Radiation Survey Around Crude Oil Pumping Stations in the Sudan

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ABSTRACT: Safety and health in the workplace are important for the welfare of both worker and public. Hence measurement of radiation doses around crude oil pumping stations were carried out for the purpose of radiation protection. Hand held radiation survey meters RDS -200 and Polymaster have been used for radiation dose measurement. The order of radiation level in investigated areas showed the following trends: Port Sudan > Alelafoon = Jabal Um Ali > Wd shalayee > Mosmar. The average level of radiation dose 5.64 $\mu\text{Sv/y}$ was examined and compared with the recommendations of international organizations concerned with radiation safety. The overall annual effective dose for the workers appears to be negligible compared with the allowable limit of 1.0 mSv/year set by ICRP. From the human health point of view, this study showed that there was no health risk to the workers and public due to radiation exposure.

Keywords: Radiation, annual effective dose, RDS-200, crude oil, pumping stations.

I. Introduction

Radiation plays an important and vital role in our everyday life. Everyday each of us is exposed to naturally occurring quantities of radiation through the air we breathe, the soil on which we walk the water we drink, the food we eat and even within our bodies^[1,2,3]. Furthermore, certain industrial activities such as oil exploration and crude processing, mining result in enhanced Naturally Occurring

Radioactive Materials (NORMs) in the environment^[4,5,6,7,8].

The gamma radiation from oil exploration and crude processing arising from inhalation or ingestion of natural radionuclides^[9,10,11,12].

The NORMs produced by the oil and gas industry are residues that are enriched with the radium and radon isotopes that originated from the uranium and thorium in the reservoir rocks^[13].

Worldwide there are more than 40,000 oil and gas fields, many of which are thought to be contaminated with NORMs^[14].

Assessment of terrestrial gamma radiation around oil facilities give a better understanding of the causes of fluctuation in dose rates of environmental radiation in the investigated areas and assist in developing a program for radiation protection^[15].

Therefore, many studies have been conducted worldwide to investigate the level of ionizing radiation around oil facilities [15,16,17,18,19,20].

From occupational radiation protection point of view, the current investigation is intended to measure the level of radiation dose and to quantify annual effective dose around five crude oil pumping stations in the Sudan.

2. Materials and Methods

2-1 Study area:

The study area consisted of five pumping station belonging to Petrodar oil company. The pumping station located in four Sudanese state Portsudan and Mosmar (Red sea state), Jabal Um ali (River Nile state), Wd shalayee (White Nile state) and Alelafoon (Khartoum state) as shown in (figure 1).

Figure: (1) Map of the study area.

2-3 Experimental procedure :

Radiation survey meters RDS200 and Polymaster were used to measure radiation dose .The dosimeter RDS200 was previously calibrated at the Secondary Standard Dosimetry Laboratory (SSDL) of Sudan Atomic Energy Commission; calibration factor was $0.88 \mu\text{Sv/h}$. Background radiations were measured in three different environments far from the area under investigation. The levels of radiation dose were measured at 1m above the ground . The gamma dose rates were measured in selected points from receiving pipe, valves , waste area ,sludge area and crude tanks.

3. Results and Discussion

Figure (2) presents the radiation dose measurements around crude oil pumping stations in the Sudan. The horizontal x-axis represents the location of the measured dose (receiving pipe, valves, waste area, sludge area and crude tanks)

Table (1) shows the statistical summary of radiation dose rate at pumping stations of Petrodar Operating Company .The measured radiation dose at Alelafoon pumping station illustrated in Figure(3) . It ranges between $0.03 - 0.09 \mu\text{Sv/h}$ with an average value of $0.05 \pm 0.02 \mu\text{Sv/h}$.

The level of radiation dose at, Wd shalayee Figure (4) was found to be in range of $0.03 - 0.09$ with an average value of $0.04 \pm 0.01 \mu\text{Sv/h}$ as shown in Table 2. Measured radiation dose at Jabal Um ali figure (5) varied from $0.04-0.07 \mu\text{Sv/h}$ with an average value of $0.05 \pm 0.01 \mu\text{Sv/h}$.

The value of radiation dose at Mosmar presented in Fig. (6) ranged from $0.03 - 0.09 \mu\text{Sv/h}$ with average value of $0.02 \pm 0.03 \mu\text{Sv/h}$. Radiation dose level at Port Sudan

Figure (7) was found, 0.04 - 0.10 $\mu\text{Sv/h}$ with average value of $0.07 \pm 0.02 \mu\text{Sv/h}$.

