

TRANSFER FACTOR ANALYSIS OF RADIONUCLIDES OF WATER, SEDIMENTS AND FISH (BONGA SHAD) IN COASTAL COMMUNITIES OF OKRIKA, RIVERS STATE, NIGERIA

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ABSTRACT

*Analysis of transfer ration of radionuclides concentration of Water to Fish (Bonga Shad) and Sediments to Fish (Bonga Shad) samples of the Coastal communities of Okrika, in Rivers State, which lies between latitude: 4^o.43'44" N and 4^o.45'57" N and ranged from longitude: 7^o.3'20" E to 7^o.6'42" E. Nigeria using gamma spectroscopy method with NaI (TI) detector. The transfer factor of radionuclides from for Sediments to Fish, ranged from 1.28 - 21.57 with a mean value of 8.35± 6.61, 0.19 to 5.74 with a mean value of 2.37 ± 2.60 and 1.49 -5.74 with a mean value of 2.82 ±1.29 for ⁴⁰K, ²³⁸U and ²³²Th respectively, and the magnitude of the transfer factor is of the order ⁴⁰K > ²³⁸U > ²³²Th. The Transfer factor of radionuclides from the Water to Fish ranged from 0.77 to 3.79 with a mean of 3.79 ± 2.05, 0.26 to 47.73 with a mean 6.58 ±15.52 and 0.94 – 3.43 with a mean value of 2.02 ± 0.90 for ⁴⁰K, ²³⁸U and ²³²Th respectively, and the magnitude of the transfer factor is of the order ²³⁸U > ⁴⁰K > ²³²Th. These results obtained are all higher than the stipulated reference point of 1.0 which indicates that bioaccumulation of radionuclides exist in the Fish (Bonga Shad) samples from the intake of radionuclides from water and sediments of the Coastal communities of Okrika.
Keywords: Coastal Communities, Natural Radionuclides, Transfer Factor.*

Introduction

The aquatic ecosystem is a major area of the natural environment and is directly affects to human in numerous ways (Ebong *et al.*, 2014). The primary environmental challenges to aquatic ecosystems are presumably degradation, pollution, biodiversity loss, and habitat destruction. Furthermore, the

contamination of aquatic habitats has raised severe environmental and health issues across the world. (Abdel Barki, 2011). Pollutants can generate a variety of biological reactions in fish, impacting organisms causing a variety of negative consequences on natural life (Adefemi, *et al*, 2004; Biswas *et al*, 2012).

Human are exposed to radiation from radioactive materials or naturally occurring radionuclides through various media such as ingestion, absorption, and inhalation of daily interaction with the environment (Cochran and David, 2008; Groudev *et al.*, 2004; Adamu *et al.*, 2013). Fish are good bioindicators of pollution in aquatic environment because fish are easily sampled. Fish accumulate metal(loid)s like heavy metals and radionuclides and bioaccumulation of these substances through aquatic contamination may pose serious effects on human health through consumption of these aquatic species. because it may be easily incorporated into the food chain (Marlinda, 2008; Adeleye *et al.*, 2020; Samavat *et al.*, 2006).

In this context, our focus will be aimed at river water of the coastal communities of Okrika. Several reports have indicated that radioactive and toxic waste compounds are discharged into the environment via water bodies through creek and rivers as a pathway disposal. These radioactive and toxic substances contaminates the environment, river water quality and fish species. Studies have shown that the consumption of fish product is one of the pathways through which human are exposure to radiation thereby increasing the dose level received by man, especially if it exceeds the guidance level as stipulated by World Health Organization (WHO, 2011).

When radionuclides wastes are released into the environment through rivers, they persist for a long time until they no longer have the potential to negatively affect the environment. They persist through radioactive decay, causing radiation exposures into the future (UNSCEAR, 2000). These, radionuclides, are absorbed in fish species, water, sediments, crops and vegetables, animals of the of the coastal communities Therefore, it is important to assess the transfer factor of radionuclides between water, fish, and sediments samples of the coastal communities of Okrika.

Materials and Methods

Study Area

Okrika Town is one of the port towns in River State. It is well known for it Fishing activities. The fish consumed within the study area act as one of the major source of proteins to the local residents. The coastal community is located within the latitude range of : 4⁰.43'44" N to 4⁰.45'57" N and longitude range of 7⁰.3'20" E to 7⁰.6'42" E (Sokari, 2018). Few multinational companies and industries are hosted within the Coastal Communities of Okrika. The sampled locations of the nine communities are shown in indicated in Figure 1.

