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Distribution of Selenium in some Egyptian Soils

Eman M. Abd El-Razik[*], A.A. Soaud[**], R. El-Kilani[**] and N. R. Habashy[*]

[**]*Soil Science Department, Faculty of Agriculture, Cairo University, and* [*]*Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt.*

DISTRIBUTION and Se content of soils has received much attention mainly in countries where the role of Se in human and animal health has been widely recognized. The objective of this study is to assess soil properties which are most highly related to distribution and soil Se content in some different Egyptian locations. Twelve soil profiles from some different Egyptian areas (*i.e.*, Matrouh, El-Arish, El-Hesynia Plain, El-Tina Plain, El-Mansoura, El-Gabal EL-Asfar, El-Fayoum and Toshki) were selected. Soil samples were collected from following depths 0-30, 30-60 and 60-90 cm. Data showed that total and available Se in soil were different depending on the soil location and also the soil characteristics. The obtained correlation between indigenous soil parameters and selenium concentration showed that soil parameters, *e.g.,* clay, cation exchange capacity, pH and sulfur content, were the most effective on soil selenium content.

Keywords: Selenium, Parent material, Soil forming factors and alluvial deposits.

Selenium (Se) is an essential element for humans, animals and some species of microorganisms (Hawrylak-Nowak, 2008). Although Se is essential for the growth of some algae and has been shown to promote the growth of many higher plant species, there is no evidence that it is essential for higher plants (Zhang and Gladyshev, 2010). Se is toxic to most organisms at elevated concentrations, largely because of its similarity to sulfur (S), which leads to nonspecific replacement of S by Se in proteins (El-Mehdawi *et al.*, 2011).

It is well documented that, the average content of selenium in the Earth's crust is estimated as 0.05 mg kg^{-1} and may be increase to 0.5 mg kg^{-1} (Kabata-Pendias, 2011). The mean total Se content in worldwide soils is estimated as 0.44 mg kg^{-1}. Se in soils is unevenly distributed and highly site-specific, varying from 0.01 to 2.0 mg kg^{-1} in many parts of the world (Oldfield, 2002). Many studies had focused on the chemical behaviors, transformation and biogeochemical cycling of Se in soils and sediments (*e.g.,* Tokunaga *et al.*, 1991, 1996). According to previuos studies, it could be concluded that the most important soil properties influencing Se availability are pH, redox potential (Eh), soil texture, clay content and type, organic matter content, the presence of competitive ions and microbial mass (Jayaweera and James, 1996 and Wang & Gao, 2001). Furthermore, Se is associated with clay fraction in sedimentary rocks and thus its abundance in argillaceous sediments (0.3–0.6 mg kg^{-1}) is higher than in sandstones and limestones (0.01–0.1 mg kg^{-1}) (Kabata-Pendias, 2011). It is also found a relationship between soil organic carbon and Se concentration in soils (Johnsson, 1991 and Zhang & Moore, 1997). They found that, carbon content is an important factor affecting Se distribution in sediment but this relationship is greatly affected by dissolved Se inputs. Likewise, these factors affect the bio-availability of Se to plants, animals and humans. Therefore, mobile Se concentration in soils may be a better indicator of Se deficiency and excess than total soil Se (Wang and Gao, 2001 and Sun *et al*., 2009).

In well-aerated, alkaline soils, selenate (Se^{6+}) is the dominant Se form. Hence, selenates occur in soluble forms in soil of arid and semiarid regions (Kabata-Pendias, 2011). Whereas, in neutral and acid soils, selenite (Se^{4+}) is the major Se form and generally fairly insoluble due to its addition by clays and hydrous oxides of Fe. Selenite ions resulting from oxidation processes are stable and able to migrate until they are adsorbed on mineral or organic particles (Frost and Griffin, 1977). Due to a lack of knowledge about selenium (Se) chemistry in the Egyptian soils, it is important to highlight about distribution of selenium in Egyptian soils. Accordingly, the objective of this study is to assess soil characteristics which are most highly related to distribution of Se content (total and available) in different soils locations of Egypt.

