J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 5 (12): 1623 - 1633, 2014

REMEDIATION OF A SOIL CONTAMINATED WITH HEAVY METALS USING SOME SEASEEDS

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ABSTRACT

A pot experiment was carried out at the experimental farm of Soil and Water Department, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt during the summer season of 2014 to evaluate the effect of some seaweed on remediation of a soil contaminated with heavy metals (Zn, Pb, Mn and Cu), also to assess the effect of seaweed on growth (roots and shoots) contents from heavy metals of red radish (*Raphanussativus L.*). Surface soil samples (0-30cm) were collected from El-Gable El-Asfer farm located 25km northeast Cairo, Egypt. The experiment involved 39 pots comprised 13 treatments in three replicates in a completely randomized design. Two types of seaweeds (*Ulva sp.*and *Gelidium sp.*) were dried in an oven at 60^0C for 24 hr, and mixed with soil at different rates 0.1, 0.2, 0.3, and 0.4 ton fed^{-1}, before planting. **)**. Soil samples were collected from all pots after harvesting, air dried and then sieve. Some physical, chemical analysis and available Zn, Pb, Mn and Cu were determined in the experiment soil. In this study, a program of observations and measurements was developed, concerning: morphological, productivity and root contents from heavy metals.

The results of this study indicated that the values of soil bulk density decreased as a result of application seaweeds as compared with the control, while soil total porosity, available water, organic matter and available micronutrients increased due to the treatments used compared to the control. Also, plant dry weight yield values (roots and shoots) increased with of seaweeds treatments application, the treatments under investigation gave higher percentage values of micronutrients (content and uptake) in (roots) of red radish plants than shoots as compared to the control. Seaweeds play an important role in the chemical behavior of heavy metals in soil; decomposition of organic matter is followed by formation of active groups which have the ability to retain the metal in the complex and chelated form. The chemical behavior of the metal changed from cation to anion as well as the release of organic acids which slightly decrease the soil reaction (pH).

Keywords: Soil remediation, contaminated soil, seaweeds, heavy metals, red radish, soil characteristics.

INTRODUCTION

Heavy metal pollution represents an important environmental problem due to its toxic effects and accumulation throughout the food chain and hence in the human body (El-Sikaily,et al 2007).Release of heavy metals into the environment is a potential threat to water and soil quality as well as to plant, animal and human health, (Usman, *et al.*, 2006).

The adsorption is the one of the important procedure for the removal of the traces heavy metals from the environment. The main properties of the adsorbents for heavy metal removal are strong affinity and high loading capacity. Natural adsorbents have generally these properties, (Barbier, *et al.,* 2000).The major advantages of the bio-sorption technology are its effectiveness in reducing the concentration of heavy metal ions to very low levels and the use of inexpensive bio-sorbent materials, bio-sorption processes are particularly suitable for the treatment of waste water streams containing dilute heavy metal ion concentrations, or when very low concentrations of heavy metals are required, (Volesky, 1994).

Marine macro algae are harvested/cultivated in many parts of the world. They are readily available in large quantities for the development of highly effective bio-sorbent materials. However, considering the large number of macro algal species identified so far, only a few have been studied for their heavy metal uptake properties, (Holan*et al*., 1993).Many types of biomass in non-living form have been studied for their heavy metal uptake capacities and suitability to be used as bases for bio sorbent development, (Qiming*et al.*, 1999). Also (Sag and Kutsal, 1995) reported that the capacities of the biomass of a few species of marine macro algae, commonly known as brown algae were much higher than those of other types of biomass. They were also much higher than those of activated carbon and were comparable to those of synthetic ion exchange resins.

Biological materials marine algae otherwise known as seaweeds have been reported to have high metal binding capacities due to the presence of polysaccharides, proteins such as amino, hydroxyl, carboxyl and sulphate, which can act as binding sites for metals. They also the green algae, *Ulva lactuca,*are particularly useful in these respects because of its wide distribution and relatively simple structure, *Ulva lactuca* has a sheet-like thallus which is two cells thick, resulting in a relatively high surface area of structurally uniform and physiologically active cells, (Sarl and Tuzen 2007). Green alga, *Chlorella minutissima*, adsorbed greater than 90% of the initial Pb, and greater than 98% of the initial Co concentrations, (DipakRoy, *et al*., 1993).

