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Activity Concentration of 226Ra, 232Th, And 40K in Some Samples from Elshaghab Region, Luxor Governorate, Egypt Based on Artificial Neural Network (ANN)

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Abstract:*Radioactivity levels in Clay and sand specimens collected from Elshaghab region, Luxor governorate-south of Egypt, were measured by gamma-ray spectrometric technique (HPGe) detector. The radioactive concentrations of the natural radioactive series of 226Ra, 232Th, and 40K have been estimated for the clay and sand samples of the study region. The mean concentrations of 226Ra, 232Th, and 40K in clay specimens were 19.7±0.8 Bq/kg, 17.18±0.7 and 272.03±16.3, respectively, where the mean concentrations of 226Ra, 232Th, and 40K for sand specimens were 15.58±0.6 Bq/kg, 13.06±0.4 Bq/kg 235.8±15.2 Bq/kg, respectively. Moreover, due to the high cost of samples measurements and the wide area of the lands in our study region, an artificial neural network (ANN) technique has been carried out to estimate and predict the activity concentrations of 226Ra, 232Th, and 40K for a wide area. A good agreement was obtained between the experimental values and predicted values from ANN.*

Keywords:*Radiation, HPGe detector, Clay, Sand, Artificial neural network*

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I. INTRODUCTION

Sand and clay are abundant in Upper Egypt and are primarily utilized in villages as building materials. The level of natural radioactive elements in each of them is therefore important and beneficial to be determined. For instance, gamma-ray spectrometer (GRS) is one of the many techniques by which these elements can be evaluated, which can be used to detect uranium-238, thorium-232 and their radioactive series, and then potassium-40. Because of the damage that affects humans due to harmful radiation exposure in the surrounding environment, sand and clay samples were collected and measured to estimate the concentration of such elements. On the other hand, a theoretical method has been used to predict these elements, and a comparison was conducted between both methods. Background radiation is found everywhere on the earth crust and it formed from two kinds namely terrestrial radiation and cosmic. The terrestrial radiation is mainly derived from uranium and thorium decay chains add to non-series 40K [1-5]. The level of background radiation devolves on the amount of radioactive nuclides in the environmental media which may be differing from region to region [7-9]. Environmental radioactivity due to gamma rays depends on geographical and geological condition [10]. The major purpose of the environmental radiation measurement is to determine the potential risks for populations arising from the natural radiation in their owns environment. Artificial neural network has been used as a tool to predict the concentration of natural radionuclide in environmental media.

II. MATERIALS AND METHODS

2.1. Specimens preparation

29 specimens were collected from Elshaghab area Luxor governorate, random selection of clay sample points and core process specimens. This region is why it's chosen because it's a new area that is recovered and it has no data. The specimens have been divided into 17 sand specimens and 12 clay specimens. At 105oC the specimens were dried in an oven to extract moisture and water from the specimens. Secondly to maximize the heavy mineral grain size, the specimens sieved through 200 mesh. Thirdly, every sample was placed in a plastic container sealing to prevent the 222Rn and 220Rn from escaping from the specimens. In addition, specimens

were left for at least 4 weeks before radiometry analysis to strike a balance between 232Th, 226Ra and their daughter products [11].

2.2. Measurement activity concentration

Radionuclide activities were determined using (HPGe) detector of n - type, an energy resolution of about 40% by 1.9 keV, a full width by half (FWHM) on the 1332.3 keV and a MCA with 8000 channels. The output of the detector is about 40%. The background concentrations of the μ to the rays were measured by an empty Marenilli beaker. The background spectra for the observed isotopes were used to correct the net μ to ray peak areas. A cylindrical lead shield of a thickness of 100 mm is used to secure the detector from the surrounding environment to reduce the − exposure from building and cosmic rays. This shield has three inner condensed plums, cadmium and copper shells [13]. The γ- ray transitions used to measure the concentration of the assigned nuclides in the series were as follows: 226Ra (186.1 KeV), 214Pb (295.1and 352.0 KeV), 214Bi (609.3, 1120.3 and 1765 KeV) for uranium series; 208Tl (583.0 KeV) 212Bi (39.86, 288.07, 727.33 and 1620.50KeV) and 228Ac (338.5 and 911.2 KeV) for thorium series; 40K (1460 KeV) for potassium.