Material and Methods

Soil sampling

This study was carried out in different locations in Egypt, which differ in its chemical and physical properties. Twelve soil profiles were selected to represent some different Egyptian soils, *i.e*., Matrouh, El-Arish, El-Hesynia Plain, El-Tina Plain, El-Mansoura, El-Gabal EL-Asfar (irrigated with sewage effluent for 0, 15, and 100 years), El-Fayoum (Qaruon lake and Khoum Oshim) and Toshki (cultivated and uncultivated soils). Soil samples were collected from following different depths 0-30, 30-60 and 60-90 cm (Fig. 1).

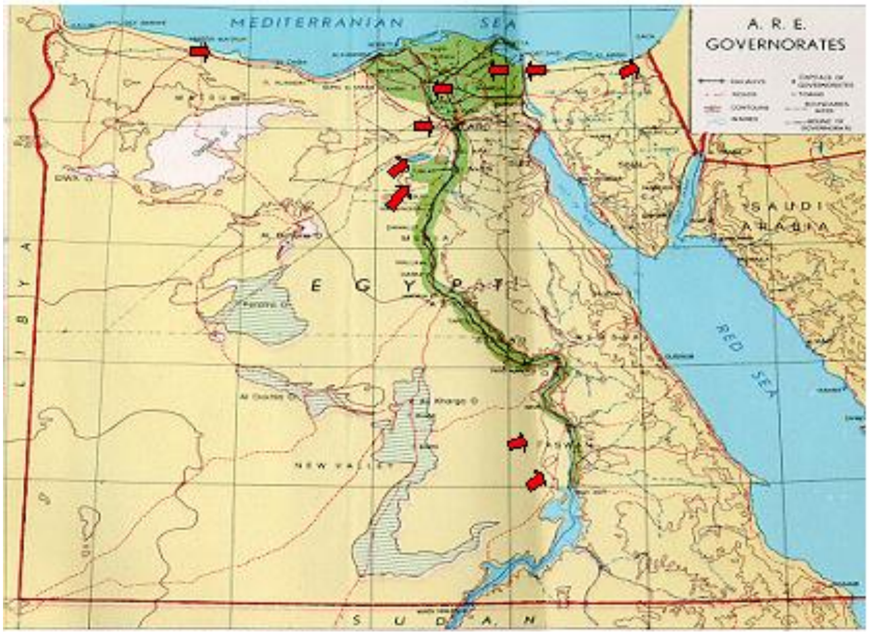

Fig. 1. Location of the study sites (the red arrow points to each selected location).

Soil analysis

Soil samples were air dried, crushed and finely ground by wood rod, then stored in bottles for analysis. Soil particle size distribution was carried out according to Klute (1986). Soil pH, organic matter (OM), cation exchange capacity (CEC), total carbonate and soil salinity (EC) were determined using the standard methods outlined by Page *et al*. (1982). Sulfur concentration in soils was determined by using a standard turbidity method (Issam and Sayegh, 2007).

Total selenium was determined by digesting 5 g soil with concentrated HNO_3 and $HClO_4$ acids (Elsokkary and Øien, 1977). Available selenium was extracted by AAAc-EDTA solution (0.5 M CH_3COONH_4, 0.5 M CH_3COOH, 0.02 M Na_2 EDTA, pH 4.65), as described by Lakanen and Ervio (1971) and modified by Sippola (1979).

Statistical analysis

Correlation and regression analysis were used to determine the relations between the factors using Pearson correlation from Statistical Package for Social Sciences program (SPSS) version 18.0 (SPSS, 2010).

Results and Discussion

Selenium status in Egyptian soils

Soil Se is inherited from parent material and its distribution highly reflects soil-forming processes and also atmospheric deposition. Furthermore, its background concentrations of various soil groups being the lowest in Pedzols (mainly sandy soils) and the highest in Histosols (organic soils). (Kabata-Pendias, 2011). The concentration of Se in different soil proflies with different depths were tabulated in Tables from 2 to 4. It could be noticed that, this concentration was decreased by depth for all different locations.