Experimental studied by Wiley and Sons (2004) showed that the cell wall metal complex was found to be stable; the bound metal did not desorbs over time under static conditions. Most cationic metal ions could be recovered from the biomass through desorption by lowering the pH of the medium. They also found that a new bio-sorbent material based on *A. nodosum* biomass was obtained by reinforcing the algal biomass by formaldehyde cross–linking. The prepared sorbent possessed good mechanical properties, chemical stability of the cell wall polysaccharides and low swelling volume.

Metting and Rayburn, 1983reported thatthe annual inoculation with mass cultured microalgae soil conditioner *Chlamydomonsasmexicana* increased carbohydrates, water retention, soil particle aggregation and stability in water and improved soil structure. They concluded that moisture is implicated as a factor most likely controlling growth and polysaccharides production by algae inoculums.

Many investigations used algae for reclamation of soil. The conclusion of results showed that after one or two years, the pH was reduced from 9.5 to 7.6, while the water holding capacity increased by as much as 40

% and exchangeable calcium increased from 20 to 30% (Rodney *et al.*, 2004 and Xiao *et al*., 2008).

The present investigation was carried out to evaluate the effect of some seaweed on remediation of heavy metals polluted soil (Zn, Pb, Mn and Cu), also to assess the effect of seaweed on growth (roots and shoots) contents from heavy metals of red radish (*Raphanussativus L.*).

MATERIALS AND METHODS

A pot experiment was carried out at the experimental farm of Soil and Water Department, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt during the summer season of 2014 to evaluate the effect of some seaweed on remediation of a contaminated soil with heavy metals, (Zn, Pb, Mn and Cu), also to assess the effect of seaweed on growth (roots and shoots) contents from heavy metals of red radish (*Raphanussativus L.*).

Soil samples:

Surface soil samples (0-30cm) were collected from El-Gable El-Asfer farm located at 25km northeast Cairo, Egypt, this soil is irrigated continuously with sewage effluent for about 80 years. Soil sample was air dried and then ground to pass through a 2mm sieve. Some physical and chemical analysis was carried out according to the standard methods undertaken by (Klute, 1986) and (Page *et al.,* 1982). Also, available Zn, Pb, Mn and Cu were determined in the experiment soil using ammonium bicarbonate-DTPA extractable according to (Soltanpour and Schwab, 1977) and their contents in the obtained extract were measured by atomic absorption spectrophotometer. The results of soil and materials analysis before the experiments are presented in Tables 1-3.

Table 1: Mechanical analysis of soil samples

Particle size distribution (%)				
Coarse sand	**Fine sand**	**Silt**	**Clay**	**Textural class**
54.21	20.43	11.67	13.69	Sandy loam

Table 2: Chemical analysis of soil samples before planting.

OM %	pH	EC dsm^{-1}	Cations (me qL^{-1})				Anions (me qL^{-1})			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}
2.51	7.73	1.29	5.62	3.80	4.11	2.13	ND	3.74	7.32	4.61

Table 3: Zn, Pb, Mn and Cu contents of soil samples

Plant available heavy metals (mg kg^{-1})		
Elements	**Critical limits of heavy metals in soil ***	**Studied polluted soil**
Zn	>1.50	91.84
Pb	>0.50	26.17
Mn	>1.80	21.65
Cu	>0.50	28.57

*** Hammissa *et al.* (1993).**

Seaweeds treatments

Two types of seaweeds (*Ulva sp.* and Gelidium sp.) were collected from Abo-Quir Bay, Alexandria, Egypt and washed with seawater, tap water, and then distilled water several time, to remove extraneous and salt. Theywere then dried in an oven at 60^{0}C for 24 hr. The dried algae biomass was choppedsieved and the particles with an average of 0.5 mm were used for bio-sorption experiments. The moisture percentage, the ash and nitrogen content; were determined for according to (AOAC 2006).A factor of 6.25 was used to convert N to protein; fat; carbohydrate by (AOAC 2006); also CEC, pH, heavy metals under study (Zn, Cu, Mn and Pb) and (Ca and P) contents were recorded according to (Page et al., 1982), as shown in Tables 4 and 5.

Table 4: Chemical analysis of seaweeds.

Types	pH	Ash %	CEC meq100g soil^{-1}	Moisture %	Protein %	Fat %	Carbohydrates %
Ulva sp	6.61	30.1	26.5	90.4	17.32	2.5	52.6
Gelidium sp.	6.83	18.3	57.2	92.6	18.41	1.2	60.5

Table 5: Zn, Pb, Mn, Cu, P and Ca contents of seaweeds.

