Frontiers in Environmental Microbiology
2020; 6(1): 1-4
http://www.sciencepublishinggroup.com/j/fem
doi: 10.11648/j.fem.20200601.11
ISSN: 2469-7869 (Print); ISSN: 2469-8067 (Online)

Radiological Survey of the Concentration Department in State Company of Phosphate

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To cite this article:
Alaa Fadhil Hashim, Zaki Abdul Jabbar, Haider Ahmad Hassan, Ali Khadum Aial. Radiological Survey of the Concentration Department in State Company of Phosphate. *Frontiers in Environmental Microbiology*. Vol. 6, No. 1, 2020, pp. 1-4. doi: 10.11648/j.fem.20200601.11

Received: December 31, 2019; **Accepted**: January 7, 2020; **Published**: January 17, 2020

Abstract: The purpose of this research is to conduct a radiological survey of the crushing, milling, screening and conveyor unit of raw materials in the al-Qa'im fertilizer plant/General Phosphate Company, in order to calculate the absorbed doses of the workers in these places as well as the work hazards. As the raw materials in the phosphate fertilizer industry are extracted from the ground, Certainly contains radioisotopes such as the series of decay of uranium, thorium and potassium, which is the main cause of radiation activity in raw materials and the results of the dose absorbed to the workers in the unit of grinding, cracking and screening, And the conveyor belt for raw materials is (0.34, 0.38) mSv/y respectively, which is less than the internationally allowed limits (1msv/y) and the risk of working on working persons (1.7×10^{-5}, 1.9×10^{-5}) For crushing and crushing unit and belt conveyor unit, respectively, within the limits of internationally licensed 10^{-5}.

Keywords: NORM, Phosphate Rocks, Radiation Contamination

1. Introduction

Radioactivity and external exposure associated with gamma radiation depend primarily on the nature of the geological and geological characteristics that vary and vary from one region to another in the world [1, 2, 4]. Radioactivity is the emission of alpha (α) and beta (β) particles as well as gamma (γ) radiation from the unstable isotopes. Most minerals, that contain potassium, uranium and thorium, are radioactive [3, 5, 6]. Long-live radioactive elements such as uranium (^{238}U), thorium (^{232}Th) and potassium (^{40}K) and any of their decay products, such as radium and radon are examples of naturally occurring radioactive materials (NORM) [5-9]. Mining like many other industries can cause environmental impact [8-10]. However, for the NORM (Naturally Occurring Radioactive Material) industries, to the impact caused by conventional ways is added the radiological impact. Phosphates are used extensively, as a source of phosphorous for fertilizers and for manufacturing phosphoric acid and gypsum. Phosphate ores typically contain about 1500 Bq/kg of uranium and radium, although some phosphates contain up to 20,000 Bq/kg of U_3O_8 [11]. Phosphate rocks with potassium ores and nitrogen compounds are among the main components used to produce fertilizers. Compounds are found to be important for plant growth. Phosphate rocks are used for the production of chemical fertilizers after phosphate extraction [4, 12]. The presence of radioactive isotopes of ^{238}U, $^{232}Th$and ^{40}K In phosphates, the specific activity of radionuclides in phosphates is based on industrial output, which depends on their concentrations in the raw materials of phosphates (phosphate rock and phosphoric acid), as well as on the process of chemical separation during production processes Phosphate fertilizers [8, 11, 13].

The Iraqi State Company for Phosphate is located at Al-Qaim city with a coordinates (N 34.33465, E 41.18273). It is located at 150 km northeast of Akashat. The design capacity of the plant is one million tons of phosphate fertilizer annually. Phosphate rocks are transported from Akashat by the railway built for this purpose. Iraq have a huge amount of phosphate reserve more than 10000 MT which is located in the Western Desert of Iraq, Al-Anbar Governorate, Akashat site, 120 km southwest of the Euphrates river. These are among the largest phosphate reserve in the world.

The amount of phosphogypsum waste produced by the phosphate industry is approximated to 20% of the ore material while the Iraqi reserve of ore phosphate is approximated to 4 billion tons. The drying and grinding stage produced radioactive material and released to the air in the form of fine powder, each ton of phosphate treated release about 100Bq of uranium ^{238}U, these contaminated air and soil of the surrounding environment [10-14].

Contaminated area with naturally occurring radioactive material (NORM) is produced from uncontrolled disposal of phosphogypsum waste in the surrounding environment or fine powder release to the air produced from the drying and grinding stage is considered as a real big problem in Iraq, which causes exposure and contamination of worker and environment [14, 15]. The excessive use of these fertilizers contributes significantly to the increase in the radiation activity of the soil and thus increase the radiation exposure rates in all the production stages that the phosphate fertilizers undergo from the industrial processes such as mining and the transfer of phosphate fertilizers and the production of fertilizers and the spread of these fertilizers in the soil, water and air, Contributes to the high exposure of workers, the public and the environment [4, 7, 10].

