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Research Article

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Verification of Components and Radioactivity Levels of Rock Samples, Quarries Atbara Cement factory (River Nile State-Sudan)

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Abstract The cement composed of raw materials that are usually found in the earth's crust, and they contain small but measurable amounts of naturally occurring radioactive materials. Although building materials act as a source of radiation to the inhabitants in their dwellings, they also have the role of a shield against outdoor radiation. The presence of natural radionuclides ^{238}U, ^{232}Th and ^{40}K. The radiation exposure risk can be estimated by finding the indoor absorbed dose rate and the annual effective dose. If the annual effective dose is within the internationally accepted value, use of cement can be considered safe and the risk will be within acceptable levels. The specific activities of ^{238}U, ^{232}Th and ^{40}K in 24 samples from rock samples were measured using gamma spectroscopy with a NaI detector and the annual effective dose was calculated to determine the radiological hazard from the natural radioactivity in the samples. The average specific activities measured in Bq kg^{-1} ranged from 4.55 to 14.44, 9.47 to 21.99 and 114.89 to 382.87 for ^{238}U, ^{232}Th and ^{40}K respectively. The average of absorbed dose rate measured in nGyh-1 ranged from 14.07 to 35.83. The elements were identified in the rock samples by XRF and the following elements appeared (Ca, Fe, Si, Mn, Sr, Cu, Ni, K, Zn, Ti, Al), the highest percentage of calcium was 97.304%.

Keywords Cement components, Radioactivity Levels, Natural Radionuclides

Introduction

Sudan is a country rich in raw materials and minerals and has seen in recent decades, a major development in the field of infrastructure, can be seen from the number of increasing in buildings with a modern style, which requires the use of some materials used in construction such as cement and other materials, the cement industry of important industries in Sudan and concentrated the industry in the state of the Nile River, which is located north of Sudan, so that helped the existing earth's crust in that area on the presence of limestone which represent a large proportion of materials consisting of cement, which the reason to the existence of four factories specialized in the manufacture of Cement due to the ease of presence of the raw material used in the manufacture of cement.

The cement composed of raw materials that are usually found in the earth's crust, and they contain small but measurable amounts of naturally occurring radioactive materials [1]. Although building materials act as a source of radiation to the inhabitants in their dwellings, they also have the role of a shield against outdoor radiation [2]. All building raw materials and products derived from rock and soil contain various amounts of mainly natural radionuclides of the uranium (^{238}U) and thorium (^{232}Th) series, and the radioactive isotope of potassium (^{40}K). In the ^{238}U series, the decay chain segment starting from radium (^{226}Ra) is radiologically the most important and, therefore, reference is often made to ^{226}Ra instead of ^{238}U [3]. It had long been known that some construction materials are naturally more radioactive than others. The level of natural radioactivity in construction materials, even of low-level activity, gives rise to external and internal indoor exposure [4].

Materials and Methods

Area of study

River Nile State locate in Northern Sudan with a population of over 1.4 million. The study's area of study located at a distance of 310 km from Khartoum city the capital of Sudan. River Nile State is rich in raw materials that can be used for cement industry, so many cement factories have been established there, for example Atbara cement factory. The area locates at the geographic coordinates 33°77'88" E and 17° 70'6" N (Figure 1) [5].

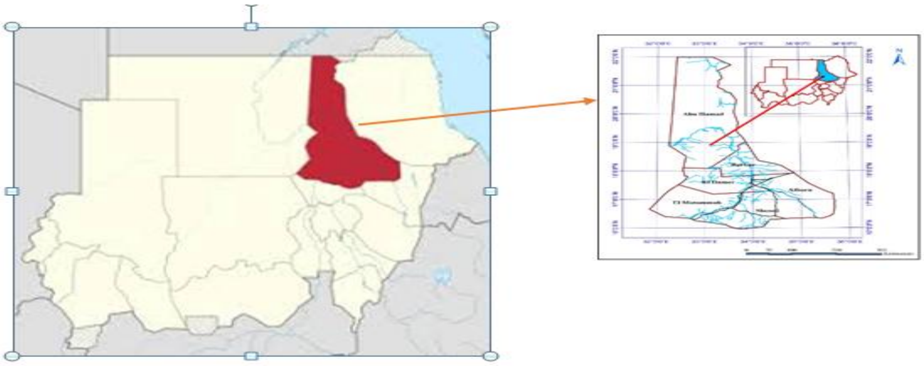

Figure 1: Map quarries Aatbra cement factory River Nile State, Sudan [5].