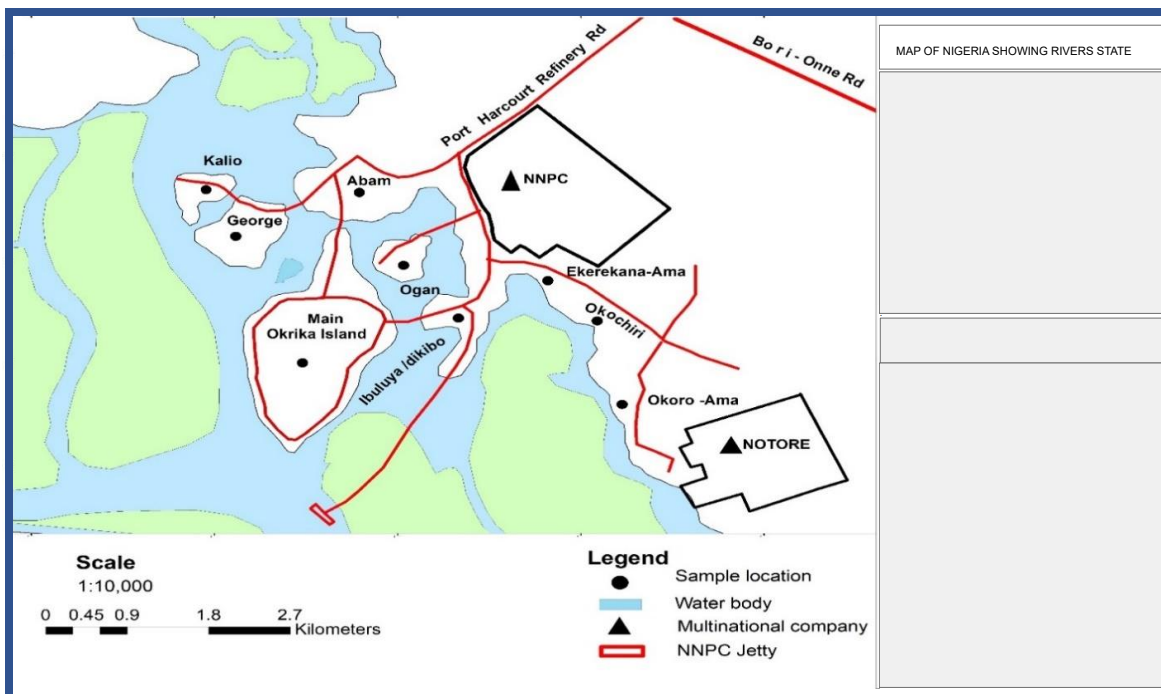


Figure 1: Modified Google Map of Okrika LGA Showing the Study Area

Sample Collection and Preparation

Two (2) samples of River water, Sediments and Fish were each from the Nine (9) Coastal communities of Okrika, making a total of fifty-four (54) samples. The sediments were obtained from a depth of 20 cm from the bottom of the rivers with the help of the rural divers. It was sundried and then pulverised to ensure homogeneity. The Fish samples were obtained from the coastal communities with the help of the community fisher men. It was dried in a controlled oven at 70°C until no change in mass is detectable. It was then pulverized to ensure homogeneity. Each of the sediments and Fish samples were weight at 250 grams. 2- Litres of plastic container was used in the collection of the river water, the containers rinsed three times with the river water being collected in order reduced the contamination from the sample container. The river water was collected and about 1% of the total volume was left of air space for thermal expansion. The samples were immediately acidified with 10 ml of HCl per Litre to prevent absorption of radioactivity on the walls of the containers (IAEA, 2003; Tchokossa *et al*, 1999). The sample containers were then tightly closed with the cover of the container. The river water, sediments and fish samples were then transported to the Nigerian Nuclear Regulatory Agency (NNRA) in Ibadan for Gamma-Ray Spectroscopy Analysis at the Federal University of Ibadan, Abeokuta for specific activity concentration measurement.

