WAS Science Nature
WASSN

ISSN: 2766 - 7715
WAS PRESS

Article

Assessment of Natural Radioactivity Levels in Soil and Chemical Fertilizers Widely used in Upper Egypt

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Received: 29/04/2020; Accepted: 15/05/2020; Published: 20/05/2020.

Abstract: In order to protect the health of the farmers from natural radiation, the assessment of natural radionuclides concentrations (226Ra, 232Th and 40K) in soil and chemical fertilizers have been done. By using NaI(Tl) detector gamma ray spectrometer , the specific activities of 226Ra, 232Th and 40K in Bqkg-1 for four types of agriculture soil textures and seven types of chemical fertilizers commonly used in upper Egypt . The obtained results were compared with the global average and tolerable limits as recommended in UNSCEAR 2008.

Keywords: Natural radionuclides; Soil; chemical fertilizers; gamma ray spectrometer.

1. Introduction

Natural Radioactivity is common in rocks, soil, fertilizers, beach sand, sediment, and even in our building materials and homes. It arises mainly from the primordial radionuclides, such as 40K and the radionuclides from 238U and 232Th series and their decay products, which are present at trace levels in all ground formations [1,2]. The background radiation from these radionuclides can be high if the environment is polluted either from man-made or natural activities [3]. Long-term exposure to uranium and radium through inhalation has several health effects such as chronic lung diseases, acute leucopoenia, anemia, and necrosis of the mouth. Radium causes bone, cranial, and nasal tumors. Thorium exposure can cause lung, pancreas, hepatic, bone, and kidney cancers andleukemia [4]. In addition, the exposure by inhalation has a variety of health effects such as chronic lung disease, and lack of sharp white blood cells, anemia, and necrosis of the mouth [5].

Therefore, the knowledge the concentrations of natural radionuclide in the soil and chemical fertilizers are of great interest since it provides useful information in monitoring of environmental contamination and associated human health by natural radioactivity.

2. Materials and Methods

The investigated samples are four types of agriculture soil textures are sandy clay loam(SCL), Clay Loam (CL), Silt Clay Loam (SCL) and Sandy (S),while the types of chemical fertilizers 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)].

All investigated samples were dried in an oven at about 110 C◦ for 24 h to ensure that moisture is completely removed. All samples were crushed, homogenized, and sieved through a 200 μm, which is the optimum size enriched in heavy minerals. Samples were placed in polyethylene beaker, of 250 cm3 volume each and weighted. The beakers were completely sealed for 4 weeks to reach

secular equilibrium radium and thorium, and their progenies [6]. Radioactivity measurements were performed by gamma ray spectrometer, employing a scintillation detector 3 × 3 inch. Its hermetically sealed assembly which includes a high-resolution NaI (Tl) crystal, photomultiplier tube, an internal magnetic/light shield, aluminium housing and a 14 pin connector coupled to PC-MCA Canberra Accuspes. In order to determine the background distribution in the environment around the detector, an empty sealed beaker was counted in the same manner and in the same geometry as the samples [7]. The measurement time of activity or background was 43,200 s. The offline analysis of each measured g-ray spectrum has been carried out by a dedicated software program genie 2000 [8].

The activity of 226Ra was estimated based on γ-lines with energies 351.9 keV (36.7%) of 214Pb and the 609.3 keV (46.1%), 1120.3 keV (15%), and 1764 keV (15.9%) of 214Bi. In case of 232Th, 911.2keV (29%) γ-lines of 228Ac and the 238.6 keV (43.6%) γ-peak of 212Pb have been used. 40K activity was estimated using the 1461 keV (10.7%) γ-peak [5]. The activity concentrations for 226Ra, 232Th, and 40K in the soil samples were calculated by Eq. (1)

$$\textbf{Activity} = \frac{\textbf{Np x100x 100}}{\textbf{B.I.x Eff}} \pm \frac{\textbf{Np (error) x100 x 100}}{\textbf{B.I.x Eff}} \quad (1)$$

Where Np is the net counts per second, B.I. is the branching intensity and Eff is efficiency of the detector.

