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Measuring Natural Radiation (N.O.R.M) inside some oil fields in Libya

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Abstract

In this study, the natural radiation which known scientifically as NORM (Naturally Occurring Radioactive Materials) was measured, six different samples from different fields were collected, Sample 1, 2 and 3 are crude oil mixed with soil (Sludge) taken from the oil lakes (pits), Sample 4 is a crude oil taken from storage tanks, samples 5 and 6 are a squamous crust (Scales) accumulated in the production pipe lines.

NORM (Gama Rays) was measured by High pure Germanium Detector- HPGe in the prevention department of Nuclear Research Center/ Tajura , Tripoli-Libya, and the results were as follows:

Sample	1	2	3	4	5	6
Activity Concentration (Bq/kg)	**54.6±7.38**	**19.69±4.43**	**12.27±3.5**	**3.97±1.99**	**4017.2±63.38**	**5522.6±74.31**

Table (1)

From these results, samples 1,2,3 and 4 were in the exemption level, samples 5,6 were recorded over the normal radiation level.

(P.S.: There was no reference to the names of fields upon the request of officials of these fields)

Key words: NORM, Scales, Sludge, crude oil, radiation

Introduction

Naturally occurring radionuclides are present at varying concentrations in the Earth's crust, and it has a nuclear activity in which the nuclei of unstable elements transferred to new nuclei of elements. Such transitions automatically occur without any external influences (1).

Most of the natural radioactive isotopes belongs to three radioactive families, i.e. uranium 238 series (^{238}U), thorium 232 series (^{232}Th) and uranium 235series (actinium series) (^{235}U). In each series, the heavy isotopes dissolved to various isotopes with low launching radiation until reached to the state of stability. . In addition to the natural radioactive series, there is in nature some other radioactive isotopes that are not belong to those chains such as potassium(^{40}K),Cesium 137(^{137}Cs) and Carbon14 (^{14}C), all of which are characterized by large half ages.

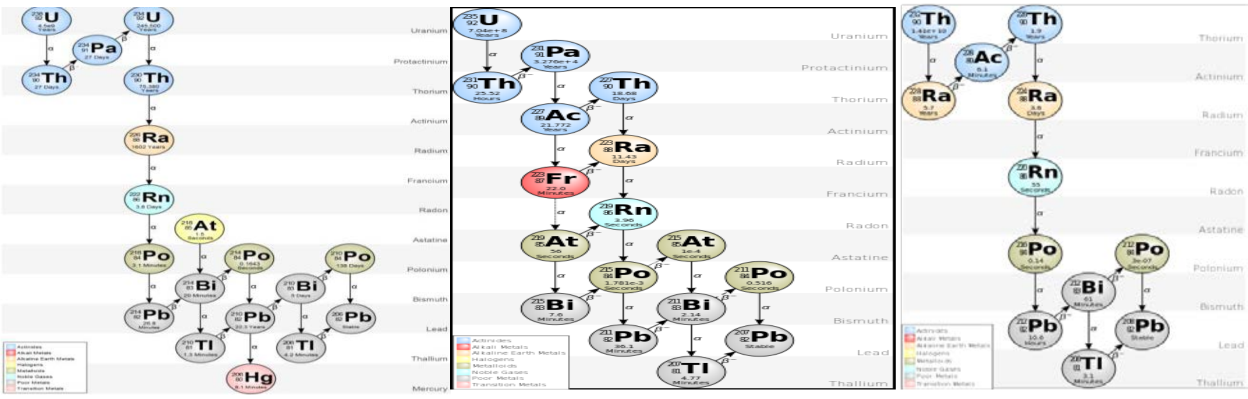

Figure (1) uranium series 235 Uranium series 238 Thorium Series 232 (3).

