RESEARCH ARTICLE

Study of some requirements of the environmental management system at the test-work facilities of the Egyptian black sands at Abu Khashaba and Rasheed.

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Manuscript Info

Abstract

Two requirements of the environmental management system at Abu Khashaba and Rasheed facilities were evaluated. The first requirement was the quantities of sands processed at both facilities. A total mass of 3509 (tons) was processed at Abu Khashaba facility representing a total radioactivity of 2.57×10^9 (Bq) while a total mass of 1973 (tons) was processed at Rashedd facility representing a total radioactivity of 5.97×10^9 (Bq). The majority of radioactivity at Abu Khashaba facility comes from raw sands while the majority of radioactivity at Rasheed facility comes from monazite mineral. This strongly suggests the establishment of an efficient marketing plan to displace monazite from Rasheed facility.

The second requirement was to evaluate the emission of radioactivity from the studied facilities to the surrounding environment. It was very difficult to relate any change in the external effective dose rate received by the public around the facilities to the radiation activities inside these facilities. On another hand, the excess radon gas concentration at the downstream of Abu Khashaba and Rasheed facilities was found to be 1 and 3.57 (Bq/m^3), respectively. These excess concentrations resulted in an increase in the annual effective doses of 0.025 and 0.092 (mSv/y) at Abu Khashaba and Rasheed facilities, respectively. The additional effective doses received by the members of public around the studied facilities are much below the recommended dose limit of 1 (mSv/y).

The study recognized an efficient plan to displace the waste sands from Abu Khashaba and Rasheed facilities. It is concluded that the radiation activities at the studied facilities are consistent with requirements of environmental safety.

Introduction:-

An environmental management system (EMS) is a systematic approach for managing an organization's environmental issues and opportunities. Good, or even 'best practices' alone do not make an EMS (Matela, 2006). The essential characteristic of an EMS is that its various components interact to provide measurable information enabling continual improvements. The 'systems' approach means that processes are stable and repeatable, yield more predictable outcomes and adapt new learning to continuous improvement (Iyer, 2006). The definition of EMS according to ISO 14000 'That part of the overall management system which includes organization structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy (Dyndgraad and Kriger, 2002). The costs and benefits of an EMS will vary significantly depending on the type of organization, the existing 'eco-efficiency' of resource utilization, the potential environmental impacts and risks, the degree to which the enterprise already has

implemented various elements of the system, and the premium placed by the enterprise's customers and others stakeholders on a formal, independently audited EMS. Eco-efficiency is the primary way in which business can contribute to the concept of sustainable development....The vision of eco-efficiency is simply to produce more from less. Reducing waste and pollution, and using fewer energy and raw materials is obviously good for the environment. It is also self-evidently good for business because it cuts companies costs (EEA, 1988; Huesemann, 2003).

On another hand, the municipality or facility's EMS must include a monitoring and measurement component. This component must meet the following specific requirements (IAEA, 2006; Matela, 2006):
   • Documented procedures for regularly monitoring and measuring the key characteristics of municipal or facility operations and activities that can have significant environmental impacts.
   • Documented procedures for tracking and recording information on performance, on relevant operational controls, and on progress toward the facility's environmental objectives and targets.
   • Procedures for calibration and maintenance of monitoring equipment and retention of records.
   • Documented procedures for periodically evaluating the facility's compliance - with applicable environmental laws and regulations.
In designing performance indicators it is necessary to link them to specific objectives or targets so that they will provide practical data for corrective action to meet the organization's environmental commitments.

Egyptian Black Sand contains several economic minerals, such as ilmenite, magnetite and rutile as well as zircon and monazite, which are classified as radioactive minerals. One source of these sands is located on of Abu-Khashanba beach at the Mediterranean coast of Nile delta. Twot test-work facilities are now going on at Abu Khashaba and Rasheed separate and concentrate these black sands by physical methods. The emission of radioactive gases and dust to the surrounding environment and may cause some hazards to the members of public at these areas. This study aims to evaluate the quantities of the radioactive minerals concentrated at both Abu-Khashaba and Rasheed facilities and to assess the excess radiation doses received by the public around these facilities. Also, the study evaluates the existing EMS in order to propose the suitable recommendations to develop this system.

