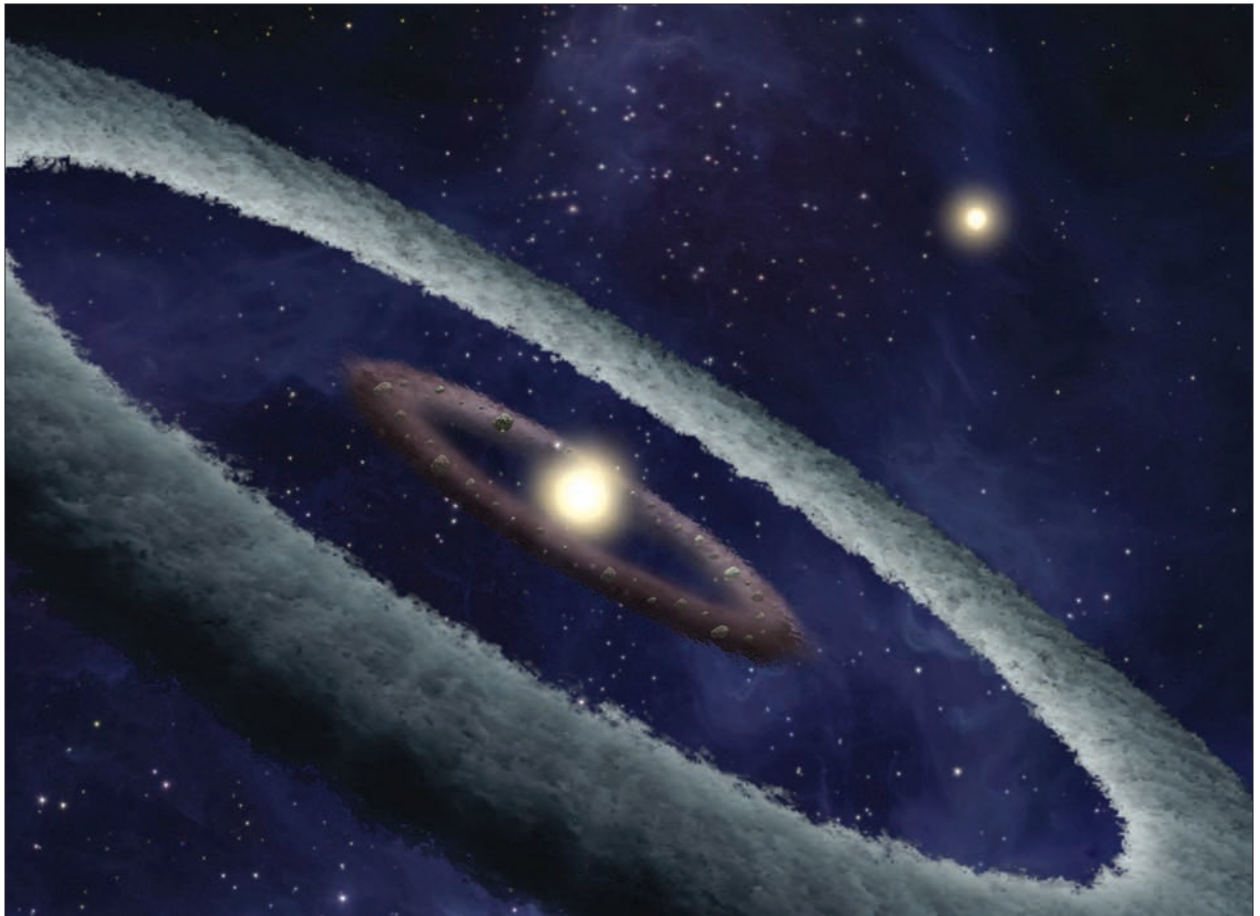




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Excess Lifetime Cancer Risks Associated with the Use of Sediments from Ogun River, Nigeria as Building Material