Classification of the studied soils

As shown in Table 1, soils inherited from different parent materials including alluvial, aerolian, fluvio marine and lacusterine deposits. This Table also includes the classification of these soils according to Soil Survey Staff (2010) for different locations. It is easy to distinguish that, different locations inherted from different parent paterials (Table 1). Some locations were alluvial deposits, 2 locations were fluvio (marine and lacustrine) deposits, whereas only one location inherted from aeolian deposits.

TABLE 1. Classification of soil samples used in the study from different locations and their parent materials according to Soil Survey Staff (2010).

Area/location	Classification	Parent material
Matrouh	Typic Haplocalcids	Alluvial deposits
El-Arish	Typic Haplocalcids, Typic Torripsamments	Alluvial deposits
El-Tina Plain	Typic Aquisalids	Fluvio marine deposits
El-Hesynia Plain	Typic Haplotrrerts	Alluvial deposits
El-Mansoura	Typic Haplotrrerts	Alluvial deposits
El-Gabal EL-Asfar	Typic Torripsamments	Aeolian deposits
El-Fayoum	Typic Haplotrrerts	Fluvio lacustrine deposits
Toshki	Typic Torriorthents, Typic Haplogypsids	Alluvial deposits

Total Se in soils

I. Coastal, middle Delta and new reclaimed areas

It is reported that, Se concentration of a soil reflects, to some extent, that of the parent material from which the soil has been formed. Thus, in arid and semi-arid areas, soils of high Se concentration have been derived from sedimentary rocks, usually shales and chalks (Moxon *et al*., 1950). Parent materials of the low-Se areas are mostly derived from granites and old metamorphic rocks. Rocks' weathering is the major source of environmental Se. Limestones and sandstones tend to have low Se concentrations (< 0.1 mg kg^{-1}), whereas shales tend to have higher concentration (0.6 mg kg^{-1}) (Di Gregerio, 2008).

Data illustrated in Table 2 showed some soil physical and chemical properties of coastal, middle Delta and new reclaimed areas of Egypt. These data showed that soils in Northern or coastal areas of Egypt have total Se concentration ranging from 0.11 to 0.46 mg Se kg^{-1} soil, with the mean value of 0.30 mg Se kg^{-1} soil and Se concentration in the surface soil layer (0-30) at Matrouh soil. At El-Arish location, soil varied from 0.11 to 0.46 mg Se kg^{-1} soil, with a mean value of 0.25 mg Se kg^{-1} soil, and mean total Se concentration in the surface layer was 0.44 mg Se kg^{-1} soil, with the mean value of 0.34 mg Se kg^{-1} soil. Se concentration in surface layer at El-Tina Plain was 0.82 mg Se kg^{-1} soil, with the mean value of 0.59 mg Se kg^{-1} soil and Se concentration in surface layer at El-Hesynia Plain soil was 1.05 mg Se kg^{-1} soil, with the mean value of 0.77 mg Se kg^{-1} soil, and Se concentrations in surface layer at El-Mansoura soil was 0.99 mg Se kg^{-1}, with the mean value of 0.77 mg Se kg^{-1} soil.

TABLE 2. Selected soil physicochemical properties of coastal, middle Delta and new reclaimed areas of Egypt.

