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The affect of industrial activities on zinc in alluvial Egyptian soil determined using neutron activation analysis

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Abstract: Thirty-two surface (0—20 cm) soil samples were collected from different locations in Egypt representing non-polluted, moderately and highly polluted soils. The aim of this study was to evaluate total Zn content in alluvial soils of Nile Delta in Egypt by using the delayed neutron activation analysis technique (DNAA), in the irradiation facilities of the first Egyptian research reactor (ET-RR-1). The gamma-ray spectra were recorded with a hyper pure germanium detection system. The well resolved gamma-ray peak at 1116.0 keV was efficiently used for ^{65}Zn content determination. Zn content in non-polluted soil samples ranged between 74.1 and 103.8 ppm with an average of 98.5 ± 5.1 ppm. Zn content in moderately polluted soils ranged between 136.0 and 232.5 ppm with an average of 180.1 ± 32.6 ppm. The highest Zn levels ranging from 240.0 and 733.0 ppm with an average of 410.3 ± 54.4 ppm, were observed in soil samples collected from, either highly polluted agricultural soils exposed to prolonged irrigation with industrial wastewater or surface soil samples from industrial sites.

Keywords: elemental analysis; pollution; neutron activation analysis

Introduction

Zn belongs to the group of trace metals potentially most hazardous to the biosphere. Together with Cu and Ni, zinc is phytotoxic, so the concern about this metal is mainly directed at effects on crop yield and soil fertility (Kiekens, 1990). The main pollutant sources for Zn is soils are metal ferrous mining activities, agricultural use of sewage sludge composed materials, and the use of agrochemicals such as fertilizers and pesticides. Zn may be considered, together with Cd, as a very mobile and bio-available metal which may accumulate in crops and human diets (Kiekens, 1990). It was also observed that the downward movement in soils of Zn increases with its loading rate. Despite results provided by long-term experiments, more information is needed to evaluate long-term changes in factors controlling Zn bio-availability.

Zn concentration of soils varies widely. The lower and upper limits range from traces to 900 ppm. The average concentration is reported to range from 50 to 100 ppm. The common range for total Zn concentration in soils varies from 10 to 300 mg/kg soil with an average of 50 mg/kg (Lindsay, 1972). Hakerlerler *et al*. (Hakerlerler, 1992) reported a value ranging from 81.2 to 650 mg/kg for total Zn for the soils of Turkey. Malini *et al*. (Malini, 1995) found that total Zn in the soils of India ranges from 50 to 100 mg/kg soil.

In recent years, Zn concentrations in some soils have gradually increased, particularly in industrialized countries, as a consequence of human activities. Hegazy (Hegazy, 1993) reported values for total Zn content in the surface and subsurface layers of 73.0 and 25 ppm, respectively, in virgin non irrigated soils, compared to 408 and 43 ppm in the surface and subsurface soils irrigated with sewage water. He also added that irrigating soils with industrial wastewater was more pronounced in raising total Zn in soils than sewage water. The above-mentioned values reached 487.2 and 120.8 ppm in the surface and subsurface layers of soils irrigated with industrial wastes. Also Ramadan (Ramadan, 1995) reported that both total and available Zn were increased due to industrial activities at Moustorod.

The aim of this study was to evaluate total Zn content in alluvial soils of the Nile Delta in Egypt, using the delayed neutron activation analysis technique, because of its high sensitivity, accuracy and its advantages over other techniques.

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1 Experimental technique

1.1 Sample preparation and irradiation

Thirty-two surface (0—20 cm) soil samples were collected from different locations in Egypt, representing non-polluted, moderately and highly polluted soils. The non-polluted soil samples were collected from different sites not affected by any known sources of Zn pollution. The moderately and highly polluted soil samples were collected from soil subjected to prolonged irrigation with either polluted industrial wastewater or samples collected from industrial sites, e.g. metallurgical work shops. The samples were air-dried and crushed with a grinder to small grains ($\approx$ 200 mesh). About 0.1g of each sample was individually wrapped in an aluminum sheet while an empty aluminum foil of the same weight was included in the irradiation can for identifying and substracting the background gamma ray lines due to aluminum envelopes. A gold foil of a (0.004g) was included as well and rolled in a separate aluminum sheet just for flux monitoring. Also 0.1g of standard reference material soil-7——analytical quality control services (AQCS, 1995) was included to certify the accuracy of the analysis.

The irradiation time was about 48h at 2MW power of the ET-RR-1 with an average thermal neutron flux of 4×10^{12} $n/(cm^2 \cdot s)$. The gamma-ray spectrum for each sample was collected for 2h, after 24h cooling time, with a hyper pure germanium detection system.

1.2 Instrumentation

The hyper pure germanium detection system had a detector of 25% efficiency and energy resolution of 1.9 keV at an energy of 1332.5 keV. The detector was connected to a low noise preamplifier, a spectroscopy linear amplifier and a multichannel analyzer with a personal computer system with a 8192 channel spectrum memory. The multi gamma-ray standard source MGS-4, was use to perform the energy and efficiency calibration of the detection system (Nuclear Measurements Group, 1994). The selected gamma-ray energies of ^{155}Eu, ^{57}Co, ^{113}Sn, ^{137}Cs, ^{54}Mn and ^{65}Zn were used for these measurements.

2 Results and discussion

^{65}Zn was calculated from the activity induced by the $^{64}Zn\ (n,\gamma)^{65}\ Zn$ reaction. The well resolved gamma-ray peak at 1116.0 keV was used for the ^{65}Zn determination. The observed Zn content in standard reference material soil 7 was in good agreement with the certified value which confirms the accuracy of the detection system. The nuclear data shown in Table 1 were useful for evaluating the concentration of Zn (IAEA, 1990) by the absolute method.