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ABSTRACT

Sediments are known to contain natural radionuclides but their presence in the sediments beyond certain limits can constitute radiological health effects. Sediments from Ogun river provide large quantities of sand for building purposes. This work aimed at determining the excess lifetime cancer risk associated with the use of the sediments as building material. A total of 320 sediment samples were collected along the course of the river; 60 in the upper region (Igboho to Idi-Ata; Oyo-Ogun axis), 90 in the middle region (Olopade to Mile 8 Oba; Ogun-Lagos axis) and 170 in the lower region (Abata to Apa Osa; Lagos axis). The number of samples collected in each region was determined by accessibility. The activity concentrations of the natural radionuclides in the samples were determined using gamma-ray spectrometer comprising 76×76 mm NaI (Tl) detector coupled to a multichannel analyser. These concentrations together with standard equations were used to evaluate indoor effective dose rates. The regional weighted mean of the Excess Lifetime Cancer Risk (ELCR) values were $(0.141 \pm 0.01) \times 10^{-3}$, $(0.137 \pm 0.02) \times 10^{-3}$ and $(0.148 \pm 0.03) \times 10^{-3}$ for the upper, middle and lower regions of the river respectively. The estimated total value of ELCR for Ogun river sediments was found to be $(0.143 \pm 0.02) \times 10^{-3}$, ranging from 0.051×10^{-3} – 0.290×10^{-3} . This value was lower than the world's average value of (0.29×10^{-3}) .

Key words: Excess lifetime cancer risk, sediment, ogun river, building material, radiation hazard

INTRODUCTION

Exposure to ionizing radiation can damage living organisms and cause health effects in humans, including leukaemia and other cancers (IAEA, 2006). Ramasamy *et al.* (2009), Taskin *et al.* (2009) and Kumar *et al.* (1986) in their studies also pointed out that long-term exposure to uranium and radium through inhalation has several health effects. In addition to the health effects mentioned above, exposure to thorium can also cause lung, pancreas, hepatic, bone, kidney cancers, leukaemia and skin cancers (Taskin *et al.*, 2009; Ramasamy *et al.*, 2009; Kumar *et al.*, 1986). The primordial radionuclides of concern are mainly potassium, uranium, thorium and the radionuclides formed during their radioactive decay chains (EL-Zakla *et al.*, 2007). It is known that the radioactive progenies of radon are responsible for its radioactive hazards through their energy interaction with the cell they come in contact with thereby causing changes in the DNA structure of the cell or even damaging it beyond repair. This can then lead to or start up cancers that are linked with radon daughters. Ahmad *et al.* (1998) was one of the authors who pointed out that the sources of Radon gas are the building materials and its components, ground water and soil. Therefore, this work aimed at determining the excess lifetime cancer risk which might be associated with the use of sediments from Ogun river as building material.

MATERIALS AND METHODS

Study area: The main channel of this river rises at approximately 8°51'N, 3°38'E in Oyo State of Nigeria around Ago Fulani area runs and passes through Ogun state and enters the Lagos Lagoon at a point on longitude 3°25'E and latitude 6°35'N. Ogun river and its tributaries are located in the Southwestern Nigeria, Fig. 1. It is one of the series of West African rivers which do not drain into the Niger system but discharges into coastal lagoons and creeks bordering the Atlantic ocean (Sydenham, 1977). The river channel in the upper section cut through the basement rocks on areas where the shallow aquifer is within 5 m of land surface. Therefore, there is a direct hydraulic connection between the river system and the upper portion of the shallow aquifers. This has encouraged fast depletion of groundwater due to rapid loss through the bottom of the channel. As cessation of rainfall starts in the month of November, the river discharges starts to decrease but can only be sustained by groundwater discharge. The low flow condition in the river (by December) makes the water level in Ogun river to drop. At the lower section of Ogun river, there is continuous

