Evaluation of Heavy Elements for Different Type of Soil in Sudan Using INAA Technique

Magdi Hassan Saad[1, 2], Jumaa Yousif Tamboul[3, 4], MohammedYousef[3, 4]

[1]Physics department, Taibah University, Yanbu,KSA
[2]Physics department, Sudan University of Science & Technology
[3]Taibah University , College of Applied Medical Sciences, Department of Diagnostic Radiologic Technology, Fax: 8475790 P.O: 30001 Almadinah Almunawwarah , KSA
[4]College of Medical Radiologic Sciences, Sudan University of Science and Technology.P.O.Box 1908, Khartoum, Sudan

Corresponding Author: Dr. Jumaa Yousif Tamboul,Tel.: +966559677525
Email: jtamboul@hotmail.com

Abstract:

Objective:

The aim of the study was to determine element concentrationsof heavy elements for different type of soil in different region in Sudan.

Material and methods:

Samplesof this study were included different types of soil mud and rocks in different regions and locations having different basements, morphology as well as climates. These samples were analyzed by INAA technique to determinate the heavy elements and its concentrations

Results:

The results showed that all types of soil has the same high element concentration of Ca^{149}in average concentration - in **p**arts **p**er **m**illion - of (189170.988ppm), also all regions have the same least element concentration of Au^{198} in average concentration of (0.001ppm).

Conclusion:

The obtained results showed that all locations has the same types elements but with different concentration.

Keywords: Sudan; INAA; nuclear analytical techniques; elemental analysis; trace elements; methodological developments; environmental samples; environmental pollution; atmospheric aerosols; dry deposition; bioindicators; fly-ash; solid waste; water; sediments.

Introduction:

Sudan is a very large country.Therefore,the most suitable way to estimate the concentration of heavy elements over the whole country is to take samples from different parts, which have different locations, climates and soil.There for samples are collected from south, middle, east and west of the Sudan including desert, tropical and equatorial climate[1, 2]. Heavy metals are general collective term applying to the group of metals and metalloids with a density greater than 6 gm/cm^3. Although it is only a loosely defined term, it is widely recognized and applied to the elements such as Cd, Cr, Cu, Hg, Ni, Pb and Zn, which are commonly associated with pollution and toxicity problems. An alternative (and theoretical) name for this group of elements is (trace metals) but it is not widely used. Unlike organic pollutants, heavy metals occur naturally in rock-forming and ore minerals and so there is a range of normal background concentration of these elements in soils sediments, water and living organisms. Pollution gives rise to anomalously high concentration of the metals relative to the normal background levels, therefore, presence of the metal is insufficient evidence of pollution, and the relative concentration is all important [3].In geological terms heavy metals are included in the group of elements referred to as trace elements which together constitute less than 1% of the rocks in the earth's crust, the macroelements (O, Si, Al, Fe, Ca, Na, K, Mg, Ti, H, P and S) comprise 99% of the earth's crust. These trace elements occur as impurities isomorphously substituted for various macroelement constituents of the crystal lattice of many primary minerals. Primary minerals are those found in igneous rocks which originally crystallized from molten magma. In sedimentary rocks trace elements occur sorbed to the secondary minerals which are the products of the weathering (physical disintegration and chemical decomposition) of primary [3].Heavy metal pollution can affect all environments but its effects are most long lasting in soils due to the relatively strong absorption of many metals onto the humic and clay colloids in soils. The duration of contamination may be for hundreds and thousands of years in many cases[4, 5, 6].Saad et al[7]studied the Relationship between Radiation Backgrounds and Concentration of Elements in Ore (in Northern Sudan) and found that the difference was only in the lowest concentration elements such as Ca, Fe, and K with concentrations of 132685.71 ppm, 303417.72 ppm and 25696.20 ppm respectively.The results of the present study were subsequently compared with international and national recommended values.Nowadays, the Neutron Activation Analysis (NAA) is accepted as an important technique for elemental analysis of local environmental studies of different materials. This will serve in the local industry and economy in each regional area.

In fact, the applications of this technique are initiated by the national needs. Therefore, it is hard to point out international trends in the use of (NAA). Accordingly, trends in the use of (NAA) in East. Asian countries, for example, will differ from those in Latin American and in African countries. The extensive use of (NAA) in environmental control and monitoring can be demonstrated by the large number of papers presented at the symposia organized by the IAEA infields such as, Applications of Isotopes and Radiation in Conservation of the Environment, in 1992[8], Harmonization of Health.Related Environmental Measurement Using Nuclear and Isotopic Techniques [9], the symposia in: Nuclear Analytical Methods in Life Sciences [10,11] and the most recent one held in Cairo (2 3 Dec. 2007) the fifth African conference (RAF / 4 / 020) on Research Reactor Utilization [The Role of Research Reactors in Nutrition, Environment and Health Related Research [12]. In order to evaluate the impact of trace element pollution, it is necessary to establish the natural elemental levels and chemical forms of the earth's environment.

