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Radioactive Waste Management

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Abstract: The present study aims to evaluate the level of radioactivity around that facility. Measurements of radiation dose in ten locations around radioactive waste facility for a period of six months were carried out and the results are presented here. It is found that the average doses for each month varies as follows: 1.48, 1.55, 1.58, 1.64, 1.77, and 1.74, µSv/h respectively. Measurements of soil samples taken around the facility showed only natural radioactivity present where uranium (^{238}U) concentration range between 8.9 and 23.9 Bq/Kg with average value 14.24 Bq/kg and (^{137}Cs) with average value 2.04 Bq/kg. There is no indication leak or contamination from artificial radionuclides observed. This indicates there are no increases in the dose level around the waste facility. Comparing the dose result with standards from the International Atomic Energy Agency (IAEA) it can be concluded that the obtained values rest within the acceptable level.

Keywords: Radioactive waste management, Evaluation, Radiation.

I. INTRODUCTION

All practices that use nuclear and radioactive materials will produce radioactive wastes. The nature of radioactive waste vary from one radioactive waste to another radioactive waste in terms of volumes, chemical and physical compositions and concentration of radioactivity. The radioactivity contained in the wastes is hazardous to living organisms. The hazardous nature of radioactive wastes to living organisms requires proper radioactive waste management. The purpose of proper management of radioactive wastes is to ensure safety and well being of the present and future generations of the general public and the environment. Radioactive waste are generated from applications of radio nuclide in various fields e.g. medical, research, industry, power generation and processes These activities lead to enhancement of Naturally Occurring Radioactive Materials (NORM). Under the Sudan Atomic Energy Commission Act (1996-95), radioactive waste is defined as any waste, which contains all or part of: Substance or item which if it is not waste is considered radioactive material; or Substance or item which was contaminated during production, storage or use of radioactive or nuclear materials or prescribed substance; or Substance or item which was contaminated by means of contact or by being in the vicinity of any other radioactive waste.

Sudan Atomic Energy Commission (SAEC) Sudan became a member of the International Atomic energy Agency in 1958; one year after it had came into being. In 1962 Sudan Atomic energy Committee was constituted to act as focal point responsible for co-coordinating between Sudan government and the Agency in matters related to nuclear energy. In 1971 Sudan Atomic Energy committee Act was issued mainly establishing a committee affiliated to the national Geology corporation and meant to supervise the implementation of the IAEA technical co operation program in Sudan .The Atomic Energy Committee Act, In 1973 established a committee , under the supervision of the chairman of National Research Council ,with the mandate of promoting use of nuclear techniques in the country and also overseeing safety in all activities involving use of ionizing radiation . In 1991 Atomic Energy Research Institute was established as one of the research institutes under the national council for research to look after research activities aimed to enhancing national capabilities in the area of the peaceful application of nuclear technology . ever ,the Atomic Energy Committee as a focal point between Sudan Government and the agency remains under supervision of the minister of higher Education and scientific research .

II. MATERIAL AND METHODS

The management and treatment of radioactive wastes: The management includes several steps, namely: --
*1- **Assembly and sorting***: a collection of radioactive waste in one place for fear of the loss or theft or use in non-peaceful purposes and to protect the public *2 – Conditioning: is* the process of shielding and making radioactive wastes more secure and safer. The process are being conducted is to put the waste in 200 litter drums are then reinforce the drums with concrete, which guarantees the additional shielding and also difficult to move which

reduces the probability of exposure to theft. Liquid waste are stored at the site until dry or when their radioactivity to a very small to be disposed like any ordinary waste. 4 - *Disposal:* It is necessary to find a place for the final disposal of these radioactive sources. But so far there are no complete solutions for the disposal of radioactive waste in the Sudan.

III. SAMPLE MEASUREMENTS

The activity concentration of radionuclides in the samples are measured using a high resolution γ-spectrometry system equipped with high purity germanium (HPGe) coaxial detector with 1.7 keV relevant resolutions at 1332 keV ^{60}Co line and 16.4% efficiency. The detector housed in 10 cm lead shield to reduce the background effect. The system is calibrated with respect to energy and efficiency for different geometries using two different geometries 0.5 and 1.0 kg Marinelli beakers contain certified mixed radionuclide's (MW 652 for 0.5 kg small geometry and MW 651 for 1 kg large geometry) supplied by International Atomic Energy Agency (IAEA) [3].

At the end of the in-growth period the samples are introduced into the lead shielded HPGe detector at liquid nitrogen temperature 77°K and counted for 12 hours to 24 hours. The energies of 295.21 keV (^{214}Pb), 351.92 keV (^{214}Pb), 609.31 keV (^{214}Bi) and 1120.39 keV (^{214}Bi) were used to determine ^{226}Ra and was taken to be equal to ^{238}U activity concentration on the assumption of prevalence of secular equilibrium in U- 238 series. The energy of 1460.38 keV γ-rays was used for 40°K. The 661.66 keV γ-rays were used to determine ^{137}Cs. In order to determine the background level around the detectors, an empty polyethylene container was counted in the same manner as the samples for different geometries .