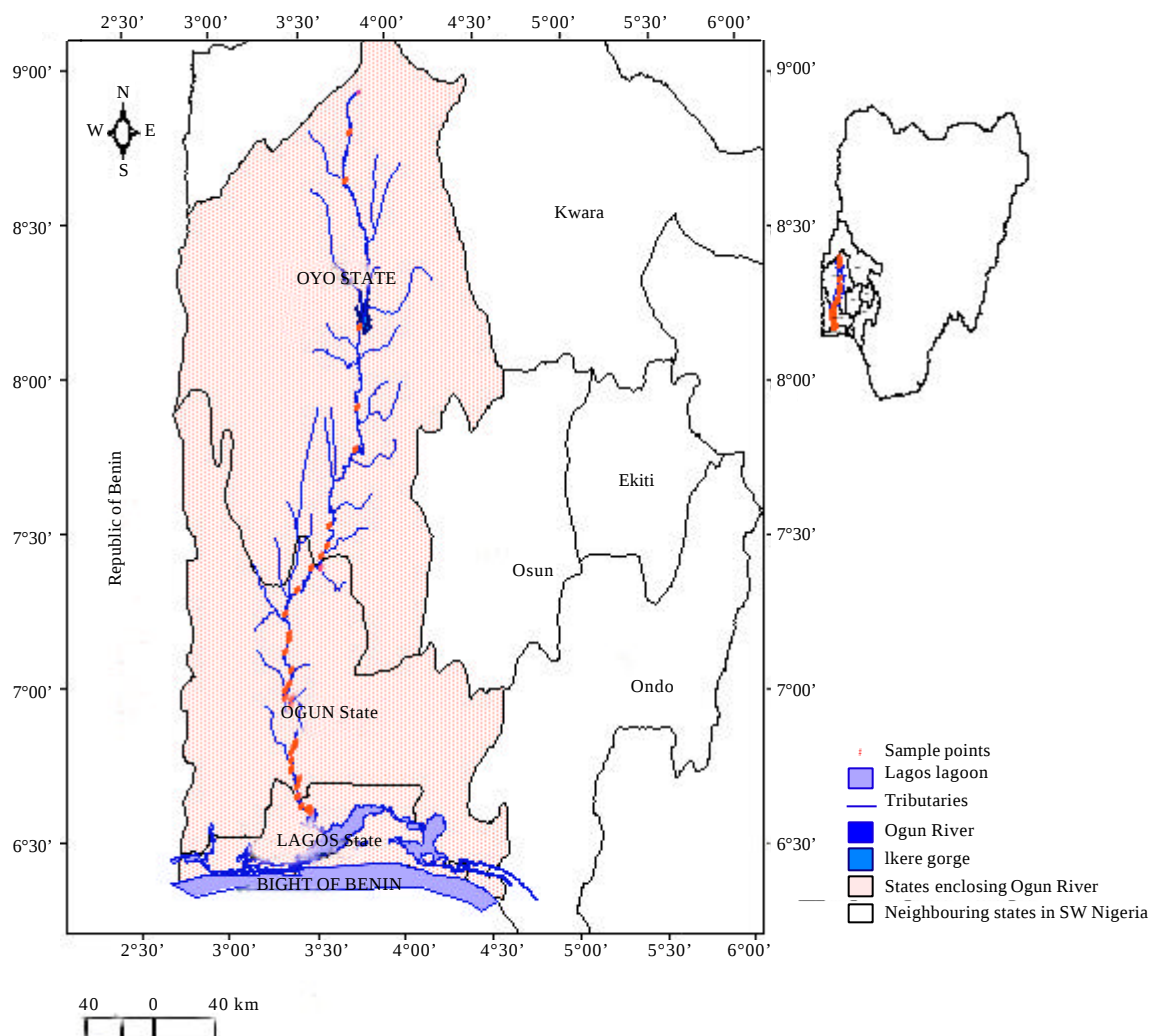


Fig. 1: Map of South Western Nigeria showing the study area and the three states the river traversed (Okeyode, 2012)

interaction between the aquifer and the river channel. This confirms that there is a hydrodynamic interaction of surface and groundwater in the river sections. It is evident that surface water bodies are integral parts of groundwater flow systems. Generally, it is assumed that groundwater is recharged from areas of high elevation and discharges at lower areas; this may be true primarily for regional flow systems. Complex interactions between surface water and groundwater exist as a result of the surface water bodies being associated with the entire local flow systems (Bhattacharya and Bolaji, 2010; Okeyode, 2012).