Experimental details and data analysis technique

Region Selection:

To give realistic representation of the whole country, the samples were taken from Dongola area, which represent the north as well as desert region. El-Burkal area also stands for the north. But the basement, unlike Dongola is dominated by rocks and hills. In the middle of Sudan Jabel El-Awlia area is dominated by hills, while El-Jazira region is a valley dominated by mud soil.The middle area also represents tropical region. The equatorial region as well as west sector is represented by three different places Jabel Mernna, Jabel Kurrun and Ouro area in which crust is dominated by rocks and hills.

Sampling and sample preparation

Samples are collectedat 20cm depth for soil from south, middle, east and west of the Sudan including desert, tropical and equatorial climate. Soil samples of about 0.2 g were heat-sealed in polyethylene foil bags for short-term irradiation and packed in aluminum cups for long-term irradiation in the pulsed fast reactor IBR-2 in Dubna.[14, 15, 16].

Results

The table below shows the concentration of heavy elements for different types of soil in different locations in Sudan.

Table (1) concentration of elements / ppm

Element	Dongola	Nuri	ElBarkel	Mernna	Kurrun	Ourro	ElGezira	Omdurman	ElTakka
NA24	5304.444	3570.000	4131.667	4657.500	4470.000	2906.667	4876.667	2395.000	4320.000
MG27	20136.670	19800.000	14843.330	21727.500	15921.670	20000.000	22666.670	35300.000	47050.000
AL28	33422.220	23000.000	31533.330	28100.000	28800.000	29033.330	28600.000	33550.000	25850.000
K42	6881.111	5020.000	5716.667	5992.500	5261.667	11623.330	3903.333	7220.000	8625.000
SC46	525.333	310.000	535.667	617.500	640.833	528.333	607.333	565.000	341.000
CA49	109988.900	150000.000	178333.300	247500.000	184550.000	208666.700	208000.000	188500.000	227000.000
V52	61.478	66.400	76.217	108.075	80.800	94.767	92.900	76.700	59.150
CR51	59.911	42.100	77.633	63.950	82.750	56.267	66.233	57.600	42.050
MN56	424.454	1110.000	621.667	458.500	324.867	595.667	543.000	643.000	840.000
Ni	28.048	28.900	48.450	38.625	44.383	45.467	51.300	18.225	3.110
FE59	13572.220	10300.000	13805.000	65175.000	17365.000	16896.670	16426.670	18400.000	15850.000
CO60	5.414	4.620	5.758	8.273	7.395	8.760	9.650	21.040	24.900
ZN65	49.089	51.200	68.883	53.125	70.683	61.100	73.200	37.500	22.050
SE75	1.891	2.770	2.575	2.355	2.450	2.490	2.997	2.835	1.865
AS76	4.229	4.470	6.138	8.925	9.785	32.933	10.787	7.140	6.765
BR82	3.374	1.710	3.852	15.875	12.680	13.370	5.060	4.575	4.960
RB86	18.578	12.700	17.267	18.875	19.775	16.633	16.867	41.600	44.350
SR87M	450.111	438.000	645.333	561.000	546.217	585.000	675.333	397.500	405.000
ZR95	336.388	885.000	52.980	248.578	172.888	487.047	439.783	1.670	498.765
NB95	1339.444	876.000	1261.167	1362.500	1117.667	907.667	954.333	1755.000	1320.000
MO99	2.799	1.700	4.098	4.313	7.388	16.050	7.600	3.725	3.985
AG110	0.054	0.049	0.040	0.035	0.065	0.093	0.089	0.101	0.028
SB122	3.263	4.190	5.307	6.185	3.915	6.170	6.723	4.180	4.425
SB124	0.316	0.342	0.434	0.565	0.526	0.503	0.566	0.480	0.371
I128	8.926	6.640	10.157	17.783	10.133	17.300	14.400	17.750	13.850
BA131	321.556	2740.000	1025.167	1068.000	464.333	545.300	3301.000	452.000	328.000
CS134	0.705	0.410	0.767	0.925	1.031	0.880	0.958	1.322	1.225
LA140	11.247	8.220	12.272	20.925	21.267	41.767	21.033	25.300	17.000
CE141	24.489	16.100	25.467	36.650	35.650	30.233	38.767	44.600	27.900
EU152	0.302	0.169	0.284	0.286	0.313	0.183	0.296	0.355	0.270
TB160	0.325	0.210	0.393	0.368	0.509	0.426	0.489	0.588	0.380
YB169	1.093	.407	1.030	1.361	1.369	1.165	1.342	1.785	1.485
LU177	.346	.111	.303	5.880	11.893	17.420	7.987	4.179	2.266
HF181	10.337	7.210	9.753	9.778	7.763	6.500	6.413	12.370	9.365
TA182	0.463	0.247	0.388	0.438	0.431	0.392	0.347	0.571	0.429
W187	0.388	0.144	0.246	0.269	.231	5.090	5.785	0.326	0.347
AU198	0.001	0.000	0.001	0.001	0.001	0.005	0.001	0.001	0.002

Discussion:

