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Investigations of the Radioactive Presence and Heavy Metallic Materials in Merowe Dam Area

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Abstract

This study investigates the existence of high levels of radiation and heavy metallic materials in the area around Merowe Dam, using different physical techniques. Two radiation survey-meters were used in order to compare results, which were Raddose and Idintifineder and several analytical devices. The survey-meter measurements were 0.1 μSv/h over the chemical waste and 0.05 μSv/h in different areas positions. The background level of radiation was determined at different positions, and the average of the measurements was 0.09 μSv/h, which was within the normal ranges. The existence of natural occurring radioactive material falls within the global wide range as well. Furthermore, the presence of the chemical materials containing heavy metals was detected by using Inductively Coupled Plasma Emission spectrophotometer (ICPE-9000), Energy Dispersive X-ray Fluorescence (EDX-8000) devices and Gas chromatograph GC-2010 plus. The analysis showed there were lots of heavy metals that they were believed to be a revert from the dam construction material, such as paint and epoxy.

Keywords

Environmental Impacts, Radiation Background Level, Chemical Analysis, Heavy Metals

1. Introduction

There are many different groups concerned about the assessment of the general environmental impact, before, during or after, of the construction of the dam to present an independent evaluation of the environmental impact to the surrounding reservoir such as: induced water quality, hydrology and water balance [1]. Also, there was a committee to declare the consequences of dam failure in terms of losing life and damage to property or services as well as environmental damage [2]. Furthermore, there are many studies that classify downstream hazard and take consideration of environmental damages. This would address situation where the reservoir contains materials which may be harmful to human. Added to that, different concerns of ionizing radiation background were assessed. This survey leads the fact that there are some raw materials used in construction when they product it may contain radioactive material or natural occurring radioactive material (NORM) during or after production processes led to possible multiplication effects [3].

Merowe dam is one of the strategically national schemes built in North Sudan, also known as Merowe high dam or Hamdab dam. It is a multi-purpose hydro project that is considered a large dam near Merowe town and it's about 370 kilometers north of the city of Khartoum [4]. Several foreign institutions are currently involved in salvage archaeology in the region under the umbrella of Merowe Dam Archaeological Salvage Project (MDASP). Resettlement and compensation were mainly offered to Manasir, Hamadab and Amri tribes [5]. Merowe dam constrained again several local settlements to be displaced in desert regions and famous archaeological sites like Napata besides the Merowe dam [6].

There are several environmental studies done in Sudan, and take consider about radiation survey including assessing radiation background to compare results with the recommendations of the International Commission on Radiological Protection (ICRP) [7]. Also, some cases refer the low dose level of natural occurring radioactive materials NORM [8]; for instance to previous studies in Sudan, there were geographical information system (GIS), predictive mapping of terrestrial gamma radiation in the northern state, of Sudan. The result presents the evaluation of absorbed dose in air due to gamma-emitting nuclides from 238U and 232Th series, 40K and 137Cs from soil sample in different location. Activity concentrations were 19 ± 4 (238U), 47 ± 11 (232Th), 317 ± 65 (40K) and 2.26 $Bq \cdot kg^{-1}$ for 137Cs. On average, the values obtained fall within a narrow range of 44 and 53 $nGy \cdot h^{-1}$ [9]. In addition, the assessment of terrestrial gamma radiation in Sudan, Sam and co-authors conducted study on calculations of the external exposure due to gamma radiation from the ground. From the results of the measurements of radionuclide activity concentrations in the soil at various locations in Sudan, the average exposure was found to be 45 $nGy \cdot h^{-1}$, corresponding to the annual dose equivalent of 278 $mSv \cdot y^{-1}$ [10]. Also in the western region, Darfur state, specifically in Jebel Mun, the activity concentrations of 238U, 232Th and 40K were found to range from 39 - 253 $Bq \cdot kg^{-1}$, 41 - 527 $Bq \cdot kg^{-1}$ and 77 - 3027 $Bq \cdot kg^{-1}$, respectively [11]. In additions, in Sinnar State, measurements were carried out using high-resolution gamma-spectrometry; on average, the activity concentrations obtained were 38 ± 8 (232Th), 17 ± 2 (226Ra), 174 ± 19 (40K) and 0.9 ± 0.2 $Bq \cdot kg^{-1}$ for the fallout radionuclide 137Cs. The average value obtained here for 232Th is slightly higher than the corresponding world-average [12].

