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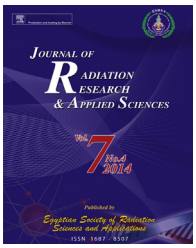

Natural radioactivity levels and radiological hazards indices of chemical fertilizers commonly used in Upper Egypt

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ABSTRACT

In order to determine the radiological hazards indices of chemical fertilizers commonly used in Upper Egypt, The concentrations of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K in seven types of chemical fertilizers used in Upper Egypt have been measured by gamma spectrometry using NaI (Tl) 3″ × 3″ detector. The ranges of concentration levels of ^{226}Ra, ^{232}Th and ^{40}K were 12 ± 0.6–244 ± 12.6, 3 ± 0.2–99 ± 4.9, and 109 ± 5.5–670 ± 34 Bq kg^{-1}, respectively. In the other side, the range values obtained from fertilizer samples under investigation were (33.1–392.3 Bq kg^{-1}), (0.6–2.7), (15.6–177.8 nGy h^{-1}) and (20.1–229.1 μSv y^{-1}) for radium equivalent activity, γ-radiation hazard index $I_{\gamma r}$, Dose rate (nGy h^{-1}) and annual effective dose equivalent (AED) in the air to the occupational workers, respectively. The obtained values were compared with available reported data from other countries in literature.

1. Introduction

During the last decades agricultural activities have expanded widely, resulting in an increase in the applications of the different chemical fertilizers. Chemical fertilizers are chemical compounds that provide necessary chemical elements and nutrients to the plants. Fertilizers have become essential to the agricultural field all over the world (Chauhan, Chauhan, & Gupta, 2013). Phosphate rocks together with potassium ores and nitrogenous compounds are the main raw materials used for fertilizers in industrial production. As a matter of fact phosphorus, potassium and nitrogen are essential elements for plants growth.

More than 30 million tons of phosphate fertilizers are annually consumed worldwide, which increase crop production and land reclamation (El-Taher and Althoyaib, 2012). However, a possible negative effect of fertilizers is the contamination of cultivated lands by t some naturally occurring radioactive materials (NORM) (Lambert, Grant, & Sauve, 2007). The natural radionuclide of fertilizers consists mainly of uranium and thorium series radioisotopes and natural ^{40}K. Phosphate rocks are the starting material for the production of all phosphate products and main source of phosphorus for fertilizers. Phosphate rock can be of sedimentary, which represent about 85% of the phosphate rocks, were formed mainly from organic residues, the remaining parts of the phosphate rock, are of volcanic origin (Roselli, Desideri, Meli, & Feduzi, 2010).

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The concentration of ^{238}U and its decay products tends to be elevated in phosphate deposits of sedimentary origin, where typical ^{238}U series concentration is about 1500 Bq kg^{-1} (UNSCEAR, 1993). Therefore, when this rock is processed into phosphates' fertilizers, most radionuclides come into the fertilizers. Thus, fertilizers redistribute naturally occurring radionuclides at trace levels throughout the environment and become a source of radioactivity. This phenomenon may result in potential radiological risks due to possible migration of elements from the agricultural fertilizers to soil and plants, and via the food chain, to human begins where this may lead to internal exposure through ingestion of food grown on fertilizer soils, (Rehman, Imtiaz, Faheem, & Matiullah, 2006). In addition, during handling, packing and transporting fertilizers, some workers can receive additional external exposure. Therefore, it is important to measure natural radioactivity in fertilizers, because the high radioactive content may lead to significant exposure of miners, manufacturers and end users. Furthermore, such measurements provide basic data for the estimation of the amount of radioactivity spread on agricultural land along with fertilizers.

The present study has been carried out to establish a consistent radiological database for the concentration of the natural radionuclides ^{226}Ra, ^{232}Th, and ^{40}K in some local fertilizer types, that used in agricultural soil of EL- Mynia governorate, Upper Egypt, to estimate their radiological impacts as a part of NRUE (Natural Radioactivity in Upper Egypt) project in physics department (faculty of science, Al-Azher University, Assuit branch, Egypt). The common fertilizers generally used in Upper Egypt are commercially named: Ammonium nitrate, Single super phosphate, Urea improved, Proprioceptive urea, Golden fertilizers and Mixed fertilizers (Nitrogen phosphorus, nitrogen potassium fertilizers and nitrogen phosphorus potassium).

2. Experimental technique

2.1. *Sample description and preparation*

Seven chemical fertilizers types were collected from the farmers and the markets. The investigated samples types are Urea improved (UI), Proprioceptive urea (PU), Ammonium Nitrate (AN), Single super phosphate (SSP), Nitrogen Potassium Fertilizers (NK), Nitrogen phosphorus (NP), and Golden Fertilizers (GF). The elemental analysis of one sample from each type of fertilizer was performed using X-ray fluorescence technique (XRF) the obtained results are listed in Table 1.

As shown in Table 1 the major range values of elemental concentrations in fertilizer samples using XRF were: Ca (0.0830–80.8%), Fe (1.95–31.19%), S (5.90–25.34%), Si (2.59–18.65%), P (2.76–10.1%), K (2.02–80.45%) and Mg (1.34–15.29%). The highest concentration of P was found in SSP (10.1%) and NP (8.45%) fertilizers. As expected the highest concentration of K was observed in NK (80.8%) fertilizer. Whereas GF fertilizer contain the highest concentration of Fe (31.19%) and Si (18.65%).

Forty-three samples of seven chemical fertilizers types were collected from the farmers and the markets. The collected samples, each are about 500 gm in weight, were dried in an oven at about 110 °C for 24 h to ensure that

Table 1 – Chemical composition (ms%) for different fertilizer samples using XRF spectrometry.

Element concentration %							
Elements	UI	PU	AN	SSP	NK	NP	GF
Mg	–	–	15.29	–	–	1.86	1.34
Ca	51.26	45.51	75.08	56.34	–	60.41	27.81
V	–	–	0.72	–	–	–	–
Mn	–	–	3.68	–	–	0.69	1.02
Fe	–	–	5.23	4.16	1.95	6.76	31.19
Al	–	–	–	–	–	–	5.59
Si	–	–	–	3.56	–	2.59	18.65
P	–	–	–	10.10	–	8.45	2.76
S	–	–	–	25.34	17.60	18.52	5.90
K	–	–	–	–	80.45	–	2.02
Ti	–	–	–	–	–	–	3.04
Zn	–	4.37	–	–	–	–	0.69
Sr	–	–	–	0.51	–	0.72	–
Cu	7.86	12.60	–	–	–	–	–
As	3.78	0.54	–	–	–	–	–
Rb	–	4.24	–	–	–	–	–
Nb	–	8.14	–	–	–	–	–
Hf	–	21.66	–	–	–	–	–
Ir	–	2.93	–	–	–	–	–
Co	9.96	–	–	–	–	–	–
Ni	6.20	–	–	–	–	–	–
As	–	0.54	–	–	–	–	–
Zr	3.30	–	–	–	–	–	–
Mo	7.29	–	–	–	–	–	–
Pb	10.34	–	–	–	–	–	–