The activity A(Ei), is given by:

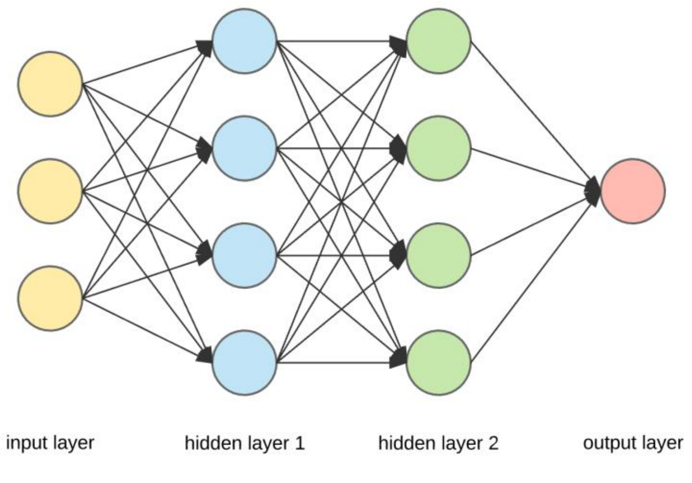
$$A(E_i) = \frac{N(E_i)/T - n(E_i)/t}{\varepsilon(E_i) \cdot P(E_i) \cdot M} \quad (1)$$

Where, N(Ei) is the counts in a given peak (i) area, T is the sample counting lifetime, n(Ei) is the number of counts in background peak (i), t is the background counting time, P(Ei) is the number of gammas per disintegration of this nuclide (emission probability), M is the mass in kg of the measured sample, ε(Ei) is the detection efficiency of the measured gamma-line energy. If a nuclear power scale has more than one cap, an attempt is made to mean the peak activity by using the weighted average nuclear activity. Furthermore, based on the gamma-ray photo-peaks measured which have been released in the different radionuclides of both the 232Th and the 226 Ra decay sets, 40K the concentrations of the radiological risk indices of the specimens were estimated. Due to the much smaller life of the daughter radionuclides in the decay series 232Th and 226Ra, the measurements are based on the determination of secular equilibrium for each sample. In particular, the average activity concentration of 212 Pb, 208 Tl and 228Ac in the specimens, and the average activity concentration of 226Ra in the 214 Pb and 214Bi decay products, are determined. Accurate measurements were therefore carried out of the concentrations of 232Th and 226Ra radiological activity while a true measurement of the concentration of 40 K was achieved.

2.3 Artificial neural network simulation result

In several fields artificial intelligence (AI) is used more and more frequently: for control, fail detection, or to predict variables. One of the most widely used AI tools is the neural network, and the most widely used neural network architecture is the multilayer feed forward Fig. 1. As proved in the universal approximation theorem [12] a feed-forward network with a single hidden layer, is capable of approximating any continuous functions defined on compact training data sets. It is common to apply the classical training algorithm, based on the minimization of the mean squared error (MSE) cost function, with the process (training) data. A comprehensive fundamentals of ANN can be found in ref [13].

Figure 1. Full connected multilayer feed forward neural network.