Gamma-Ray Spectroscopy

The activity concentration measurement was determined using a thallium activated Canberra vertical high purity 2"×2" Sodium iodide NaI (TI) detector connected to ORTEC 456 Digi base amplifier. The detector was connected to a computer program MAESTRO window that matched gamma energies to a library of possible isotopes according to IAEA standard. The detector was shielded by 15cm

thick lead on all four sides and 10 cm thick on top. The energy resolution of 2.0 keV and relative efficiency of 33% at 1.33Mev was achieved in the system with the counting time of 10800 seconds, Sodium iodide detector were used.

Transfer Factor

Radionuclides maybe transferred between biota and reference media (water and sediment) in river water ecosystem. Referring to bioaccumulation models, the aquatic organisms are assumed to be in equilibrium with water and sediment in their environment (IAEA, 2010). The accumulation of radionuclides in biota can be represented in simplified ratio by relating radionuclides concentration in biota to radionuclides concentration in water and sediment (IAEA, 2010). The transfer factor radionuclides between fish-water-sediment using Equation 1-3(Jianguo and Zhaorong, 2008; Luna-Porres et al., 2014; Ugbede *et al.*, 2021).

$$T.F = \frac{\text{Activity Concentration of a specific radionuclide in fish Bq/kg (dry weight)}}{\text{Activity Concentration of same radionuclide in sediments Bq/kg(dry weight)}} \quad (1)$$

$$T.F = \frac{\text{Activity Concentration of a specific radionuclide in fish Bq/kg(dry weight)}}{\text{Activity Concentration of same radionuclide in river Water } \left(\frac{\text{Bq}}{\text{l}}\right)} \quad (2)$$

Results and Discussions

The results of the activity concentration of water samples are presented in Table 1. The average activity concentration of radionuclides ranged in River Water ranged from 105.12 in Ekerekana-Ama to 121.07 in Ogan-Ama with a mean value of 147.06±34.01 Bq/l, varied from 0.22 in Ibuluya/Dikibo to 10.1 in Kalio-Ama with a mean value of 4.03±3.70 Bq/l and ranged from 2.57 in Kalio-Ama to 6.25 Ekerekana-Ama with a mean value of 4.65±1.20 Bq/l in terms of ⁴⁰K, ²³⁸U, and ²³²Th respectively as Tabulated in Table 2. The radionuclides are of the order ⁴⁰K > ²³²Th > ²³⁸U. This order in phase to the work carried out by (Agyeman *et al.*, 2019; Oyebanjo and Magbagbeola, 2015).

The results of the activity concentration of sediments samples are presented Table 3. The mean activity concentration value of radionuclides in each of the Coastal community is tabulated in Table 4. The radio- isotope ⁴⁰K ranged from 116.90 on Okoro-Ama to 22.88 in Kalio- Ama with a mean value of 80.88±32.27, ²³⁸U varied from 1.97 in Abam/Igbiri to 10.15 in Kalio-Ama with a mean value of 5.27±3.21 and ²³²Th has a minimum value of 2.60 in Main Okrika Island to 3.82 in Ekerekana-Ama with a mean value of 3.22±0.48. The radionuclides are in the order of ⁴⁰K > ²³²Th > ²³⁸U, the results obtained agrees to the study carried out in Ogun River Sediments (Sowole and Ehindero, 2017).

The results of the activity concentration of Fish samples are presented in Table 5. The average activity concentration of radionuclides is shown in Table 6. The activity concentration ranged from 104.88 in Ibuluya/Dikibo to 1271.04 in George-Ama with a mean value of 551.47±336.50 Bq/Kg, varied from 1.04 in Okoro-Ama to 49.35 in George- Ama with a mean value of 13.67±14.47 Bq/Kg and ranged from 4.47 in Abam/Igbiri to 16.62 in George-Ama with a mean value of 8.81±3.32 Bq/Kg in terms of ⁴⁰K, ²³⁸U, and ²³²Th respectively. The radionuclides are of the order ⁴⁰K > ²³⁸U > ²³²Th. This order is similar to the work previously reported by (Alam *et al.*, 1995; Ogundele *et al.*, 2020; Adeleye *et al.*, 2020).