Measurements

The radioactivity content and risk assessment were determined for the imported ceramic samples. Gamma spectrometry system model 802- 4 NaI(Tl) crystal with a resolution range from 7.5 to 8.5% at a 662 kev peak of Cs-137 connected to a personal computer analyzer using Win TMCA32 software was employed for these measurements. The detector system comprises built-in electronic modules plugged to a PC via a USB link. For measurements, a Marinelli beaker containing the sample was placed in the detector for three. The spectrum was stored in the computer and evaluated using "Win TMCA32 target" Gmbh software (Genie 2000, Canberra, Meriden, CT, USA). The system was regularly calibrated using a standard mixed gamma source in the same geometry. Additionally, measurement with an empty beaker taken regularly for background deduction was carried out [6]. The MDA was determined at a 95% confidence level, while ten consecutive measurements were carried out to estimate the precision and accuracy associated with the activity concentrations of ^{232}Th, ^{238}U, and ^{40}K, and the obtained data were satisfied. The uranium (or radium) content of samples was evaluated via daughter isotopes that emit gamma rays and radium evaluated mainly from the gamma line of 609 keV of Bi-214 (assuming secular equilibrium between parent nuclides (^{238}U and ^{226}Ra) and daughters). Thorium content was estimated from 239 keV (gamma line) of Pb-212 and potassium content was evaluated from 1460 keV (gamma line).

Samples collection and preparation

In order to Determination of components and Radioactivity Levels in Quarries cement factories, twenty four (24) samples of cement's rock were collected randomly from different locations in the River Nile state include several points of Atbara cement quarries. Each rock sample was packed shipped to the laboratory for crushing and grinding.

After collected all samples and return to the laboratory, Rock samples were broken into small pieces easily crushed by milling machine and then the samples were placed in a custom plastic bags to collect samples after the transfer of designation.

After that, it was transferred to the laboratory of the Institute of Radiation Safety of the Sudanese Atomic Energy Authority and there it was packed in Marinelli cups of 500 grams which were sealed tightly with adhesive tape to prevent the escape of the ^{222}Rn and ^{220}Rn airborne in the samples and for fear of breaking the natural chain.

A total of 24 rock samples were transferred to a powder amount of each sample 10 grams. These samples were analyzed using an X – ray fluorescence.

Results and Discussion

Specific activity concentration levels

The result of measurement of specific activity concentration (Bq.kg^{-1}) of ^{238}U, ^{232}Th and ^{40}K in rock samples obtained from Quarries Atbara Cement factory were given in Table 1. All values are given in Bq.kg^{-1} of dry weight.

The average concentrations of ^{238}U, ^{232}Th and ^{40}K were found in rock samples 7.55, 12.84 and 182.61 respectively. The worldwide average concentrations of the radionuclides ^{238}U, ^{232}Th and ^{40}K reported by UNSCEAR (2000) [7], are 35, 30, and 400 (Bq.kg^{-1}), respectively shown in figure (2). Our results show that the average activity concentrations of ^{238}U, ^{232}Th and ^{40}K in our samples are within the worldwide limits concentrations. The calculated values for the samples were presented in Table (1).

Table 1: The results of the mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K in all rock samples

