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EVALUATION OF NATURAL RADIOACTIVITY LEVELS IN NGO RIVER SEDIMENTS, RIVERS STATE, NIGERIA

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Abstract: Assessment of Radionuclide Contents of Sediment in Ngo River, Andoni L.G.A of Rivers State in Nigeria was carryout successfully. Ten (10) samples were collected at ten different points within the river and it environ. The collected samples were analyzed in the laboratory to ascertain the radionuclide content. The result shows the presence of radionuclide of potassium – 40, radium – 226 and thorium – 232 in the samples. The concentration level of the samples result in the area were found to be 68.48 ± 4.84 BqKg-1, 23.47 ± 4.23 BqKg-1 and 77.25 ± 12.54 BqKg-1 for Potassium – 40, Radium – 226 and Thorium – 232, which when compared with the world average of value of 400 BqKg-1, 35BqKg-1 and 30 BqKg-1 (UNSCEAR , 2000) respectively, the value for thorium – 232 exceeds the world average values for sediments while Potassium -40 and Radium – 226 are within the safe value. The activity concentration of the sediments when calculated with radiological parameters was within the safe value for Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) while the calculated value exceeded the safe value for Absorbed Dose (D) and Annual Gonadal Equivalent Dose (AGED) respectively. The area is prone for health hazards and risk as many dwellers are exposing to absorbed dose due to anthropological activities.

Keywords: Absorbed Annual Effective Dose; Annual Gonadal Equivalent Dose; and Excess Lifetime Cancer Risk.

INTRODUCTION

Sediment is an essential feed platform to many oceanic animals and humans. Sediment play a key role to existence of coastal populace as major occupation of the people revolves around the oceans and pave way for survival. Sediment acts as the last target for all fallout and flows from the inland to river. It is the basement for survival of fishes, prewinkle, Oyester, amphibians, ocean animals and humans. The radiation activities which undergoes daily in life cannot be exempted from the fact that all are exposed unconditionally.

Bubu *et al.,* (2018) explains that coastal zone is an area of convergence of activities in urban centres, such as shipping in major ports, and wastes generated from domestic sources and by major industrial facilities. More than 90 percent of all chemicals, refuge and other material entering coastal waters remain there in sediments, wetlands, fringing reefs and other coastal ecosystems (Newman *et al*., 2011). Coastal region acts as sink to radiological and non – radiological waste.

Radiation travels in form of waves and has magnetic and electrical properties. All things whose temperatures are arbitrarily higher than absolute zero emit radiation independently on size.

The radiation occurs naturally and artificially. It becomes artificial when human activities influence the natural occurrence. The natural occurrence is unconditionally and certain as various factors contributed to it, does not required human influence and input. The natural occurrence includes cosmic radiation, terrestrial radiation and internal radiation. Naturally radionuclide contents depend completely on the earth properties of a region and could move (flow) consecutively from the upper stream line of the river to the downstream line of the river (UNSCEAR, 2000). The radionuclides are noted to be carried by serious flow of rain fall which wash them into the river (Essiett *et al*., 2015).

The exposure to background ionizing radiation which are present everywhere in the environment may be enhanced by activities of industries such as spill of crude oil in the oil and gas installations, geological materials for mappings, spills of toxic and chemical materials, gas flaring in oil and gas centres as well other activities in the industries. The fallout and washing of toxic chemicals into the river and during importation, spills of oil in the rivers during transportation, capsizing of industrial materials in the oceans during heavy storms and transporting of refined crude products enhance the radionuclide contents of the sediment as the base for settlement of all these products and thus becomes necessary for examination. The crucial effects of the health which mostly ignore as oceans as play major means of mobility for companies led to arbitrary incessant health challenges to the dominant (dwellers) of the coastal regions and therefore affect the living standard of the proposed people. (Agbalagba, 2017) explains that there is a strong correlation between radiation exposure and health effects (hazards) among populace and industrial workers in a given environment.

Adetutu *et al.,* (2018) carried out a research to determine radionuclide concentrations, hazard Indices and Physiochemical Parameters of water, Fishes and Sediments in River Kaduna, Nigeria. The radionuclide concentrations in fishes, water and sediments were analyzed using the NaI(TI) gamma-ray spectrophotometer and from the activity concentrations their radiological health hazard indices were mathematical computed and the physiochemical parameters of River Kaduna, Nigeria were also carried out. The result of the physiochemical parameters analysed in the river showed that BOD had mean value of 0.070mg/L ± 0.003, COD mean value was 3.84 ±

0.07 mg/L, TSS obtained was 0.018 mg/L ± 0.023, Conductivity and TDS mean results were

0.380 ± 0.001 mS/cm and 0.18 ± 0.026 mg/L respectively while the pH and temperature were 6.70 ± 0.01 and 24.00 ± 0.040 C respectively. The results of the samples analysed showed that the activity concentrations of ^{226}Ra in fishes was 3.83±0.44 Bq/kg, in water was 29.85±0.32 Bq/l and in sediments was 23.97±1.60Bq/Kg. ^{40}K was 149.78±5.041 Bq/Kg, 32.18±0.322 Bq/l, 52.61±0.965 Bq/kg for fish, water, sediment respectively. ^{232}Th was 11.4025±0.9437 Bq/kg,

68.53±0.0786 Bq/kg, 15.57±0.4325 Bq/l for fishes, sediment and water respectively. Radium equivalent dose, absorbed dose rate and annual gonad equivalent dose mean results were 70.76 Bq/kg, 31.62 nGyh-1 and 217.01 mSvyr-1 respectively. Internal and external hazard mean indices were 0.24 and 0.19 respectively. However, the results are below the control samples obtained. This showed that the water, fishes and sediments are within the ICRP/UNSCEAR standards and minimal or no anthropological radiological degradation.