During the Merowe dam construction, there were a lot of social media news providing uncertain/unconfirmed information about existence of the radioactive materials. It may grieve inside the body of dam during construction. The aims of this investigation ascertain a denial of the argument or confirm this information by using several physical techniques.

2. Materials and Methods

Two radiation survey-meters (RadDose-RDS-120 and Idintifineder) were used in different position, to calculated absorbed dose rate in air at a height of 1 m above ground surface and corresponding annual effective dose was estimated [13], and different samples were collected in order to investigate the existence of heavy metals and natural occurring radioactive material (NORM).

In order to detect NORM, 32 soil samples pulverized and packed in 1kg by mass in the cylindrical plastic containers of radius 3 inch and height 3.5 inch, which sits on the (3 inch × 3 inches) high purity germanium (HPGe) detector with geometry the containers are sealed for one week to ensure radioactive equilibrium between the parent radionuclides and their gaseous daughter decay products in the uranium and thorium series [14]. In term of existence heavy metallic elements experiment were carried out by using several devices, Energy Dispersive X ray Fluorescence (EDX8000) fundamental parameters(FP) method to the quantitative analysis were used [15], the first step should supply completely homogeneous and perfectly flat polished surface [16], for any unknown the analysis sensitivity coefficients were calculated by using standard samples, then unknown sample was analyzed the sensitivity coefficients, the closer the composition of the standard sample is to the composition of the unknown sample, the more precise the quantitative analysis, the sequences of the analysis are flowing: generation analysis conditions, analyzing the standard sample, calculating the sensitivity coefficient and analyzing the unknown sample (soil) [17].

The water and plant and un known samples were detected by using ICP 9000 atomic emission spectrometry for environmental purpose, an water and plant sample and gas chromatograph GC-2010 plus (Shimadzu cooperation) for unknown samples, the samples digestion was conducted the flowing process:

0.5 of sample was add to 5 ml of nitric acid to digestion container the mixture had let stand about 30 min, also 9.5 ml nitric acid and 0.5 ml hydrochloric acid were add and set container in microwave digester and digest approximately 1 hour after that the solution refrigerated and transferred to volumetric flask finally 25 ml were adjusted and eject in to device.

The analytical conditions for ICP-AES were: 1.2 Kw rad frequency power, 10 l/min plasma gas flow rate, 0.6 L/min auxiliary gas flow rate and 0.7 L/min carrier gas flow rate [18].

Data Collection Process

The Different samples were collected by using soil collection auger from waste hole near the dam was buried during dam construction and the local citizens were propagated about existence of radioactive materials in the buried hole. The survey was made over the hole and the hole was divided into four sectors.

3. Results

The investigation results were obtained by using two radiation survey-meters and several analytical devices (Inductively Coupled Plasma Emission spectrophotometer (ICPE-9000), Energy Dispersive X-ray Fluorescence (EDX-8000) devices and GAS chromatograph GC-2010 plus). All results were showing in Tables 1-3 and Figure 1 and Figure 2.

Table 1. Soil, water, and plant sample screened by ICP device.

	Samples		
	Soil	Plant	Water
Main Elements Detected	Si - Ca	Ca	Ca
	Ba	-	-
	Fe	Fe	-
Trace	S	-	S
	Co	-	-
	Mg	Mg	Mg
Elements Less than 5%	Al	-	-
	P	P	-
	Sr	-	-
		-	Tb
	-	-	Na

Table 2. Unknown samples found in hole grave waste detected by using gas chromatograph GC-2010 plus.