Soil depth (cm)	Particle Size Distribution (%)				Soil texture	pH 1:2.5	EC, dS m^{-1}	$CaCO_3$ (%)	SO_4^{2-} cmol kg^{-1}	OM (g kg^{-1})	CEC (cmol kg^{-1})	Se content (mg kg^{-1})	
	C.S	F.S	Silt	Clay								Total	Avail
Coastal regions													
Profile (1): Matrouh													
0-30	9.35	40.82	31.78	17.99	SL	7.697	10.33	78.94	26.0	3.5	15.67	0.46	0.13
30-60	9.99	38.25	32.24	19.42	SL	7.56	11.25	91.40	30.2	1.9	14.89	0.18	0.05
60-90	10.75	38.07	33.96	18.27	SL	7.47	11.93	87.65	34.8	0.8	13.28	0.11	0.03
Profile (2): El-Arish													
0-30	11.97	42.85	25.71	19.48	SL	7.78	2.17	4.33	10.5	3.7	8.08	0.44	0.13
30-60	12.3	42.20	26.11	19.40	SL	7.65	2.86	4.87	12.2	2.5	7.25	0.37	0.08
60-90	12.32	42.35	25.94	19.38	SL	7.77	3.32	7.72	14.7	1.4	9.01	0.22	0.05
Middle Delta region													
Profile (3): El-Mansoura													
0-30	9.52	23.04	35.19	32.25	SL	7.78	2.17	4.33	64.6	3.7	8.08	0.99	0.27
30-60	8.46	22.53	36.20	33.89	SL	7.65	2.86	4.87	66.2	2.5	7.25	0.73	0.18
60-90	7.85	22.35	37.08	43.19	SL	7.77	3.32	7.72	70.5	1.4	9.01	0.55	0.13
New reclaimed areas													
Profile (4): El-Tina Plain													
0-30	7.96	32.98	40.42	18.65	SL	7.697	10.33	78.94	67.90	3.5	15.67	0.82	0.36
30-60	7.67	32.61	40.98	18.74	SL	7.56	11.25	91.40	85.46	1.9	14.89	0.50	0.24
60-90	7.16	33.36	41.76	17.74	SL	7.47	11.93	87.65	88.87	0.8	13.28	0.45	0.13
Profile (5): El-Hesynia Plain													
0-30	6.50	31.5	44.52	17.48	SL	7.78	2.17	4.33	39.02	3.7	8.08	1.05	0.36
30-60	6.97	32.66	43.32	17.18	SL	7.65	2.86	4.87	46.19	2.5	7.25	0.76	0.25
60-90	8.17	32.14	43.30	16.40	SL	7.77	3.32	7.72	53.05	1.4	9.01	0.49	0.19

Abbreviations: CS, coarse sand; FS, fine sand; SL, sandy loam; OM, soil organic matter; CEC, cation exchange capacity; EC, soil salinity as electrical conductivity; Avail., available.

It could be concluded that, the new reclaimed areas were the highest Se concentration, whereas the coastal regions were the lowest. It may be related to the soil properties including soil salinity, pH, soil organic matter, deposits kind ...etc.

II. Middle Egypt and Toshki areas

As shown in Table 3, in middle Egypt (El-Fayoum), soils have total Se concentration ranging from 0.70 to 1.11 mg Se kg^{-1} soil, with the mean value of 0.90 and Se concentration ranging from 0.61 to 1.04 mg Se kg^{-1} soil, with the mean value of 0.85 at El-Fayoum soil (Qaroun Lake and Kom Oshim, respectively). While at Toshki location, the total Se concentration ranged from 0.36 to 0.79 mg Se kg^{-1} soil, with the mean value of 0.59 mg Se kg^{-1} soil and ranged from 0.40 to 1.07 mg Se kg^{-1} soil, with the mean value of 0.75 mg Se kg^{-1} soil (uncultivated and cultivated soil, respectively).

Agricultural activity, atmospheric fall out (Wang *et al*., 1995) and parent materials (Cao *et al*., 2001) may be the main factors affecting total Se concentration in soils. Surface soil received much more fallout and extensive agricultural activity than subsoil and deep subsoil. This may result in much higher total selenium concentration of surface soil than that of subsoil and deep subsoil. Moreover, the total Se concentration of soil decreased with increasing soil depth. In addition to atmospheric fallout, agricultural activity such as a long term period of deep-plough practice maybe one of the reasons that the total Se concentrations of surface soil and subsoil were much higher than that of deep subsoil (Wang and Chen, 2003).

TABLE 3. Selected soil physicochemical properties of El-Fayoum and Toshki areas.