Cancer Risk due to Radionuclides concentration in tin ores and sediments at Barkin –Ladi, Plateau State, North Central, and Nigeria was evaluated by Masok *et al.,* (2015). The specific activity concentrations of natural radionuclides ^{40}K, ^{226}Ra and ^{232}Th in soil samples of abandoned tin ore and sediment from tin mining areas at Barkin-ladi were measured by gamma-ray spectrometry system using Sodium Iodide NaI(Tl) detector. Radiological hazard assessments due to these natural radionuclides were carried out. The calculated activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in the collected ore samples were 275.44 ± 46.14 $Bqkg^{-1}$, 239.95 ± 30.82 $Bqkg^{-1}$ and 778.78 ± 29.30 $Bqkg^{-1}$ respectively while those of the sediment samples were 1608.25 ± 55.60 $Bqkg^{-1}$, 759.62 ± 47.95 $Bqkg^{-1}$ and 4861.82 ±48.78 $Bqkg^{-1}$ respectively. However, the mean absorbed dose rate in ores (629.86 $nGyh^{-1}$) and in sediments (3612.05 $nGyh^{-1}$), the mean radium equivalent in ores (1374 $Bqkg^{-1}$) and in sediments (7835.88 $Bqkg^{-1}$) and the mean annual effective dose rate in ores (0.77 $mSvy^{-1}$) and in sediments (4.43 $mSvy^{-1}$) were all found to be higher than the recommended global average values of 59 nGy^{-1}, 370 $Bqkg^{-1}$ and 0.07 $mSvy^{-1}$ correspondingly. The excess lifetime cancer risk (ELCR) value obtained in this study for the ores samples ranges from 0.0026 to 0.0473 with an average of 0.0107 while the ELCR value in sediments samples was found to range from 0.3205 to 0.0036 with an average of 0.0620. The study shows that an average excess lifetime cancer risk value is more in the sediment samples compare to ore samples, the excess lifetime cancer value within all the sample locations were above the world average value of 0.00029. Therefore, there is a lifetime cancer risk to the general public within this study area thus precaution need to be taken by ensuring inhabitants live in well ventilated houses since no level of radioactivity is harmless.

Ngo is local government headquarters of Andoni Local Government Area, where major activities are carried out and it rivers links to all the major oceans in the area where industrial activities are carryout on daily basis. There is regular dredging and fillings and sand fillings of water ways, erosion and flows, spills which has denude acidification of water in the sea, old corroded leakages and untimely maintained pipelines, industrial and garbage wastes and discharges of heavy water produce contained quantities of hydrocarbon, offshore rigs and oil wells which are abandons. These activities elevate the concentration of radionuclide in sediment, thus the need for study via health hazard and challenges. The study in no doubt will definitely create data for baseline and radiation surveillance reference in the area.

2. METHODS AND MATERIALS

2.1 Samples collection and Preparation

A total of 10 samples of sediments were collected alongside with the use of geographical positioning system (GPS) machine for perfect coordinates (Aman & Avwiri, 2023). Sediment of about 4kg was collected and bag in a black nylon, separately depends on each collection point for proper identification with label of sample site code. The samples were air dry and pulverized for perfect grinding, which was then filled in a container in a quantity needed for activity concentration of element present in the samples. The samples are kept to attain a secular equilibrium of 28 days (Four weeks), to ascertain the level of concentration of radionuclide in the samples in the laboratory.

Gamma-ray spectroscopy is the quantitative study of the energy spectra of gamma-ray sources, both nuclear laboratories and astrophysical. Gamma-ray spectrometer also determines the energies of the gamma-rays photons emitted by the source. It is an instrument of high proximity and accuracy in analyzing the emitted gamma rays in the speculated samples.

2.2 Experimental

The instrument that was used to analyze the work is Gamma –ray Spectrometer. The instrument of a very high quality and proficient in given the exact situation report of the analyze samples. Gamma-ray spectrometer consisting of activated Canberra vertical high purity 2”x2” Sodium iodide [Nal(TI)] detector coupled to ORTEC 456 digibase amplifier, which amplifies the incoming signals and integrates them to volts (0-10 volts) (Azionu *et al.*, 2021). The research was carried out at Federal University of Agriculture Abeokuta, Nigeria with clear and prompt timing of secular equilibrium. **2.3 Risk and Hazard Analyses**

The risk analysis and radiological hazard from activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in the sediment samples were calculated. This analysis includes absorbed dose, annual effective dose equivalent, excess lifetime cancer risk and annual gonnadal effective dose. The calculated values are then compared with the world standard values (USA-EPA, 2012).

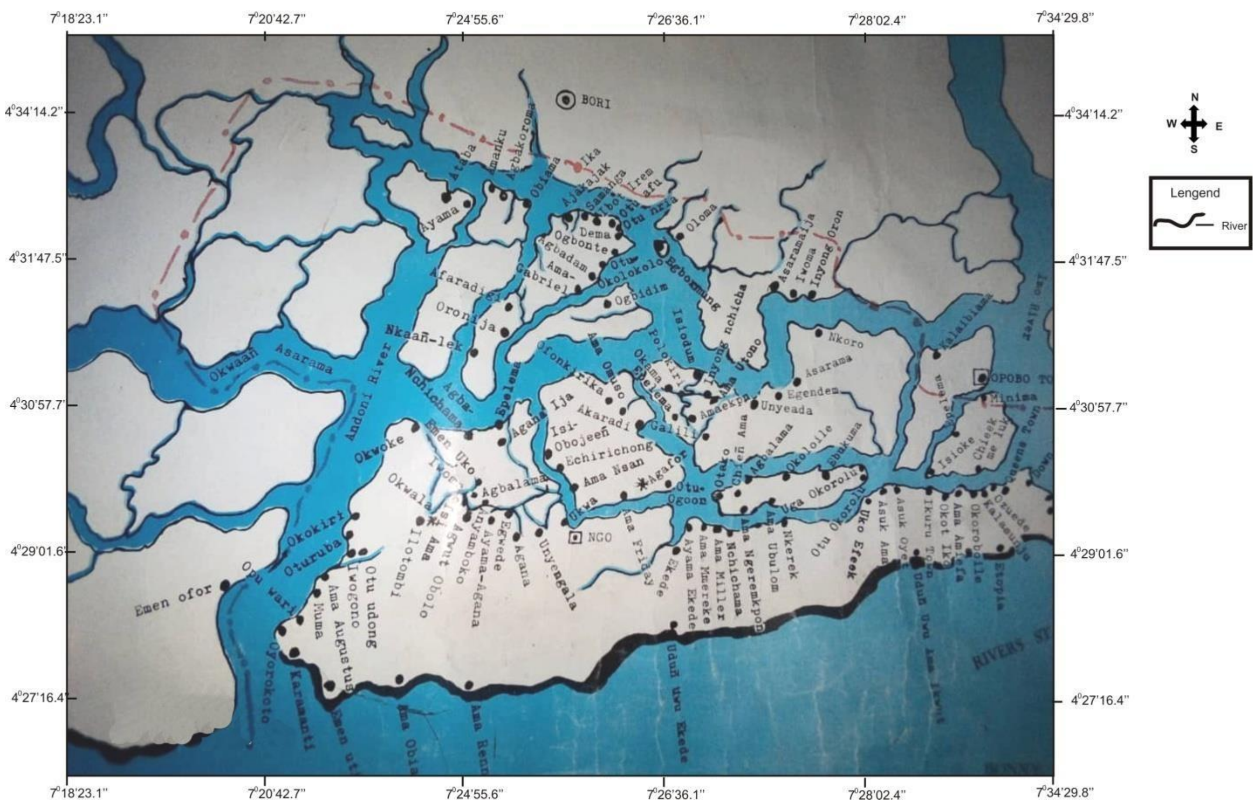

Fig 1: Map of the study area

2.4 Study Area

Ngo Town is the Headquarters of Andoni Local Government Area of Rivers State. It has a major river which is linked to the Atlantic Ocean and sub creeks. Andoni is a coastal area, in Rivers State and located in South – East geopolitical zones of Rivers State.