Field works and experimental methods:-
Site monitoring:-
This study investigated the radioactivity in the sands and minerals at three different areas and the resulting radiation exposures. The first is at the beach of Abu Khashaba area, Fig (1). Thirty three monitoring stations were chosen to study the natural source of the black sands. The second is at Abu Khashaba village where the test-work facility of black sands is located at its south. Monitoring stations were distributed over 36 locations; upstream, inside and downstream of the facility, Fig (2). Rasheed test-work facility is located to the south of Rasheed city. Seventy two monitoring station were located over the area in the same manner, Fig. (3).
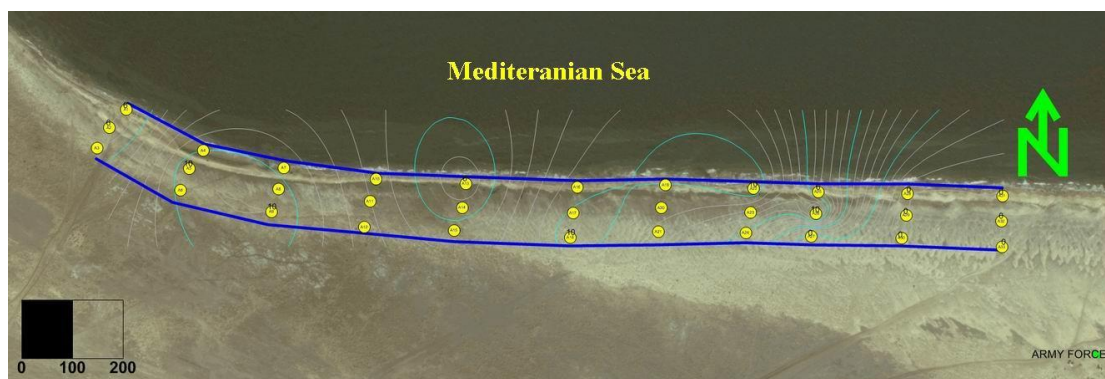
Fig. (1): Thirty three locations at Abu Khashaba shore.

Quantities and radioactivity of the sands:-
Two samples from each mineral or sand tails were collected to measure its radioactivity; one from Abu-Khashaba facility and the other from Rasheed facility. The raw sands were represented by four samples collected from the natural source at Abu-Khashaba beach and two samples from each facility. The collected samples from each mineral were mixed to make one representative sample of this mineral.

Fig. (2): Thirty six locations distributed upstream, inside and downstream of Abu Khashaba facility.

Fig. (3): Seventy two locations distributed upstream, inside and downstream of Rasheed facility.

Radioactivity in the studied sands and minerals:-
About 300-350g from each sample was packed in a plastic container, sealed well and stored for about 30 days before analysis. This prevents the escape of radiogenic gases ^{222}Rn and ^{220}Rn and allows the in-growth of uranium ^{238}U and thorium ^{232}Th decay products to reach secular equilibrium. After attainment of secular equilibrium, each of the prepared samples was measured in the laboratory for their U, Th, Ra and K contents using a high efficiency multichannel analyzer of γ-ray spectrometer (NaI detector). Each sample was counted for 1000s. The radiometric measurement for the studied radionuclides was carried out through four energy regions of interest (ROIs). Since uranium and thorium are not γ-emitters, they were measured indirectly through the γ-ray photons emitted from their decay products, ^{234}Th (81-108keV) for ^{238}U, ^{212}Pb (221-273keV) for ^{232}Th, and radium was measured from the γ-ray photon emitted by ^{214}Pb (327-390keV) whereas potassium was measured directly from the γ-ray photon emitted by ^{40}K (1319-1471keV). Consequently, they are expressed as equivalent U (eU), equivalent thorium (eTh) and equivalent radium (eRa). The chosen energy regions for U, Th, Ra and K were determined from the indicated energy lines of the spectra generated by means of laboratory uranium, thorium, radium and potassium reference standard samples provided by the IAEA. This technique was carried out at laboratory of γ-ray spectrometry of the Egyptian Nuclear Materials Authority (ENMA). Its probable measurement error was about 10% (Matolin, 1991).