Soil depth (cm)	Particle size distribution (%)				Texture	pH 1:2.5	EC (dS m^{-1})	$CaCO_3$ (%)	SO_4^{2-} cmol kg^{-1}	O.M (gkg^{-1})	CEC, cmol kg^{-1}	Se content (mg kg^{-1})	
	C.S	F.S	Silt	Clay								Total	Avail.
El-Fayoum region													
Profile (6): Qaroun Lake													
0-30	8.38	24.88	34.4	32.35	CL	7.99	27.27	20.08	51.89	10.9	23.82	1.11	0.49
30-60	7.56	26.49	36.36	29.60	CL	7.64	30.64	25.21	54.03	8.5	23.47	0.90	0.41
60-90	6.31	26.69	37.62	29.37	CL	7.36	31.87	20.04	54.03	6.7	24.82	0.70	0.28
Profile (7): Kom Oshim													
0-30	8.45	22.99	36.13	32.44	SCL	7.86	20.80	5.70	60.41	15.4	23.70	1.04	0.32
30-60	7.64	19.93	38.01	34.42	SCL	7.65	21.40	11.25	59.23	9.8	24.02	0.89	0.26
60-90	7.03	18.84	35.73	38.40	SCL	7.81	21.21	3.76	59.34	7.0	25.39	0.61	0.20
Toshki region													
Profile (8): Uncultivated soils													
0-30	20.02	44.98	21.64	13.34	SL	7.85	15.32	1.94	33.13	2.4	11.76	0.79	0.19
30-60	18.85	45.24	20.01	15.49	SL	7.63	19.88	4.06	61.07	1.3	13.42	0.61	0.16
60-90	19.50	46.64	18.01	15.86	SL	7.48	15.98	4.90	56.38	0.9	13.44	0.36	0.17
Profile (9): Cultivated soils													
0-30	13.01	31.19	36.53	19.20	SL	7.78	1.03	3.55	1.86	3.2	4.33	1.07	0.41
30-60	10.38	35.01	40.69	15.59	SL	7.62	1.29	4.68	3.24	2.7	2.92	0.77	0.21
60-90	10.83	35.72	36.20	13.69	SL	7.77	1.71	3.18	5.39	1.8	3.03	0.40	0.18

Abbreviations: CS, coarse sand; FS, fine sand; SL, sandy loam; CL, clay loam; SCL, sandy clay loam; OM, soil organic matter; CEC, cation exchange capacity; EC, soil salinity as electrical conductivity; Avail., available.

III. Total Se in EL- Gabal EL-Asfar area

It could be noticed that, low Se concentrations have been recorded in the El-Gabal EL-Asfar (which received sewage sludge and sewage effluent for 0, 15 and 100 years) as shown in Table 4. The Se concentration was negligible in case of normal soil (without irrigation with sewage effluent). In case of soil irrigated for 15 years with sewage effluent, the values ranged from 0.01 to 0.03 mg Se kg^{-1} soil, with the mean value of 0.02 mg Se kg^{-1}. On the other hand, the values ranged from 0.03 to 0.25 mg Se kg^{-1} soil, with the mean value of 0.15 mg Se kg^{-1} soil in soil profile which received sewage sludge and sewage for 100 years, and Se concentrations in surface layer ranged from nil to 0.25 mg Se kg^{-1} soil. This result may be due to the food habits (Borowska and Koper, 2007). As organic matter decreases along soil profile, so does total selenium (Johnsson, 1991). Selenium fixation may also be due to microbiological incorporation into amino acids and other Se-containing organic compounds (Mao, 1999). In addition to humus distribution, Se distribution along soil profile resembles those of Fe, Al and clay (Ĉuvardià, 2000).

TABLE 4. Selected soil physicochemical properties of EL- Gabal EL-Asfar area.