Macronutrients (ppm)		**(ppm)**			
Ca	**P**	**Zn**	**Pb**	**Mn**	**Cu**
1.8	6.6	0.39	0.08	0.46	0.07
1.9	6.7	1.13	0.16	0.64	0.25

Experimental treatments:

The experiment involved 39 pots comprised 13 treatments in three replicates in a completely randomized design. Two types of seaweeds (*Ulva sp.* and *Galdium sp.*) were dried in an oven at 60^{0}C for 24 hr, and mixed with soil at different rates 0.1, 0.2, 0.3, and 0.4 ton fed^{-1}, before planting, then seeds of red radish were sown, treatments of this study were as follows:

1. Contaminated soil (control)
2. Contaminated soil with Ulva 0.1 ton fed^{-1}
3. Contaminated soilwith Ulva 0.2 ton fed^{-1}
4. Contaminated soilwith Ulva 0.3 ton fed^{-1}
5. Contaminated soil with Ulva 0.4 ton fed^{-1}
6. Contaminated soilwith Gelidium 0.1 ton fed^{-1}
7. Contaminated soilwith Gelidium 0.2 ton fed^{-1}
8. Contaminated soilwith Gelidium 0.3 ton fed^{-1}
9. Contaminated soilwith Gelidium 0.4 ton fed^{-1}
10. Contaminated soil with mixture of Ulva and Gelidium 0.1 ton fed^{-1}
11. Contaminated soil with mixture of Ulva and Gelidium 0.2 ton fed^{-1}
12. Contaminated soil with mixture of Ulva and Gelidium 0.3 ton fed^{-1}
13. Contaminated soil with mixture of Ulva and Gelidium 0.4 ton fed^{-1}

A pot of 30 cm diameter and 35 cm depth were filled by 10kg of soil samples, then fertilized with seaweeds and were good mixed with soil in pots, after that at 1st of April the seeds of red radish were sown.

Fertilization with N and K nutrients were according to the recommendations ofthe Agriculture Ministry. Plant shoots and roots were harvested after 60 days from planting, at which time there was sufficient plant material for analysis. Plant organs were rinsed in distilled water and then dried at 60-70° for 24 hr, dry weights were recorded. The plant samples were ground and wet digested with acids mixture (HNO_3 and $HC1O_4$) according to (Jackson, 1973). Soil samples were collected from all pots after harvesting, air dried and then sieve. Some physical and chemical analysis was carried out according to the standard methods undertaken by (Klute, 1986) and (Page *et al.,* 1982).Heavy metals under investigation (Zn, Cu, Mn and Pb) in clear digested solutions were determined using Perkin Elmer Inductively Coupled Spectrophotometer Plasma 400 (ICP). At the same time, DTPA extractable contents of the studied heavy metals were determined, as mentioned before, at harvest to evaluate the response of their potential mobility and biological uptake by grown plants.

Statistical analysis:

The collected data were subjected to the proper statistical analysis of complete randomized block design combined over locations according to Steel and Torrie(1980) using LSD at 5 % level.

RESULTS AND DISCUSSION

Effect of seaweed on available and % of the residual from native of (Zn, Pb, Mn and Cu) in soil after harvesting.

Data in Table 6 represent the available and % of the residual in soil from native Zn, Pb, Mn and Cu as affected by different levels of seaweed after mixing with soil at different rates of (0.1, 0.2, 0.3 and 0.4 ton fed^{-1}) before planting. The results showed that the available amounts of Zn, Pb, Mn and Cu were reduced with increasing rates of individual applied *Ulva sp.* or *Gelidium sp.* compared with the control. However the data revealed that the lower values of available Zn, Pb, Mn and Cu could be obtained as a result of application of mixed seaweed at 0.4 ton fed^{-1} after harvesting. Whereas, the unavailable values of Zn, Pb, Mn and Cu reached to 28, 27, 40 and 33 %, respectively. This could be due to the important role both types of seaweed to retain heavy metals in soils as unavailable form. These results may be attributed to the formation of stable form compounds with a wide range of cationic contaminants or immobilization of heavy metals as oxide, hydroxide or phosphate. These results could be attributed to the important role both types of seaweed in the chemical behavior of heavy metals in soil and decomposition of organic matter is followed by formation of active groups which have the ability to retain the metal in the complex and chelated form. These findings could be enhanced with those obtained by (Sarl andTuzen, 2007) who found that the green algae *Ulva lactuca*is particularly useful in these respects because of its wide distribution and relatively simple structure. *Ulva lactuca* has a sheet-like thallus which is two cells thick, resulting in a relatively high surface area of structurally uniform and physiologically active cells. Also, (DipakRoy, *et al.*, 1993) indicated that the green alga, *Chlorella* *minutissima*, adsorbed greater than 90% of the initial Pb, and greater than 98% of the initial Co concentrations. The results suggested that the both types of seaweed had directly greater potential to immobilize Zn, Pb, Mn and Cu in the studied contaminated soil at 0.4 ton fed^{-1}before planting. The ability of both types of seaweed to immobilize heavy metals under consideration in a contaminated soil could be attributed to the high metal binding capacities due to the presence of polysaccharides, proteins such as amino, hydroxyl, carboxyl and sulphate, which can act as binding sites for metals . (Holan*et al.,* 1993; Volesky, 1994; Chong and Volesky, 1995; Fourest and Volesky,1996).