The state of radioactive equilibrium makes it possible to employ the obtained uranium concentration instead of radium concentration to estimate the external absorbed dose rates due to the external exposure to γ-rays(5). The values of eU and eTh in ppm as well as K in percent were converted to activity concentrations, (Bq/kg), using the conversion factors given by the International Atomic Energy Agency (IAEA, 1989). The activity concentration of a sample containing 1 ppm by weight of eU yields 12.35 (Bq/kg) of ^{238}U, 1 ppm of eTh yields 4.06 (Bq/kg) of ^{232}Th and 1 % of K yields 313 (Bq/kg) of ^{40}K.

Volumes and masses of the studied sands:-
The pile's shape of each mineral or sand type was approximated to a representative parallelogram.

Radiation exposures:-
Measurements of gamma effective dose rate:-
The effective dose rates (μSv/h) due to γ-ray exposures were measured at 1m over the sands at each location, using ALNOR RDS-100 gamma survey meter calibrated against a ^{60}Co γ-source of activity 7.4 x10^8 Bq at the National Institute of Standards and Technology (NIST). To obtain the effective dose rate (E_γ) due to the emitted γ-rays from the radioactive elements in the sands only, the dose rate from the cosmic rays at sea level, which is 0.031 (μSv/h), (UNSCEAR 2000), was subtracted from the recorded readings.

Measurements of radon gas concentration:-
The RTM-1688 devise used to measure the radon concentration at each location. An air sample was withdrawn from the air at each location by the pump of the monitor. After one hour from the start of the sampling, a direct reading from the screen of the monitor represents the concentration of radon gas (Bq/m^3).

Result and discussions:-
Physical separation of the economic minerals from black sands at Abu Khashaba and Rasheed facilities represents a reasonable potential to radiation exposures to the occupants and the surrounding environment. However, the radiation effective doses received by workers or members of public are proportional to the activity of the radiation source which in turn is proportional to the mass of the processed sands.

Quantities of the studied sands:-
Senior management should ensure that the resources5 that are essential to the implementation of the strategy for the management system and the achievement of the organization's objectives are identified and made available. Resources include individuals, infrastructure, the working environment, information and knowledge, and suppliers, as well as material and financial resources (IAEA, 2006).

Table (1) represents the dimensions (length L, width W and thickness T), the density ρ of the different sands and the masses M of the sand piles of the different minerals at both Abu Khashaba and Rasheed facilities. From these tables, the quantities of the processed or stored sand at Abu Khashaba facility is almost twice the quantity processed at Rasheed facility.

In fact, radiation exposures depend on the activity of the radioactive source. Accordingly, the activity concentration of the terrestrial radionuclides ^{238}U, ^{232}Th and ^{40}K in the studied sands should be assessed. Table (2) represents the activity concentrations of these radionulides in the sand piles at both Abu Khashaba and Rasheed facilities and the bulk activity of these piles. From the table, the total activity of the sands processed at Rasheed facility is almost twice the total activity of the sands processed at Abu Khashaba facility. Also, it is clear that most of the activity at Rasheed facility comes mainly from monazite mineral while most of the activity at Abu Khashaba facility comes from raw sands.

Table (1): Dimensions of the sand and mineral piles and their masses at Abu Khashaba and Rassheed facilities. ρ represents the density.