No.	Sample code	Position		Activity concentrations (Bq.kg^{-1})			Absorbed Dose (nGyh^{-1})
		Latitude (°N)	**Longitude (°E)**	**^{238}U**	**^{232}Th**	**^{40}K**	
1	ATB -1	17˚42.398	033˚48.217	13.98	21.99	382.87	35.83
2	ATB -2	17˚42.299	033˚48.307	6.30	15.87	191.44	20.54
3	ATB -3	17˚42.341	033˚48.333	9.64	10.49	153.15	17.23
4	ATB -4	17˚42.324	033˚48.290	7.69	10.49	191.43	17.93
5	ATB -5	17˚42.305	033˚48.281	14.44	11.51	153.15	20.06
6	ATB -6	17˚42.410	033˚48.267	9.43	9.47	191.43	18.12
7	ATB -7	17˚42.433	033˚48.251	5.94	9.47	153.15	14.90
8	ATB -8	17˚42.281	033˚48.223	7.69	15.87	191.44	21.18
9	ATB -9	17˚42.271	033˚48.191	7.69	10.49	191.44	17.93
10	ATB -10	17˚42.269	033˚48.178	6.29	11.51	153.15	16.30
11	ATB -11	17˚42.237	033˚48.162	6.29	10.49	153.15	15.68
12	ATB -12	17˚42.214	033˚48.148	6.29	10.49	114.86	14.07
13	ATB -13	17˚42.198	033˚48.129	7.69	10.49	191.44	17.93
14	ATB -14	17˚42.177	033˚48.108	7.69	15.87	153.15	19.58
15	ATB -15	17˚42.169	033˚48.069	6.29	15.87	191.44	20.54
16	ATB -16	17˚42.144	033˚48.041	7.69	10.49	191.44	17.93
17	ATB -17	17˚42.277	033˚48.021	6.29	9.47	191.44	16.67
18	ATB -18	17˚42.326	033˚47.419	7.69	14.85	191.44	20.57
19	ATB -19	17˚42.287	033˚47.416	6.29	21.25	191.44	23.79
20	ATB -20	17˚42.159	033˚47.230	4.55	14.85	191.44	19.12
21	ATB -21	17˚42.649	033˚47.415	4.55	14.85	153.15	17.51
22	ATB -22	17˚42.503	033˚47.219	6.29	9.47	191.44	16.67
23	ATB -23	17˚42.713	033˚46.498	7.69	10.49	191.44	17.93
24	ATB -24	17˚42.391	033˚46.305	6.29	9.47	191.44	16.67
Min				**4.55**	**9.47**	**114.86**	**14.07**
Max				**14.44**	**21.99**	**382.87**	**35.83**
Mean				**7.55**	**12.84**	**182.61**	**18.95**

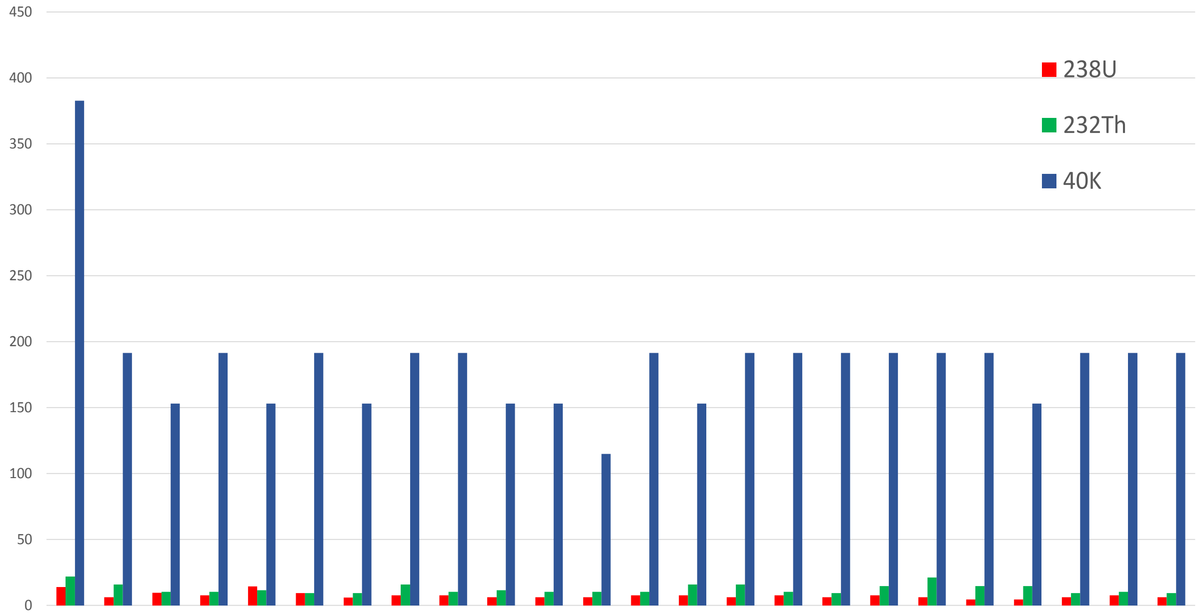

Figure 2: The mean average values of ^{238}U, ^{232}Th and ^{40}K activity concentrations