It is located on 70^{0} 181E and 70^{0} 331E of Greenwich meridian but transverse laterally by latitude

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40^0 311N. It is bounded by the Ogoni's in the North, Bonny to the West, Imo River/Opobo /Ikot Abasi to the East and the Atlantic Ocean to the South (Nte & Aman, 2019).

2.5 Statistical Analysis

The activity concentration of sediment with elements ^{40}K, ^{226}Ra and ^{232}Th are compared with their standard (UNSCEAR, 2000) to evaluate the risks and level of exposure of the people, prior to possible health effects. The valid of instrument of Bar chart and Histogram were used for clear and visible comparison of the radionuclides and radiation radiological parameters as statistical tools.

3. RESULTS AND DISCUSSION

The result of activity concentration of radionuclides ^{40}K, ^{226}Ra and ^{232}Th are presented in Table 1 while the comparisons with the radiation radiological parameters are presented in Table 2.

Fig. 2 to Fig. 4 shows the comparison of the activity concentration of radionuclides ^{40}K, ^{226}Ra and ^{232}Th with the World average values, while Fig. 5 to Fig. 7 shows the histogram analysis of the activity concentration of each of the radionuclides. Fig.8 to Fig.11 shows the statistical comparison of radiological hazard Indices of the activity concentration of ^{40}K, ^{226}Ra and ^{232}Th in sediment with the world average values (UNSCEAR, 2000).

The mean activity concentrations content of ^{40}K, ^{226}Ra and ^{232}Th in sediment from the studied area is shown in Table 1. The mean activities of the samples are 68.48 ± 4.84 $BqKg^{-1}$, 23.47 ± 4.23 $BqKg^{-1}$ and 77.25 ± 12.54 $BqKg^{-1}$ for ^{40}K, ^{226}Ra and ^{232}Th respectively. The mean values of ^{40}K, ^{226}Ra and ^{232}Th when compared with the average weighted value (UNSCEAR, 2000) it was observed that the mean results exceeds the world average value of 30 $Bqkg^{-1}$ for ^{232}Th but was within the world average values for ^{226}Ra and ^{40}K respectively. The obtained result also exceeds that values reported by Essiett *et al.,* (2015) but was below that reported by Ononugbo & Ofuonye (2017). The activity concentration of radionclides contents of the result obtained and that of the reported works shows that industrial and anthropological activities has enhanced the radioactivity of the area. This may also be attributing to pipeline vandalism, fuel and oil spills due to transportation of oil product across the area and dumping of waste as the only major means of disposal in the area.

The specific activity concentration of ^{226}Ra is extremely low in sediment. The relatively low value of ^{226} Ra could be attributed to the mobility of uranium than thorium- ^{232}Th (NCRP, 1987).

Table 2 shows the statistical radiation parameters and hazard indices of absorbed dose, annual effective dose equivalent, annual gonadal equivalent dose, excess lifetime cancer risk, radium equivalent activity (Raeq), internal (Hin) and external hazard (Hex) indices of ^{40}K, ^{226}Ra and

^{232}Th in sediments. It ranged from 38.05 $nGyh^{-1}$ to 91.31 $nGyh^{-1}$ with mean value of 61.67 $nGyh^{1}$ for absorbed dose, 0.05 $mSvy^{-1\ 1}$ to 0.11 $mSvy^{-1}$ with mean value of 0.08 $mSvy^{-1}$ for annual effective dose, 257.62 $mSvyr^{-1}$ to 617.98 $mSvyr^{-1}$ with mean value of 416.92 $mSvyr^{-1}$ for annual gonadal equivalent dose, 0.16 $x10^{-3}$ to 0.39 x 10^{-3} with the mean value of 0.27 x 10^{-3} for excess lifetime cancer risk, 206.12 $Bqkg^{-1}$ to 84.75 $Bqkg^{-1}$for radium equivalent activity, 0.637 $mSvy^{-1}$ to 0.302 $mSvy^{-1}$ for internal hazard indices and 0.557 $mSvy^{-1}$ to 0.229 $mSvy^{-1}$ external hazard indices. When compared with the world average value (UNSCEAR, 2000) of 57 $nGyh^{-1}$, $1\mu Rh^{1}$, $300mSvyr^{-1}$, 0.29 x 10^{-3}, $370Bqkg^{-1}$, $1mSvy^{-1}$ and $1mSvy^{-1}$for absorbed dose rate, annual effective dose equivalent, annual gonadal equivalent dose, excess lifetime cancer risk, radium equivalent activity, internal hazard indices and external hazard indices; it was observed that the result of absorbed dose and annual gonadal equivalent dose were higher than the world average values while the result of annual effective dose equivalent, excess lifetime cancer risk, radium equivalent activity, internal hazard indices and external hazard indices were below the world average values.

This high dose in the area could be attributed to oil company's and radiological activities which involves transportation of radioactive materials in the area, technically enhanced naturally occurring radioactive materials, dumping of refuses and wastes along the riverside, maritime activities in the area, continuously drilling and sand fillings activities in the area.

The high rate of absorbed dose and annual gonadal equivalent dose may increases the numbers of health challenges in the area and side effects on human reproduction cells and organ in the study area. Therefore there is need for medical health facilities in the area.