Mineral	L (m)	W (m)	T (m)	V (m³)	ρ (kg/m³)	M (tones)
Abu Khashaba facility						
ilmenite	5	3	1	15	4670	56
magnetite	14	17	2	476	5000	1904
zircon	1.5	4.7	1.8	12.69	4820	48.93
rutile	2	2.2	1	4.4	4370	15.38
raw	5	3	0.5	7.5	2700	16.2
raw	20	17.5	1.5	525	2700	1134
zircon	1	1.5	0.5	0.75	4820	2.89
Gr+IL+Mg	4	4	2	32	5000	128
monazite	0.5	0.5	0.5	0.13	5190	0.52
waste	3.6	7	0.75	18.9	2700	40.8
waste	0.5	0.5	0.25	0.07	2700	0.14
waste	1.5	0.5	0.5	0.38	2700	0.81
ilm. med.	4.6	4.7	2	43.24	4670	161.5
					Total mass	3509
Rasheed facility						
ilmenite	6	3	2	36	4670	134.5
magnetite	8	4	1.5	48	5000	192.0
zircon	3	3	1.5	13.5	4820	52.1
waste	9.5	4.5	0.5	21.4	2700	46.2
monazite	12	6	1.5	108	5190	448.4
raw	14	10	1.5	210	2600	453.6
rutile	10	8	2	160	4370	559.4
waste	0.5	0.25	0.5	0.06	2700	0.1
raw	5	4	2	40	2700	86.4
					Total mass	1973

Gr+IL+Mg=mixture from green silicates, ilmenite and magnetite for the strengthening of agricultural areas. ilm. Med.= ilmenite medling

However, monazite mineral is known to be a very important resource of the rare earth elements which represent the base of many industries. This along with the high activity of monazite suggests strongly the establishment of an efficient marketing plan to displace monazite from Rasheed facility.

Table (2): Activity concentration of ^{238}U, ^{232}Th and ^{40}K, , the total activity concentration A, tested total activity concentration A$_{U+Th}$ and the bulk activity A$_T$ of the sand and mineral piles at Abu Khashaba and Rassheed facilities.

Mineral	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	A (Bq/kg)	A$_{U+Th}$ (Bq/kg)	A$_T$ (Bq)
Abu Khashaba facility						
ilmenite	49.4	140	82.9	272.4	189.4	1.53E+07
magnetite	15.44	56.84	70.4	142.7	72.28	2.72E+08
zircon (R)	2678	4385	BDL	7063	7063	3.46E+08
rutile (R)	237.7	90	BDL	1147	1147	1.76E+07
raw (R)	429.2	924	5.22	1359	1353	2.20E+07
raw (R)	429.2	924	5.22	1359	1353	1.54E+09
zircon (R)	2678	4385	BDL	7063	7063	2.04E+07
Gr+IL+Mg	123.5	592.8	25.04	741.3	716.3	9.49E+07
monazite (R)	3952	5278	BDL	9230	9230	4.79E+06
waste	138.94	252.4	145	536.4	391.3	2.19E+07
waste	138.94	252.4	145	536.4	391.3	7.24E+04
waste	138.94	252.4	145	536.4	391.3	4.34E+05
ilm. med. (R)	389	958	BDL	1347	1347	2.18E+08
					Total activity	2.57E+09
					Total regulated	2.15E+09
Rasheed facility						
ilmenite	49.4	140	82.95	272.4	189.4	3.66E+07
magnetite	15.44	56.84	70.43	142.7	72.28	2.74E+07
zircon (R)	2678	4385	BDL	7063.2	7063	3.68E+08
waste	138.9	252.4	145	536.4	391.3	2.48E+07
monazite (R)	3952	5278	BDL	9230	9230	4.14E+09
raw (R)	429.2	924.3	5.22	1359	1353	6.16E+08
rutile (R)	237.7	909	BDL	1147	1147	6.42E+08
waste	138.9	252.4	145	536.4	391.3	7.24E+04
raw (R)	429.2	924	5.22	13593	1353	1.17E+08
					Total activity	5.97E+09
					Total regulated	5.76E+09

BDL=below detection limit.
(R)=regulated sand or mineral.