Oil and Gas Industry is considered as an industry whose employees were exposed to the risk of natural radioactive materials that are concentrated and enhanced by processes associated with the recovery of oil and gas . This “enhanced'' NORM, often known as TENORM (Technologically-Enhanced Naturally Occurring Radioactive Materials). The natural radioactive materials accompanied the oil extracted from the ground, to position on the inner walls of pipes and oil separation or stored depots. Such localizations took the form of squamous (scales) deposits. The produced water attached to the oil holds(sludge) also such Radioisotopes, which not deposited in the pipes and reservoirs in the form of scales , so this water thrown into the surrounding environment contaminates the soil. The oil residue from the productive waters and scales sediments thrown in the surrounding environment lead to contamination of natural radioactive materials (2). The workers, through their work near the equipment containing the scales deposits, receive an external radiation dose caused by gamma radiation that can penetrate large thicknesses of iron. Such dose considered as less dangerous than the internal radiation dose that workers can be received when direct touch with squamous sediment, during equipment, pipes and reservoirs maintenance operations due to the possibility of entry of molecules carrying radioactive materials to their bodies through the respiratory tract (2).

Figure (1) indicates where NORM may accumulate, *eg* at wellheads in the form of scale; at Gas/Oil Separation Plants (GOSP) in the form of sludge; and at gas plants the form of thin films as the result of radon gas decay.

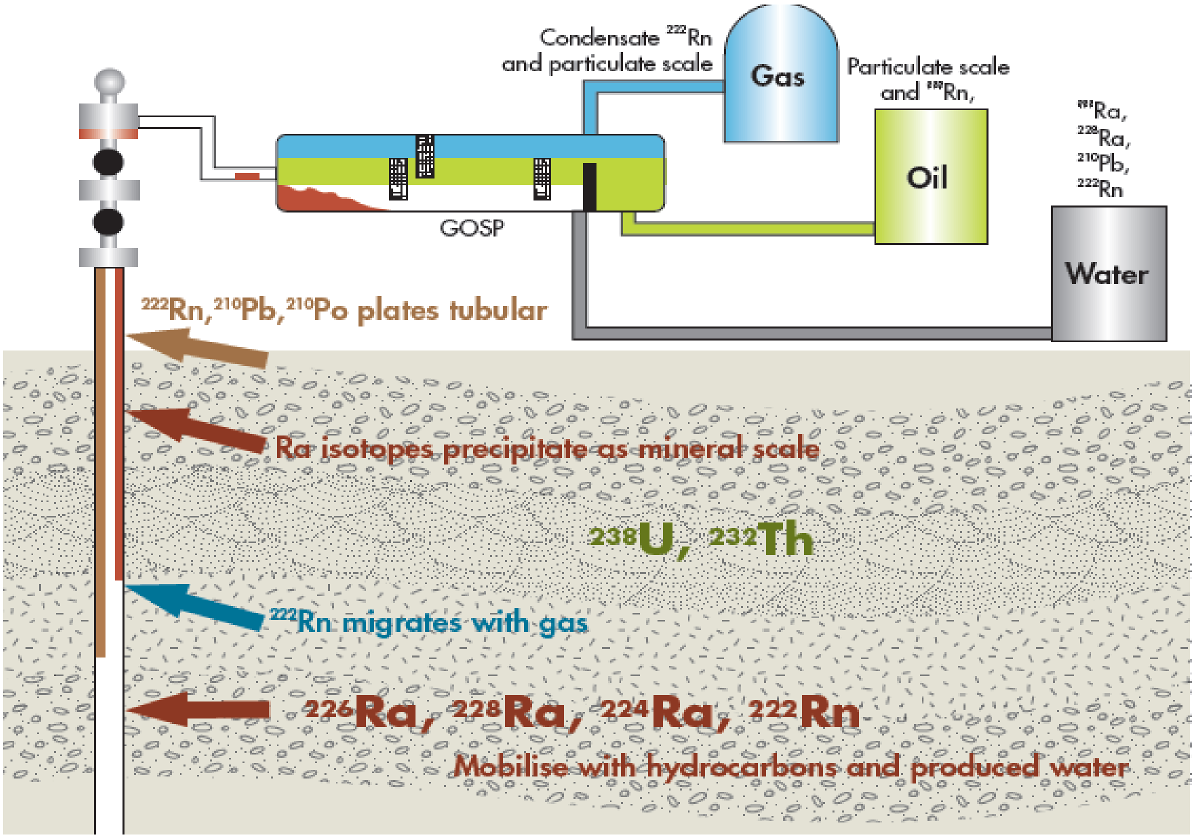

Figure 2- The origins of NORM, indicating where NORM may accumulate in the recovery process.(4)