Ogun river has a flowing rate and density which change depending on the geomorphology of the area between its spring and the point at which it joins the Lagoon. Taking these into consideration, the river was divided into three main parts traversing the course of the river: As upper, middle and lower regions. The upper course of the river is known as the upper Ogun, the middle course, middle Ogun and lower course is known as the lower Ogun. It covers part of the following states: Oyo, Ogun and Lagos State. Some of the communities and towns along the course of the river from upper Ogun through the middle and then the lower Ogun river are: Igboho, Sepeteri, Ojubo Sango, Odo Ogun-Oyo West, Lasupo, Idi-Ata, Olopade, Olokemeji, Ekerin, Opeji, Lerin, Ago Odo, Sokori, Adigbe, Mile 8 (Oba), Abata, Owere, Ogunpa Wasimi, Iro, Magbon, Ilate, Oba Oseni, Ibaragun, Orudu, Maidan, Igaun, Akute, Kara, Mile 12-Maidan, Towolo, Agbariwu and Apa Osa etc. (Okeyode, 2012). The river flows southwards for a distance of approximately 440 km, discharging into the Lagos Lagoon through two distributaries 15 km to the North-East of Lagos city. The major tributaries of Ogun river are the Oyan and the Ofiki systems (Bhattacharya and Bolaji, 2010).

Geology of the study area: The geology of the study area, Fig. 2 is described as a rock sequence that starts with the Precambrian Basement (Jones and Hockey, 1964) and which consists of quartzites and biotite schist, hornblende-biotite, granite and gneisses. The foliation and joints on these rocks control the course of the rivers, causing them to form a trellis drainage pattern, particularly to the north of the area. The sedimentary rock sequences are from Cretaceous to Recent; the oldest of them, the Abeokuta formation, consists of grey sand intercalated with brown to dark grey clay. It is overlain by Ewekoro formation, which typically contains thick limestone layers at its base. About 9 km upstream of Abeokuta town there is a sharp change in land gradient, changing the river morphology from fast flowing to slow moving and leading to the formation of alluvial deposits overlying the sedimentary formation of Ewekoro, Ilaro and Coastal plain sands in sequence towards the Lagos lagoon (Bhattacharya and Bolaji, 2010).

Social economic activities of the study area: Ogun river serves three states (Oyo, Ogun and Lagos) greatly in terms of economic and social importance. In areas of high population density the river is used for domestic purposes such as bathing, washing and drinking. Fishing is also carried out in major part of the river. Artisanal fisheries are major activities in lower Ogun river. At Isheri-Olofin, lower Ogun river receives effluents from 'Kara' Abattoir which was established in 1984. An average of 200 cows are slaughtered and butchered at the abattoir on daily basis (Ikenweije *et al.*, 2011). Meat and milk production are done around the river banks. The effluents being discharged into the river chiefly contain the gut contents of the slaughtered and butchered cows, therefore, the river acts as sink to most organic wastes from abattoirs located along its course. The source of income of most people are based on this river because sanding and excavations are done day and night. The sediments obtained from the river is used to build houses where people