3. Results and discussion

The average values of activity concentrations radionuclides (226Ra, 232Th and 40K) for soil and chemical fertilizers [Urea improved (UI), Proprioceptive urea (PU), Ammonium Nitrate (AN), Single super phosphate (SSP), Nitrogen Potassium Fertilizers (NK), Nitrogen phosphorus (NP) and Golden Fertilizers (GF)] that are applied in the study soil were presented in Table (1) and diagrammatically plotted as shown in figures (1 to 21).

Table 1. Soil texture, activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K for soil and fertilizers.

Soil Texture	**Activity in soil (BqKg^{-1})**			**Fert. Code**	**Activity in fertilizers (BqKg^{-1})**		
	^{226}Ra	**^{232}Th**	**^{40}K**		**^{226}Ra**	**^{232}Th**	**^{40}K**
Sandy Clay Loam	20.6	11.2	164.5	PU	16.7	6.7	191.5
	13	8	154	AN NP,	15.5	7.3	153.8
	30	16	165	SSP	103.1	37.8	216.8
	11	7	101	UI	41.4	9.1	184.7
	21	11	156	NK	51.7	91.2	507.5
	28	18	168	UI,NP	58.2	22.3	181
	16.3	11	356.5	UI,GF	44.2	44.8	188.4
	14.8	10	363.5	AN	15.5	7.3	153.8
	17	18.4	384.9	PU	16.7	6.7	191.5
	17.5	11.6	411	UI	41.4	9.1	184.7
Clay Loam	18.3	11.6	167.3	PU	16.7	6.7	191.5
	25.7	15.7	140.7	NP, SSP	132.9	51.9	228.6
	18.3	11.4	152	UI	41.4	9.1	184.7
	15	9	157	Nk	51.7	91.2	507.5

	19	10	127	NK, UI	46.55	50.2	346.1
	21.8	11	150	PU	16.7	6.7	191.5
	21	11.9	149.5	AN	15.5	7.3	153.8
	17	10	157	UI,GF	44.2	44.8	188.4
	13.7	9	147	UI	41.4	9.1	184.7
	19	12	197	NK	51.7	91.2	507.5
Silt Clay Loam	19.8	9.2	194.7	PU	16.7	6.7	191.5
	24.7	16	335.7	UI	41.4	9.1	184.7
	24.4	8.8	274.4	AN	15.5	7.3	153.8
	21	9.6	159	PU	16.7	6.7	191.5
	19	7.4	133.9	UI	41.4	9.1	184.7
	26.7	12.7	163	NK, UI	46.6	50.2	346.1
	19	11	143	UI ,PU	29.1	7.9	188.1
	17	12	153	AN	15.5	7.3	153.8
Sandy **Sandy**	17	5.7	97.7	UI	41.4	9.1	184.7
	10	5	119	AN	15.5	7.3	153.8
	10.7	6.7	119.9	PU	16.7	6.7	191.5
	11	7.7	111	AN, UI	28.45	8.2	169.3

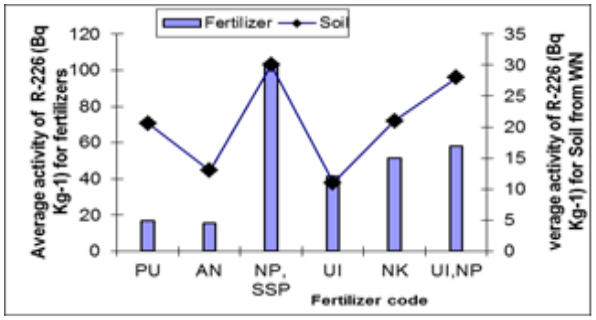

Figure 1. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for sandy clay loam soil collected from WN.