Materials and methods

Table (2) The necessary information about Sampling

Number of Sample	Shape of the Sample	Weight of the Sample (Kg)	Time of the detect (hr)	Date of Collect	Date of Detect
1	Sludge	1.35	14	Oct/2013	Mar/2014
2	Sludge	1.35	14	Oct/2013	Mar/2014
3	Sludge	1	13	Oct/2013	Mar/2014
4	Crude Oil	0.7	15	2013	Mar/2014
5	Scales	0.7	12	Dec/2013	Mar/2014
6	Scales	1.35	12	2013	Mar/2014

Table (2) shows the necessary information about Sampling

Figure (3) Scales inside the pipes

Figure (4) samples 1,2,4

1. After cleaning the samples, were left for a month and a half in order to reach equilibrium radiation, and calibration of HPGe processed, the samples placed for a period of 12 to 15 hours within the detection system.

2. The used Germanium detector is equipped with software that gives readings directly, it means count rate "cps", without counting the background radiation (radiation found in the lab and not associated to samples).

3. Measurement system electronically equipped in order to give a table results.

4-Constants such as gamma rays ratio "$I\gamma$" for each energy or efficiency Eff were taken from lab documents.

Results and discussion

The radioactivity A can be calculated shortly as follows: $A = \frac{net(Cps)}{Eff.W.I_{\gamma}}$ Bq / kg

Eff : The devise efficiency at specific energy, net (Cps) net count rate per second for specific energy, Iγ rate of gamma rays emitted at Gamma Yield, W is sample weight ((kg).

Table 3- illustrates the contents of samples, the radionuclides and their average activity

Sample No		**The radionuclides in the samples**	**radioactivity average (Bq/kg)**
1		Ac-228,Bi-214,K40,Pb-212,Pb-214,Ra-226,Tl-208	54.6±7.38
2		Ac-228,Bi-212,Bi-214,K40,Pb-212,Pb-214,Ra-226,Tl-208	19.69±4.43
3		Ac-228,Bi-212,Bi-214,Cs137,K40,Pb-212,Pb-100,Pb-214,Ra-226,Tl-208	12.27±3.5
4		Bi-214,K40,Pb-212,Pb-214-Tl-234,Tl-208	3.97±1.99
5		Bi-211,Bi-214,Pb-212,Pb-214,U-235	4017±63.38
6		Ac-228,Bi-212,Bi-214,Pb-212,Pb-214,Ra-223,Tl-208	5522±74.31

Table 3- illustrates the contents of samples in terms of radioactive elements and radioactivity average.

Radioactivity elements in the samples			
Nuclide	Half-Life	Decay Modes	Series
Ac-228 (Actinium)	6.13hr	B^{-} γ	Th232
Bi-211 (Bismuth)	2.17m	B^{-} α γ	U235
Bi-212 (Bismuth)	60.55min	B^{-} α γ	Th232
Bi-214 (Bismuth)	19.9min	B^{-} α γ	U238
Pb-212 (lead)	10.64hr	B^{-} γ	Th232
Pb-214 (lead)	26.8min	B^{-} γ	U238
CS137 (Cesium)	30.17y	B^{-} γ	
K40 (Potassium)	1.28x109y	B^{-} γ	
Ra223 (Radium)	11.43d	α γ	U235
Ra-226 (Radium)	1622y	α γ	U238
Tl-208 (Thallium)	3.055m	B^{-} γ	Th232
U-235 (Uranium)	7.038X109y	α γ	