Table 1 Activity Concentration Result in Sediment

S/n	Samples location	ACTIVITY CONCENTRATION		
		^{40}K (Bq/Kg)	^{226}Ra(Bq/Kg)	^{232}Th (Bq/Kg)
1	NGS 1	118.01 ± 6.04	29.77 ± 2.97	116.97 ± 10.17
2	NGS 2	61.69 ± 3.00	22.85 ± 6.22	66.83 ± 9.72
3	NGS 3	60.48 ± 3.32	27.08 ± 3.40	37.07 ± 9.29
4	NGS 4	74.01 ± 4.58	15.55 ± 5.10	91.12 ± 14.39
5	NGS 5	50.81 ± 4.69	17.08 ± 3.40	55.08 ± 24.19
6	ECS 6	82.23 ± 3.00	24.77 ± 3.73	48.82 ± 10.00
7	AFS 7	19.86 ± 6.20	11.32 ± 5.33	123.23 ± 15.56
8	AFS 8	83.68 ± 6.20	28.23 ± 5.44	76.23 ± 7.50
9	OTS 9	79.33 ± 5.87	29.38 ± 3.45	97.38 ± 11.90
10	AGS 10	54.67 ± 5.52	28.62 ± 3.22	59.78 ± 12.63
	MEAN VALUE	**68.48±4.84**	**23.47± 4.23**	**77.25± 12.54**
	World Average Values	**400**	**35**	**30**

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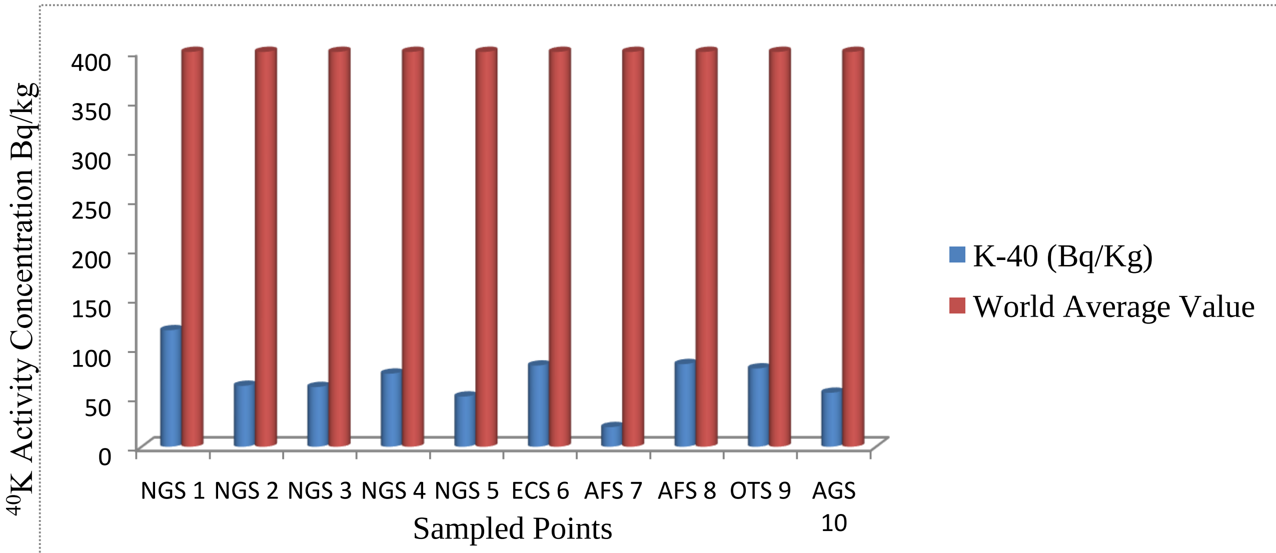

Fig 2: Comparison of ^{40}K activity concentration (Bq/Kg) in Sediment with World average values from Ngo River, Andoni.

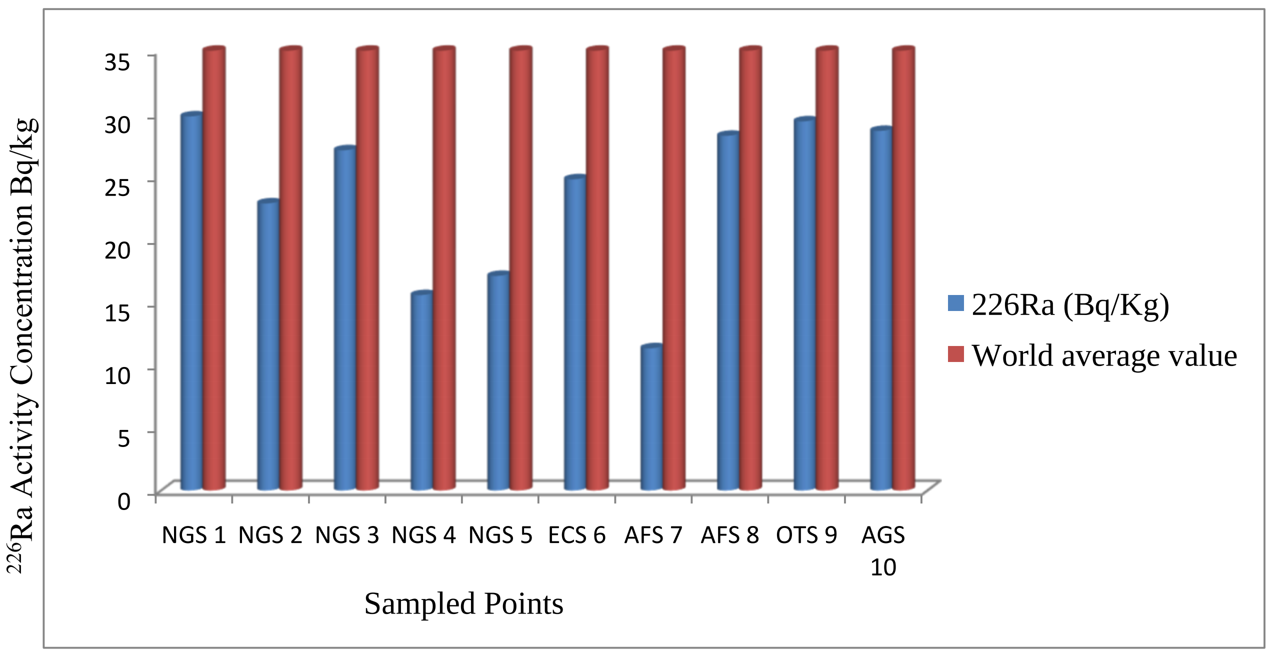

Fig 3: Comparison of ^{226}Ra activity concentration (Bq/Kg) in Sediment with World average values from Ngo River, Andoni.