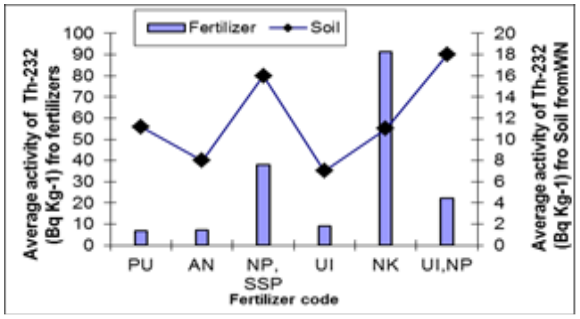

Figure 2. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for sandy clay loam soil collected from WN.

From figures (1 to 22), we observe high values of the activity concentration of 226Ra in sandy clay loam samples, where the fertilizers used are Single super phosphate (SSP), and Nitrogen phosphorus (NP). Also the high values of the activity concentration of 232Th and 40K have been found in sandy clay loam samples, where the fertilizers used is Proprioceptive urea (PU). Finally from these figures we have note decrease the values of activity concentration for 226Ra, 232Th and 40K in sandy soil, where the fertilizers used is Ammonium Nitrate (AN) and Urea improved (UI). The mean concentrations of 226Ra and 232Th soil and chemical fertilizers samples were lower than the permissible activity levels which are 35 and 35 Bqkg-1, respectively [9,10]. In the other side, the mean concentrations of 40K were lower than the permissible activity levels (370 Bqkg-1).

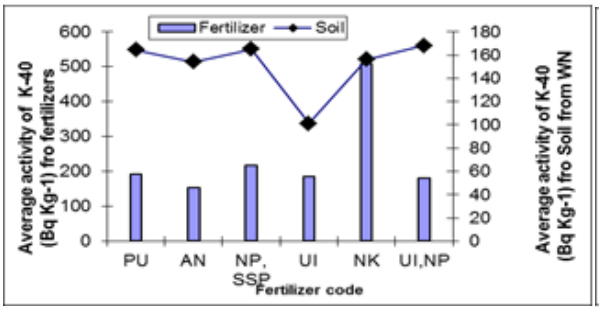

Figure 3. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for sandy clay loam soil collected from WN.

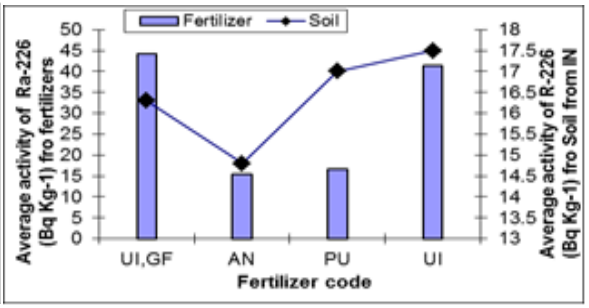

Figure 4. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for sandy clay loam soil collected from IN.

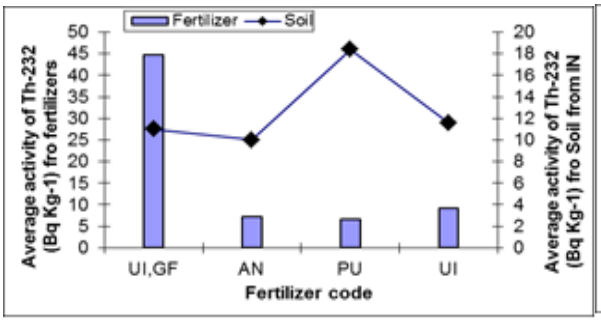

Figure 5. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for sandy clay loam soil collected from IN.