Spatial distribution of radiation dose measurement has revealed that the highest average of radiation dose was recorded in Port-Sudan station $0.07 \mu\text{Sv/h}$, while the lowest average radiation dose was measured in Alelafoon station $0.02 \mu\text{Sv/h}$. The trend of radiation level increases towards downstream and seems to be slightly higher than upstream. This could be attributed to NORM perception and sedimentation in the pipe line and downstream is the area of manifolds, separators, and cleaning/decontamination operations are performed. The level of radiation dose rates in our study seem to be fall far below than those obtained in the Algeria ($0.07\text{--}0.8 \mu\text{Sv/h}$), United Kingdom ($10\text{--}300 \mu\text{Sv/h}$) and USA ($15\text{--}100 \mu\text{Sv/h}$) [8].

For health risk assessment of radiation dose measurements, the annual effective dose received by workers were calculated by using equation (1).

$$E = D \times F \times T \times CC \quad (1)$$

Where E ($\mu\text{Sv/y}$) is annual effective dose, D is absorbed dose rates ($\mu\text{Sv/h}$), F is occupancy factors (20%), T (h) is time to convert from year to hour (8760 hours), and CC is conversion coefficient (0.7 for adults) reported by UNSCEAR to convert absorbed dose in air to the effective dose in human (UNSCEAR).

The average value of annual effective dose at Alelafoon, Mosmar, Portsudan, Wd shalayee and Jabal Um ali were 6.13, 2.45, 8.58, 4.91 and $6.13 \mu\text{Sv/y}$ respectively.

Upon comparing the obtained results of radiation dose with global data it was found that the radiation dose is far below the recommended dose level for the public set by International Commission on Radiological Protection which is 1 mSv/y (ICRP, 2007). Therefore, the radiation dose rate measured

around Portsudan, Mosmar, Jabal Um ali, Wd shalayee and Alelafoon are relatively normal as well as the possible radiological effects to workers and public due to oil activity are insignificant.

Figure: (2) Distribution of radiation dose at pumping stations.

Table :(1) Statistical summary of radiation dose rate at pumping stations of Operating Company.

Location	No of samples	Min	Max	Average	Std
Alelafoon	20	0.03	0.09	0.05	0.02
Mosmar	7	0.03	0.09	0.02	0.03
Portsudan	23	0.04	0.10	0.07	0.02
Wd shalayee	25	0.03	0.09	0.04	0.01
Jabal Um ali	25	0.04	0.07	0.05	0.01
Total	100	0.03	0.1	0.046	0.008

Figure: (3) Distribution of radiation dose at Alelafoon pumping station.

Figure: (4) Distribution of radiation dose at Wd shalayee pumping station.

Figure: (5) Distribution of radiation dose at Jabal Um Ali pumping station.

Figure: (6) Distribution of radiation dose at Mosmar pumping station.

Figure: (7) Distribution of radiation dose at Port Sudan pumping station.

4. Conclusions

- The measurement of radiation dose around oil pumping facilities is very important from the viewpoint of environmental radiation protection.
- The radiation dose rate measured around Portsudan, Mosmar, Jabal Um ali, Wd shalayee and Alelafoon are relatively normal. Possible radiological effects to workers and public due to oil activity are insignificant.

5. Recommendations

Further studies are needed in order to quantify the concentration of natural radioactivity in waste and sludge areas.

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المسح الإشعاعي حول محطات ضخ النفط الخام في السودان

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المستخلص. السلامة والصحة في مكان العمل مهمة من أجل رفاهية كل من العمال والجمهور. لذلك تم إجراء قياس للجرعات الإشعاعية حول محطات ضخ النفط الخام لغرض السلامة والحماية من الإشعاع. وقد استخدمت كواشف الرادوز-٢٠٠ والبوليماستر لقياس الجرعة الإشعاعية. وأظهر ترتيب مستوى الإشعاع في مناطق الدراسة الاتجاه التالي: بورتسودان < العيلفون = جبل أم علي < ود شعلي < مسمار. تم مقارنة متوسط مستوى الجرعة الإشعاعية للدراسة ٥,٦٤ مايكروسيفرت/سنة مع المستويات الموصى بها من قبل المنظمات الدولية المعنية بالسلامة من الإشعاع. وجد أن الجرعة السنوية الفعالة ضئيلة مقارنة مع الحد المسموح به من اللجنة الدولية للوقاية الإشعاعية ١,٠ ملي سيفرت / سنة. و من منظور صحي خاص بالإنسان، وأظهرت هذه الدراسة أنه لا توجد مخاطر صحية محتملة للعمال والجمهور بسبب التعرض الإشعاعي.

كلمات مفتاحية: الإشعاع، الجرعة السنوية الفعالة ، رادوز-٢٠٠ ، النفط الخام ، محطات الضخ