Sample 1	**Octoil/phytan/m-diacety/benzene**
Sample 2	Farnesan/Dodecane/146pergnane
Sample 3	N-methylbenzyl piperatine.MB2p/Octadlecan/Bicetyl
Sample 4	Hexene,2,5-diphenyl[beta-tert-Buty-1,1-diphenyleThylene Syn-Tricyclo[5.1.0.0E2,4] OCT.5.EN.3,3,5,6,8,8.h-examelhy1
Sample 5	P-chlorobenzoic acid/1,1,2-Trime Thylcyclohexane
Sample 6	O-Nitroethyl benzene
Sample 7	D-Theronine
Sample 8	Alpha-alpha-Dicumyl/Indenopyrene/Beta fenchyl alcohol
Sample 9	O-Biphenylmethan/anThracen/9H-carbazole/ pyrentriphenylen m-diacety/benzene
Sample 10	Mefenamic acid
Sample 11	Epoxide

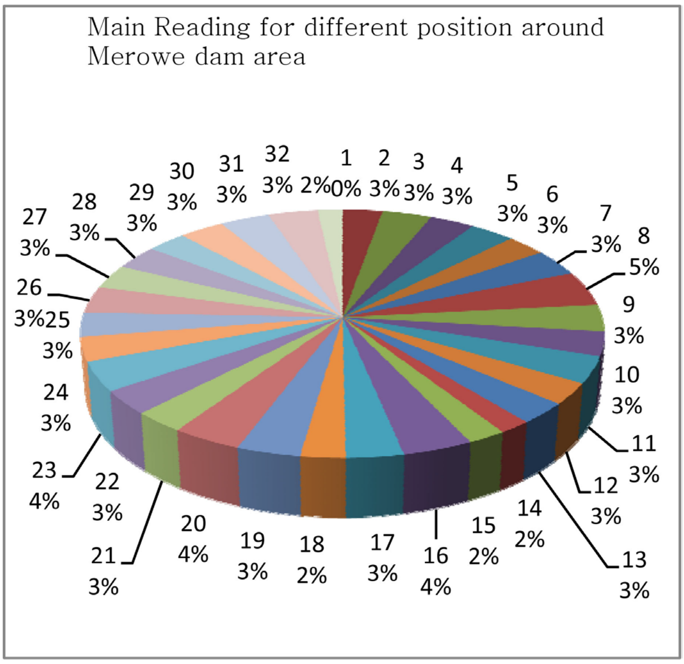

Figure 1. The percentage of Radiation dose in different location around the dam compared to the main value range reading 0.09 μSv/h.

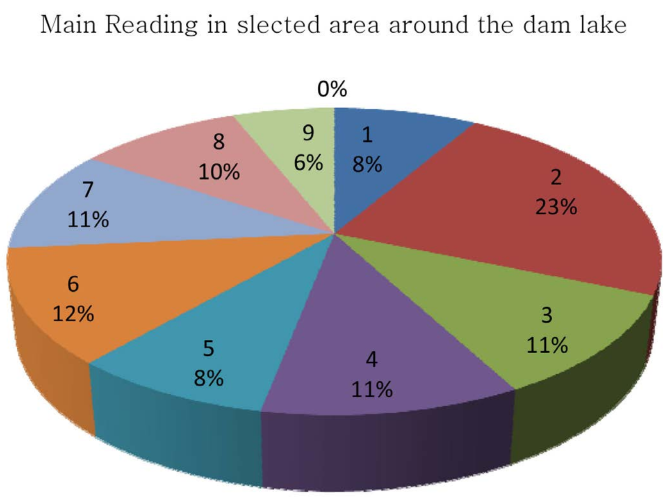

Figure 2. The percentage of radiation dose measurement reading in the both side of dam lake compared to total average reading 0.09 μSv/h.

Table 3. The present of Natural occurring Radioactive Material in the soil samples.