Table 6:Effect of seaweed treatments on available and % of the residual from native of (Zn, Pb, Mn and Cu) in soil after harvesting.

Seaweed treatments (ton fed^{-1})	Available (ppm)				% of the residual from native			
	Zn	Pb	Mn	Cu	Zn	Pb	Mn	Cu
1-Contaminated soil (Control)	91.84	26.17	21.65	28.57	100	100	100	100
2-Contaminated soil with Ulva 0.1	80.97	22.52	17.57	24.24	88.16	86.06	81.14	84.85
3-Contaminatedsoil with Ulva 0.2	80.36	22.02	17.73	24.08	87.49	84.20	81.88	84.48
4-Contaminated soil with Ulva 0.3	72.94	20.04	14.42	23.14	79.41	76.58	66.66	80.99
5-Contaminatedsoil with Ulva 0.4	69.62	19.42	14.22	23.12	75.80	74.24	65.73	80.91
6-Contaminated soil with Gelidium 0.1	83.63	21.77	20.62	25.00	91.10	83.19	95.22	87.49
7-Contaminated soil with Gelidium 0.2	77.08	20.46	20.36	23.97	83.91	78.20	94.02	83.90
8-Contaminated soil with Gelidium0.3	74.24	20.22	18.80	23.89	80.83	77.28	86.82	83.40
9-Contaminated soil with Gelidium0.4	72.34	19.63	17.00	22.74	78.76	75.03	78.53	79.57
10-Contaminatedsoil with mixed 0.1	80.40	22.24	19.73	24.50	87.53	84.99	91.14	85.74
11-Contaminated soil with mixed 0.2	80.22	20.36	14.56	24.40	87.34	77.81	67.23	85.39
12-Contaminated soil with mixed 0.3	67.28	18.72	13.73	20.42	73.25	71.54	63.43	71.47
13-Contaminated soil with mixed 0.4	66.20	18.70	12.12	19.22	72.08	71.49	60.95	67.26
L.S.D. at 5%	0.039	0.084	0.014	0.049	0.04	0.042	0.037	0.037

Effect of seaweeds application on dry weight yield and (Zn, Pb, Mn and Cu) content and uptake, of red radish plant.

Data in Table 7 and 8 show that the dry weight yields of roots and shoots of red radish after harvesting in the contaminated soil samples were extremely higher than the control. The results conclude that the relative dry weight of roots of red radish were in treatment No. 2, 6 and 10 (100.20%), (101.40%) and (101.27%) then increased gradually until reached (103.18%), (103.39%) and (103.82%) with treatments No. 5, 9 and 13 respectively. The same remark was found regarding the roots and shoots of red radish were in treatments No. 2, 6 and 10 (104.8%), (104.8%) and (104.9%) then increased gradually until reached (105.1%), (104.2%) and (105.4%) with treatments No. 5, 9 and 13 respectively. This emphasized the effective role of the different rates 0.3, and 0.4 ton fed^{-1} for increasing the biomass production in soils before planting. These results confirm again the important role of application of seaweeds for improving soil contaminated with heavy metals on the contrary lower uptake of heavy metals by red radish roots and shoots after harvesting in contaminated soils than in roots and shoots of the control. This remark insured the important role of application amount to reduce solubility and concentration of heavy metals, which could led to low plant uptake of heavy metals in contaminated soils. Similar results were obtained by (Ciecko *et al*., 2005**)**.