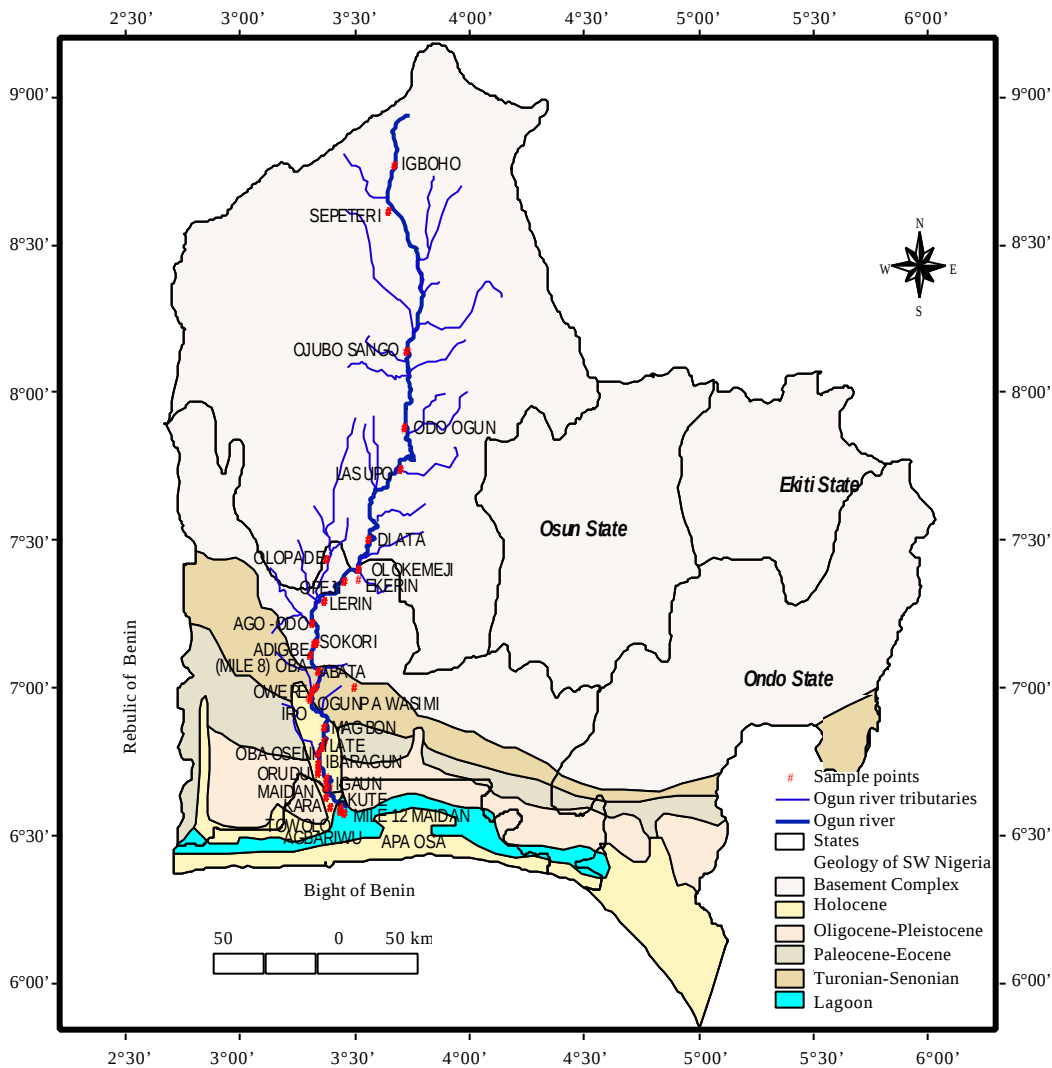


Fig. 2: Geological map of South Western Nigeria showing the distribution of major rock types and sites of study areas (Okeyode, 2012)

live. Importantly, the three states through which the river passes, are heavily industrialised cities: most especially, Lagos and Sango-Ota (ogun state) for instance, about six major industries including Vitabiotics, Nestle, Glaxos, Smith kline, Sona Breweries and Nigerian German chemicals discharge their wastes into the river (Farombi *et al.*, 2007). The study area is an area where there is diversification of trade. There is a dam, Ikere Gorge, situated on Ogun River, about 8 km east of Iseyin around Ojubo Sango in Oyo state. There is also a basin, which lies between latitudes 6°33 N and 8°58 N and between longitudes 2°40 E and 4°10 E with total area of about 23,700 km². Different water uses, including domestic, commercial, industrial and agricultural takes place within the basin (Ojekunle *et al.*, 2011). Farming of all sorts with the use of fertilizer to facilitate good crops, most especially cassava plantation, hunting, mat making, fishing, cloth dyeing have been the chief occupations of the local people for many decades. However, commerce and industry are other major human activities within the area, which include the Planet Plastic industries in

Mile 12, sawmill (plank) industries, as well as the popular food market at Mile 12 (Tejuoso, 2006). Human and industrial activities are more at the middle and toward the lower parts of the river than at the upper part.