Table 7. gives the transfer factor of radionuclides from Sediments to Fish, and

water to Fish respectively. For Sediments to Fish, the transfer factor ranged from 1.28 - 21.57 with a mean value of 8.35 ± 6.61 , 0.19 to 5.74 with a mean value of 2.37 ± 2.60 and 1.49 - 5.74 with a mean value of 2.82 ± 1.29 for ^{40}K , ^{238}U and ^{232}Th respectively. The values are all above the stipulated reference point of 1.0 which mean that there is bioaccumulation of radionuclides exist in the fish from the intake of radionuclides from sediments, if the value is less than zero it means there is bioaccumulation does not exist (Oyakhilome and Ajiwe, 2019; UNSCEAR, 2000). The magnitude of the transfer factor is of the order $^{238}\text{U} > ^{40}\text{K} > ^{232}\text{Th}$. as shown in Figure 2. Also, the Transfer factor of radionuclides from the Water to Fish ranged from 0.77 to 3.79 with a mean of 3.79 ± 2.05 , 0.26 to 47.73 with a mean 6.58 ± 15.52 and 0.94 - 3.43 with a mean value of 2.02 ± 0.90 for ^{40}K , ^{238}U and ^{232}Th

respectively. These results obtained are all higher than the stipulated reference point of 1.0 which mean that bioaccumulation of radionuclides exist in Fish samples from the intake of radionuclides from water, and the magnitude of the transfer factor in this sequence is of the order $^{238}\text{U} > ^{40}\text{K} > ^{232}\text{Th}$ as displayed in Figure 3. The presence of radionuclides in high levels in Fish aquatic environment does not indicate a direct toxic risk to fish, if there is no significant accumulation of metals by fish tissues. But in the real perspective, the most results of the Transfer Factors (TF) were found higher than unity. And this work agrees with the study carried out on Transfer Factors for, water, sediments and plant in Fish (*Tilapia nilotica*) in Nasser Lake (Rashed, 2014) and water, sediments and *Tilapia* fish samples in Saudi Arabia (Abdel-Baki *et al.*, 2011).

Table 1: Activity Concentration in Water Samples

ACTIVITY CONCENTRATION (Bq/l)					
S/N	Location	Code	K-40	U-238	Th-232
1	Main Okika Island-1	MOI/W-1	141.60±9.95	BDL	5.60±0.54
2	Main Okika Island-2	MO/W -2	188.90±13.41	3.93±0.84	6.50±0.63
3	Ogan-Ama-1	OGA/W -1	214.07±15.20	BDL	3.39±0.33
4	Ogan-Ama-2	OGA/W -2	214.07±15.20	BDL	3.39±0.33
5	Kalio-Ama-1	KAL/W -1	134.10±9.42	8.50±1.73	2.51±0.24
6	Kalio-Ama-2	KAL/W -2	108.86±7.65	11.70±2.40	2.63±0.25
7	Okochiri-1	OKC/W -1	110.65±7.78	1.60±0.32	5.72±0.55
8	Okochiri-2	OKC/W -2	187.52±13.17	7.66±1.58	5.29±0.51
9	Ibuluya/Dikibo-1	IBU/W -1	135.73±9.54	0.30±0.10	3.52±0.34
10	Ibuluya/Dikibo-2	IBU/W -2	136.20±9.57	0.14±0.03	4.67±0.45
11	Abam/Igbiri-1	ABM/W -1	109.12±7.67	6.92±1.41	4.77±0.46
12	Abam/Igbiri-2	ABM/W -2	147.08±10.44	11.20±2.37	4.70±0.45
13	George-Ama-1	GEG/W -1	143.68±10.10	BDL	5.32±0.51
14	George-Ama-2	GEG/W -2	192.94±13.56	BDL	4.36±0.42
15	Okoro-Ama-1	OKRW -1	60.52±4.29	0.37±0.08	4.04±0.39
16	Okoro-Ama-2	OKR/W -2	188.20±13.23	7.55±1.55	4.81±0.50
17	Ekerekana-1	EKE/W -1	177.03±12.44	0.96±0.20	5.52±0.53
18	Ekerekana-2	EKE/W -2	33.21±2.36	7.78±1.65	6.97±0.68

BDL= below detectable limit

Table 2: Mean Activity Concentration in Water Samples

S/N	location	MEAN ACTIVITY CONCENTRATION (Bq/l)		
		K-40	U-238	Th-232
1	Main Okika Island	177.08	3.93	6.05
2	Ogan-Ama	214.07	BDL	3.39
3	Kalio-Ama	121.48	10.1	2.57
4	Okochiri	149.09	4.63	5.51
5	Ibuluya/Dikibo	135.97	0.22	4.10
6	Abam/Igbiri	128.10	9.06	4.74
7	George-Ama	168.31	BDL	4.84
8	Okoro-Ama	124.36	3.96	4.43
9	Ekerekana-Ama	105.12	4.37	6.25
Mean		147.06±34.01	4.03±3.70	4.65±1.20