Sample NO	^{238}U ($Bq \cdot kg^{-1}$)	^{232}Th ($Bq \cdot kg^{-1}$)	^{40}K ($Bq \cdot kg^{-1}$)	Ra_{eq} ($Bq \cdot kg^{-1}$)	Radiation Dose (nGy/h)
1	29.93	45.19	259.84	113.21	53.84
2	40.44	41.62	247.76	117.78	55.43
3	38.53	50.18	222.62	125.93	59.21
4	37.92	33.03	159.23	96.34	44.82
5	39.08	37.31	198.74	106.62	49.89

Continued

6	39.73	47.19	193.18	120.67	56.47
7	88.14	71.71	275.88	209.79	96.89
8	13.10	17.61	18.76	39.19	18.04
9	27.31	26.82	148.48	76.28	35.77
10	35.75	36.72	167.98	100.08	46.76
11	2296	27.25	112.36	70.05	32.82
12	39.21	44.29	221.21	118.26	55.54
13	38.19	14.31	129.46	68.20	31.31
14	50.70	54.69	238.66	145.65	68.07
15	39.37	65.75	257.39	151.24	71.37
16	28.72	32.89	275.23	95.96	45.84
17	38.57	41.63	256.63	116.62	55.03
18	30.56	24.54	158.09	77.09	36.06
19	41.70	57.04	310.15	145.43	68.86
20	33.29	30.51	182.62	90.06	42.23
21	05.22	44.95	149.45	79.66	38.41
22	293.57	34.57	03.62	342.26	148.11
23	126.18	141.16	139.14	334.52	153.18
24	30.73	34.45	212.11	95.29	45.02
25	49.94	37.15	172.68	115.26	53.29
26	28.72	30.81	240.59	90.38	42.98
27	25.79	23.53	198.98	74.05	35.12
28	32.53	34.77	195.97	96.31	45.31
29	38.81	31.48	177.25	96.53	44.99
30	51.02	37.21	219.97	120.4	55.82
31	27.45	20.02	173.97	68.88	32.43
32	17.26	21.61	97.71	55.04	25.86
Average	117.3	40.4	188.0	117.3	54.5
Σ	400.7	22.6	68.7	66.5	29.4

4. Discussions

The calculated exposure falls within the global wide range of outdoor radiation exposure given in the UNSCEAR publications. The Screening analysis shown a present element such as Si, Ca, Ba, Fe, S, Co, for all samples as shown in Table 1 around the dam area this existence not different when compare over all Merowe area. Table 2 shows the present organic compound found in the buried hole near the dam, the existence revere to the human activity Mechanical workshop, car fuel, and construction martial like epoxide. Table 3, shows that, the level of Natural Occurring Radioactive Material in 32 soil sample around dam area is normal compared with previous studies [10] [11] [12]. The Result in **Figure 1** indicates that, the percentage of the radiation dose in different location around the dam to the main value range reading 0.09 μSv/h according overall Sudan measurement were within the normal range. Finally, in **Figure 2**, it shows that The percentage of radiation dose measurement reading in the both side of the dam lake and average reading is 0.09 μSv/h, its normal reading.

5. Conclusion

Radioactivity and Heavy Metallic Materials in Merowe Dam Area were investigated by two radiation survey-meters and several analytical devices. Heavy metallic elements were detected in soil, water and plant. These elements may result from human activities. Current study confirmed that, the organic waste materials were buried inside the safety contained region and did not refer to any additive material buried from outside area. The radiation survey found that, the radiation dose is within the normal range 0.09 μSv/h.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Energy Projects (2016) Social License, Public Acceptance and Regulatory Systems in Canada: A White Paper. The School of Public Policy Publications.

[2] Carley, J.K., Pasternack, G.B., Wyrick, J.R., Barker, J.R., Bratovich, P.M., Massa, D.A., *et al.* (2012) Significant Decadal Channel Change 58 - 67 Years Post-Dam Accounting for Uncertainty in Topographic Change Detection between Contour Maps and Point Cloud Models. *Geomorphology*, **179**, 71-88. https://www.sciencedirect.com/science/article/abs/pii/S0169555X12003819

[3] Nwankwo, L. and Akoshile, C. (2005) Monitoring of External Background Radiation Level in Asa Dam Industrial Area of Ilorin, Kwara State, Nigeria. *Journal of Applied Sciences and Environmental Management*, **9**, 91-94. https://doi.org/10.4314/jasem.v9i3.17359

[4] Draft, F., Dirar, A., Anglia, E., Basin, N., Forum, D., Hashim, M.J., *et al.* (2014) Dis-

placement and Resistance Induced by the Merowe Dam: The Influence of Justice and International Norms. DEV Reports and Policy Paper Series, 1-117.

