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RADIOACTIVE AND HEAVEY METALS IN SAHL EL-TENA AND THEIR ENVIRONMENTAL IMPACT, NORTHWESTERN SINAI, EGYPT

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ABSTRACT

Egyptian great governmental efforts are paid to convert Sahl El Tina into cultivated lands after 1967 war. The present soil is belonging to the fluvio- marine plain. Textural analysis has been performed to classify the studied soil into fluvio- marine type as loamy–sand texture.

Epidot, garnet, sphene, rutile, ilmenite, magnetite, chromite, pyrite and zircon are the main identified heavy minerals which concentrated in the study fraction of the studied soil. kaolinite is the most common clay mineral associated with montmorillonite in all the studied samples .

The Sahl El-Tina soil shows significant metal pollution because of the loading of some elements such as Ba,V, Zr, Zn, Cr, Sr, U and Th. Also the dry plant (bearl) has the same elements in addition to Ni, Pb, Co and Cu. These metals could be absorbed by plant roots and concentrated in leaves causing some harmful problems.

The obtained cU results of Sahl El-Tina soil (av. 20ppm) and plant (av.11.4 ppm.) are higher than the Egyptian and International soils and plants values. It can be noted that the studied soil was considered as high hazard polluted source for radioactive.

INTRODUCTION

Sahl El-Tina area has a triangular shape located in northwestern Sinai on the coastal region of the Mediterranean Sea. It covers an area of about 200 km ^{2} between long. 32° 15' and 32° 45' E and lat. 30° 38' and 31° 18' N (Fig. 1).

The pollution of soils by toxic metals has increased considerably since the onset of industrialization and urbanization (Nriagu, 1990). Elawa (1997 & 2005) found that the uranium content in Abu Zaable soil ranges from 1.3 to 28.9 ppm and from 0.5 to 8 ppm in Damietta soil. Butink et al., (1989) found that the highest U accumulation in the root system followed in descending order by potatoes, cotton, beans, tomatoes and rice. They also mentioned that, the highest concentrations of total U were found in vegetables. The increase of U within the plant causes variation in flowers colour, presence of abnormal fruits and increase in chromosomes of nucleus stimulation (Azam and Prasad, 1988). Vandenhove et al. (2006) concluded that, some plant species have adsorption efficiency of U than others (1 to100 ppm), while the normal plants ranging from (0.2-1 ppm). Zidan (2012) suggested that the phosphatic fertilizers represent a pollution source for radioactivity in the agriculture soil. The world U limit of soils and dry matter plants ranges between (0.08 to 6 ppm and 0.005 to 0.1ppm, respectively (IAEA Report, 1988). Turkdogan et al., (2002) found that the high prevalence of upper gastrointestinal cancer rates was related to the high concentration of heavy metals in the soil, fruit, and vegetables.

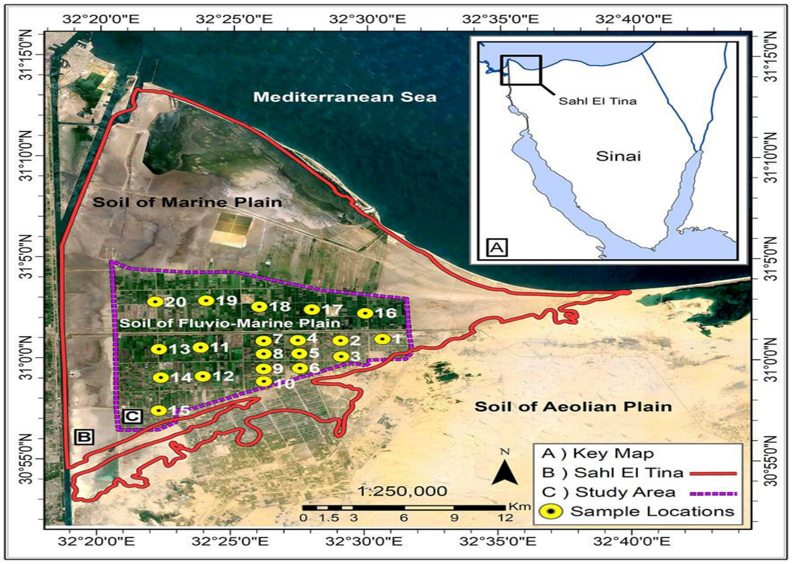

Fig.1 : Landsate map of the studied Sahl El-Tina area, northwestern of Sinai,Egypt