Table 1 Nuclear parameter of the measured nucleus

Element	Nuclear reaction	Nuclear data		Cross-section σ barns	Abundance, %
		Half-life, d	Energy, keV (intensity, %)		
Zinc	$^{64}Zn(n,\gamma)^{65}Zn$	244	1116.0 (50.7)	0.78	48.60

Table 2 shows total Zn concentrations determined in this study. Zn content in non-polluted soil samples ranged between 74.1 to 103.8 ppm with an average of 98.5 ± 15.1 ppm. Previous data (Hegazy, 1993) showed that total Zn of the alluvial soils collected from Giza, Khafr Shiek and Moshtohor ranged from 10 to 120 ppm with an average of 95.0 ppm while the calcareous soils of El-Nobaria have an average of 27.5 ppm total Zn and sandy soils from Ismailia have the lowest total Zn (12.5ppm). El-Sayad (El-Sayad, 1983) found that total Zn content in Fayoum soils ranges from 16 to 216 ppm with an average of 91 ppm. Rashad *et al*. (Rashad, 1995) reported that total Zn in the non-polluted soils of the Nile Delta ranged between 81.0 and 101.0 ppm with an average of 92.0 ppm.

Table 2 Total Zn content (ppm) in alluvial soil samples collected from different delta sites (non-polluted and polluted) as determined by NAA technique

Non polluted sites		Moderately polluted sites		Highly polluted sites	
Location	Total Zn content	Location	Total Zn content	Location	Total Zn content
1	83.85	9	154.5	21	254.7
2	88.20	10	217.0	22	281.5
3	74.10	11	198.5	23	560.6
4	114.0	12	208.7	24	353.5
5	122.7	13	144.5	25	362.3
6	96.6	14	198.6	26	362.5
7	97.8	15	136.0	27	400
8	103.8	16	146.6	28	240
Mean	98.5	17	164.8	29	250
SD	±5.1	18	232.5	30	733
		19	210.5	31	631
		20	148.5	32	495.4
		Mean	180.1	Mean	410.3
		SD	±32.6	SD	±154.4

Zn content in this study in moderately polluted soils samples ranged between 136.0 and 232.5 ppm with an average of 180.1 ± 32.6 ppm. The highest levels, ranging from 240.0 up to 733.0 ppm with an average of 410.3 ± 154.4 ppm, were observed in soil samples collected from, either highly polluted agricultural soils due to prolonged irrigation with industrial waste water or surface soil samples from industrial sites. These values are higher than previously reported in contaminated soils in Egypt (El-Sabbagh, 1991; Ramadan, 1995). They reported that total and available Zn were increased due to industrial activities at Mostorod.

El-Sabbagh (El-Sabbagh, 1991) reported 40.0 to 67.0 ppm, while (Ramadan, 1995) reported 130.0 to 158.0 ppm for total Zn in the surface layer of soils. Rabie *et al*. (Rabie, 1996) reported that both total and available Zn were increased due to industrial activities in the El-Saff area.

3 Conclusion

It is clear that from the obtained results, the prolonged irrigation of soil with industrial wastewater leads to the accumulation of Zn in soil. For this reason we must avoid irrigation of soil with industrial wastewater because its bad effect on the crops and human health.

References:

AQCS (Analytical Quality Control Services), 1995. Inter comparison runs reference materials, Vienna, Austria[Z].

El-Sabbagh T A, 1981. Environmental impact of industrial area mostorod on the concentrations of some elements in water, soil and plant[D]. M Sc Thesis, Inst of Environ Studies and Res, Ain Shams Univ Egypt.

El-Sayad E A, 1983. Studies on some micro nutrients in some soils of El-Fayoum Governorate[D]. M Sc Thesis, Fac of Agric, Cairo Univ Egypt.

Hakerlerler H A, Taysum A, Okur B *et al*., 1992. Heavy metals content of soil of the GAP region[J]. Ege Univer Ziraat Fakultesi Dergisi, 29(313): 60—70.

Hegazy I M A, 1993. Studies on soil pollution[D]. M Sc Thesis, Fac of Agric Moshtohor Zagazig Univ Egypt.

Kiekens L, 1990. Zinc, chapter 13. Heavy metals in soil (Alloway B J ed.)[M]. U K: Blackic Acad and Professional. 284—305.

Lindsay W L, 1972. Inorganic phase equilibrium of micro nutrients in soil[M]. Chapter 3. In: Micro nutrients in Agricultural. WM USA: Soil Sci Amer Soc. 41—58.

Malini S, Nagaiah N, Paramesh L *et al*., 1995. Study of the distribution of trace elements in soils and water[J]. Environmental Geology, 26: 107—110.

Nuclear Measurements Group, Microanalysis Group, Oxford Instruments Inc. Serial number 1036[Z]. Source type 2" disk. 6-03-1994.

Rabie F, Rashad I F, Khader M Y *et al*., 1996. Contents of biogenic and non-biogenic heavy metals in El-Saff soils as related to different pollution sources[J]. Egypt J Soil Sci, 36:163—177.

Ramadan M A, 1995. Studies on the pollution of the agricultural environment in Egypt[D]. Ph D Thesis, Fac of Agric, Cairo Univ, Egypt.

Rashad I F, Abdel-Nabi A O, El-Hemely M E *et al*., 1995. Background levels of heavy metals in the Nile Delta soils[J]. Egypt J Soil Sci, 35:239—252.

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