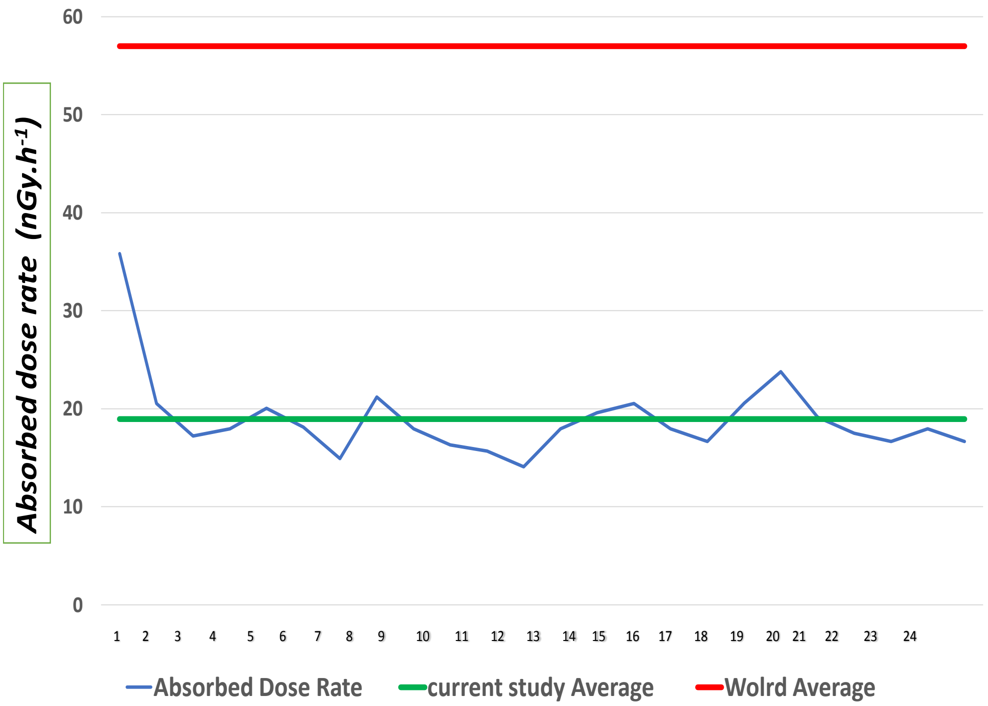

Figure 3: Comparison between the average mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K with the mean value for the worldwide

Table 2: Heavy metal content in the evaluation in rock samples concentrations in percentage (%)