Some serious health problems can develop as a result of excessive dietary accumulation of heavy metals such as Cd and Pb in the human body (Oliver, 1997).

Trace metals, either derived from natural inputs or anthropogenic emissions, are ubiquitous in the global environment. Metals such as copper (Cu) and lead (Pb) are potentially toxic to living terrestrial and aquatic ecosystems (Blackmore, 1998). Contamination in soil comes from local sources, mostly industrial effluents, agricultural activities, urban/ domestic wastes, fossil fuels and other anthropogenic activities (Aksoy et al., 2000). Background or native concentration of an element in soil is mainly due to the mineral constituent of the parent rock from which the soil has resulted, modified by pedogenic processes. And trace elements in native forms occur in primary soil minerals as components of the mineral structure, especially Cu, Co, Pb, Ni, and Zn which are present in a variety of silicate and aluminosilicate minerals (Chen et al. 2001).

The present work aims to study the effect of radioactive and heavy metals on the agricultural environment of the studied area to element the characteristic features of the soil for development and radiation hazard could face those working in the area.

METHODOLOGY

Twenty samples were collected from the uppermost 0-30 cm top layer of soil at different sites from Sahl El-Tina area (Fig.1), as well as five plant samples (bearl) were also collected.

The soil samples are subjected to separation by using heavy liquids and magnetic fractionation. The handpicked heavy minerals were investigated under the binuclear microscope.

Clay, silt and sand fractions were separated by sieving and sedimentation after removal of cementing materials. Clay and silt were separated by wet sieving from sand using 0.63mm sieve. The clay and silt were transferred to one liter cylinders pipette analysis according to method of Piper (1953).

Oriented clay samples were prepared from separated clay as Mg–Saturated glycerol solvated, K- Saturated air dried and K- Saturated heated to 550 ^{0}C for 2 hours. X-ray diffraction technique (XRD), was used to identify the known minerals using PHILIPS pw 3710/ 31 diffractometer.

The contents of eU, eRa and eTh were determined radiometrically by gamma-ray spectrometer, also U was chemically analyzed by spectrophotometer using arsenazo lll. The trace elements concentrations were determined by atomic absorption techniques. The total REEs were estimated using ICP technique. All these analyses were performed in the Labs of the Nuclear Materials Authority, Cairo, Egypt.

RESULT AND DISCUTIONS

Textural Classes Of The Study Soil

Ali and Abdel Kawy (2007) classified soil of Sahal El Tina into three main soil units: marine soil, fluvio- marine soil and aeolian soil. The marine soil; includes the landforms of sand sheets, shore ridge, sabkha and gypsiferous deposits, while the fluvio- marine soil; includes clay and silty-clay deposits. The Aeolian soil includes sand sheet and sand dunes. The studied soil samples are belonging to the fluvio- marine horizon according to Ali and Abdel Kawy (Op.Cit.) classification and represent as loamy sand type according to (FAO, UNESCO,1974).

Texturally, these soils are composed of 50% clay, 41% silt and 9% sand sandy silt clay. These are resulted from weathering processes and composed of clay, silt and sand with organic matters (Table 1).