BDL = below detectable limit

Table 3: Activity Concentration in Sediments Samples

S/N	location	Code	CONCENTRATION (Bq/Kg)		
			K-40	U-238	Th-232
1	Main Okika Island-1	MOI/SD-1	31.21±2.24	4.93±1.07	2.47±0.24
2	Main Okika Island-2	MOI/SD -2	80.79±5.79	BDL	2.73±0.27
3	Ogan-Ama-1	OGA/SD -1	85.86±6.17	2.21±0.49	3.38±0.33
4	Ogan-Ama-2	OG/SD A-2	67.98±4.87	3.77±0.82	3.10±0.30
5	Kalio-Ama-1	KAL/SD -1	30.44±2.18	10.15±2.20	2.78±0.27
6	Kalio-Ama-2	KAL/SD -2	15.32±1.10	BDL	3.96±0.39
7	Okochiri-1	OKC/SD -1	89.44±6.43	15.97±3.43	4.23±0.41
8	Okochiri-2	OKC/SD -2	69.43±4.97	1.24±0.28	3.81±0.37
9	Ibuluya/Dikibo-1	IBU/SD -1	94.04±6.74	BDL	2.69±0.26
10	Ibuluya/Dikibo-2	IBU/SD -2	69.79±5.02	BDL	2.68±0.26
11	Abam/Igbiri-1	ABM/SD -1	62.63±4.50	1.97±0.44	2.77±0.27
12	Abam/Igbiri-2	ABM/SD -2	66.76±4.79	BDL	3.21±0.31
13	George-Ama-1	GEG/SD -1	75.82±5.43	10.63±2.33	2.57±0.25
14	George-Ama-2	GEG/SD -2	121.74±8.72	2.00±0.45	3.22±0.31
15	Okoro-Ama-1	OKO/SD -1	151.62±10.85	5.59±1.24	3.85±0.37
16	Okoro-Ama-2	OKO/SD -2	82.17±5.90	BDL	2.89±0.28
17	Ekerekana-Ama-1	EKE/SD -1	94.30±6.77	10.05±2.17	2.58±0.25
18	Ekerekana-Ama-2	EKE/SD -2	166.39±11.92	3.74±0.82	5.08±0.49

BDL= below detectable limit

Table 4: Mean Activity Concentration in Sediment Samples

S/N	location	MEAN ACTIVITY (Bq/Kg)		
		K-40	U-238	Th-232
1	Main Okika Island	56.00	4.93	2.60
2	Ogan-Ama	76.92	2.99	3.24
3	Kalio-Ama	22.88	10.15	3.37
4	Okochiri	79.44	8.61	4.02
5	Ibuluya/Dikibo	81.93	BDL	2.69
6	Abam/Igbiri	64.70	1.97	2.99
7	George-Ama	98.78	6.32	2.90
8	Okoro-Ama	116.90	5.59	3.37
9	Ekerekana-Ama	130.35	6.90	3.83
Mean		80.88±32.27	5.27±3.21	3.22±0.48

BDL = below detectable limit

Table 5: Activity Concentration in Fish Samples

S/N	location	Code	ACTIVITY CONCENTRATION (Bq/Kg)		
			K-40	U-238	Th-232
1	Main Okika Island-1	MOI/F-1	753.65±52.90	BDL	10.39±1.00
2	Main Okika Island-2	MOI/F -2	865.68±60.78	20.88±4.26	9.89±0.95
3	Ogan-Ama-1	OGA/F -1	188.90±13.41	3.93±0.84	6.50±0.63
4	Ogan-Ama-2	OGA/F -2	595.70±41.81	BDL	10.10±0.97
5	Kalio-Ama-1	KAL/F -1	642.56±45.12	15.56±3.18	8.17±0.79
6	Kalio-Ama-2	KAL/F -2	344.42±24.17	6.57±1.34	9.25±0.89
7	Okochiri-1	OKC/F -1	251.36±17.96	10.74±2.38	9.01±0.88
8	Okochiri-2	OKC/F -2	545.63±38.31	BDL	8.54±0.82
9	Ibuluya/Dikibo-1	IBU/F -1	BDL	BDL	7.53±0.73
10	Ibuluya/Dikibo-2	IBU/F -2	104.88±7.53	10.50±2.30	8.52±0.83
11	Abam-1	ABM/F -1	168.32±11.82	1.63±0.33	5.73±0.60
12	Abam-2	ABM/F -2	490.93±34.50	16.10±3.30	3.20±0.31
13	George-Ama-1	GEG/F -1	1842.73±129.40	49.35±10.10	23.32±2.24
14	George-Ama-2	GEG/F -2	699.34±49.10	BDL	9.92±0.95
15	Okoro-Ama-1	OKR/F -1	725.63±50.94	BDL	8.02±0.77
16	Okoro-Ama-2	OKR/F -2	509.19±36.32	1.04±0.24	5.22±0.51
17	Ekerekana-Ama-1	EKE/F -1	540.70±37.96	BDL	5.81±0.60
18	Ekerekana-Ama-2	EKE/F -2	495.94±34.83	6.70±1.40	9.6±0.92