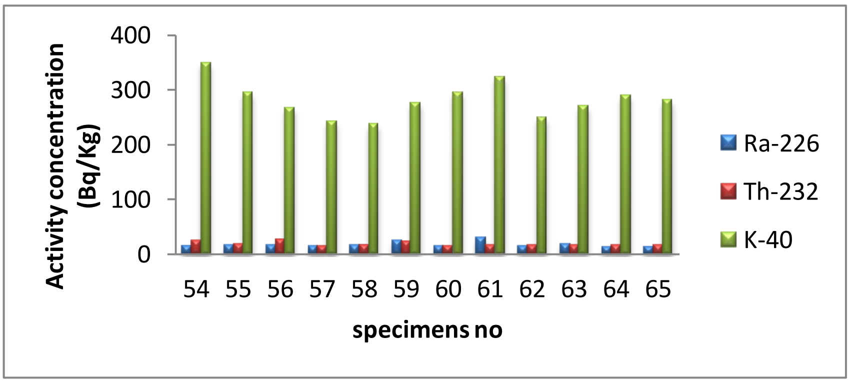


III. RESULTS AND DISCUSSION

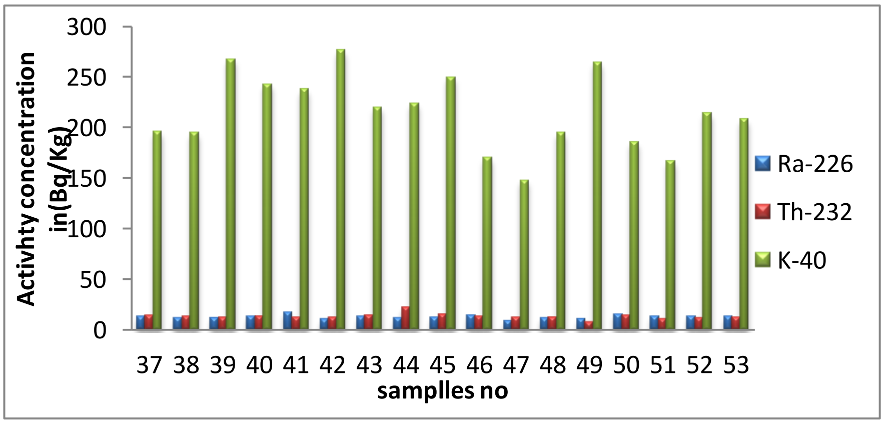
3.1. Natural activity concentration

Table 1 illustrates the activity concentration of the natural radionuclide (226Ra, 232Th, and 40K) in the sand and clay specimens collected from the area under investigation. The specific activities are given throughout the work in Bq/kg dry weight. The activity concentrations in sand specimens the activity concentrations (Bq/kg) for 226Ra, 232Th, and 40K, in Elshaghab region were ranged from 11.88±0.4 to 18.42±0.7 Bq/kg with the average value 15.58±0.6 Bq/kg, from 9.01±0.2 to 17.1±0.7 Bq/kg with the average value 13.06±0.4 Bq/kg and from 135.5±11.6 to 298.4±17.3 Bq/kg with the average value of 235.8±15.2 Bq/kg, respectively. On the other hand, 226Ra, 232Th, and 40K concentration for clay specimens were ranged from 12.3±0.4 to 23.3±1.1 with an average value of 19.7±0.8 Bq/kg, from 11.3±0.3 to 21.4±0.9 with an average value of 17.18±0.7 and from 123.6±11.1 to 387.2±19.6 with an average value of 272.03±16.3, respectively. . 226Ra, 232Th, and 40K concentration in clay are higher than those in sand specimens and the reason may be attributed to the used of fertilizers in clays for agriculture purpose [19]. The measured concentration of radionuclides has been found lower than average world level which reported by UNSCEAR (30, 35,400 Bq/Kg) [21]. The detailed distribution of studied radionuclides is given in Figure 2.

Figure 2. Activity concentrations (Bq/kg) for 226Ra, 232Th and 40K a for clay b for sand.



(a)



(b)

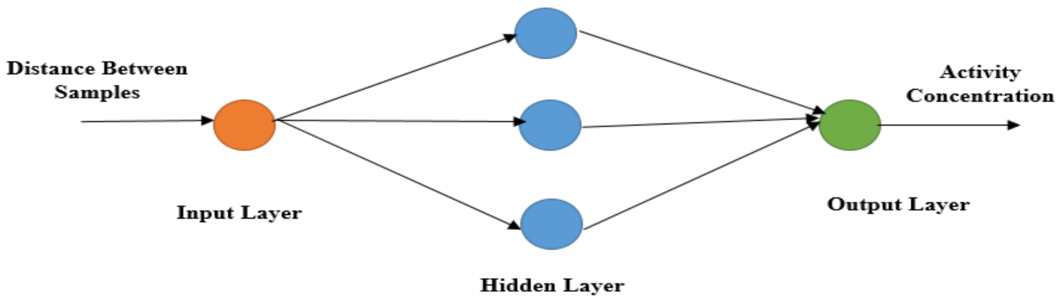
3.2 Artificial Neural Network Simulation Resul

In the current paper our used training data set is a real data set as mentioned above so we will use least mean log squares cost function [16]. The use of (LMLS) will help training algorithm to robustly train ANN and hence provide reliable ANN in the presence of real training data sets. The ANN architecture considered is a 3-layer feed forward NN with 18 hidden neurons as shown in Fig. 5. The training data set pairs can be written as (distance between specimens, activity concentration). The following table summarizes both ANN architecture and training parameters.

Table 1 Training and ANN architecture parameters.

Parameter	Value
No. of layers	3(input – hidden - output)
No. of input neurons	One (distance between specimens)
No. of hidden neurons	18
No. of output neurons	One (activity concentration)
Training Algorithm	Trainlm (its default parameters)
Cost Function	LMLS
Activation Function	Logsig
No. of epochs	1000

Figure 3. The structure of inputs and output of ANN model.