3.6- Energy Calibration

Energy Calibration is important for the qualitative analysis of the samples containing radioactive nuclei. The exactidentity of photo peak present in the spectrum produced by the detector system is a necessary requirement for the measurement of gamma-emitters. The energy calibration is the establishing of the number of the channels present in a multi-channel analyzer (MCA) or plus height analyzer in relation to gamma-rays energy. This calibration was made by measuring radioactive Amersham mixed standard for twelve hours (Table 3.1).The simple relationship used for energy calibration using two points different in energy and channel number is :

$E_2 = E_1 + (\Delta E/\Delta C) * (C_2 - C_1)$

Where :

E_1 is the unknown energy shown at channel C_1.
E_2 is the unknown energy shown at channel C_2.
ΔE is the difference in energy.
ΔC is the difference in channel.

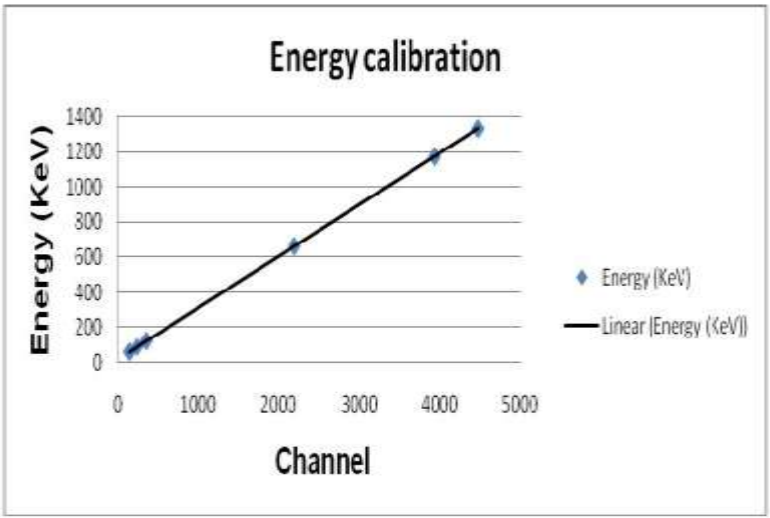

Figure (1.1): Actual Energy Calibration obtained using HPGe detector

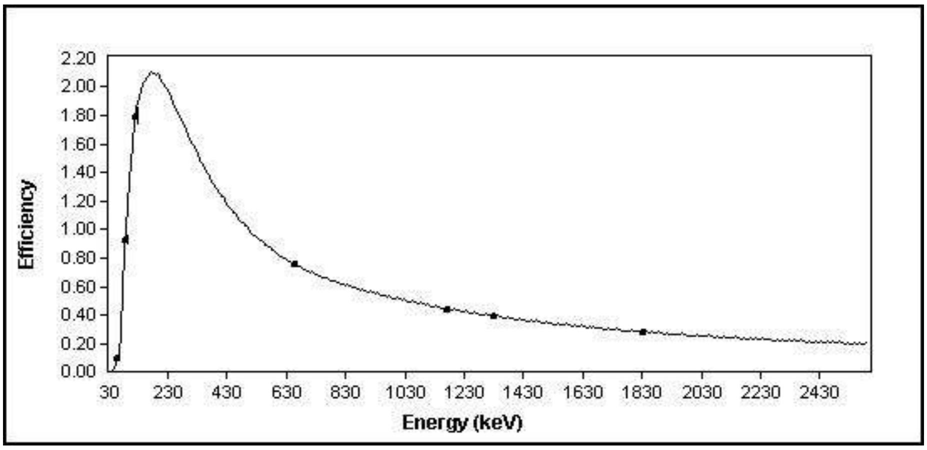

Figure (3.4): Results of Efficiency (%) calibration for HPGe detector

Table (1.1): Gamma Energies

Nuclide	γ-ray energy (Kev)	Half-life	Branching ratio %
241_{Am}	60	432.7 y	36.6
109_{Cd}	88	463 d	3.6
^{57}Co	122	271d	85.6
139_{Ce}	166	137.66 d	79.9
203_{Hg}	279	46.6 d	81.5
113_{Sn}	392	115 d	64.17
137_{Cs}	662	30 y	84.62
^{60}Co	1173	5.2 y	99.35
60_{Co}	1333	5.2 y	99.90
88_{Y}	898	106.01 d	99.90
88_{Y}	1836	1929 d	99.98

IV. RESULTS AND DISCUSSION

Measurements of radiation dose in ten locations around radioactive waste facility of the Atomic Energy Commission for a period of six months were conducted and the results are presented here.Table (1.2) and figures from (4.1 up to 4.6) present the data of dose measurement during 6 month in the 10 location. It is found that the consciences of the average dose for each month from month1 to 6 are: 1.48, 1.57, 1.57, 1.63, 1.76,and 1.74, µSv/h respectively. This indicates there are no increases observed in the dose level around the waste facility. If comparing the dose result with standards of the IAEA it can be concluded that the obtained values are within the acceptable level for most of the sample. Contamination due to release or leakage from stored source may occur, radiation measurements were taken.