It is observed that all locations have the same elements but with different concentrations. In Dongola city (north of the Sudan) the highest element concentration is Ca49 (109988.9 ppm), and the lowest element concentration is Au189 (0.001ppm). But in Al-Burkal city and mountains (north of the Sudan), the highest element concentration is Ca49 (178333.3ppm), and the lowest element concentration is Au189 (0.001 ppm). While in Mernna mountains (south of Abojbiaha city- south of the Sudan), the highest element concentration is Ca49 (247500 ppm), and the lowest element concentration is Au189 (0.00113 ppm). In Kurrun mountains (East of Abojbiaha city- south of the Sudan), the highest element concentration is Ca49 (184550 ppm), and the lowest element concentration is Au189 (0.001ppm). In Ourro area (north of Abojbiaha city- south of the Sudan) the highest element concentration is Ca49 (208666.7 ppm), and the lowest element concentration is Au189 (0.001 ppm). Also in AL-Jazeera project (middle of the Sudan), the highest element concentration is Ca49 (208000 ppm), and the lowest element concentration is Au189 (0.001ppm). And in AL-Merkhiat mountains (north of Omdurman city- Khartoum state) the highest element concentration is Ca49 (188500 ppm), and the lowest element concentration is Au189 (0.001ppm). In Toteel mountains (Kasala city- East of the Sudan), the highest element concentration is Ca49 (227000 ppm), and the lowest element concentration is Au189 (0.001ppm).

Conclusion:

IANN technique has been employed in order to determine the heavy elements in soil. The experimental results indicate that the concentrations of heavy elements vary from region to another, depending on the nature of the land and the region. The highest concentration element is Ca^{49} recorded in all regions but the maximum value obtained in Merrna Mountains (247500ppm), and The lowest concentration element is Au^{198} recorded in all regions but the minimum value obtained was in Nuri (0.00ppm).

References

1. Eby, G. N., Woolley, A., and Collerson, K. (2004) The Chilwa Alkaline Province, Malawi - geochemistry, isotope geology, and petrogenesis. 32nd International Geological Congress Florence 2004 - Scientific Sessions: abstracts (part 1), p. 703.

2. Zozulya, D. and Eby, N. (2004) Late Archean felsic alkaline magmatism: geology, geochemistry, and tectonic setting. 32nd International Geological Congress Florence 2004 - Scientific Sessions: abstracts (part 2), p. 904.

3. F.W. Fifield and P.J. Haines (1995):" Environmental analytical chemistry", first edition Champan& Hall.

4. Creasy, J. W. and Eby, G. N. (1993) Ring dikes and plutons: A deeper view of calderas as illustrated by the White Mountain igneous province, New Hampshire. In Cheney, J. T. and Hepburn, J. C. (eds.) Field Trip Guidebook for the Northeastern United States: 1993 Boston GSA, Vol. 1. Contribution No. 67, Department of Geology and Geography, University of Massachusetts, Amherst, MA, pp. N1-N25.

5. Eby, G. N., Krueger, H. L., and Creasy, J. W. (1992) Geology, geochronology, and geochemistry of the White Mountain batholith, New

Hampshire. In Puffer, J. H. and Ragland, P. C. (eds.) Eastern North American Mesozoic Magmatism, Geological Society of America Special Paper 268, pp. 379-397.

6. Eby, G. N. (1992) Chemical subdivision of the A-type granitoids: petrogenetic and tectonic implications. Geology 20, 641-644.

7. Saad,MH., Tamboul J, Yousef M. The Relationship between Radiation Backgrounds and Concentration of Elements in Ore (in Northern Sudan).*Life Sci J* 2014;11(2):131-133]. (ISSN:1097-8135).
8. IAEA Applications of isotopes and radiation in conservation of the environment Proc. Symposium, Karlsruhe, Germany (1992) IAEA, Vienna (1992)
9. IAEA, Harmonization of Health Related Environment Measurements using Nuclear and Isotopic Technicques (Proc. Symp. Hyderabad, India (1996), IAEA, Vienna (1996)
10. Kucera, J. Oberusnik, I. Sabbiani, E. (Eds) Nuclear Analytical Methods in the Life Sciences, Biol. Trace El. Res. 43/45 (1994), Humana Press. Totowa, New Jersy (1994)
11. CHAL, Z. (ED) Nuclear Analytical Methods in the life sciences, Biol. Trace El. Res. 71 (1999), Humana Press, Totowa New-Jersy (1999)
12. The Role of Research Reactors in Nutrition Environmental and Health Related Research (2 - 3) Dec. (2007). The 5th. African conf. (RAF/4020) on reasearch reactor utilization Cairo Egypt. (2007).

13. Muecke, G.K., ed., 1980, Neutron Activation Analysis in the Geosciences: Mineralogical Association of Canada Short Course Handbook 5.

14. Eby, N. and Eby, S. (2008) Instrumental Neutron Activation Analysis (INAA): practice and potential forensic applications. In: Donnelly, L. J. 2008 (ed). Geoscientific Equipment & Techniques at Crime Scenes. The Geological Society Forensic Geoscience Group. FGG 2008 conference, booklet of abstracts, 17 December 2008, Geological Society of London, pp. 28-30.

15. Eby, G. N. (2008) Instrumental neutron activation analysis (INAA) - practice and application. National Organization of Test, Research, and Training Reactors 2008 Annual Meeting Program with Abstracts, p. 21.