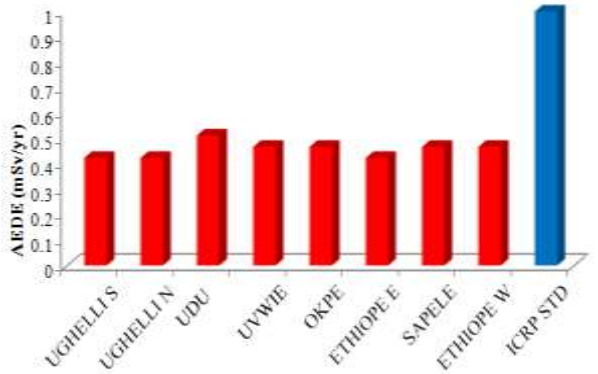

Fig. 4: Inter comparison of AEDE values in each study areas against ICRP standard

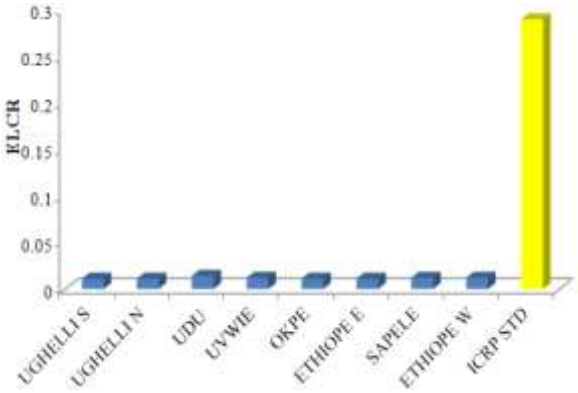

Fig. 5: Inter comparison of ELCR values in each study areas against ICRP standard

Figures 6 and 7 depicts a pattern distribution of BIR exposure, the area coordinates and its elevation graph reflecting the topography of the study environments and was developed with values of longitude, latitude an elevation at point where radiation levels were measure. The highest latitude of 6.098 is at Otefe Oghara and the lowest latitude is 5.465 observed at Okpara while the maximum and minimum values for longitude are 6.676 and 5.460 which is recorded for Afiesere and Ebrumede. On the other hand, the highest elevation of 99 m is at Kokori and the lowest elevation is 4 m observed at Ajmuniavwe.

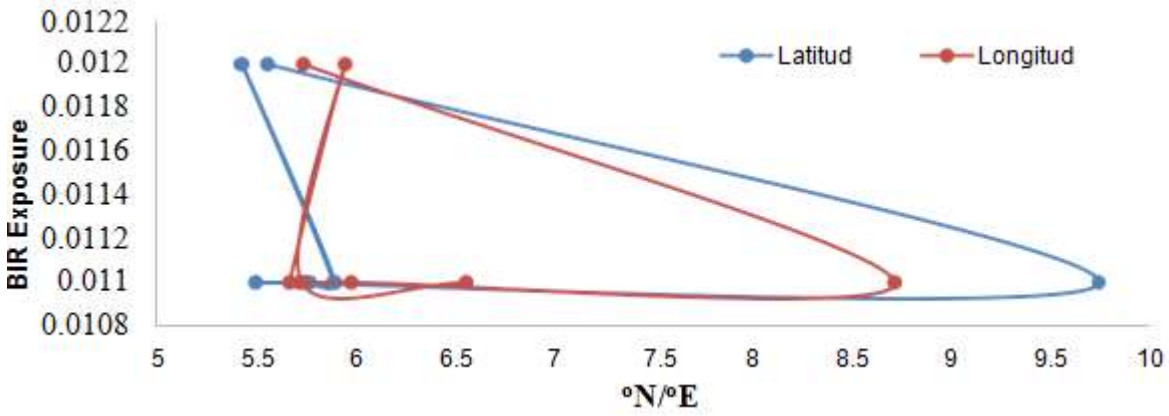

Fig. 6: Pattern of BIR exposure distribution of with coordinates

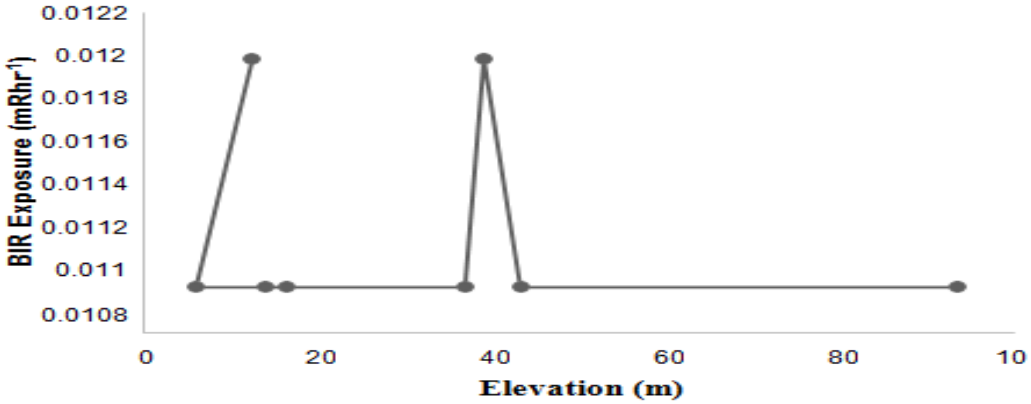

Fig. 7: Pattern of BIR exposure distribution with elevation

Conclusion

Assessment of the B1R level in the study areas has been conducted using (GMC 320+) radiation meter. The following corresponding mean results were obtained as: 0.10, 0.010, 0.012, 0.011, 0.010, 0.011 and 0.011 (mRh^{-1}) respectively with an average value of 0.10 (mRh^{-1}). comparing this average results obtained with (ICRP, 2003) standard limit of 0.013 mRh^{-1} and other studies carried out within Nigeria and internationally, the present average results is lower and in accordance with others literature results (research work). The mean results for close equivalent estimated ranged from 0.693 to 0.998 ($mSvy^{-1}$) with an average value of 0.813 $msvy^{-1}$ which is equally far less than the worldwide value of 1 $mSvy^{-1}$ for the member of the public. However, some communities like Ekpan, Kokori, Jeddo and Ugbokorodo has a high level of BIR, and one may strongly attribute this to the operational activities of the oil and gas in these region. Base on the fact that oil and gas upshot the level of BIR. The implication is that members of public, residents and workers are not over exposed to radiation but continuous and long time exposure of an individual may have effect. The calculated health parameters associated with BIR are: Dose rate (0.819 nGY^{-1}), AEDE (0.511 $mSvy^{-1}$) and ELCR (0.091 x 10^{-3}), respectively. Comparing this with their respective international potential limit of 1.0 nGy^{-1} and $0.29x10^{-3}$, respectively. The obtained results are lower than recommended average by (ICRP, 2006). Again, it is an indication that individuals are not over-exposed and the environments is radiologically safe. However despite the low levels of BIR in the study areas, radiation regulatory bodies carrying out a routine check bearing in mind the ALARA principle.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

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