Mineralogical Studies

The total heavy minerals content separated from the sand fraction of the studied samples are identified under the binuclear microscope (Figs.2-9) and by x-ray diffraction. These minerals reach about (1%) and also are classified into two main mineral groups, the first group is the opaque minerals represented by magnetite (ASTM card 1-1111), ilmenite (ASTM card 3-078), chromite (ASTM card 3-873) and pyrite (ASTM card 6-710). The second non-opaque minerals include: epidote (ASTM card 2-755), garnet (ASTM card 10-367), sphene (ASTM card 2-521) and rutile (ASTM card 4-551). The percentage of these minerals are given in Table 2.

The X-ray diffraction of the clay fractions shows that, the kaolinite is the most prominent mineral associated with montmorillonite (Fig.10). Kaolinite is a typical mineral of continental weathering where the conditions prevailing are mainly encountered in continental and marsh environment (Millot,1970). Also, it is dominant in low latitude areas,

Table 1: Partical size distribution (%) and textural classes of the studied soil of Sahl El-Tina area, Sinai, Egypt

S. No.	Sand (%)	Silt (%)	Clay (%)	Total (%)
1	10	40	50	100
2	5	35	60	100
3	7	49	44	100
4	5	33	62	100
5	14	48	38	100
6	8	37	55	100
7	12	47	41	100
8	12	48	40	100
9	10	38	52	100
10	7	43	50	100
11	8	40	52	100
12	10	39	51	100
13	5	35	61	100
14	8	44	48	100
15	7	39	54	100
16	6	34	60	100
17	7	44	49	100
18	11	48	41	100
19	13	45	42	100
20	11	36	53	100
Average	9	41	50	100

Depth (030-cm)

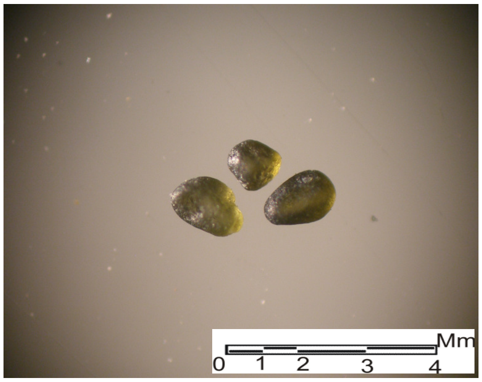

Fig. 2 : Photomicrograph showing Epidot grains, rounded to subangular , Sahl El-Tina soil

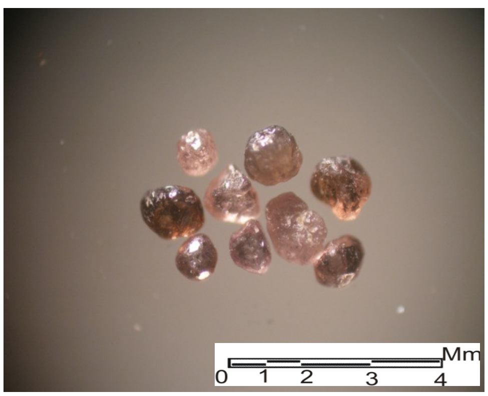

Fig. 3: Photomicrograph showing Garnet grains, rounded to subrounded , Sahl El-Tina soil

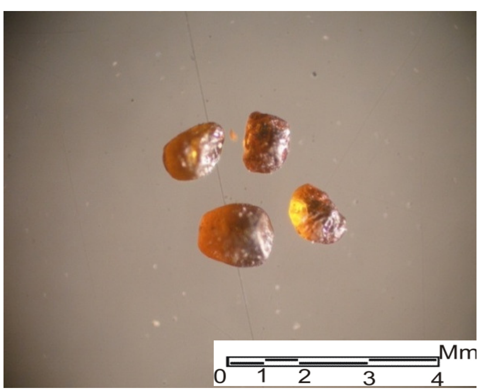

Fig. 4: Photomicrograph showing Sphene grains, rounded to subangular, Sahl El-Tina soil