Table (4.1): Average dose and standard deviation for a period of 6 months around the radioactive waste facility

No of samples	Month	Min	Max	Mean	Std
40	1	0.37	7.2	1.48	1.97
40	2	0.40	7.2	1.57	2.02
40	3	0.39	7.1	1.57	2.04
40	4	0.35	7.3	1.63	2.01
40	5	0.27	6.98	1.76	1.99
40	6	0.33	7.1	1.74	2.07

The results of these measurements shown in Table (4.2) and figures from (4.1 up to 4.6) present counts per second (CPS). The results indicates that no contamination occurred since that all readings were below the natural background levels. The soil sample taken around the facility are reported in Table (4.3) showed low levels of radioactivity. Only tracers of ^{137}Cs were observed. Statistical Package for the Social Sciences (SPSS) program (Kolmogorov - smirnov Test) has been used for normality test. Found that the data of dose and CPS distributed normally because the significant less than 0.05. Correlation test showed that there significant relation between CPS and dose (at p-value of 0.05).Fig (4.7) presents the measurement of dose during the May month it is greater value showed in this month.

Table (4.2): Average cps and standard deviation for a period of 6months around the radioactive waste facility

NO of samples	Month	Min	Max	Mean	Std
40	1	2.4	42.2	10.31	1.11
40	2	2.2	41.1	10.40	1.13
40	3	2.2	37.1	10.76	1.14
40	4	2.1	44.2	10.24	1.09
40	5	2.2	37	9.60	1.06
40	6	2.1	36.6	10.08	1.08

Table (4.3): Concentration of radionuclide, average value and standard deviation in the soil sample from location A up to J (uncertainty ± 2%)

Location	^{238}U [Bq/kg]	^{137}Cs[Bq/kg]
A	23.91	2.04
B	8.90	-
C	14.24	-
D	11.49	-
E	21.72	-
F	10.91	-
G	10.92	-
H	11.13	-
I	14.26	-
J	14.93	-
Mean ± Std	14.24 ± 4.67	-

Radiation level measurements different points were selected around the units to check the background or radiation level at these points through the quality assurance program under the whole program of radioactive waste management. The points represent the technical check of exposure and contamination in term of dose rate. The other parts of management system was regarding documentation, inspection, and, audits.

Table (4.4) : Measurement of radiation dose in30 location around radioactive waste facility

Point number	Dose rate µSv/h
1	1.99
2	0.30
3	0.19
4	0.30
5	0.46
6	4.90
7	2.04
8	8.67
9	0.39
10	0.35
11	0.40
12	5.38
13	33.17
14	0.11
15	3.46
16	1.55
17	8.24
18	0.51
19	8.15
20	8.92
21	84.13
22	0.096
23	0.11
24	0.096
25	0.48
26	0.19
27	0.31
28	0.96
29	0.19
30	0.13

In this discussion we are going to draw scenario about how the periodic measurement of each point can show the radiation level within the facility.

If the dose rate indicate high reading this means some radiation sources is still in the storage step , and if indicate low reading it means the source move from period storage to be transported to other side for application intended to use .

Values of dose rate of the points range from 0.096 minimum to 84.13µSv/h maximum. Some point with extremely low dose rate according to suitable location of radiation source in permanent and temporary storage.The remainder with high dose rate located in the corner of temporary storage which prepared for source being under processing after it has been removed this points will be extremely with back ground level of radiation .The remainder with high dose rate located in the corner of temporary storage .In the remainder with high dose rate located in the corner of temporary storage which prepared for source being under processing for transport after it has being removed this point will be extremely high background level of radiation . There are no increases observed in the dose level around the waste facility. If comparing the dose result with standards of the IAEA it can be concludes that the obtained values are within the acceptable level for most of the sample.

V. CONCLUSIONS

Based on this review of dose characterization around the waste facility, one can be draw the following concluding remarks:

The obtained dose values within the acceptable level for most of the samples also soil samples taken around the facility showed low levels of radioactivity. Only tracers of ^{137}Cs were observed due to contamination from conditioning operations. Finally analytical results demonstrate that no radiological anomaly exists.

VI. RECOMMENDATIONS

One can recommend that :

The site is duly fenced off to prevent unauthorized entry. Also the storage area should be treated as restricted area and subjected to periodic environmental surveillance by the Radiological Safety Officer to ensure that the appropriate disposal limits and operational limits are not exceeded.

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