Table 4- some details about radionuclides in the samples

The following figures show the percentage of radionuclides inside the samples

Sample 1

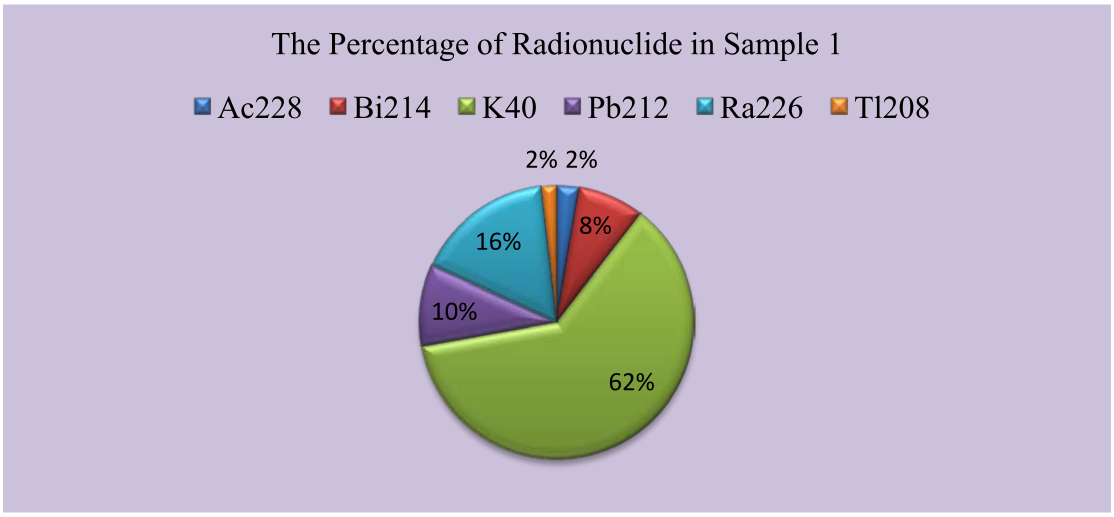

Figure 5- The percentage of Radionuclide in the sample 1

Sample 2

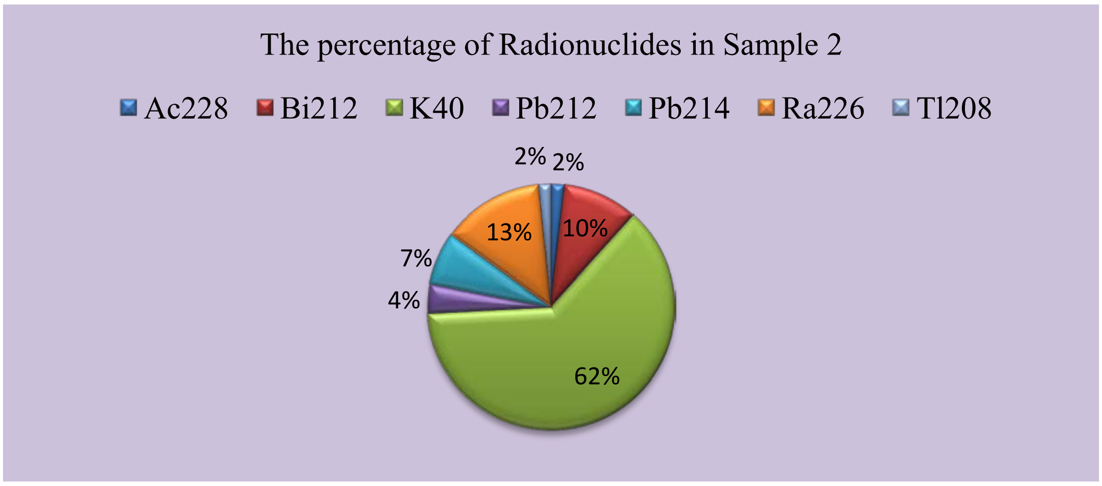

Figure 6- The percentage of Radionuclide in the sample 2

Sample 3

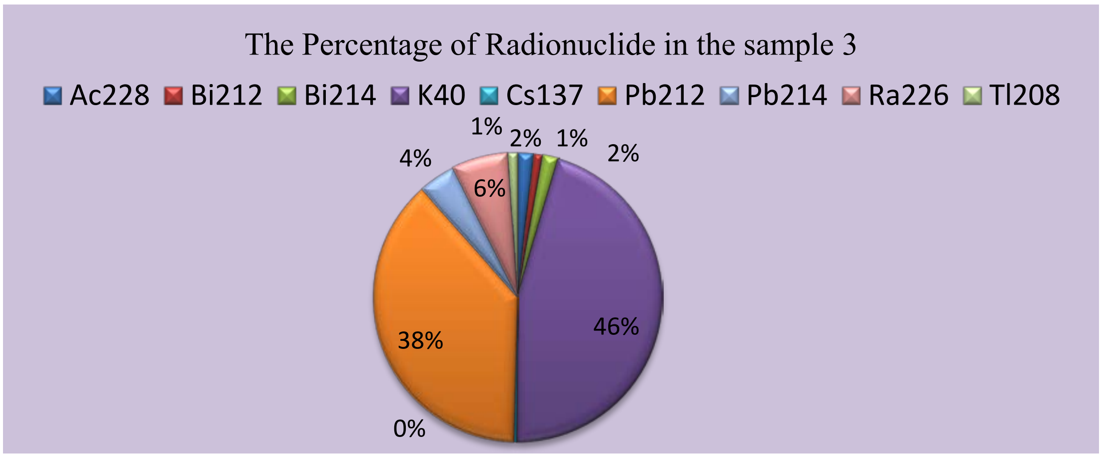

Figure 7 – The percentage of Radionuclide in the sample 3

Sample 4

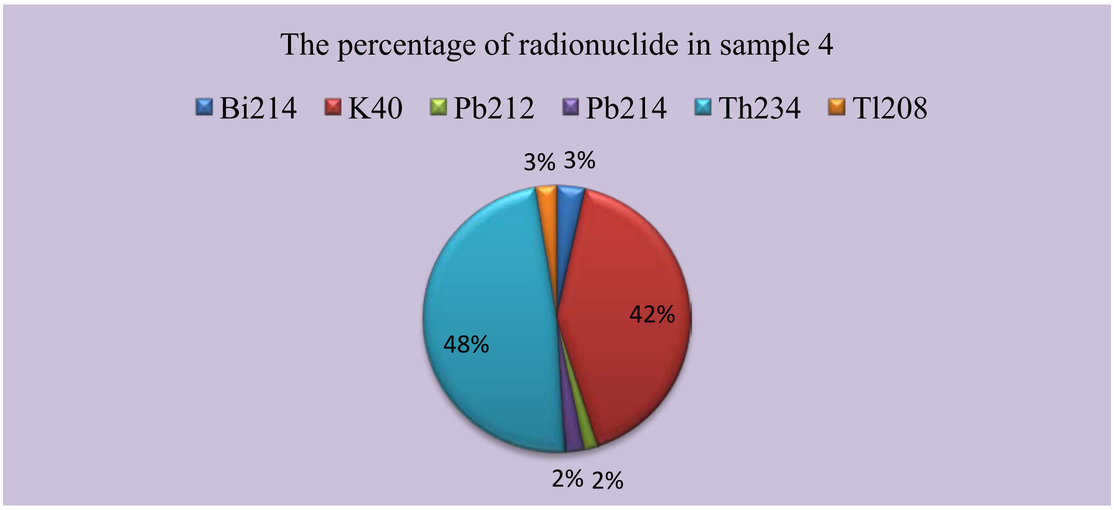

Figure 8 – The percentage of Radionuclide in the sample 4

Sample 5

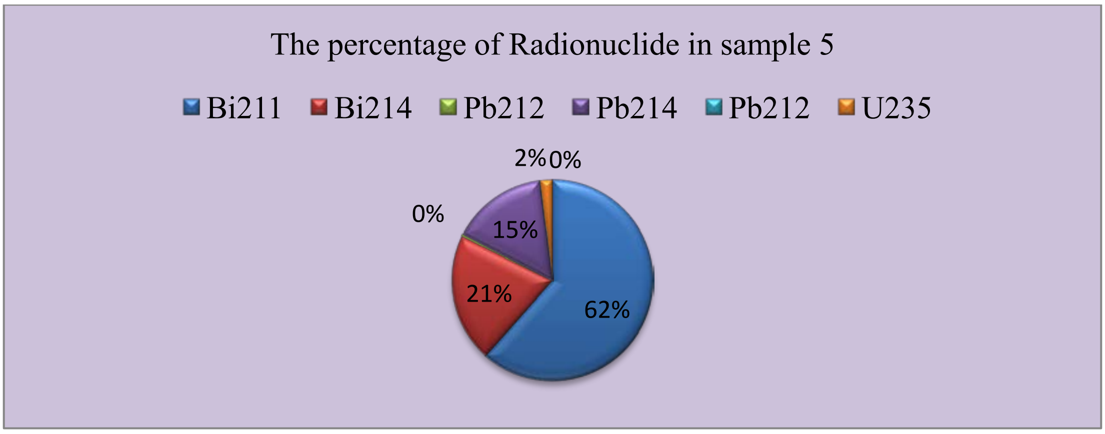

Figure 9 - The percentage of Radionuclide in the sample 5

Sample 6

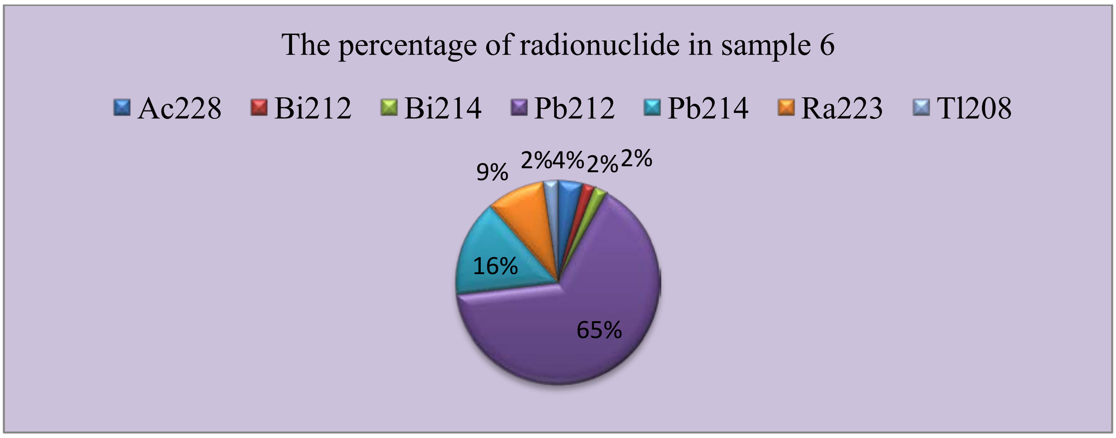

Figure 10- The percentage of Radionuclide in the sample 6

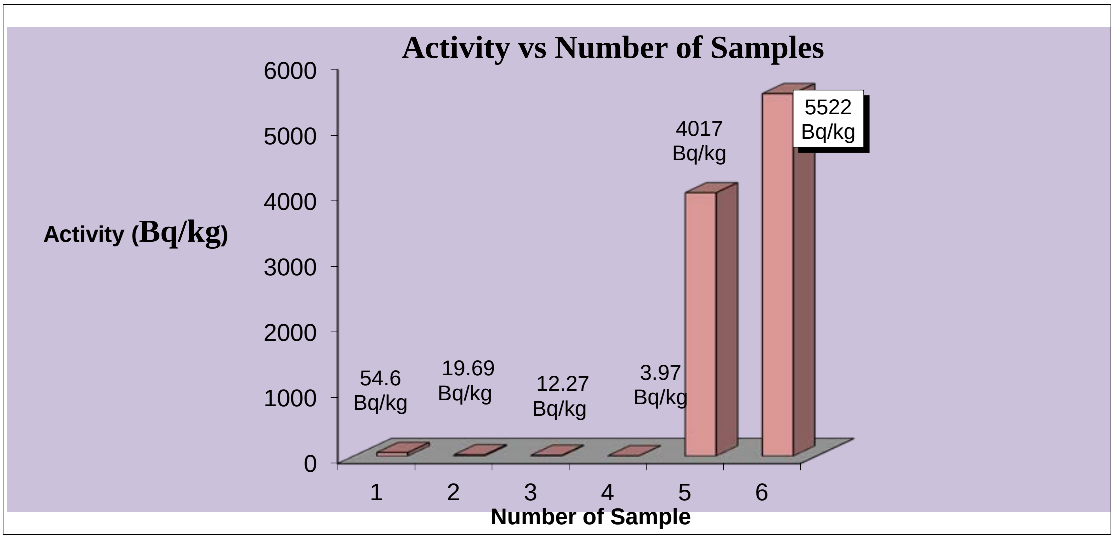

Figure 11- graphically shows the radioactivity of the samples

Radionuclide	Exemption level (Bq/kg)	Exemption level (pCi/g)

The most important risk of N.O.R.M. in oil and gas is caused by radioactive materials when they enter the body through inhalation or ingestion, as well as external exposure when accumulate