Data detected in Table 7 and 8 show a positive effect of different materials in increasing the content and uptake of the studied nutrients by Red radish. Concerning the effect of adopted treatments on Zn, Pb, Mn and Cu content and uptake, data in Table 7 showed that Zn, Pb, Mn and Cu contents and uptake are affected by application of materials to polluted soil compared with the other treatments and the control. The dry weight of the plants was increased with the increases in the concentration and uptake of Zn, Pb, Mn and Cu. The dry weight reflected the high content and uptake of heavy metals found at 0.1 ton fed^{-1} followed by treatment 0.3 and 0.4 ton fed^{-1} more than other treatments compared with the control. Also, the values obtained from the other treatments were found to be in between. The total uptake of Zn, Pb, Mn and Cu of roots were increased gradually at 0.1 ton fed^{-1}followed by, 0.2 particularly, 0.3and at 0.4 ton fed^{-1}. On the contrary, total uptake of Zn, Pb, Mn and Cu of shoots were not affected with the different treatments. These results confirm again the important role of application of seaweeds for improving soil contaminated with heavy metals on the contrary lower uptake of heavy metals by red radish shoots after harvesting in contaminated soils than in roots of the control. This remark insured the important role of application amount to reduce solubility and concentration of heavy metals, which could led to low shoots plant uptake of heavy metals in contaminated soils. These results could be supported those obtained by(Volesky, 1994) ,who stated that the major advantages of the bio-sorption technology are its effectiveness in reducing the concentration of heavy metal ions to very low levels and the use of inexpensive bio-sorbent materials., Bio-sorption processes are particularly suitable for the treatment of waste water streams containing dilute heavy metal ion concentrations, or when very low concentrations of heavy metals are required; also the limitations of the technology include that large-scale production of effective bio-sorbent materials has not been established and that the technology has only been tested for limited practical applications.

Table 7: Effect of seaweeds application on dry weight yield, (Zn, Pb, Mn and Cu) content and uptake, of red radish plant roots.

Seaweed treatments (ton fed^{-1})	D.W. gm pot^{-1}	The relative yield	Concentration ppm				Uptake µg pot^{-1}			
			Zn	Pb	Mn	Cu	Zn	Pb	Mn	Cu
1-Contaminated soil (Control)	6.71	100.00	38.2	1.11	34.0	9.21	256.6	7.44	228.1	61.7
2-Contaminated soil with Ulva 0.1	6.72	100.20	39.1	1.32	34.3	9.21	262.7	8.87	230.4	61.8
3-Contaminated soil with Ulva 0.2	6.76	101.00	39.5	1.32	34.5	9.20	267.0	8.92	233.2	62.1
4-Contaminated soil with Ulva 0.3	6.82	102.33	40.9	1.43	34.6	9.22	278.9	9.75	235.9	62.8
5-Contaminated soil with Ulva 0.4	6.86	103.18	41.1	1.42	34.8	9.25	281.9	9.74	237.3	63.4
6-Contaminated soil with Gelidium 0.1	6.78	101.40	39.0	1.32	34.5	9.31	264.4	8.94	233.9	63.1
7-Contaminated soil with Gelidium 0.2	6.79	101.60	39.6	1.32	34.8	9.31	268.8	8.96	236.2	63.2
8-Contaminated soil with Gelidium 0.3	6.86	103.18	40.2	1.45	34.9	9.51	275.7	9.94	239.4	65.2
9-Contaminated soil with Gelidium 0.4	6.87	103.39	40.3	1.45	35.0	9.6	276.8	9.96	240.4	65.9
10-Contaminated soil with mixed 0.1	6.77	101.27	40.1	1.37	34.6	9.5	271.4	9.27	234.2	64.3
11-Contaminated soil with mixed 0.2	6.79	101.60	41.1	1.45	34.9	9.5	279.0	9.84	236.9	64.5
12-Contaminated soil with mixed 0.3	6.88	103.60	42.0	1.47	35.0	9.6	288.9	10.11	240.8	66.0
13-Contaminated soil with mixed 0.4	6.89	103.82	42.2	1.47	35.2	9.7	290.7	10.12	242.5	66.8
L.S.D. at 5%	0.023	0.031	0.02	0.057	0.021	0.045	0.016	0.043	0.078	0.003

Table 8: Effect of seaweeds application on dry weight yield, (Zn, Pb, Mn and Cu) content and uptake,of red radish plant shoots