BDL= below detectable limit

Table 6: Mean Activity Concentration in Fish Samples

S/N	LOCATION	MEAN ACTIVITY CONCENTRATION (Bq/Kg)		
		K-40	U-238	Th-232
1	Main Okika Island	837.67	20.88	10.02
2	Ogan-Ama	392.30	3.93	8.30
3	Kalio-Ama	493.49	11.07	8.71
4	Okochiri	398.50	10.74	8.78
5	Ibuluya/Dikibo	104.88	10.50	8.03
6	Abam	329.63	8.87	4.47
7	George-Ama	1271.04	49.35	16.62
8	Okoro-Ama	617.41	1.04	6.62
9	Ekerekana-Ama	518.32	6.70	7.71
	Mean	551.47±336.50	13.67±14.47	8.81±3.32

BDL = below detectable limit

Table 7: Transfer Factor of Activity Concentration of Radionuclides

S/N	location	<u>Sediments to</u>					
		<u>Fish</u>				<u>Water to Fish</u>	
		K-40	U-238	Th-232	K-40	U-238	Th-232
1	Main Okika Island	14.96	4.24	3.85	4.73	5.31	1.66
2	Ogan-Ama	5.10	1.31	2.56	1.83	N/A	2.45
3	Kalio-Ama	21.57	1.09	2.58	4.06	1.10	3.39
4	Okochiri	5.02	1.25	2.18	2.67	2.32	1.59
5	Ibuluya/Dikibo	1.28	N/A	2.99	0.77	47.73	1.96
6	Abam/Igbiri	5.10	4.50	1.49	2.57	0.98	0.94
7	George-Ama	12.87	7.81	5.74	7.55	N/A	3.43
8	Okoro-Ama	5.28	0.19	1.96	4.96	0.26	1.50
9	Ekerekana-Ama	3.98	0.97	2.01	4.93	1.53	1.23
	Min	1.28	0.19	1.49	0.77	0.26	0.94
	Max	21.57	7.81	5.74	7.55	47.73	3.43
	Mean	8.35±	2.37±	2.82±1.29	3.79±2.05	6.58±15.52	2.02±
		6.61	2.60				0.90
	UNSCEAR	1	1	1	1	1	1

