IMPACT OF SOIL RADIOACTIVITY LEVELS ON CANCER RISK IN ATBARA REGION: A STUDY UTILIZING RELATIVE RISK ANALYSIS

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ABSTRACT

This study investigates the impact of soil radioactivity levels on cancer risk in the Atbara region. Utilizing a gamma-ray spectroscopy system with a NaI (Tl) "1.5×2" detector in a low-background environment, soil samples were collected and analysed for concentrations of Th-232, U-238, and K-40. The measured radioactivity concentrations ranged from 29.34 to 20.34 Bq/kg for U-238, from 20.92 to 7.17±0.22 Bq/kg for Th-232, and from 220.50 to 176.51 Bq/kg for K-40. Additionally, absorbed dose rate values ranged from 22.9±1.80 to 32.4±1.70 nGy/h, with annual effective doses varying from 28.10±2.20 to 42.33±2.29 µSv/y. Through relative risk analysis, the calculated relative risk (RR) values for each sample were determined, providing insights into the potential cancer risk associated with radiation exposure. The results indicate that while detectable levels of radioactivity were found in the soil samples, they remain below international safety thresholds. This study contributes to our understanding of environmental radioactivity in the Atbara region and underscores the importance of continued monitoring to ensure the health and safety of the local population.

KEYWORDS: *Soil radioactivity, Relative risk analysis, Cancer risk assessment, Atbara region*

1- INTRODUCTION

The assessment of natural radioactivity in soil holds significant importance for scientific inquiry, with widespread interest among researchers globally. Recent decades have witnessed extensive national surveys aimed at evaluating terrestrial gamma dose rates to understand outdoor occupation risks accurately[1]. Additionally, estimating the distribution of radiation dose is pivotal in assessing health risks to populations and documenting changes in environmental radioactivity, particularly due to anthropogenic activities [2]. It is well recognized that natural environmental radioactivity varies based on geological and geographical conditions, resulting in distinct levels across different geological regions [3].

Human exposure to ionizing radiation is multifaceted, stemming from various sources, including naturally occurring radioactive elements in soil and rocks, cosmic rays, and internal exposure through food, water, and air [4]. Of particular interest are natural radionuclides with half-lives comparable to the age of the Earth or their corresponding decay products, such as 232Th, 238U, and 40K. The distribution of these radionuclides in soil is influenced by the geological formations, highlighting the complexity of their presence in the environment [5].

While radioisotopes permeate the Earth's ecosystem without posing significant problems to human beings, certain isotopes entering the food chain may reach concentrations that are potentially harmful to organisms and their consumers[6]. Consequently, a higher concentration of radioactive substances in the environment is undesirable due to associated health risks.

The present study aims to assess the impact of soil radioactivity levels on cancer risk in the Atbara region, taking into account the presence of cement industry activities and artisanal mining in nearby areas. Through a meticulous examination of naturally occurring radionuclides (232Th, 238U, and 40K) in soil, the study endeavors to evaluate γ-radiation doses. Soil samples were meticulously collected and subjected to γ-ray spectrometry analysis in the laboratory. The investigation encompasses measurements of radionuclide activity concentrations in surface soil, outdoor gamma absorbed doses, and the external hazard index (Hex), with the ultimate goal of comprehensively understanding radiation exposure levels in the study area.

2- METHOD

The study was conducted in Atbara, situated at 17°43′N 33°59′E in the River Nile State of northeastern Sudan. Atbara is renowned for its significance as a railway junction and manufacturing center, earning it the moniker "Railway City." The sampling locations were carefully selected to ensure representativeness, with each soil sample collected from nine subsamples within an area of approximately 120 m^2. Samples were obtained from the surface layer of soil, specifically from depths ranging between 10 cm and 15 cm.

Upon collection, soil samples underwent meticulous preparation procedures. Larger objects were removed by sieving through a 0.8 mm mesh, followed by grinding into a fine powder using a mortar and pestle to maintain consistency in the matrix compared to reference samples. Subsequently, the samples were dried at room temperature for several days before being subjected to further drying in an oven at 100°C for approximately three days. To ensure radioactive equilibrium between Rn222 and its parent Ra226 in the uranium chain and their respective daughters, the soil samples were sealed in 500-mL Marinelli beakers and stored for one month.

The measurement of soil samples was carried out using a gamma-ray spectroscopy system equipped with a NaI(Tl) "1.5×2" detector under low-background conditions over a 24-hour period. Absorbed dose rates (D) were calculated in accordance with the recommendations of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) due to gamma radiation in air, 1m above the ground level for ^{232}Th, ^{238}U and ^{40}K radio nuclides as follows:

$$D \ (nGy.h^{-1}) = (0.604 \ A_{Th} + 0.462 \ A_U + 0.0417 A_K) \quad (1)$$

Where A_{Th}, A_U and A_K are the activity concentrations of primordial radionuclides viz., ^{232}Th, ^{238}U and ^{40}K existing in the soil in $Bq.Kg^{-1}$.