Regulated and non-regulated sands:-

The Egyptian Ministry of Electricity published the ministerial order No. 202/2008 which stated that the radioactive material of natural origin is classified as dangerous material if the activity concentration of ^{238}U and ^{232}Th together, A$_{U+Th}$, in the material exceeds 1000 (Bq/kg) or the activity concentration of ^{40}K exceeds 10000 (Bq/kg), (MoE, 2008). The materials which have activity concentrations exceed the concentrations proposed by MoE should be subjected to the regulations of the International Atomic Energy Agency (IAEA).

Table (2) labels the regulated sands according to the value of A$_{U+Th}$ with the letter (R). It is clear that most of the sand piles at both Abu Khashaba and Rasheed facilities are classified as regulated sands. Indeed, the most of the total activity A (Bq) mainly comes from the regulated sands.

Waste sands:-

The raw sands at both Abu Khashaba and Rasheed facilities represent a total mass of 1690 tons. At maximum, only 10% represent the economic minerals that may be separated from the black sands. Accordingly, the waste sands represent a total mass of 1520 tons. Only 88 tons of the waste sands remain at both Abu Khashaba and Rasheed facilities. This indicates an efficient plan to displace the waste sands from the studied facilities.

However, from table (2), waste sands are not classified as regulated sands as they have an activity concentration which is lower than the condition in equation (1). As there is no other contaminant or pollutant in the waste sands from Abu Khashaba and Rasheed facilitie, the members of public around these facilities get these waste sands for their regular uses; manufacturing of building bricks, fill-up of buildings and roads and uplifting the agricultural areas (Abdel-Razek et. al., 2013).

Radiation exposures:-
Enhanced concentrations of the radionuclides ^{238}U, ^{232}Th and ^{40}K in any terrestrial rocks or sands lead to high radiation exposures to the workers or public. Gamma emitters from the decay chains of ^{238}U and ^{232}Th and from ^{40}K give rise to the external effective doses. On another hand, radon gas originated from ^{238}U series emanates from the sands and diffuses into the surrounding atmosphere.

At Abu Khashaba shore:-
The studied site represents an area of 100mx2km, Fig. (1). Table (3) shows the external effective dose rate E_γ (µSv/h) at 1m above the ground due to the terrestrial radionuclides in the shore sands and the concentration of radon gas C_{Rn} (Bq/m^3) in the air at the studied area.

Table (3): External effective dose rate E_γ at 1m above the ground and the radon gas concentration C_{Rn} at Abu Khashaba shore.

No.	E_γ(µSv/h)	C_{Rn}(Bq/m^3)	No.	E_γ(µSv/h)	C_{Rn}(Bq/m^3)	No.	E_γ(µSv/h)	C_{Rn}(Bq/m^3)
1	0.118	6	12	0.238		23	0.118	
2	0.068	6	13	0.168	6	24	0.108	
3	0.078		14	0.098		25	0.128	6
4	0.118		15	0.138		26	0.128	10
5	0.138	10	16	0.118		27	0.138	
6	0.178		17	0.148		28	0.168	
7	0.238		18	0.218	10	29	0.188	
8	0.198		19	0.178		30	0.168	
9	0.148	10	20	0.178		31	0.158	
10	0.118		21	0.118		32	0.108	
11	0.158		22	0.118	10	33	0.208	
Overall Average			E_γ= 0.148 (µSv/h)			C_{Rn}= 8.22 (Bq/m^3)		

The values of E_γ over the sands at At Abu Khashaba shore range between 0.068 and 0.238 (µSv/h) with an average of 0.148 (µSv/h). However, direct measurements of the effective dose rates E_γ in air have been carried out in many countries of the world. The population-weighted average is 0.059 (µSv/h). The average values range from 0.018 to 0.093 (µSv/h). A typical range of variability for measured absorbed dose rates in air is from 0.010 to 0.200 (µSv/h) (UNSCEAR, 2000). This indicates that the external effective dose rate at Abu Khashaba shore is consistent with worldwide average.