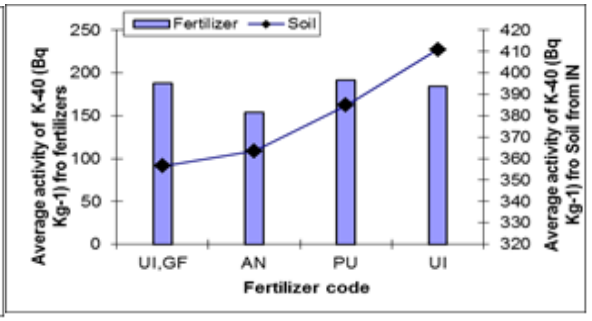

Figure 6. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for sandy clay loam soil collected from IN.

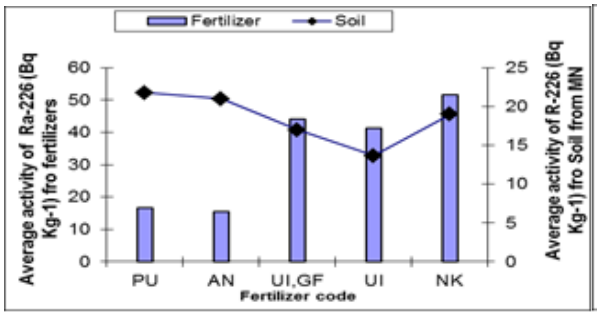

Figure 7. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for clay loam soil collected from MN.

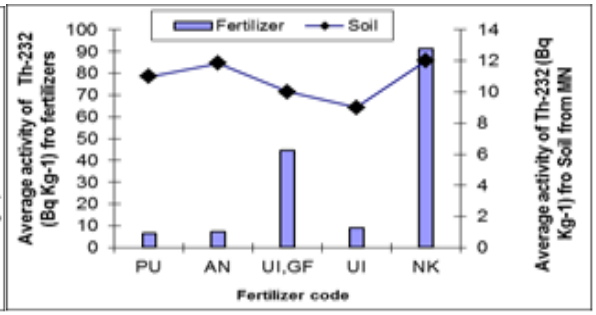

Figure 8. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for clay loam soil collected from MN.

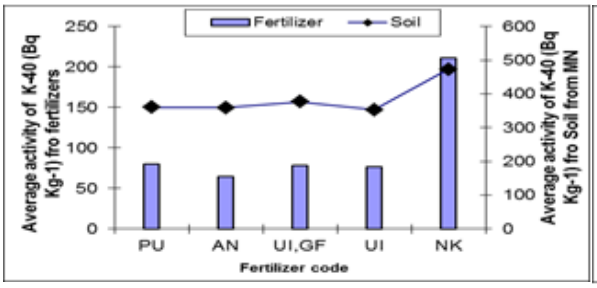

Figure 9. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for clay loam soil collected from MN.

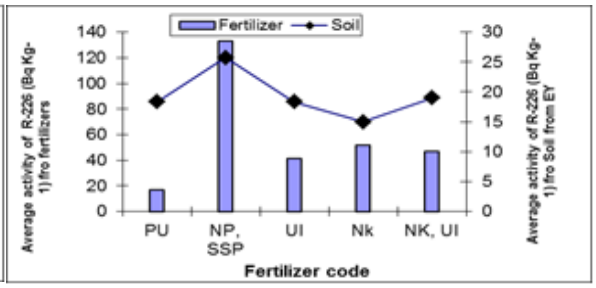

Figure 10. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for clay loam soil collected from EY.

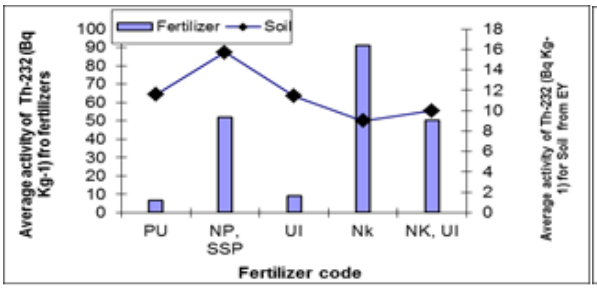

Figure 11. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for clay loam soil collected from EY.