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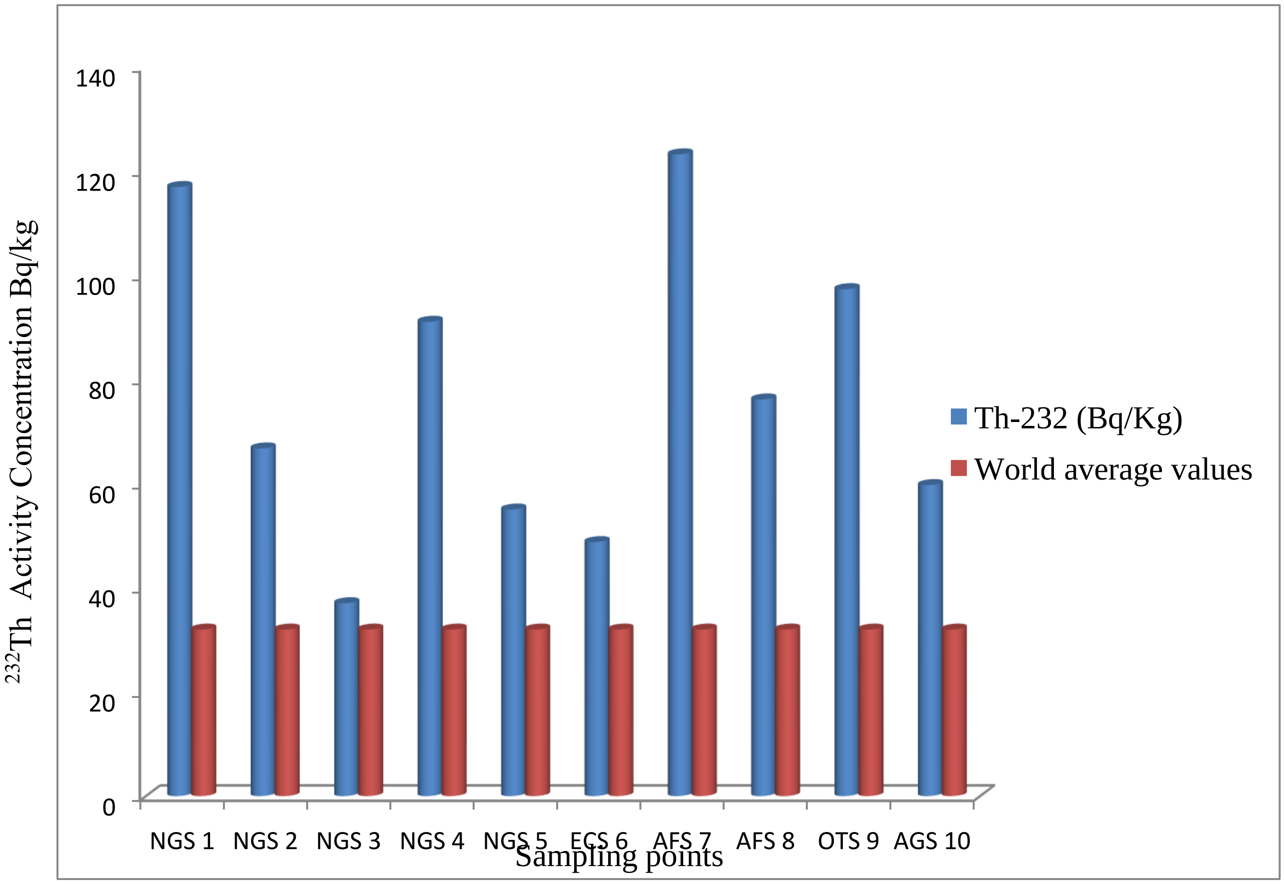

Fig 4: Comparison of ^{232}Th activity concentration (Bq/Kg) in Sediment with World average values from Ngo River, Andoni.

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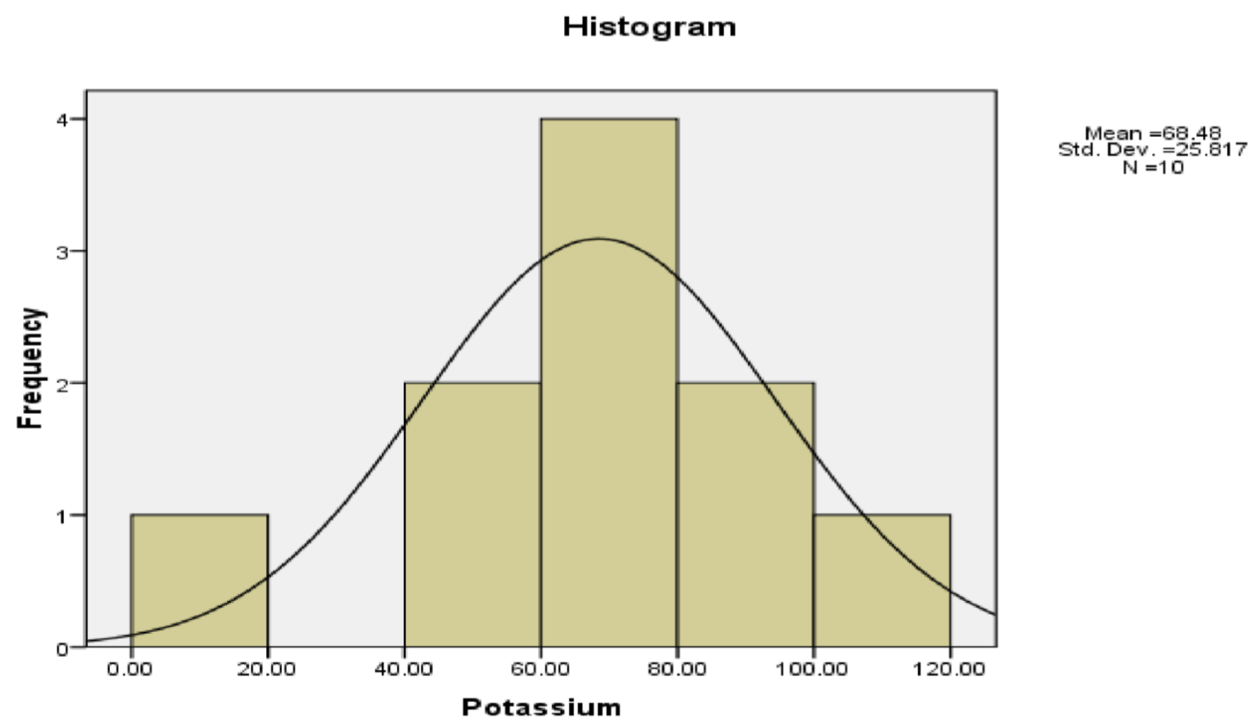