Excess lifetime cancer risk (ELCR): The significance of exposure from natural radioactivity in soil and the potential risk for causing health detriment, especially cancer, have not received the desired attention in Nigeria. With the establishment of Nigeria Nuclear Regulatory Authority (NNRA), the public interest in the long-term effects of radiation has assumed great prominence (Farai *et al.*, 2006). Some regulatory bodies use a quantitative risk assessment process to determine an excess cancer risk over a lifetime (ELCR). Two of these bodies are UNSCEAR and BEIR V i.e., Committee on the Biological Effects of Ionizing Radiations, known as the BEIR. Both organizations stated that their risk estimates should be reduced for low dose exposures protracted over several months or years to account for a reduced effectiveness of the cell damage mechanism (Ahier and Tracy, 1995). Using a maximum reduction factor of 2, (UNSCEAR, 1993) recommends a lifetime risk estimate of 5% Sv⁻¹ for fatal cancer following a protracted whole-body exposure of low dose and low dose rate radiation (Ahier and Tracy, 1995). The International Commission on Radiological Protection (ICRP) (1991), while relying mainly on the assessment of the Japanese survivors by organizations such as UNSCEAR (1993) and Beir (1990), has taken into consideration the entire body of literature in their estimate of risk (Ahier and Tracy, 1995). The lifetime risk estimate for low-dose exposures as given in the 1990 recommendations of the ICRP is 5% Sv⁻¹ for the entire population, based on a linear, no-dose threshold model. On the basis of copious and on-going research in human epidemiology, animal studies and cell biology, these organizations concluded that the risk estimates at low doses are likely conservative. Therefore, the need to determine the excess cancer risk over a lifetime (ELCR). This approach mathematically calculates the probability of developing cancer over a lifetime at a given exposure level. It is presented as a value representing the number of extra cancers expected in a given number of people on exposure to a carcinogen at a stated dose.

Excess Lifetime Cancer Risk (ELCR) was calculated using (Taskin *et al.*, 2009):

$$\text{ELCR} = \text{AEDE} \times \text{DL} \times \text{RF} \quad (1)$$

where, AEDE, DL and RF are the annual effective dose equivalent, average duration of life (70 years) and risk factor (Sv⁻¹), i.e., fatal cancer risk per sievert, respectively. For stochastic effects, ICRP 60 uses values of 0.05 for the public (Taskin *et al.*, 2009; Ahier and Tracy, 1995). The activity concentrations of natural radionuclides in the sediments of this river has been published (Jibiri and Okeyode, 2011).

Data analysis: Descriptive statistics were used for analysing the data. Precisely the minimum and maximum values (range) of the excess lifetime cancer risks were found in each location and the mean value in each location was also found. The regional weighted mean in each of the region was found as well using the relation in Eq. 2:

$$\text{Weighted mean} = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3 + \dots + w_n x_n}{w_1 + w_2 + w_3 + \dots + w_n} \quad (2)$$

RESULTS AND DISCUSSION

The range and mean values of the Excess Lifetime Cancer Risk (ELCR) estimated for each location in the upper, middle and lower regions of Ogun river respectively are presented in Table 1-3.

As it could be observed from Table 1-3, in the upper region, the highest value of the ELCR was at Lasupo (0.198×10^{-3}) and the least was at Igboho (0.051×10^{-3}). In the middle region, Olopade had the highest value of (0.290×10^{-3}) while Ekerin had the least value of (0.061×10^{-3}). In the lower region, Ogunpa Wasimi had the highest value (0.238×10^{-3}) and Orudu had (0.062×10^{-3}).