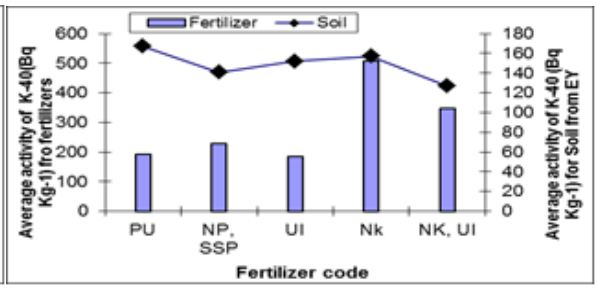

Figure 12. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for clay loam soil collected from EY.

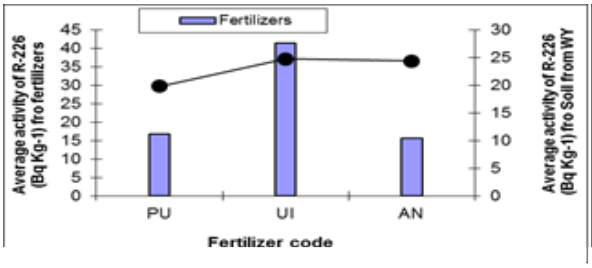

Figure 13. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for clay loam soil collected from EY.

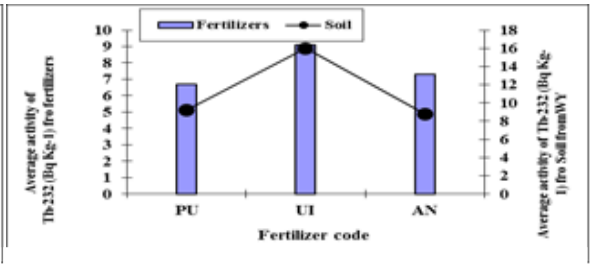

Figure 14. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for silt clay loam soil collected from WY.

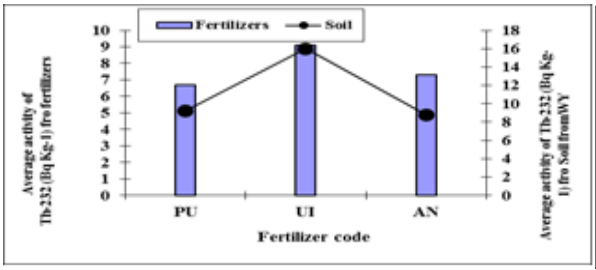

Figure 15. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for silt clay loam soil collected from WY.

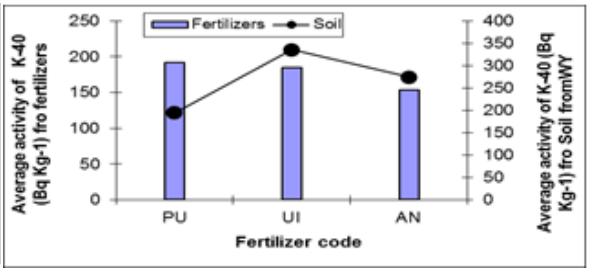

Figure 16. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for silt clay loam soil collected from WY.

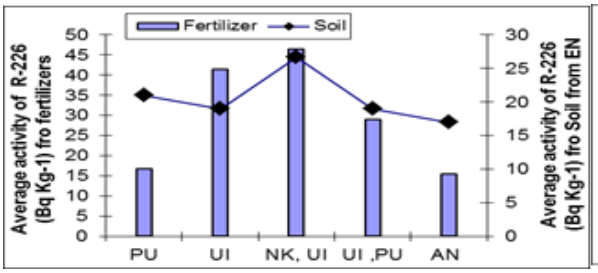

Figure 17. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for silt clay loam soil collected from EN.