[5] Saad, M.H. (2017) Study of Natural Radioactivity in Lake Miri in South West of Sudan. *Journal of Taibah University for Science*, **11**, 613-616. https://doi.org/10.1016/j.jtusci.2016.05.005

[6] Failer, E., El-Hadari, M.H. and Mutaz, M.A.S. (2011) Der Merowe-Staudamm und dessen wasserkraftwerk im Sudan. WasserWirtschaft. https://doi.org/10.1365/s35147-011-0004-0

[7] Wrixon, A.D. (2008) New ICRP Recommendations. https://doi.org/10.1088/0952-4746/28/2/R02

[8] United Nations Scientific Committee on the Effects of Atomic Radiation (2010) Sources and Effects of Ionizing Radiation. Volume I.

[9] Bashier, E.H., Salih, I. and Sam, A.K. (2012) GIS Predictive Mapping of Terrestrial Gamma Radiation in the Northern State, Sudan. *Radiation Protection Dosimetry*, **151**, 500-510. https://doi.org/10.1093/rpd/ncs022

[10] Sam, A.K. and Holm, E. (1995) The Natural Radioactivity in Phosphate Deposits from Sudan. *Science of the Total Environment*, **162**, 173-178. https://doi.org/10.1016/0048-9697(95)04452-7

[11] Sam, A., Sirelkhatim, D., Hassona, R., Hassan, R., Hag Musa, R. and Ahmed, M. (2002) Assessment of Gamma Dose Rate over a Suspected Uranium Mineralisation Area of Jebel Mun, Western Sudan. *Radiation Protection Dosimetry*, **102**, 169-174. https://doi.org/10.1093/oxfordjournals.rpd.a006086

[12] Sam, A.K. and Elmahadi, M.M. (2008) Assessment of Absorbed Dose Rate in Air Over Plowed Arable Lands in Sinnar State, Central Sudan. *Radiation Protection Dosimetry*, **129**, 473-477. https://doi.org/10.1093/rpd/ncm448

[13] Garba, N.N., Ramli, A.T., Saleh, M.A. and Gabdo, H.T. (2019) Natural Radioactivity and Associated Radiation Hazards in Soil of Kelantan, Malaysia. *Human and Ecological Risk Assessment*, **25**, 1707-1717. https://doi.org/10.1080/10807039.2018.1474433

[14] Korna, A.H., Fares, S.S. and El-Rahman, M.A. (2014) Natural Radioactivity Levels and Radiation Hazards for Gypsum Materials Used in Egypt. *Natural Sciences*, **6**, 5-13. https://doi.org/10.4236/ns.2014.61002

[15] Kantarelou, V. and Karydas, A.G. (2016) A Simple Calibration Procedure of Polycapillary Based Portable Micro-XRF Spectrometers for Reliable Quantitative Analysis of Cultural Heritage Materials. X-Ray Spectrum. https://doi.org/10.1002/xrs.2661

[16] Rousseau, R. (2013) How to Apply the Fundamental Parameters Method to the Quantitative X-Ray Fluorescence Analysis of Geological Materials. *Journal of Geosciences and Geomatics*, **1**, 1-7.

[17] Nazarov, V.A., Zelenova, A.N., Rybkov, V.S., Sineltsev, A.A. and Zelenov, V.A. (2018) Improvement of Fertilizing Properties of Glauconite under Microwave Radiation. *ARPN Journal of Engineering and Applied Sciences*, **13**, No. 4.

[18] Division, L., Safety, F., Method, A. and Preparation, S. (2002) LAAN-A-CP-E011. J98.