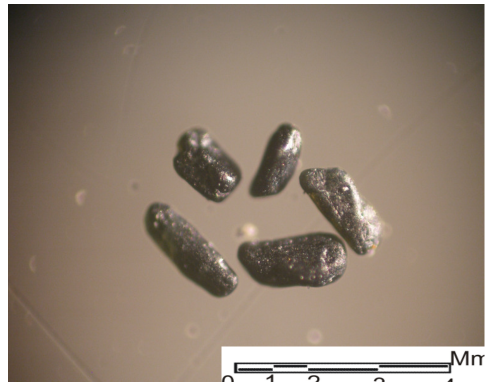

Fig. 5: Photomicrograph showing Rutile grains, elongated and angular, Sahl El-Tina soil

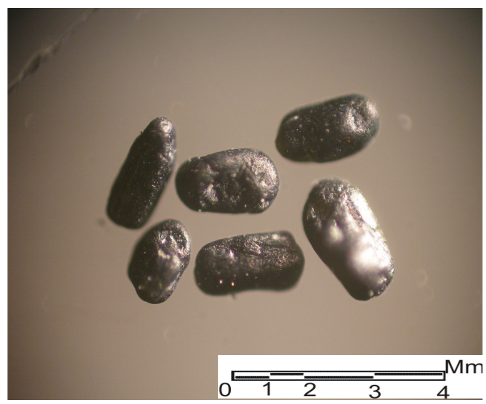

Fig. 6: Photomicrograph showing Chromite, subrounded to elongated , Sahl El-Tina soil

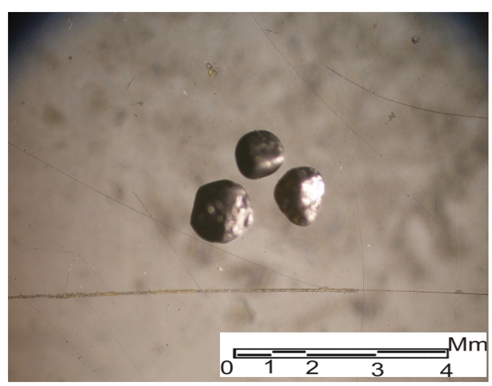

Fig. 7: Photomicrograph showing Ilmenite grains, rounded to surrounded, Sahl El-Tina soil

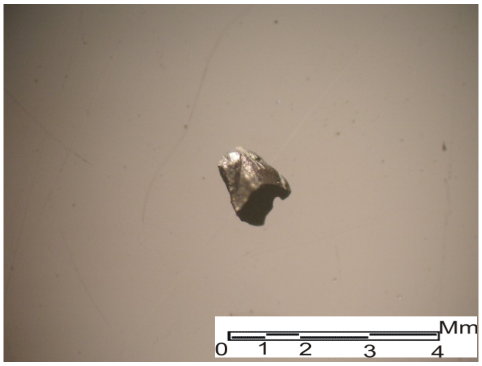

Fig. 8: Photomicrograph showing Pyrite grain, angular to subangular, Sahl El-Tina soil

Fig. 9: Photomicrograph showing Zircon grain, elongated, Sahl El-Tina soil

Table 2: Average percentage of heavy minerals content in the sand fraction of Sahl El-Tina soil

Minerals	Epidot	Garnet	sphene	Rutile	Ilmenite	Chromite	Magnetite	Pyrite	Zircon
Average	63	15	7	6	3	3	2	1	traces

particularly of major rivers during regions of tropical weathering (Tuker, 1984).

Any aluminum silicate parent material can produce kaolinite by weathering under conditions which remove K, Mg, Ca, Na and ferrous iron and the addition of hydrogen (Pettijion, 1975).

Kaolinite gives a strong d- spacing at 7.16 and 3.57 °A . After heated to 550 °C for

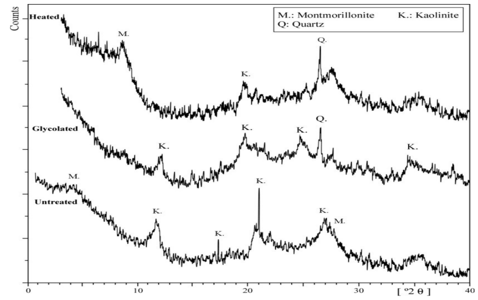

Fig. 10: X- ray diffractograms pattern of < 24u clay fraction separated from soil of Sahl El-Tina area

four hours, its reflection is disappeared of one to atomic water loss. The variation of clay minerals is related to more than source rocks prevailed in the study area and also to fluctuating climatic conditions.