The mean for the upper region was (0.141 ± 0.009) 10^{-3} , for the middle region it was (0.137 ± 0.02) 10^{-3} and the mean for the lower region was (0.148 ± 0.03) 10^{-3} .

The estimated total value of ELCR for Ogun river sediments was found to be (0.143 ± 0.02) 10^{-3} , ranging from 0.051×10^{-3} - 0.290×10^{-3} . Looking at the range of values obtained in the upper, middle and lower regions, it was observed that the highest value in each region was increasing down the region and also the lowest value in each region increased down the region (upper < middle < lower). The mean in each of the regions did not follow a particular pattern. The upper and the middle regions had almost the same value of 0.14×10^{-3} but the mean of the lower region had a higher value of 0.15×10^{-3} . In the whole of the locations studied, Olopade was the location where the highest value was obtained. Comparing the value of the ELCR estimated for Ogun river sediments with the value obtained in Tamilnadu, India. Ramasamy *et al.* (2009) reported that the average value of ELCR was estimated to be 0.202×10^{-3} and the values ranged from 0.071×10^{-3} - 0.370×10^{-3} . Also comparing with the work done by Avwiri *et al.* (2012), the value for Ogun river sediment was

Table 1: Range and the mean of Excess Life Cancer Risk (ELCR) and Annual Effective Dose Rate ($m\text{ Sv/y}$)_{indoor} for the upper region of Ogun river

S/N	Locations	ELCR $\times 10^{-3}$ range	Mean (10^{-3})	Effect. dose rate	
				($m\text{ Sv/y}$) _{indoor} range	Mean
1	IGBOHO	0.051-0.179	0.147 $\pm$ 0.04	0.112-0.393	0.321 $\pm$ 0.08
2	SEPETERI	0.097-0.175	0.148 $\pm$ 0.02	0.212-0.381	0.324 $\pm$ 0.05
3	OJUBO SANGO	0.113-0.160	0.137 $\pm$ 0.02	0.247-0.350	0.300 $\pm$ 0.03
4	ODO-OGUN (OYO WEST)	0.123-0.165	0.145 $\pm$ 0.01	0.270-0.363	0.318 $\pm$ 0.03
5	LASUPO	0.104-0.198	0.143 $\pm$ 0.03	0.226-0.434	0.314 $\pm$ 0.07
6	IDI-ATA	0.103-0.142	0.124 $\pm$ 0.02	0.223-0.311	0.270 $\pm$ 0.03
	Regional weighted mean		0.141 $\pm$ 0.01		0.308 $\pm$ 0.02

Table 2: Range and the mean of Excess Life Cancer Risk (ELCR) and Annual Effective Dose Rate ($m\text{ Sv/y}$)_{indoor} for the middle region of Ogun river

S/N	Locations	ELCR $\times 10^{-3}$ range	Mean (10^{-3})	Effect. dose rate	
				($m\text{ Sv/y}$) _{indoor} range	Mean
1	OLOPADE	0.080-0.290	0.117 $\pm$ 0.04	0.175-0.457	0.256 $\pm$ 0.09
2	OLOKEMEJI	0.064-0.157	0.120 $\pm$ 0.02	0.141-0.346	0.263 $\pm$ 0.06
3	EKERIN	0.061-0.211	0.120 $\pm$ 0.05	0.132-0.459	0.263 $\pm$ 0.11
4	OPEJI	0.072-0.146	0.120 $\pm$ 0.02	0.158-0.320	0.262 $\pm$ 0.32
5	LERIN	0.111-0.177	0.144 $\pm$ 0.02	0.242-0.386	0.314 $\pm$ 0.04
6	AGO ODO	0.118-0.183	0.141 $\pm$ 0.02	0.257-0.412	0.307 $\pm$ 0.04
7	SOKORI	0.162-0.211	0.180 $\pm$ 0.01	0.352-0.459	0.392 $\pm$ 0.03
8	ADIGBE	0.118-0.168	0.144 $\pm$ 0.02	0.258-0.366	0.316 $\pm$ 0.04
9	MILE 8 (OBA)	0.135-0.176	0.150 $\pm$ 0.01	0.294-0.384	0.328 $\pm$ 0.03
	Regional weighted mean		0.137 $\pm$ 0.02		0.300 $\pm$ 0.05