Soil depth (cm)	Particle Size Distribution (%)				Texture	pH 1:2.5	EC (dS m^{-1})	$CaCO_3$ (%)	SO_4^{2-} cmol kg^{-1}	O.M (g kg^{-1})	CEC, cmol kg^{-1}	Se content (mg kg^{-1})	
	C.S	F.S	Silt	Clay								Total	Avail.
Profile (10): Normal soil (without irrigation with sewage effluent)													
0-30	83.32	13.44	0.09	3.15	S	8.77	3.31	3.89	2.79	0.9	2.41	Nil	Nil
30-60	89.17	8.01	0.06	2.76	S	8.75	2.34	3.75	12.61	0.7	3.75	Nil	Nil
60-90	90.56	6.88	0.06	2.50	S	8.63	2.25	2.28	10.38	0.5	2.44	Nil	Nil
Profile (11): Soil irrigated for 15 years with sewage effluent													
0-30	51.89	10.90	15.88	21.33	SCL	6.58	9.17	3.00	43.11	37.9	4.85	0.03	Nil
30-60	63.60	10.35	13.35	12.70	SCL	6.90	7.65	3.21	40.84	31.6	2.62	0.02	Nil
60-90	70.32	8.36	13.47	7.85	S	7.14	8.11	2.21	58.35	22.1	1.15	0.01	Nil
Profile (12): Soil irrigated for 100 years with sewage effluent													
0-30	36.60	18.21	21.40	23.79	SCL	6.08	14.16	1.57	50.40	61.5	8.76	0.25	0.03
30-60	55.01	13.69	13.89	17.41	SCL	6.22	13.57	2.00	70.23	52.4	6.15	0.16	0.01
60-90	58.51	12.11	19.38	10.00	SCL	6.80	13.90	1.50	90.52	31.4	3.20	0.03	0.01

Abbreviations: CS, coarse sand; FS, fine sand; S, sandy; SCL, sandy clay loam; OM, soil organic matter; CEC, cation exchange capacity; EC, soil salinity as electrical conductivity; Avail., available.

In general, mean of total Se concentration in soils varied from 0.01 to 1.11 mg Se kg^{-1} soil at El-Gabal El-Asfar and El-Fayoum soils (Qaroun Lake), respectively, the variation may be depending on site of location and soil depth. Data also showed that the highest value (1.05 mg Se kg^{-1} soil) was found in the surface layer (0-30 cm) of El-Hesynia plain soil, and the lowest value (0.01 mg kg^{-1}) was found in the 30-60 cm soil depth of El-Gabal El-Asfar (irrigated with sewage effluent for 15 years), this value could be attributed to the highest concentration of shells, fine fractions and sesquioxides. It is found that soil native substrate, climate, relief and age factors may contribute either to selenium accumulation during soil forming or its removal during or after soil forming (Mayland *et al*., 1989 and Ĉuvardià, 2000). Soils formed on sedimentary rocks that contain high amounts of organic matter typically have high to toxic selenium concentrations, whereas soils formed on magmatic rocks, which are poor in Se, usually have a low Se concentration (Ĉuvardić, 2000). Selenium concentration of most soils varies between 0.1 and 2.0 mg kg^{-1} depending on geographical area (Dhillon and Dhillon, 2003). Selenium concentration in soil typically decreases with depth because it binds with proteins, fulvic acids and other organic compounds that contain nitrogen (Ĉuvardià, 2003). The total Se concentration of surface soil was much higher than that of subsoil and deep subsoil. Relatively low Se concentration in the deep subsoil maybe due to equilibrated soluble selenium between soil colloid and underground water (Wang and Chen, 2003).

Since the total Se concentration in soil is predominantly determined by its concentration in the native substrate, it is understandable why the soils in our country have very low Se concentrations. For example, the soils in El-Gabal El-Asfar have the Se concentrations from nil to 0.25 mg Se kg^{-1} soil, with the mean value of all depths being 0.057 mg Se kg^{-1} soil. As a result, in organically-cultivated cereals the Se concentration is low, 0.01 to 0.02 mg kg^{-1}. Also, Se-supplemented fertilizers are not yet allowed in greenhouse cultivation. In a survey study about Se distribution, fractionation and adsorption in some Egyptian soils, Elsokkary (1980) stated that, total Se varied from 0.18 to 0.85 mg kg^{-1} with an average of 0.45 mg kg^{-1}.

It could be concluded that, El-Fayoum region had the highest Se concentration, whereas El- Gabal El-Asfar regions were the lowest. It may be related to the soil properties including soil salinity, pH, soil organic matter, deposits kind, ... etc. On the other hand, the distinguished factor dominant in El-Fayoum region is soil salinity, which ranged from 20.8 to 31.8 dS m^{-1}. It may be related to climatic conditions, soil texture and parent material. Concerning to El-Gabal El-Asfar region, it is worth to mention that, the value of soil organic matter, soil salinity and sulfate content were increased by time for irrigation with sewage effluent up to 100 years (from 0.5 to 61.5 g kg^{-1}, 2.25 – 14.2 dS m^{-1} and 2.79 – 90.5 cmol kg^{-1}, respectively), whereas soil pH was decreased (from 8.77 to 6.08).