Trace Elements Distribution

The trace elements distributions in the studied soils depend on the parent rocks from these soils are derived (Michael,1975) may of these trace elements occurred by isomorphous substitution in soil materials (Kruskupf,1972).

The abundance and distribution of the trace elements in Sahl El–Tena soil are listed in (Table 3).

Chromium (Cr) concentration in the fluvio-marine was relatively high; but in soil ranges from 72ppm to 111ppm with an average 88ppm. Clavert et al.(1985) suggested that the Cr radius is very close to that of Fe^{+3}, but it shows a high degree of preferential concentration relative to ferric ion. According to Aubert and Pinta (1977), the studied soil may be derived from debris mafic or volcanic rocks.

Zr is high in the studied samples and it ranges from 132ppm to 259ppm with an average 192ppm. In the present soil Zr may be due to the recorded detritus zircon grains. Zircon is highly resistant to weathering, therefore it is considered to be only slightly mobile in soil

(Kabata-Pandias, 2001).

Ba and Zn concentrations are high in the studied samples and range from 2119ppm to 3220ppm and 31ppm to 49ppm with an average 2515ppm and 39ppm, respectively. Ba and Zn are mobilized during weathering under oxidizing acid conditions and its mobility is reduced by adsorption or co-precipitation on Fe-Mn oxides (Kabata-Pandias, 2001).

V and Ni contents in the studied samples are ranged from 134ppm to 214 ppm and 48ppm to 70ppm with an average 165ppm and 58ppm, respectively (Table 3). The V and Ni contents may be related to the presence of iron oxides.

Sr content is high in the study soil and ranges from 115ppm to 400ppm with an average 282ppm. The Sr enters the basin of deposition associated with Ca in carbonates or evaporates but can also be accumulated via sorption on clay minerals. It is easily mobilized during weathering especially in acid environment.

The content of Cu in the study soil ranges from 28ppm to 36ppm with an average 31ppm. Cu is most abundant in mafic, intermediate, carbonate rocks and their soils, also it may be associated with silicates (Kabata-Pandias, 2001). The Cu in the studied soil may be due to the organic matter, where it has high affinity to humic matterial (Clavert et al., 1985).

The content of Pb in the studied samples

Table 3: Trace elements concentrations (ppm) of the soil samples of Sahl El-Tina area

S. No.	V	Cr	Ni	Cu	Pb	Zn	Rb	Sr	Y	Zr	Nb	Ba	REE
1	149	77	51	30	17	33	81	218	52	161	21	2270	528
2	137	81	51	31	20	39	123	247	56	172	23	2121	613
3	166	110	60	31	17	39	112	232	56	172	23	2561	494
4	134	74	52	28	19	32	106	207	43	132	17	2149	517
5	159	84	57	30	23	40	88	345	74	228	31	2373	562
6	200	103	66	28	9	46	96	299	69	218	28	3126	498
7	187	91	62	29	22	39	81	343	76	233	31	2869	625
8	155	80	56	31	16	44	84	303	59	182	25	2328	458
9	184	91	63	33	20	45	78	372	78	240	33	2773	538
10	141	72	49	29	20	31	83	115	35	106	14	2173	523
11	214	107	70	36	1	48	73	400	84	259	35	3220	601
12	146	74	55	32	19	33	79	219	54	164	22	2268	521
13	138	81	50	32	21	38	122	246	58	170	26	2119	614
14	169	111	63	31	17	35	113	231	55	173	24	2560	490
15	138	79	48	29	22	31	107	204	41	135	19	2137	520
16	162	85	56	30	24	39	90	341	76	231	33	2371	559
17	198	99	64	27	10	49	99	296	72	221	25	3118	494
18	184	87	68	31	24	35	79	342	78	230	34	2679	628
19	154	80	53	32	18	43	85	304	60	179	27	2324	492
20	181	89	61	34	22	41	80	374	77	238	33	2768	537
Average	165	88	58	31	18	39	93	282	63	192	26	2515	541