large quantities of these materials. The radioactive damage of living cells occurs as a result of the ionization caused by the absorption of radiation energy in cells. Given the fact that water represents about 70% of the human body components, the free radicals such as H, OH, HO_2, H_2O_2 cause chemical reactions have an awful biological effect on the body (1). Furthermore, it can produce direct damages due to collision of radiation with molecules of DNA that control the genetic process. Such damages can extend for generations (5).

The most important parts where the impact of N.O.R.M is shown are tanks, pipes, transport equipment, pumps and accessories. The workers who work in the field of cutting, extending and transferring the pipes, removing solids and cleaning the pipes, pumps and equipment are the most likely workers to be exposed to the risk of radiation. Therefore, they have to wear appropriate outfit to protect themselves as shown in figure (13).

Figure (12) shows the appropriate outfit for oil workers when cleaning the pipes and equipment(3).

^{226}Ra	1100	30
^{228}Ra	1100	30
^{210}Pb	200	5
^{210}Po	200	5
^{238}U	5500	150
Uranium (nat)	3000	80

Table (5) NORM exemption levels (3)

The first thing which should be pointed out in this paper is the amount of radiation recorded in the samples. Samples 1, 2, 3 and 4 recorded a low level of radiation not exceeded the action level limits (exemption levels**),** see table 4, nevertheless, it has noted that the presence of Radium element (Ra226), an isotope of alpha emitter found in compositions, if alpha particles entered human body, they will be stabilized directly into the tissue and bones. Then with energy from 4-6kev, alpha particles began the processes of biological tampering. Therefore, the low levels of radiation cannot be overlooked like those elements. The largest radioactivity in the samples 4,3,2,1, was for Potassium 40 (k^{40}) which is expected when we know that, the potassium represents 2.4% of global weight (6).

The proportion of radiation in the samples 5 and 6 are considered high, and this is expected because the samples are scales taken from the inner surface of the pipes used in pumping and production operations in great underground depths.

Finally, it must be noted that, medical surveillance for low-level radiation exposures is typically triggered by exceedance of an established regulatory action level. However, medical surveillance is an imperfect and non-specific tool. It is difficult to find medical tests that detect meaningful abnormal changes in a timely fashion. Most medical tests do not have high sensitivity or specificity. . There is no perfect set of tests for every potential health concern. Therefore, while medical surveillance is a standard strategy that is often used, it must be emphasised that source control, exposure monitoring, worker education and safe operating practices are the most important strategies for preventing significant worker exposures(4).

Conclusion

It is clear from this study that the radioactivity of the scales samples exceed the exemption limit, therefore, National Oil Corporation, associated national and foreign partners and competent bodies in the country shall give this issue more attention and research through giving the opportunity and support to the researchers in this field and work to draw a radioactive map of Libya.

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