3.2.1 Case1: ANN results for predicting activity concentration of sand specimens collected from Elshaghab region

In the current section the proper performances of different ANNs are demonstrated for predicting different activity concentration measurements of 226Ra, 232Th and 40K for surface sand specimens collected from Elshaghab region - Egypt. Table 2 shows the predictions of different ANN models and its related the practical measurements. From the tabulated results we can note that, the trained ANN models achieved accurate predictions for all (226Ra, 232Th, and 40K) activity concentrations for surface sand specimens. Also, the obtained results indicate that the used ANNs are well trained. It can be noted from Table 2 that, the rate of errors for the ANN model ranged from 0% to 5.872568%.

Table 2 ANN results and experimental results for 226Ra, 232Th and 40K concentration in Elshaghab sand specimens.

Activity concentration in (Bq/Kg)									
Displacement of specimens (km)	**Experimental results**	**ANN estimation**	**Error (%)**	**Experimental results**	**ANN estimation**	**Error (%)**	**Experimental results**	**ANN estimation**	**Error (%)**
0	15.14	15.14	0	9.77	9.78	0.00102	267.41	267.41	0
0.5	14.38	14.41	0.00209	9.01	9.01	0	286.90	286.90	0
1	15.20	15.20	0	13.60	13.60	0	197.30	197.30	0
1.5	15.60	14.42	0.075641	12.79	14.60	0.14152	271.02	271.02	0
2	12.39	12.39	0	11.34	11.34	0	229.24	284.19	0.23971
2.5	17.08	17.08	0	13.91	13.91	0	186.02	186.02	0
3	11.88	11.88	0	10.77	10.77	0	227.96	236.04	0.03544
3.5	17.13	17.13	0	14.77	14.77	0	208.23	208.23	0
4	14.82	14.82	0	13.70	13.70	0	247.07	247.07	0
4.5	15.50	15.50	0	12.90	12.90	0	135.50	135.50	0
5	18.42	18.44	0.00109	13.90	13.90	0	235.00	235.00	0

5.5	13.90	13.85	0.003597	17.10	17.55	0.02632	222.30	222.30	0
6	18.03	18.03	0	16.40	15.71	0.042073	275.50	275.50	0
6.5	17.20	17.13	0.00407	11.20	11.20	0	298.40	328.15	0.0997
7	17.10	17.10	0	13.80	13.80	0	235.60	237.03	0.00607
7.5	15.60	16.28	0.04359	14.00	15.46	0.10429	249.40	249.40	0

3.2.2 Case2: ANN results for predicting concentration of clayspecimens collected from Elshaghab region

In the current section the proper performances of different ANNs are demonstrated for predicting different activity concentration measurements of 226Ra, 232Th and 40K for surface clay specimens collected from Elshaghab region - Egypt. Table 3 shows the predictions of different ANN models and its related the practical measurements. From the tabulated results we can note that, the trained ANN models achieved accurate predictions for all activity concentrations (226Ra, 232Th and 40K) for surface sand specimens. Also, the obtained results indicate that the used ANNs are well trained. Also, it can be noted that, the rate of errors for the ANN model ranged from 0% to 5.272512%. According to Table 3, excellent agreement between experimental data and ANN results was indicated.

Table 3 ANN results and experimental results for 226Ra, 232Th and 40K concentration in Elshaghab clay specimens.

Activity concentration in (Bq/Kg)

Displacement of specimens (km)	**Experimental results**	**ANN estimation**	**Error (%)**	**Experimental results**	**ANN estimation**	**Error (%)**	**Experimental results**	**ANN estimation**	**Error (%)**
0	21.90	21.90	0	19.90	19.73	0.008543	387.20	378.91	0.02141
0.5	23.10	26.41	0.14329	19.30	17.83	0.076166	271.60	27.60	0.89838
1	23.30	23.63	0.01416	20.40	20.49	0.00441	268.30	268.30	0
1.5	19.10	19.10	0	17.10	16.92	0.010526	286.20	340.38	0.18931
2	18.20	18.20	0	16.50	16.32	0.010909	293.10	293.10	0
2.5	12.30	12.30	0	11.30	10.92	0.033628	229.20	229.20	0
3	19.90	19.90	0	17.70	16.88	0.046328	320.60	320.60	0
3.5	17.40	17.47	0.00402	12.20	14.08	0.1541	123.60	123.60	0
4	18.50	19.95	0.07838	15.50	15.51	0.00065	264.60	264.60	0
4.5	20.30	20.30	0	17.70	17.66	0.00226	281.70	281.70	0
5	19.10	19.10	0	15.40	15.43	0.00195	255.90	259.13	0.01262
5.5	21.10	21.10	0	21.40	20.13	0.059346	236.30	236.30	0
6	22.70	22.70	0	19.03	19.34	0.01629	318.20	215.69	0.322156