Fig 5 Chart of Activity concentration of ^{40}K in sediment

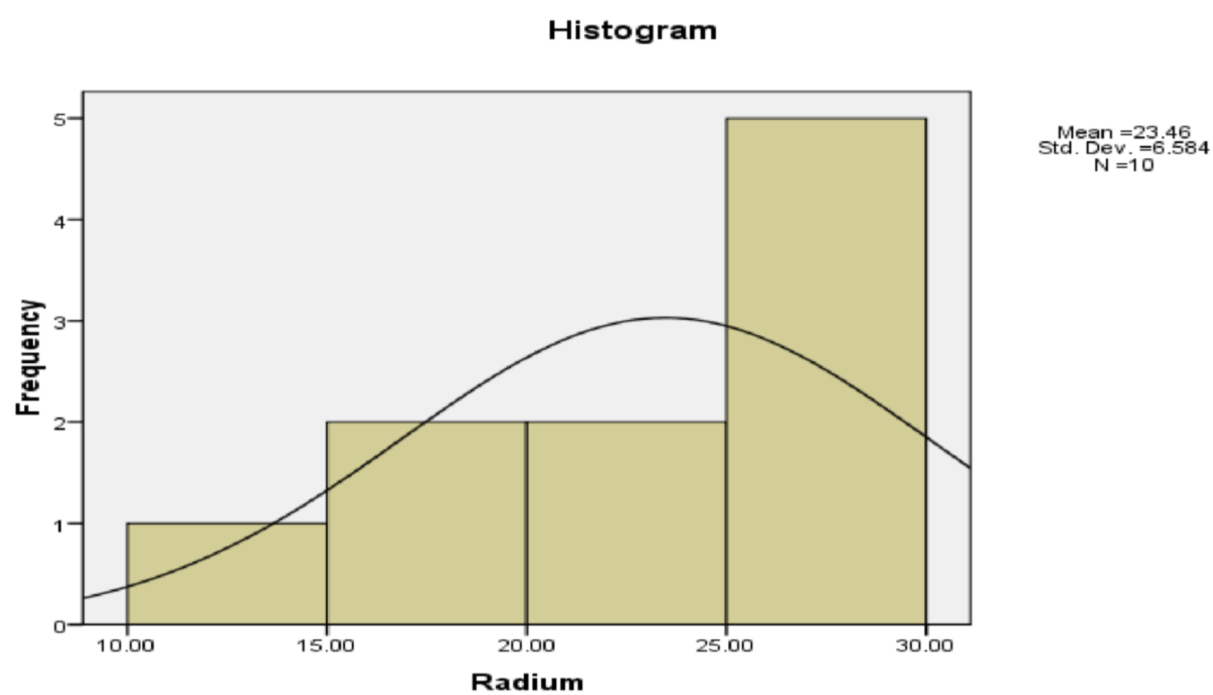

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Fig 6: Chart of Activity concentration of ^{226}Ra in sediment

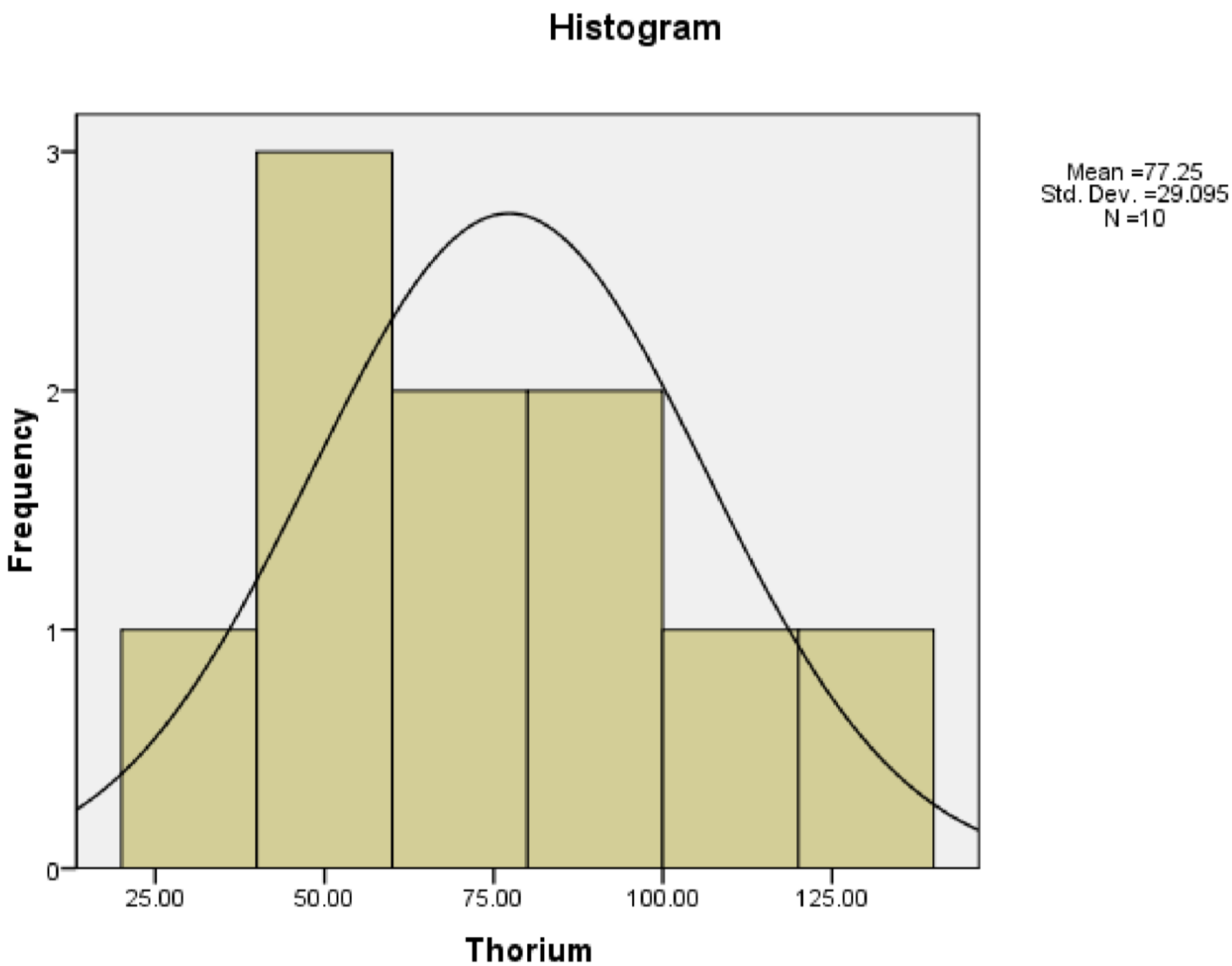

Fig 7: Chart of Activity concentration of ^{232}Th in sediment

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Table 2 Radiation Radiological Hazard Indices in Sediment