The maximum value of radon gas concentration equals exactly the reported worldwide average of 10 (Bq/m^3). Finally, it must be recalled that the radiation exposures at this area are the result of an average activity concentration A_T of 1359 (Bq/kg) embedded in the shore raw sands.

At Abu Khashaba and Rasheed facilities:-
Table (4) represents the external effective dose rate E_γ (µSv/h) and the radon gas concentration C_{Rn} (Bq/m^3) at the studied locations; upstream, inside and downstream of Abu Khashaba and Rasheed facilities. The value of E_γ inside each facility is almost one order magnitude the value of E_γ at the upstream and the downstream of the facility. Also, the average value of E_γ at the upstream of each facility is higher than the average value at the downstream of the facility. This is because the measurements of E_γ at the upstream are achieved between the public buildings which add external exposures from the terrestrial constituents of these buildings. The average value of E_γ at the upstream of Abu Khashaba facility is higher than the average value at the upstream of Rasheed facility. Indeed, the streets and allies between the buildings at Abu Khashaba are narrower than that at Rasheed which strengthens the effect of gamma rays emitted from the buildings around the studied locations at Abu Khashaba facility.

Table (4): External effective dose rate E_γ at 1m above the ground and the radon gas concentration C_{Rn} at the studied location; upstream, inside and downstream of Abu Khashabs and Rasheed facilities.

Upstream			Inside			Downstream		
No.	E_γ (µSv/h)	C_{Rn} (Bq/m^3)	No.	E_γ (µSv/h)	C_{Rn} (Bq/m^3)	No.	E_γ (µSv/h)	C_{Rn} (Bq/m^3)
Abu Khashaba facility								
0.064	0.034	BDL	9	0.839	BDL	14	0.024	
2	0.034	BDL	10	0.194	6	29	0.024	6
3	0.034		11	0.229		30	0.039	
4	0.034		12	0.289	6	31	0.039	
5	0.034	6	13	0.214		32	0.029	
6	0.039		16	0.414		33	0.029	BDL
7	0.039	6	17	0.299	10	34	0.029	
8	0.044		18	0.384		35	0.034	6
15	0.049		19	0.299	BDL	36	0.039	BDL
20	0.119	BDL	21	0.414				
28	0.044	BDL	22	0.649	6			
			23	0.289				
			24	0.309	6			
			25	0.044				
			26	0.394	BDL			
			27	0.279				
Ave.	0.046	2	Ave.	0.346	4.25	Ave.	0.032	3
Rasheed facility								
1	0.029		19			17	0.029	
2	0.029	BDL	20	0.059		18	0.034	
3	0.029		21	0.079		25	0.024	
4	0.029		22	0.139	6	26	0.039	
5	0.034		27	0.074		33	0.049	
6	0.049		28	1.619		34	0.049	6
7	0.049		29	1.619	10	41	0.039	
8	0.049	BDL	30	2.369		42	0.079	BDL
9	0.034	BDL	35	0.064		49	0.049	
10	0.039		36	0.099		50	0.029	BDL
11	0.049	BDL	37	0.114		55	0.034	
12	0.034		38	0.244		57	0.049	
13	0.029		43	0.109	6	58	0.029	
14	0.034		44	0.109		59	0.029	10
15	0.054	BDL	45	0.114		60	0.034	
16	0.049		46	0.279		61	0.029	6
23	0.039		51	0.104		62	0.034	BDL
24	0.054		52	0.099	6	63	0.024	
31	0.029		53	0.104		64	0.029	
32	0.039	BDL	54	0.199		65	0.024	
39	0.024					66	0.024	
40	0.034					67	0.029	
47	0.024					68	0.034	
48	0.049					69	0.024	
56	0.039					70	0.024	
						71	0.024	
						72	0.029	
Ave.	0.038	BDL	Ave.	0.383	7	Ave.	0.0342	3.67