The aim of the research is to detect the radiation contamination rates of the concentration unit and surrounding areas in the General Phosphate Company in Qaim to take the necessary measures to prevent and reduce radiation contamination in the case of high concentration of radiation activity, using portable survey meter.

2. Materials and Methods

2.1. RadEye Model PRD

RadEye model PRD (Alarming personal radiation detector, Thermo Scientific, Germany) was used in the field for monitoring gamma radiation dose rates [16]. RadEye model PRD is a highly sensitive device used to measure gamma radiation in terms of counts per second (cps), ambient equivalent dose rate in microsevert per hour (µSv/h) and the accumulated ambient equivalent dose (in µSv). The RadEye model PRD incorporates a highly sensitive NaI (TI) scintillation detector which is equipped with alow radiation levels. The detection for gamma radiation dose rate range from 0.01 µSv/h to 250 µSv/h. The selection of RadEye model PRD over other available radiation detector is primarily based on the RadEye PRD's ability to detect low energy gamma radiation, which comprises the majority of the gamma radiation from the radionuclides of the conserved in the studies areas.

2.2. Ludlum (Ludlum Measurements, Inc. (LMI) Designs and Manufactures Radiation Detection Instruments and Technologies, Sweetwater, Texas, USA)

This device is a multipurpose survey, gross counting, digital ratemeter with a built-in scaler that provides timed counts over a user specified period. The instrument additionally includes an External: Supports GM & Scintillation Detectors, Alpha, Beta, and Gamma surveying Display Range (0.000 µSv/h to 9999 Sv/h and 0 cps to 100 kcps).

Measurements of levels of exposure and radiation contamination were made on the ground and by mobile device Radeye (the Measurements of the levels of radiation contamination at a height of 3 cm and The Measurements of the levels of radiation exposure at a height of 1 m) in Crushing, grinding and screening units, conveyor belts for silo and the residential complex, which was considered a radiological background area.

The silo was divided to grids, each grid with an area (1 m^2) inside the silo. The points were (21 points) inside the silo for Crushing, grinding and screening units, conveyor belts for silo and the residential complex and these points are represented by (x, y) axes. The Measurements were adopted to calculate the received dose and risk rates inside at (1 m) height for each point because it is the effective dose on the human.

3. Calculations & Discussion

Measurements of radiation levels of the residential complex were carried out and the Measurements ranged from (0.02-0.05 µSv/h) with the rate of Radiation background 0.03 µSv/h by RadEye and the Measurements of levels of radiation contamination ranged from 11-14 cps with the rate of Radiation background is 12 cps, the Measurements of the residential complex are considered as a radiological background area.

Measurements of levels of radiation exposure ranged from (0.20-0.23 µSv/h), (0.24-0.26 µSv/h) for crushing, grinding and screening units and conveyor belts respectively, Measurements of levels of radiation contamination ranged from (89-111 cps), (183-213 cps) for Crushing, grinding and screening units and conveyor belts respectively.

The rate of radiation exposure for Crushing, grinding and screening units and conveyor belts (0.22 µSv/h) and (0.25 µSv/h) respectively, these Measurements more than seven times of the rate of the background radiation (0.03 µSv/h). The rate of radiation contamination for Crushing, grinding and screening units and conveyor belts (96 cps) and (192.3 cps) respectively, these readings more than eight and seventeen times of the rate of the background radiation (12 cps).

Table 1. *Measurement of levels of radiation exposure and contamination.*

No.	Name of place	X	Y	RadEye µSv/h	Ludlum C/s
1	The residential complex (radiological background area)	3433491	4119663	0.02	10
2				0.02	12
3				0.02	13
4				0.05	12
5				0.04	11
6				0.03	14
7				0.03	12

No.	Name of place	X	Y	RadEye µSv/h	Ludlum C/s
	Average			0.03	12
8				0.22	111
9				0.21	95
10				0.21	100
11	Crushing, Grinding and Screening units	3431617	4117819	0.22	95
12				0.20	89
13				0.23	89
14				0.23	92
	Average			0.22	96
15				0.25	213
16				0.25	202
17				0.26	186
18	Conveyor Belts	3431569	4117698	0.25	191
19				0.24	187
20				0.26	184
21				0.25	183
	Average			0.25	192.3

The received dose per year of the workers on 1m height in the Crushing, Grinding and Screening units calculated by following:

a. Dose received = 0.22 µSv/h × 1 h × 10^{-3}

$$= 22\times10^{-5} \text{ mSv/h}$$

b. By assumed the worker works (8 hour/day) with (4 day/week)