ranges from 1ppm to 24ppm with an average 18ppm. The Pb has a tendency to concentrate in the argillaceous sediments(Kabata-Pandias,2001). During weathering it has the ability to be incorporated in clay minerals and within Fe and Mn oxides.

In the study soil the contents of Y and Nb are ranges from 35ppm to 84ppm and 14ppm to 35ppm with an average 63ppm and 26ppm respectively (Table 3), which may be related to the presence of black rutile mineral.

The study soil samples have total REEs content ranging between 490 ppm and 628 ppm with an average of (541ppm) ,(Table 3). Cullers et al. (1979) reported that the REEs in sedimentary rocks essentially concentrate in the silt and clay size fractions. While Prudencio et al. 2007) suggest that the kaolinite, among the clay minerals tends to be the principal REEs carrier in the clay fraction of sediments from central Portugal. The intimate relationship between REE and the terrestrial indicator such as Zn, confirms their clastic origin.

Comparing trace element concentration in the study of Sahl El-Tina soil with different international thresholds show that the studied soil is enriched in Cr, Ni and Ba with lower concentrations of Cu, Pb and Zn relative to the world values (Table 4). These metals can be harmful to different degrees including death for life forms in the ecosystem if they are ingested and bioaccumulate with time. Also the higher content of Ba, Sr, Zr and REEs in Sahl El Tina soil shows a signal pollution effect.

On the other hand, the chemical analysis of the dry plant samples (bearl) of Sahl El-Tina area (Table 5) shows their some heavy metals such as V, Cr, Ni, Pb, Co and Cu with their average contents as 59, 6, 54, 1, 1 and 0.1ppm, respectively. The plants, can accumulate trace elements, especially in on their tissues due to their great ability to adapt to variable chemical properties of the environment, thus, they are intermediate reservoirs through which these elements from soils and partially from water and air move to man and animals. The ratio of an element in plants to its concentration in soil is called Biological Absorption Coefficient, (Kabata-Pendias, 2001).

Table 4: Average trace elements concentrations (ppm) of the Sahl El-Tina soil and world soils values

S. No.	V	Cr	Ni	Cu	Pb	Zn	Rb	Sr	Y	Zr	Nb	Ba	REE
Present study (Sahl El-Tina)	165	88	58	31	18	39	93	282	63	192	26	2515	541
World soil	-	64	50	63	70	200	-	-	-	-	-	750	-
CCME,2007													
SSL	550	390	1600	-	400	23	-	-	-	-	-	5500	-
SGV	-	130	50	-	450	-	-	-	-	-	-		-
IV	-	380	210	190	530	720	-	-	-	-	-	625	-

(SSL): The USEPA soil – screening levels; (SGV): Soil guideline values by the United Kingdom Department of Environment; (IV): Values developed by Food and Rural Affairs and Environment Agency and intervention the Netherlands Ministry of Housing.

Table 5: Uranium and heavy metals content (ppm) of the Sahl El-Tina plant (bearl) samples

S. No.	Co	Cr	Cu	Ni	Pb	V	U
A	1	6	0.1	6	1	61	11
B	1	6	0.1	5	1	59	10
C	1	5	0.1	6	1	63	12
D	2	6	0.2	5	1	54	14
E	1	7	0.1	5	1	57	11
Average	1	6	0.1	5	1	59	12

Ni is easily mobilized during weathering and co-precipitated with Fe and Mn metals in plants. Generally the range of toxic amount of Ni in most plant species varies from 10 to 100 ppm (Kabata-Pendias, 2001). The Cr content of plants has received much attention where it participates in glucose and cholesterol metabolism and therefore is essential to man and animals. Common level of this element found in plant is usually on the order of 0.02 to 0.2ppm but it is toxic at about 49ppm

(Anderson et al.,1980 and Kabata-Pendias, 2001).