Table 3: Range and the mean of Excess Life Cancer Risk (ELCR) and Annual Effective Dose Rate(m Sv/y)_{indoor} for the lower region of Ogun river

S/N	Locations	ELCR $\times 10^{-3}$ range	Mean (10^{-3})	Effect. dose rate	
				(m Sv/y) _{indoor} range	Mean
1	ABATA	0.1100-0.208	0.169 $\pm$ 0.03	0.241-0.453	0.368 $\pm$ 0.07
2	OWERE	0.1450-0.193	0.163 $\pm$ 0.01	0.317-0.419	0.356 $\pm$ 0.03
3	OGUNPAWASIMI	0.1470-0.238	0.190 $\pm$ 0.03	0.320-0.517	0.412 $\pm$ 0.06
4	IRO	0.1100-0.214	0.169 $\pm$ 0.04	0.239-0.466	0.368 $\pm$ 0.08
5	MAGBON	0.1080-0.195	0.142 $\pm$ 0.03	0.240-0.424	0.311 $\pm$ 0.06
6	ILATE	0.1040-0.228	0.167 $\pm$ 0.04	0.228-0.498	0.364 $\pm$ 0.09
7	OBA OSENI	0.1550-0.196	0.174 $\pm$ 0.02	0.335-0.430	0.378 $\pm$ 0.03
8	IBARAGUN	0.0920-0.172	0.135 $\pm$ 0.02	0.202-0.377	0.294 $\pm$ 0.05
9	ORUDU	0.0617-0.138	0.106 $\pm$ 0.02	0.165-0.371	0.285 $\pm$ 0.07
10	MAIDAN	0.0850-0.127	0.107 $\pm$ 0.01	0.227-0.340	0.287 $\pm$ 0.03
11	IGAUN	0.1170-0.151	0.132 $\pm$ 0.01	0.253-0.331	0.290 $\pm$ 0.03
12	AKUTE	0.1480-0.205	0.180 $\pm$ 0.02	0.320-0.449	0.391 $\pm$ 0.05
13	KARA	0.0850-0.140	0.111 $\pm$ 0.02	0.186-0.306	0.242 $\pm$ 0.04
14	MILE 12 MAIDAN	0.0660-0.156	0.117 $\pm$ 0.03	0.145-0.342	0.257 $\pm$ 0.07
15	TOWOLO	0.1060-0.175	0.152 $\pm$ 0.02	0.228-0.379	0.330 $\pm$ 0.05
16	AGBARIWU	0.1090-0.194	0.141 $\pm$ 0.02	0.237-0.419	0.306 $\pm$ 0.06
17	APA OSA	0.1210-0.179	0.159 $\pm$ 0.02	0.264-0.390	0.348 $\pm$ 0.04
Regional weighted mean			0.148 $\pm$ 0.03		0.329 $\pm$ 0.05

a little higher than 0.057×10^{-3} value for the soil profile of Udi and Ezeagu Local Government areas of Enugu State, Nigeria and was lower than the value of Tamilnadu, Indian sediments done by Ramasamy *et al.* (2009).

CONCLUSION

The ELCR for Ogun river was found to be $(0.143 \pm 0.02) 10^{-3}$, lower than the world's average value of (0.29×10^{-3}) (Taskin *et al.*, 2009). This showed that the probability of developing cancer over a lifetime by the people around Ogun river and its environs who use the sediments for building of dwellings and other purposes is very low.

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