Available Se in soils

In general, data presented in Tables from 2 to 4 showed that the general mean of available selenium concentration in soils varied from 0.01 to 0.49 mg Se kg^{-1} soil at El-Gabal El-Asfar and El-Fayoum (Qaroun Lake) soils, respectively.

I. Coastal, middle Delta and new reclaimed areas

Data in previous Tables showed that the soils in Northern Egypt have available Se concentrations from 0.03 to 0.36 mg Se kg^{-1} soil, with the mean value of 0.07 mg Se kg^{-1} soil. The available Se concentration at Matrouh soil ranged from 0.03 to 0.13 mg Se kg^{-1} soil, with mean value of 0.07 mg Se kg^{-1} soil. The soil concentration of Se at El-Arish soil ranged from 0.05 to 0.13 mg Se kg^{-1} soil, with the mean value of 0.09 mg Se kg^{-1} soil. Se concentration in soil layers at El-Tina Plain ranged from 0.13 to o.36 mg Se kg^{-1} soil, with the mean value of 0.24 mg Se kg^{-1} soil. Se concentration in surface layer at El-Hesynia plain soil ranged from 0.19 to 0.36, with the mean value of 0.27 mg Se kg^{-1} soil. Se concentrations in layer at El-Mansoura soil ranged from 0.13 to 0.27, with the mean value of 0.19 mg Se kg^{-1} soil.

II. Middle Egypt and Toshki area

In Southern Egypt (Toshki area), soils have available Se concentration ranged from 0.16 to 0.41 mg Se kg^{-1} soil, with the mean value of 0.36 mg Se kg^{-1} soil (Table 3). The available Se concentration at El-Fayoum (Qaroun Lake) soil ranged from 0.28 to 0.49 mg Se kg^{-1} soil, with the mean value of 0.39 mg Se kg^{-1} soil. Se concentration in soil layers at El-Fayoum (Kom Oshim) soil ranged from 0.20 to 0.32 mg Se kg^{-1} soil, with the mean value of 0.26 mg Se kg^{-1} soil). While available Se concentration in the soil layers at Toshki (uncultivated soil) ranged from 0.16 to 0.19 mg Se kg^{-1} soil, with the mean value of 0.17 mg Se kg^{-1} soil. Se concentration in soil layers at Toshki (cultivated soil) ranged from 0.18 to 0.41 mg Se kg^{-1} soil, with the mean value of 0.27 mg Se kg^{-1} soil.

III. El- Gabal El-Asfar area

Soil available Se at El-Gabal El-Asfar (which received sewage sludge and sewage effluent for 100 years) was negligible in soil profiles without sewage effluent irrigation and 15 years, but in soil profiles 100 years was ranged from 0.01 to 0.03 mg Se kg^{-1} soil, with mean value of 0.02 mg Se kg^{-1} soil (Table 4). This result may be due to the food habits.

It is worth to mention that, under well-aerated conditions in the alkaline soils of semiarid regions, selenium is present in the form of selenate which is not adsorbed, does not form insoluble salts and is readily available to plants (Cary *et al.*, 1967). Although soil reaction plays a major role in determining Se solubility and availability, its influence lessens as the concentrations of clay and organic matter in the soil increase (Johnsson, 1991).

The effect of redox on Se species in solution was reported by Elrashidi *et al.* (1987). They mentioned that in a slightly acid soil, Se uptake dropped with the increase in clay content. In subsequent cuttings, however, the effect of soil acidity evidently weakened because Se became more and more available. Soil provision with selenium affects its level in food and feed via nutrition chain (Finley *et al.*, 2000). However, selenium reactivity and bioavailability depends not only on its total concentration in soil but also on its chemical form.