The geochemical behavior of V is mainly dependent on oxidation state and the acidity of the media. Phytotoxicity of V appears at about 2ppm in some plants, also the excess of V can reduce plant growth (Shacclette and Boerngen 1984). Cu in plants is essential both for health of the plants and for nutrient supply to man and animals. In several plant species, Cu of about 20 ppm is most considered to indicate the threshold of excessive contents. Also, the reduction growth of sensitive plants was observed at 15 to 20 ppm in tissue Kabata-Pendias (2001).

Radioactivity

The radiometric uranium (eU) content of Sahl El-Tina soil ranges between 3 and 7 ppm with an average of 4 ppm, while the chemically determined uranium (cU) attains a value between 15 and 24 ppm with an average 20 ppm (Table 6). The higher chemically measured uranium than the radiometric one indicates a state of disequilibrium as a result of secondary uptake. The radioactive elements may be fixed on the surface of clay minerals, and may also occur in the detrital heavy minerals especially zircon (Kruskupf,1979).

The (cU/Th) ratio at Sahl El-Tina soil ranges between 3.5 and 10ppm with an average of 6 ppm. This is reflects higher degree of uranium mobilization and enrichment. The equilibrium P- factor (eU/Ra) is less than unity, indicating a possible removal of the U than Ra and disequilibrium state (Naumov,1959). Also, these results are confirmed by the calculation of D- factor (Uc/eU) which is mainly more than one reflecting disequilibrium state with addition of U young gamma – ray (Adams and Weaver,1958).

Comparing trace elements contents of Sahl El-Tina plant samples (bearl) with Egyptian and World plants average limits (Table 7) reveals that the studied plant (bearl) parts are highly enriched in uranium (9.5 - 14ppm) relative to the World plant limits (0.005 -

Table 6: Radioactive elements concentrations (ppm) of the Sahl El-Tina soil samples

S. No.	cU	eU	eTh	Ra	cU /Th	eU/Ra	cU / eU
1	15	3	4	5	4	0.6	5
2	19	3	3	4	6	0.8	6
3	22	4	5	3	4	0.8	0.6
4	20	5	2	2	10	0.5	4
5	15	3	4	5	4	0.6	5
6	19	4	6	6	6	0.6	5
7	20	7	5	9	4	0.7	3
8	24	5	3	6	9	0.8	5
9	23	3	4	3	6	1	8
10	18	4	3	5	6	0.8	5
11	24	6	6	6	4	1	4
12	15	3	2	4	8	0.8	5
13	20	5	3	5	7	1	4
14	22	4	4	6	6	0.6	5
15	21	4	3	4	7	1	5
16	16	3	5	4	6	0.8	5
17	16	3	2	5	9	0.6	5
18	20	4	4	7	5	0.6	5
19	22	5	6	6	4	0.8	4
20	22	6	5	7	5	0.8	4
Average	20	4	4	5	6	0.8	5

eU= equivalent uranium cU= chemical uranium

Table 7 : Average values of U (ppm) and Ra (ppm) in the Sahl El-Tena area world and Egyptian soils and plants

Radioactive element / Area	U(ppm)	Ra (ppm)
Sahl El-Tena soil	15 – 24	5
Egyptian Soil		
Abu Zaable Soil (ElAwa,1997)	1.3 – 28.9	-
Damietta Soil (ElAwa,2005)	0.5 – 8	
World Soil limits (IAEA Report,1988)	0.08- 6.00	1
Sahl El-Tena Plant	9.5 – 14	-
Egyptian plants (Elawa,1997)		
Abu Zaable, berseem dry matter	0.01 – 15	-
Mansoura plant, berseem dry matter	0.15 – 0.36	-
World plant limits (IAEA Report,1988)	0.005 - 0.1	1

0.1ppm) (IAEA Report,1988).