IV. CONCLUSION

The current work provides information on the concentration and distribution of radionuclides in these sources and the associated hazards of 226Ra (U-238) series, 232Th series and 40K. This knowledge should be known as Elshagab is a new area. The result refers to the mean value of 226Ra, 232Th, and 40K were lower than the world average value (30,35,400) respectively (15) and sand has lower natural radioactivity than clay in the same region. It is concluded that sand and clay used in agriculture in Elshaghab region have not got any health risk about the radiation hazard. The ANN technique has a minimum value of error. The ANN errors explain the percentage of the difference between the experimental results and the estimated ANN results of activity concentration.

Conflict of interest

There is no conflict to disclose.

REFERENCES

[1]. A. Jabbar, W. Arshed, A.S. Bhatti et al (2010) Measurement of clay radioactivity levels and radiation hazard assessment in southern Rechnainterfluvial region, Pakistan. Environ. Monit. Assess, 169: 1-4.

[2]. N. Akhtar, M. Tufail, M.A. Choudhry et al (2004) Radiation dose from natural and manmade radionuclides in the clay of NIAB, Faisalabad, Pakistan. The Nucleus, 41: 1-4.

[3]. S.U. Rahman, M. Faheem, J. Anwar et al (2009) External dose assessment from the measured radioactivity in clay specimens collected from the Islamabad capital territory, Pakistan. J. Radiol. Prot, 29:499-505.

[4]. A. Jabbar, W. Arshed, A.S. Bhatti et al (2010) Measurement of clay radioactivity levels and radiation hazard assessment in mid Rechnainterfluvial region, Pakistan. J. Radioanal. Nucl. Chem., 283: 371-378.

[5]. S.U. Rahman (2010) Measurement of indoor radon levels, natural radioactivity and lung cancer risks estimation. PhD thesis.

[6]. N. Ahmed, Matiullah and A.J.A. Hussein (1998) Determination of natural radioactivity in Jordanian clay and building materials and the associated radiation hazards. J. Environ. Radioact. 39: 9-22.

[7]. B.N. Hamid, M.I. Chowdhury, M.N. Alam and M.N. Islam (2002) Study of natural radionuclide concentrations in an area of elevated radiation background in the northern districts of Bangladesh. Radiat. Prot. Dosim, 98: 227-230.

[8]. M. Faheem, S.A. Mujahid and Matiullah (2008) Assessment of radiological hazards due to the natural radioactivity in clay and building material specimens collected from six districts of the Punjab Province-Pakistan. Radiat. Meas., 43: 1443-1447.

[9]. K. Khan, P. Akhter, and S. D. Orfi (2005) Estimation of radiation doses associated with natural radioactivity in sand specimens of the north western areas of Pakistan using Monte Carlo simulation. J. Radioanal. Nucl. Chem. 265: 371-375.

[10]. G.SenthilkumaraY.RaghubS.SivakumarcA.ChandrasekarandD.Prem AnandeR.Ravisankarf Natural radioactivity measurement and evaluation of radiological hazards in some commercial flooring materials used in Thiruvannamalai, Tamilnadu, India Volume 7, Issue 1, January 2014, Pages 116-122.

[11]. Shoeib, M.Y. and Thabayneh, K.M. (2014) Assessment of natural radiation exposure and radon exhalation rate in various specimens of egyptian building materials. J. Radiat. Res. and Appl. Sci., 7: 174-181.

[12]. K. Hornik, M. Stinchcombe, and H. White (1989) Multilayer feedforward networks are universal approximators. Neural Netw., 2: 359–366

[13]. Simon Haykin (1999) Neural Networks: A Comprehensive Foundation. 2nd Edition, Pearson.

[14]. R. Mustonen (1984) Natural radioactivity in and radon exhalation from finnish building materials. Health Phys. 46: 1195–1203.

[15]. UNSCEAR (2000) United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and effects of ionizing radiation, Report to General Assembly, NY: United Nations Publication, New York.

[16]. Moumen T. El-Melegy, Mohammed H. Essai and Amer A. Ali (2009) Robust training of artificial feedforward neural networks. Foundations of Computational, Intelligence, 1: 217-242.

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