The effective dose rate (ED) due to natural activity in the soil was subsequently determined using Equation (2), with conversion coefficients from absorbed dose to effective dose taken from authoritative sources [7-8].

$$ED(\mu Sv.y-1) = D \times 24(h) \times 365.25(d) \times rate \quad (2)$$

the committee used $0.7 \ Sv.Gy^{-1}$ as the conversion coefficient from absorbed dose in air to effective dose received by adults, and 0.2 for the outdoor occupancy factor.

Additionally, to assess the potential external hazard posed by soil radioactivity, the external hazard index (Hex) was calculated using Equation (3) as defined by UNSCEAR (2000). This index considers the activity concentrations of primordial radionuclides 238U, 232Th, and 40K in the soil, with values ≤ 1 indicating acceptable levels of external radiation hazard.

$$H_{ex} = A_U/370 + A_{Th}/259 + A_K/4810 \leq 1 \quad (3)$$

3- RESULTS

The natural radioactivity of soil depends on the soil formation and transport processes that were involved since soil formation; chemical and biochemical interaction influence the distribution [9].the principal primordial radionuclides are ^{232}Th, ^{238}U and ^{40}K. Both ^{232}Th and ^{238}U head series of radionuclides that produce significant human exposures. The decay of naturally occurring radionuclides in soil produces a gamma-beta radiation field in soil that also crosses the soil-air interface to produce exposures to humans(5) The radioactivity concentration of ^{238}U, ^{232}Th, and ^{40}K in the soil samples collected from different parts of the studied area are given in Table.1.

The radioactivity concentration ranged from 29.34to 20.34 $Bq.kg^{-1}$ for U-238 show as Fig1 ; from 20.92to 7.17±0.22 Bq/kg^{-1} for Th-232 show as Fig2 ; from 220.50to 176.51$Bq.kg^{-1}$ for K-40 show as Fig3 . The reported world median radioactivity levels for U- 238, Th -232, K- 40 are 35, 30, and 400 $Bq \ kg^{-1}$, respectively.

the absorbed dose rate (D) $(nGy.h-1)$ representing the mean energy imparted to matter per unit mass by ionizing radiation reported in Table2. The calculated absorbed dose rate values are between 22.9±1.80 to 32.4±1.70 $nGy.h^{-1}$. its corresponds to the world average value (60 nGy/h). The corresponding outdoor annual effective doses range from 28.10±2.20 to 42.33±2.29 $\mu Sv.y-1$ for Atbara, while the worldwide average annual effective dose is approximately 0.5 $mSv.y-1$ Thus, our results are one order magnitude less (0.05 $mSv.y-1$) than the average worldwide limits as reported by UNSCEAR.

comparison of the calculated external hazard index from the measured samples with the corresponding world accepted upper limit (Hex = 1) are calculated in Table 2. the external hazard index values from sample are under the corresponding UNSCEAR upper limits.

Table1.Concentration of (U-238, Th-232, and K-40) BqK^{-1} in Atbara soil samples

Sample code	Location	K-40	Th-232	U-238
S1	Alshargi	201.10±18.02	18.92±0.65	25.34±1.90
S2	Alshamali	220.50±17.90	15.92±0.40	25.14±1.41
S3	khiliwa	196.51±20.94	8.77±0.42	27.05±1.95
S4	Almatar	186.42±18.98	8.19±0.32	22.65±1.98
S5	Ombacol	199.70±17.40	20.92±0.55	29.34±1.75
S6	Almawrada	116.10±18.02	19.92±0.65	24.34±1.88
S7	Alrayan	185.81±17.91	7.75±0.75	24.22±1.41
S8	Alhasaia	176.51±18.94	7.17±0.22	27.05±1.91
S9	Alsawdan	197.45±21.90	15.49±0.39	21.85±1.94
S10	Aldakhla	184.70±19.40	10.02±0.75	20.34±1.73
S11	Alsiala	200.70±21.09	19.02±0.44	27.01±1.21
Max		220.50±17.90	20.92±0.55	29.34±1.75
Min		176.51±18.94	7.17±0.22	20.34±1.73
Mean		187.7±19.13	13.86±0.50	24.9±1.73

Table2.Absorbed dose rate A.dose(nGy.h^{-1}) , Annual effective dose AED (µSv.y^{-1}) and External hazard index for Atbara

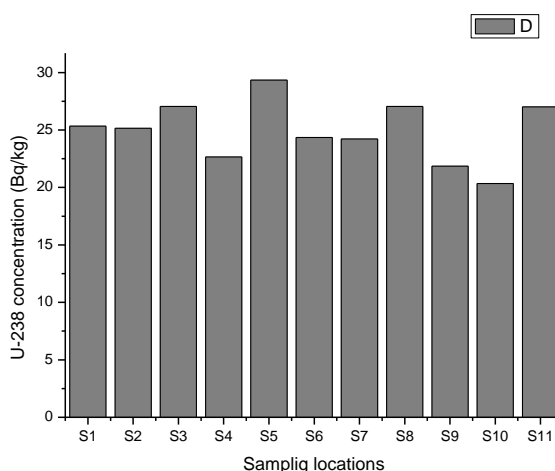| S.C	A.dose	A.E.D	E.H.I
S1	31.52±2.0	38.7±2.45	0.18±0.01
S2	30.4±3.81	37.3±4.67	0.17±0.01
S3	30.0±2.05	36.81±2.51	0.15±0.01
S4	23.1±1.07	28.34±1.31	0.13±0.01
S5	34.5±1.87	42.33±2.29	0.20±0.01
S6	28.1±2.01	34.48±2.46	0.17±0.01
S7	23.6±2.05	28.96±2.51	0.14±0.01
S8	22.9±1.80	28.10±2.20	0.14±0.01
S9	27.7±1.21	33.99±1.41	0.16±0.01
S10	23.2±2.05	28.47±2.51	0.13±0.01
S11	32.4±1.70	39.7±2.08	0.19±0.01