S/N	Location	Raeq (Bq/kg)	Hex ($mSvy^{-1}$)	Hin ($mSvy^{-1}$)	D ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	AGED ($mSvy^{-1}$)	ELCR x 10^{-3}
1	NGS 1	206.12	0.557	0.637	91.31	0.11	617.98	0.39
2	NGS 2	123.17	0.333	0.394	54.63	0.07	369.33	0.24
3	NGS 3	84.75	0.229	0.302	38.05	0.05	257.62	0.16
4	NGS 4	151.55	0.409	0.451	66.86	0.08	452.17	0.29
5	NGS 5	99.76	0.269	0.316	44.21	0.05	298.97	0.19
6	ECS 6	100.91	0.273	0.340	45.19	0.06	306.43	0.19
7	AFS 7	189.07	0.511	0.541	82.58	0.10	556.32	0.36
8	AFS 8	143.68	0.388	0.464	63.87	0.08	432.15	0.27
9	OTS 9	174.74	0.472	0.551	77.36	0.10	522.74	0.33
10	AGS 10	118.32	0.320	0.397	52.63	0.07	355.48	0.23
	Mean Value	**139.21**	**0.376**	**0.439**	**61.67**	**0.08**	**416.92**	**0.27**
	UNSCEAR 2000	**370**	**1**	**1**	**57**	**1**	**300**	**0.29**

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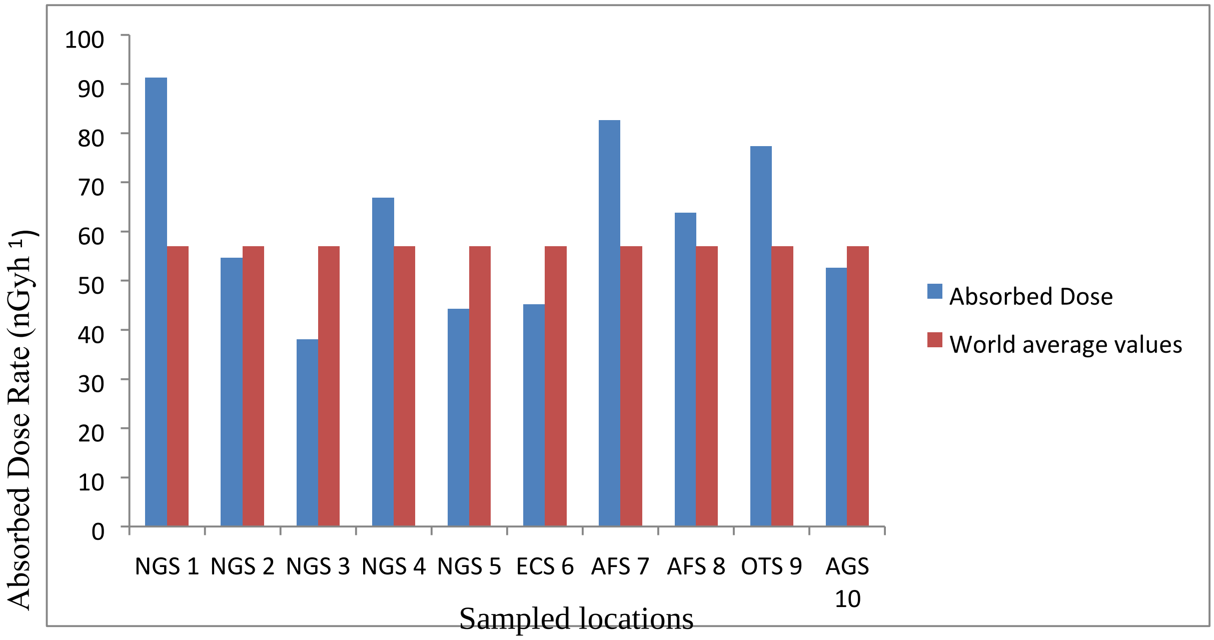

Fig 8: Comparison of Absorbed Dose Rate (nGyh^{-1}) in sediment with World average values in all the locations.

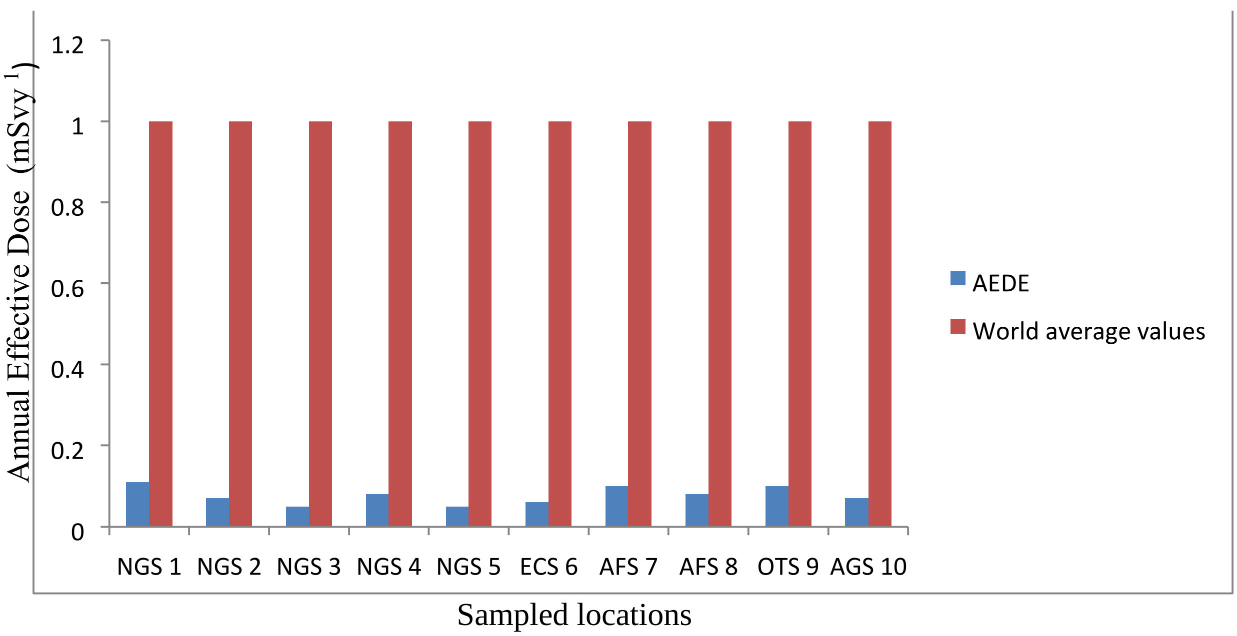

Fig 9: Comparison of Annual Effective Dose (mSvy^{-1}) in sediment with World average values in all the locations