BDL = below detectable limit

N/A= not applicable

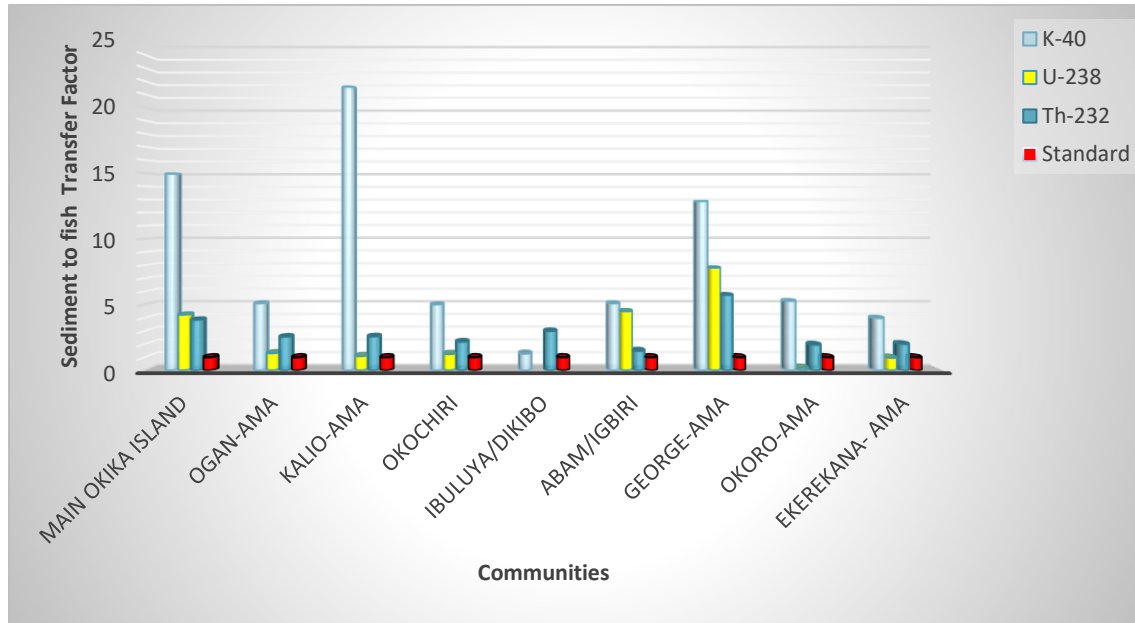


Fig 2: Transfer factor of Radionuclides from Sediments to Fish

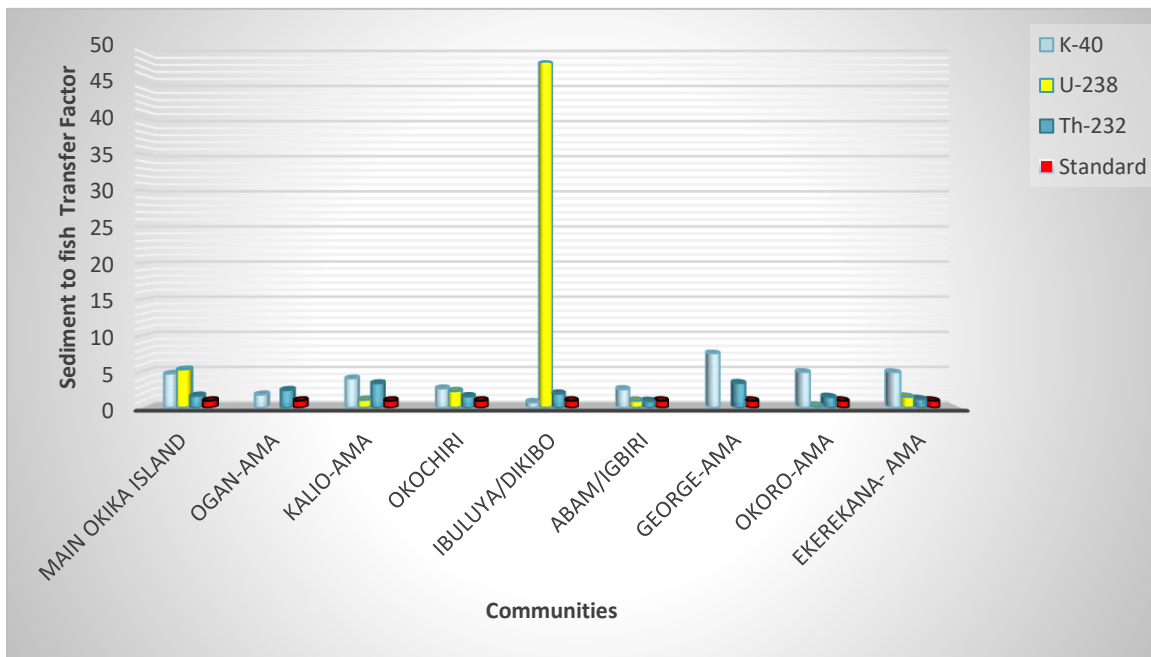


Fig. 3: Transfer factor of Radionuclides from Water to Fish

Conclusion

It was generally noted that ²³⁸U and ⁴⁰K has the highest rate of Transfer factor from sediments to fish and water to fish respectively and the least value is found in ²³²Th. Bioaccumulation of radionuclides occurs in the fish (*Bonga Shad*) samples of the Coastal communities of Okrika. The higher transfer ratio in the fish (*Bonga Shad*) samples could be attributed to their habitat, dietary and species.

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