On the other hand, the values of radon gas concentration C_{Rn} ranged between below the detection limit to a maximum of 10 (Bq/m^3). The average value of C_{Rn} at both facilities is below the worldwide public average of 10 (Bq/m^3) (UNSCEAR, 2000). The narrow streets at Abu Khashaba decrease the natural ventilation rate. This allows radon gas emanating from the buildings to build up between these buildings. The average value of C_{Rn} at the upstream of Abu Khashaba facility is 2 (Bq/m^3). The average value of C_{Rn} at the upstream of Rasheed is below the detection limit because of the wide distances between the buildings which disperses the gas over wider areas and dilutes its concentration.

The respective high values of C_{Rn} and E_γ at Rasheed facility compared to Abu Khashaba facility is related to the fact that the total radioactivity processed at Rasheed facility is almost twice that processed at Abu Khashaba facility, Table (2).

Emission of radioactivity from the studied facilities:-
As discussed above, the average values of the external effective dose rate E_γ at the upstream of the studied facilities are higher than the average values at the downstream of the facilities. Accordingly, it is very difficult to relate any additional external exposures received by the public around the studied facilities to the activities inside these facilities.

From table (4), the difference between the average value radon gas concentration C_{Rn} in the air at the downstream of Abu Khashaba facility and the average value at the upstream of the facility is 1 (Bq/m^3). This difference adds a value of 0.025 (mSv/y) to the annual effective dose received by the members of public at Abu Khashaba facility. The International Committee on Radiological Protection (ICRP) recommended a limit of 1 (mSv/y) received by the public as a result of any radiation activities (ICRP, 2007). The estimated value of the additional annual effective dose at Abu Khashaba facility is much lower than the recommended limit. Also from table (4), the difference between the average value of the radon gas concentration at the downstream of Rasheed facility and the upstream is 3.67 (Bq/m^3). This difference is not necessarily attributed to the activities inside the facility since a part of the area at the downstream of Rasheed facility represents a sandy hill which has a high porosity that emanates radon gas to the surrounding atmosphere. At maximum, the additional effective dose received by the members of public at Rasheed facility due to radon gas is 0.092 (mSv/y) which is much below the recommended limit.

It must be mentioned that each facility established an internal cycle to treat the used waters which assures that no radioactivity is discharged to the surrounding environment by means of liquids. Also, many previous studies measured the concentration of the dust that may be released through the different stages of physical separation of minerals from the black sands at Abu Khashaba and Rasheed facilities. The results showed that the concentrations of radioactivity in the dust at the inside borders of the studied facilities is not detected (Abdel-Razk et. al., 2012; Nasr, 2012[)].

Records:-
This work represents the first effort to evaluate the quantities of the sands or the radioactivity processed at both Abu Khashaba and Rasheed facilities. The study evaluated and recorded the emission of radioactivity from the studied facilities to the surrounding environment. However, the facility's EMS must have procedures for identifying, maintaining, and disposing of environmental records. Environmental records are the output of the EMS and include training records, monitoring results (e.g., air emissions and wastewater treatment), EMS audits, and regulatory permits. The environmental records management process must ensure that records are legible, identifiable, and traceable to the activity, product or service involved. Environmental records must be readily retrievable and protected against loss or deterioration. Environmental records retention times must be documented (ADEQ, 2014).

Conclusions:-
Processing of 3509 and 1973 (tons) of black sands at Abu Khashaba and Rasheed facilities added annual effective doses of 0.025 and 0.092 (mSv/y), respectively. These doses are much below the recommended limit of 1 (mSv/y). Accordingly, the radiation activities at Abu Khashaba and Rasheed facilities are consistent with requirements of environmental safety. While there is an efficient marketing plan to displace waste sands from the studied facilities, it is suggested to establish another one to displace monazite from Rasheed facility.

Acknowledgements:-

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