Number of working hours per the year

$$= 8 \text{ h/d} \times 4 \text{ d/w} \times 4 \text{ w/m} \times 12 \text{ m/y}$$

$$= 1536 \text{ h/y}$$

c. Rate of dose received per the year

$$= 22\times10^{-5} \text{ mSv/h} \times 1536 \text{ h/y}$$

$$= 0.34 \text{ mSv/y}$$

Also, the received dose per year of the workers on 1m height during (8 hour working) in the Conveyor Belts is equal to (0.38 mSv/y). [17]

The risk assessment is the systematic identification of potential hazards in the workplace as a first step to controlling the possible risk involved. The risk of developing a fatal cancer (Rf) as a result of radiation exposure is estimated as below:-

$$R_f = D \times RF \ldots \quad (1)$$

Where D is the dose to an exposed individual or exposed population, and RF is the risk factor.

Based on an occupational risk factor of 0.05Sv^{-1} (risk factor to injury with fatal cancer) [17].

Risk for one person= dose rate × number of year × risk factor

$$= 0.34 \text{mSv/y} \times 1 \text{ y} \times 0.05 \text{ Sv}^{-1}\times10^{-3}$$

= 1.7×10^{-5} (in the Crushing, Grinding and Screening units).

Also, the risk for one person in the Conveyor Belts is equal to (1.9×10^{-5}).

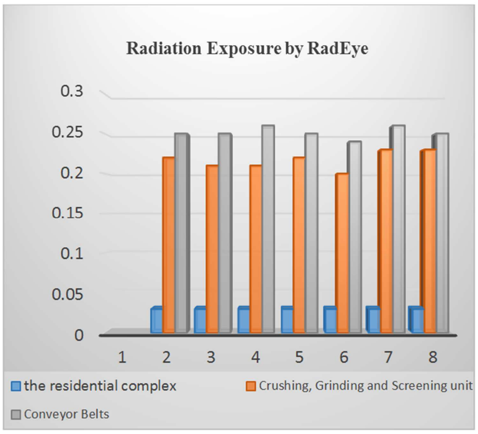

Figure 1. *Measurements of levels of radiation exposure by RadEye in the residential complex, crushing, grinding and screening units and conveyor belts.*

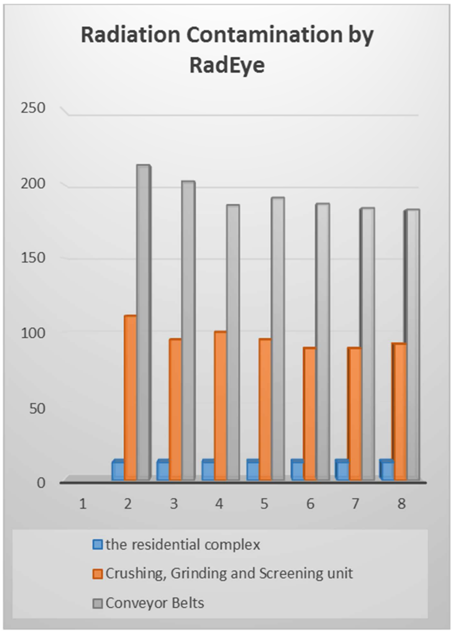

Figure 2. *Measurements of levels of radiation contamination by RadEye in the residential complex, crushing, grinding and screening units and conveyor belts.*

4. Conclusion

The total annual dose limit and approved by the International Commission on Radiological Protection (ICRP) in Publication 60 and the International Atomic Energy Agency (IAEA) in Basic Safety Standards (Safety Series No. 15) for each year is (1 mSv), the dose rate received in the Crushing, Grinding and Screening units was (0.34 mSv/y), it is within the dose limits (1 mSv), also the dose rate received the Conveyor Belts was (0.38 mSv/y) are within the doses limits (1 mSv).

The risk for one person is (1.7×10^{-5}) in the Crushing, Grinding and Screening units, It is within the international limits permitted and approved by the International Commission on Radiological Protection (ICRP) in Publication 60 and the International Atomic Energy Agency (IAEA) in Specific Safety RequirementsNo. SSR-5 which is (10^{-5} per year) [18, 19]. Also the risk in the Conveyor Belts was is (1.9×10^{-5}), it is within the international limits permitted (10^{-5}).

The reason for the increase in readings more than the radiation background is about eighty times due to the presence of phosphate ore and this indicates the presence of Naturally Occurring Radioactive Material (NORM), such as uranium (^{238}U), thorium (^{232}Th) and potassium (^{40}K). To reduce the risk of internal exposure to workers must wear protective glasses, special suits and the particulate respirator is preventing about 95% from the entered dust to the respiratory system.

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