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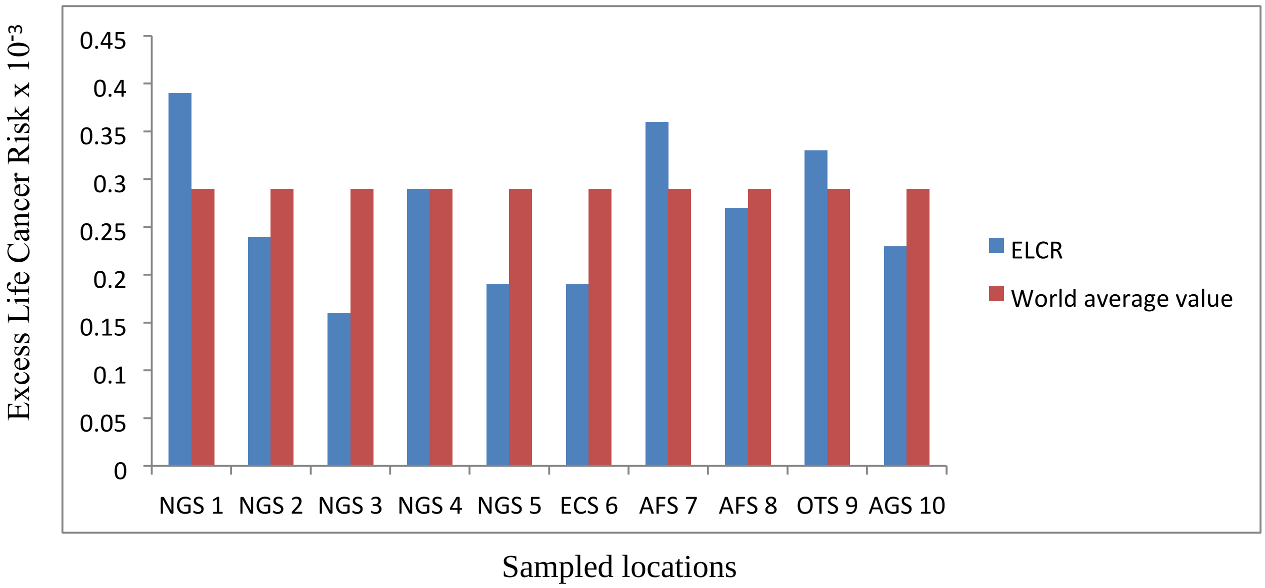

Fig 10: Comparison of Excess Lifetime Cancer Risk in sediment with World average values in all the locations

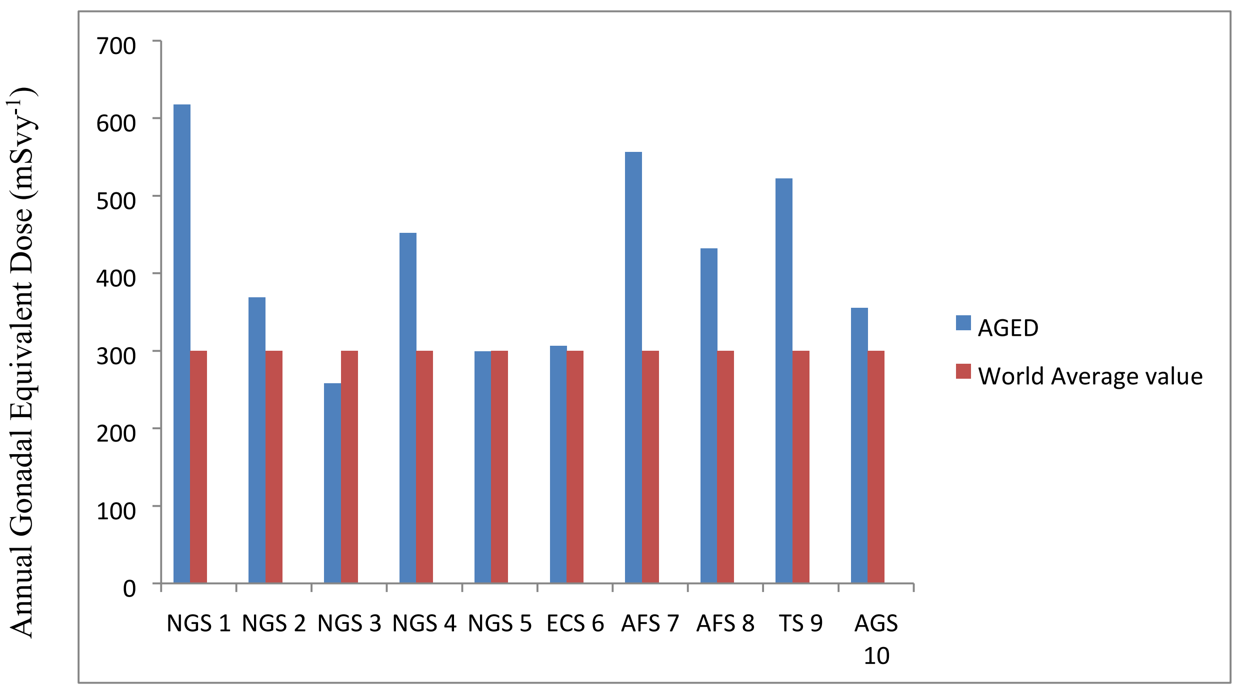

Fig 11: Comparison of Annual Gonadal Equivalent Dose in sediment with world average value in all the locations

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4. CONCLUSION

The assessment of radionuclides contents of sediments in Ngo River, Andoni LGA of Rivers State, Nigeria has been carried out successfully with ten (10) samples collected at different points along the Ngo River and it environ. The samples are analyzed through the use of Sodium Iodide Nal(TI) Detector. The result of the findings shows the presents of three naturally occurring radionuclides ^{40}K, ^{226}Ra and ^{232}Th respectively. The mean activity concentrations content of ^{40}K, ^{226}Ra and ^{232}Th in sediment from the studied area are 68.48 ± 4.84 BqKg^{-1}, 23.47 ± 4.23 BqKg^{-1} and 77.25 ± 12.54 BqKg^{-1} for ^{40}K, ^{226}Ra and ^{232}Th while when compared with (UNSCEAR, 2000) world average value for ^{40}K, ^{226}Ra and ^{232}Th, it was observed that the mean results exceeds the world average values of 30 Bqkg^{-1} for ^{232}Th and below 400Bqkg^{-1}for ^{40}K, and 35 Bqkg^{-1} for ^{226}Ra respectively.

The radiation radiological hazards parameters calculated from the values the measurement of radionuclide concentration contents in sediment shows that the absorbed dose and annual gonadal equivalent dose are higher than the permissible limits. Therefore the area may be grossly polluted and with health challenges including reproductive cells malfunction among the dwellers in the study area. The high dose may be attributed to industrial exploration and exploitation activities of multi-dimensional companies, oil and gas activities of multinational companies, high transporting of radioactive materials in the area across the sea, erosion and washing of materials to the river, bunkeries activities, Pipeline vandalism, corroded pipes, and spills from engine boat and flying boat transit in the area. The area needs fast intervention as health risk is very high and people are prone to more hazards.

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