ENVIRONMENTAL IMPACT OF THE RADIOACTIVE METALS

In order to evaluate the environmental impact of radioactive elements within the studied soil, we should investigate the toxic limits of these metals and their effects on plants. These plants when consumed by man would lead to continuous radiation dose and harmful effect. According to an estimation of Cathren and Lappenbusch (1983), food contributes about 15% of ingested uranium, while drinking water contributes about 85%. An exposure of about 0.1 mg/kg of body weight of soluble natural uranium results in chemical damage to the kidneys (Lussenhop, et al., 1958). U and Th could be absorbed by plant roots and concentrated in leaves causing some harmful problems.

Comparing U and Ra concentrations in the studied soil and its plants with their average limit in the world and other Egyptian soil and plants, it can be stated that the U content determined in the Sahl El-Tina area is higher than their world and Egyptian average limits (Table 7). This reflects that, the study soil can be considered as high hazardous polluted source for radioactive and then represent polluted loading for plants. But this soil if dilute with sands become safe for agriculture.

CONCLUSIONS

–The studied soil samples of Sahl El Tina area are belonging to the fluvio- marine regime where the composition of these samples are clay, silt and sand with average contents of 50%, 41% and 9% respectively.

–The present samples having about 1% heavy minerals sand fraction, that includes epidot, garnet, sphene, rutile, ilmenite, chromite, magnetite, pyrite and zircon minerals. On the other hand the X-ray diffraction pattern of clay fraction shows that the kaolinite is the most prominent clay mineral associated with montmorillonite in all studied samples.

–The Sahl El-Tina soil shows significant metal pollution loading for some elements such as Ba,V, Zr, Zn, Cr, , Sr, U and Th. The dry plant (bearl) having some heavy metals such as V, Cr, Ni, Pb, Co and Cu. These metals can be harmful to different degrees, including death for life forms in the ecosystem if they are ingested and bioaccumulate with time.

–The obtained U results of Sahl El-Tina soil (av. 20ppm) and plants (av.12 ppm.) are higher than of that the Egyptian and International soils and plants. As a matter of fact, the study soil can be considered as hazarous polluted source for radioactive and then represent polluted loading for plants. This soil must be dilute with sands to become safe for agriculture.

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الفلزات المشعة والثقيلة فى منطقة سهل الطينة وتأثيرها البيئى

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تقع منطقة سهل الطينة فى الركن الشمالى الغربى من سيناء على ساحل البحر الابيض المتوسط . عينات التربة التى جمعت من المنطقة تتكون من ٥٠٪ طين ، ٤١٪ غرين ، ٩٪ رمل. أثبتت الدراسة ان نسب المعادن الثقيلة لهذه العينات تمثل حوالى ١٪ وهى عبارة عن معادن الابيدوت، الجارنت، السفين، الروتيل، الالمنيت، الكروميت، الماجنيتيت، البيريت والزركون . بينما المعادن الطينية عبارة عن الكاولين بالاضافة الى المنتومورلونيت. هذه العينات تحتوى على تركيزات عالية نسبيا من العناصر الشحيحة مثل الباريوم، الفناديوم،الكروم، النيكل، والاسترانشيوم مقارنة بالمتوسطات العالمية مما يعطى مؤشرا على حدوث تلوث بيئى. من ناحية اخرى تحتوى هذه العينات على متوسط ٢٠جزء فى المليون من اليورانيوم فى التربة، و حوالى ١١,٤جزء فى المليون فى عينات النبات الجاف. وهذه النسب أعلى من النسب العالمية للتربة والنبات مما يؤدى الى حدوث مخاطر وتلوث بيئى. وهذه التربة يجب أن تخفف بالرمال حتى تصبح امنة للزراعة.