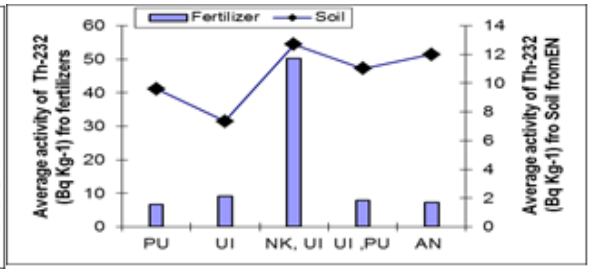

Figure 18. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for silt clay loam soil collected from EN.

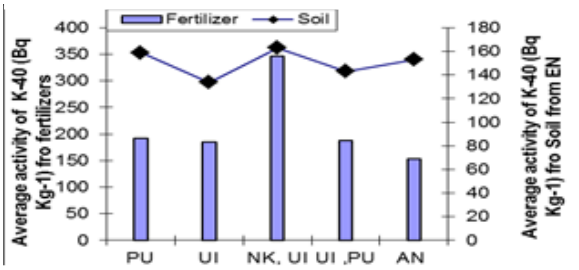

Figure 19. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for silt clay loam soil collected from EN.

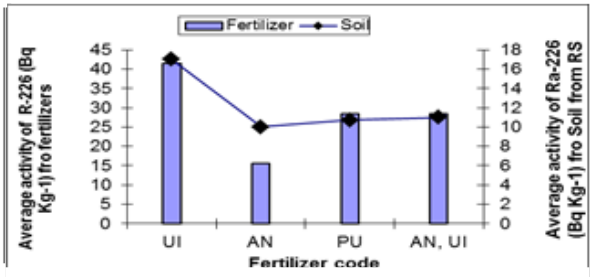

Figure 20. Effect of chemical fertilizers on 226Ra activity concentration (BqKg-1) for sandy soil collected from RS.

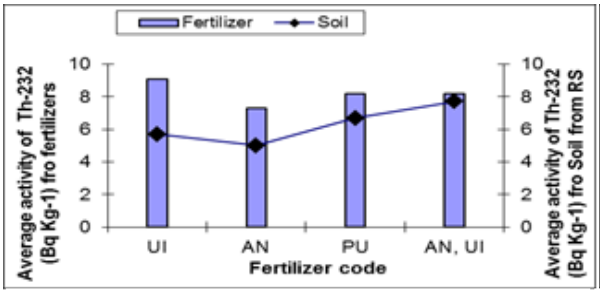

Figure 21. Effect of chemical fertilizers on 232Th activity concentration (BqKg-1) for sandy soil collected from RS.

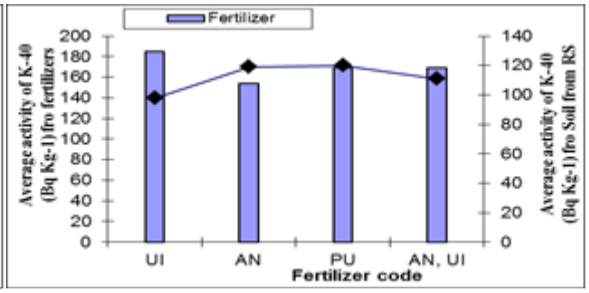

Figure 22. Effect of chemical fertilizers on 40K activity concentration (BqKg-1) for sandy soil collected from RS.

4. Conclusions

The specific activities of 226Ra, 232Th and 40K (Bq/kg-1) for soil and chemical fertilizers that are applied in the study were measured by using gamma ray spectrometer using NaI (Tl) detector. From resulting values of 226Ra, 232Th and 40K (Bq/kg-1) the using of fertilizers SSP, UI and NK in large extent have affected increasing of radionuclides concentration. While we note that, the more save chemical fertilizers for agriculture soil are proprioceptive urea (PU) fertilizer and Ammonium Nitrate (AN) fertilizers. The obtained results were compared with the global average and tolerable limits as recommended in UNSCEAR 2008.

Author Contributions: Both **AMS and FHG** contributed equally in conceptualization, methodology, validation and formal analysis, investigation, writing original draft preparation, writing review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest for this article.

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