No.	Sample code	Elements										
		Ca	**Fe**	**Si**	**Mn**	**Sr**	**Cu**	**Ni**	**K**	**Zn**	**Ti**	**Al**
1	ATB -1	80.573	1.988	12.181	0.083	0.044	0.023	ND	0.962	0.006	0.195	3.945
2	ATB -2	98.253	0.796	0.705	0.054	0.055	0.031	0.004	0.098	0.004	ND	ND
3	ATB -3	95.154	2.512	1.981	0.125	0.058	0.027	ND	0.139	0.005	ND	ND
4	ATB -4	98.358	0.748	0.678	0.066	0.052	0.034	ND	0.062	ND	ND	ND
5	ATB -5	97.346	1.297	1.144	0.073	0.055	0.028	ND	ND	0.005	ND	ND
6	ATB -6	96.051	1.973	1.747	0.113	0.047	0.061	ND	ND	0.009	ND	ND
7	ATB -7	94.991	2.776	1.435	0.091	0.087	0.025	ND	0.338	0.012	ND	ND
8	ATB -8	97.352	1.278	1.146	0.109	0.044	0.030	ND	ND	0.006	ND	ND
9	ATB -9	98.392	0.826	0.578	0.072	0.043	0.025	ND	0.064	ND	0.245	ND
10	ATB -10	97.973	0.913	0.879	0.097	0.053	0.036	0.001	0.064	ND	ND	ND
11	ATB -11	98.896	0.919	ND	0.105	0.051	0.029	ND	0.048	ND	ND	ND
12	ATB -12	98.138	0.937	0.64	0.076	0.049	0.031	ND	ND	0.004	ND	ND
13	ATB -13	99.111	0.600	0.054	0.047	ND	0.008	ND	ND	0.005	ND	ND
14	ATB -14	98.452	0.709	0.686	0.056	0.057	0.032	ND	0.127	ND	ND	ND
15	ATB -15	99.271	0.586	ND	0.056	0.056	0.031	ND	ND	ND	ND	ND
16	ATB -16	98.245	0.656	0.889	0.051	0.053	0.035	ND	ND	ND	ND	ND
17	ATB -17	98.438	0.641	0.745	0.040	0.054	0.032	ND	0.071	ND	ND	ND
18	ATB -18	99.032	0.694	ND	0.054	0.053	0.031	ND	0.049	0.005	ND	ND
19	ATB -19	98.556	0.575	0.598	0.040	0.045	0.036	0.002	0.132	0.003	ND	ND
20	ATB -20	98.315	0.778	0.778	0.046	0.051	0.028	ND	0.144	0.004	ND	ND
21	ATB -21	98.701	0.588	0.477	0.044	ND	0.019	0.017	ND	ND	ND	ND
22	ATB -22	98.557	1.267	ND	0.073	0.054	ND	0.007	0.94	0.094	ND	ND
23	ATB -23	98.324	0.588	0.797	0.080	0.046	0.028	0.003	0.129	0.034	ND	ND
24	ATB -24	98.822	0.599	0.454	0.047	0.051	0.026	ND	ND	0.129	ND	ND
Average		**97.304**	**1.052**	**1.430**	**0.071**	**0.053**	**0.0299**	**0.006**	**0.225**	**0.0217**	**0.220**	**3.945**

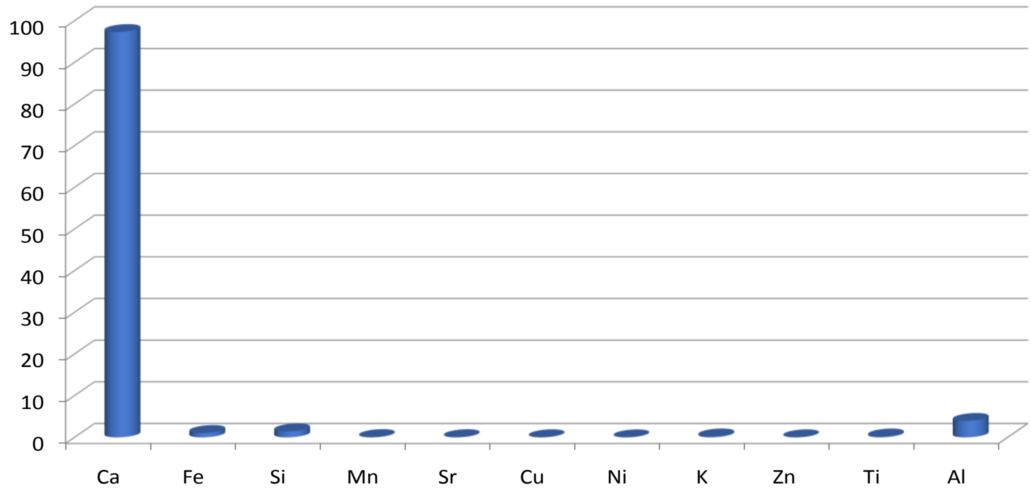

Figure 4: Average concentration of 24 samples

Conclusions

The activity levels and distribution of the natural terrestrial radionuclides of ^{238}U, ^{232}Th and ^{40}K were measured using a gamma-ray spectrometry system for the rock samples collected from Quarries Atabra Cement factory (River Nile State - Sudan), radiological hazard indices were evaluated in order to determine the effects of the natural radionuclides in samples. All fell within the average worldwide ranges from the measured values.

Through this study, the presence of basic cement component in the Atbara cement quarries was verified after samples were taken from this area. The concentration of calcium in the analyzed samples was found to be highly disparate. The average concentration of this element (calcium) was (97.304)%, after the statistical work of the results obtained. The samples were analyzed using XRF.

Acknowledgment

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