Correlation between indigenous soil parameters and Se content

As shown in Table 5, the correlation coefficient among some soil parameters with total and available soil selenium. Data showed that organic matter, clay and CEC was the most effective soil parameter on available soil selenium and contributed with 0.34, 0.50 and 0.57, respectively, while the lowest effective soil parameter on available soil selenium was sulfate and soil pH (contributed with 0.15 and 0.24).

TABLE 5. Correlation between indigenous soil parameters and Se content.

	Total Se	**Available Se**	**Clay**	**pH**	**EC**	**$CaCO_3$**	**Sulfate**	**OM**	**CEC**
Total Se		0.94 **	0.59 **	0.21	0.27	-0.12	0.16	-0.32	0.53 **
Avail. Se			0.50 **	0.24	0.35 *	-0.09	0.15	-0.34 *	0.57 **
Clay				-0.15	0.41 *	0.07	0.42 *	0.01	0.65 **
pH					-0.23	0.02	-0.44 **	-0.82 **	0.06
EC						0.18	0.47 **	0.20	0.82 **
$CaCO_3$							-0.13	-0.19	0.31
Sulfate								0.28	0.38 *
OM									-0.16
CEC									

** Correlation is significant at the 0.01 level (2-tailed). n= 36.
* Correlation is significant at the 0.05 level (2-tailed). n= 36.

Data also, revealed that, the same trend was observed for the total Se. It is clear to notice that, clay content, CEC, soil pH, sulfate were positively correlated with soil Se concentration, whereas soil organic matter had a negative correlation. These results are in agreement with results from Elsokkary (1980), who reported that soil Se concentration was positively correlated with total carbonate and clay content of the soils. That means the high Se concentration is realted with high total carbonate and clay content in soils the opposite trend for the negative correlation.

Conclusion

Information about selenium distribution in Egyptian soils is extremely important for evaluating the status of the selenium inventory in these soils. Due to its importance for humans and animals, study of selenium distribution in Egyptian soils is very important issue for general health. That means, Se concentration in Egyptian soils (in arid and semi-arid regions) is low in general and it should be produced Se-biofortified crops for humans and animal in Egypt. This study demonstrated that parent material is one of the most important factors controlling the distribution of Se in soils. Furthermore, the soils which resulted from fluvio lacustrine deposits were higher in Se concentration, whereas the lowest one from aeolian deposits. Further studies should be done to establish Se distribution in whole country and to draw a complete plan for human health in Egypt.

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توزيع السلينيوم في بعض الأراضى المصرية

إيمان محمد عبد الرازق *، عبده عبده سعود ، رشدي الكيلاني** و نادر رمزي حبشي***
**قسم الأراضي – كلية الزراعة – جامعة القاهرة و*معهد بحوث الأراضي و المياة و البيئة – مركز البحوث الزراعية – الجيزة – مصر.

تزايد الإهتمام بدراسة توزيع و محتوى التربة من السيلينيوم نظراً لأهميته لتغذية الأنسان والحيوان ، لذلك كان الهدف من هذه الدراسة هو معرفة أي من خصائص التربة له التأثير علي محتوي بعض الأراضي المصرية من السيلينيوم. لذلك تم أختيار 12 موقعاً شملت مناطق مرسي مطروح ، العريش ، المنصورة ، سهل الطينة ، سهل الحسينبة ، الجبل الأصفر ، الفيوم و منطقة توشكي حيث تم أخذ عينات تربة من علي ثلاثة أعماق صفر- 30 و 30-60 و60-90سم . و قد أظهرت النتائج المتحصل عليها أن محتوي التربة من عنصر السيلينيوم الكلي والميسر قد أختلف في القيم معتمداً علي موقع أخذ العينات أو المنطقة و كذلك بأختلاف خواص التربة تحت الدراسة لكل منطقة. و أظهرت علاقات الإرتباط المتحصل عليها بين خواص التربة المختلفة وتركيز عنصر السيلينيوم بالتربة أن كل من نسبة الطين والسعة التبادلية الكاتيونية ورقم حموضة التربة و محتوى التربة من الكبريت كانت أكثر إرتباطاً و تأثراً على محتوى التربة من السيلنيوم.