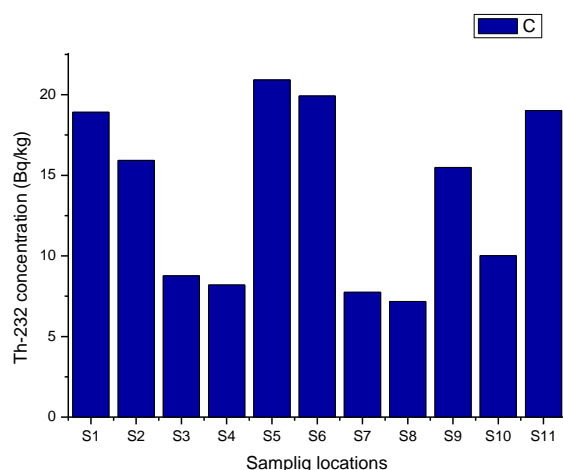**Fig. 1. Activity concentration U-238 for Atbara**

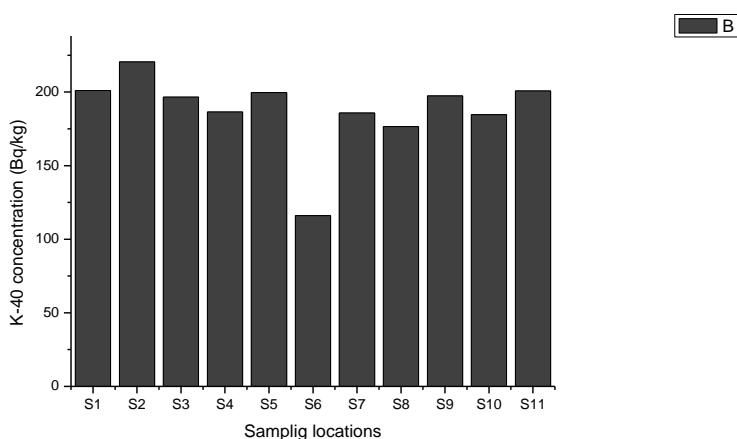**Fig. 2. Activity concentration for Th-232 for Atbara**

Fig. 3. Activity concentration K-40 for Atbara

Cancer Risk in Atbara Soil Samples

According to the World Health Organization (WHO), the acceptable threshold for radiation risk concerning exposure to the general population is 1 millisievert (mSv) annually. This threshold is considered as an average over the course of the year for radiation exposure from all sources, including medical, environmental, and occupational radiation.

To evaluate the potential health risk associated with radiation exposure in our study area, we calculated the Relative Risk (RR) for each soil sample collected. The RR was calculated using the formula $RR=1+(AED/1000)$ RR=1+(AED/1000), where AED represents the Annual Effective Dose (mSv/y). The results of the RR calculations for all samples are presented in Table 1.

Table 1: Relative Risk (RR) Assessment for Atbara soil samples

Sample Code	AED (mSv/y)	Relative Risk (RR)
S1	0.0387	1.0387
S2	0.0373	1.0373
S3	0.03681	1.03681
S4	0.02834	1.02834
S5	0.04233	1.04233
S6	0.03448	1.03448
S7	0.02896	1.02896
S8	0.0281	1.0281

S9	0.03399	1.03399
S10	0.02847	1.02847
S11	0.0397	1.0397

The calculated RR values for all samples indicate the potential risk associated with radiation exposure in the study area. Comparing these values with the international threshold set by the WHO provides insights into the level of radiation risk in the region.

4- CONCLUSION

The results of this study shed light on the potential cancer risk associated with radiation exposure in the Atbara region. It is important to note that activities such as industrial operations, including cement production, and other industrial activities within the city, as well as local mining activities near the area, may contribute to increased radiation levels in the environment.

These industrial and mining activities can lead to the release of radioactive materials into the soil and air, thereby posing potential health risks to the local population. The findings underscore the significance of considering anthropogenic sources of radiation when assessing environmental radioactivity and its associated health risks.

By calculating the Relative Risk (RR) for each soil sample and comparing it with the international threshold set by the World Health Organization (WHO), we gained valuable insights into the combined impact of natural and anthropogenic factors on radiation risk in the region. This emphasizes the importance of comprehensive approaches to radiation monitoring and management, considering both natural and human-induced sources of radiation.

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