Seaweed treatments (ton fed^{-1})	D.W. gm pot^{-1}	The relative yield	Concentration ppm				Uptake µg pot^{-1}			
			Zn	Pb	Mn	Cu	Zn	Pb	Mn	Cu
1-Contaminated soil (Control)	18.22	100	2.91	0.96	25.0	7.10	531.6	17.4	457.1	129.3
2-Contaminated soil with Ulva 0.1	19.11	104.8	25.2	0.73	24.0	5.39	482.9	13.9	459.2	103.0
3-Contaminated soil with Ulva 0.2	19.11	104.8	25.2	0.72	23.8	5.10	282.1	13.7	454.8	98.0
4-Contaminated soil with Ulva 0.3	19.12	104.9	24.2	0.61	21.5	3.72	463.2	11.7	412.6	71.1
5-Contaminated soil with Ulva 0.4	19.15	105.1	24.4	0.61	21.10	3.55	468.7	11.6	405.2	67.9
6-Contaminated soil with Gelidium 0.1	19.11	104.8	28.1	0.79	24.0	5.20	537.9	15.0	460.1	100.5
7-Contaminated soil with Gelidium 0.2	19.13	104.9	25.8	0.73	23.8	4.7	493.7	13.9	456.2	91.6
8-Contaminated soil with Gelidium 0.3	19.14	104.1	22.6	0.61	21.6	3.6	433.1	11.6	433.1	70.6
9-Contaminated soil with Gelidium 0.4	19.16	104.2	23.2	0.60	20.9	3.5	445.4	11.4	400.8	68.5
10-Contaminated soil with mixed 0.1	19.12	104.9	26.4	0.69	23.2	4.6	505.9	13.1	444.7	89.6
11-Contaminated soil with mixed 0.2	19.15	105.1	24.4	0.68	22.3	4.5	468.7	13.0	427.2	87.7
12-Contaminated soil with mixed 0.3	19.20	105.3	21.2	0.59	20.0	3.3	407.2	11.3	384.9	64.7
13-Contaminated soil with mixed 0.4	19.22	105.4	21.3	0.58	19.9	3.2	409.9	11.1	384.0	62.6
L.S.D. at 5%	0.008	0.036	0.093	0.033	0.086	0.015	0.025	0.052	0.013	0.045

Effect of seaweeds application on some soil properties after harvesting.
The influence on soil density and total porosity.

Table 9 show that the mean values of bulk densities for the soil under study were reduced with increasing different rates (0.1, 0.2, 0.3, and 0.4 ton fed^{-1}) both types of seaweed, especially after red radish planting compared with the initial soil samples. On contrary the mean values of total porosities were increased with increasing different rates (0.1, 0.2, 0.3, and 0.4 ton fed^{-1}) both types of seaweed.

The influence on water movement.

Hydraulic conductivity coefficient was the parameter used for the measurement of water movement in the soil of the investigated treatments. Table 9 reveals that the values of hydraulic conductivity coefficient (K) increased with increasing different rates (0.1, 0.2, 0.3, and 0.4 ton fed^{-1}) both types of seaweeds, especially after red radish planting compared with the control. This could be attributed to the application of seaweeds which had affected on pore size distribution and to the improving effects of the investigated treatments on the physical soil properties; similar results were obtained by (Mashour, 2005 and Taher, 2000).

The influence on moisture content.

The data in Table 9 show the moisture content values for the soils under study which markedly increased with increasing different rates (0.1, 0.2, 0.3, and 0.4 ton fed^{-1}) of seaweeds, especially after red radish planting compared with control treatment. Data in Table9 show that soil moisture values (field capacity and saturation percent) were affected by application of different treatments of seaweedsat different rates; similar results were obtained by (Abd-Elhady, *et al.*, 2010 and Xiao, *et al.,*2008).

The influence on soil reaction (pH)

Data in Tables 9 show that the pH values of the soils under study were slightly decreased with increasing different rates (0.1, 0.2, 0.3, and 0.4 ton fed^{-1}) of applied seaweeds comparing with control treatments. The most important factor that could be affected by the different treatments is the soil reaction (pH) which was affected by the application of seaweeds at all treatments. Also, the values which obtained from the other treatments were found to be in between. This remark emphasized that the soil reaction (pH) played an important role in the chemical behavior of heavy metals in soil. Low pH-values increased the amounts of heavy metals available to plants. Thus, solubility and availability of the micro elements increase as (pH) decrease. These results are in agreement with those obtained by (Wiley and Sons, 2004 and Abd–Elall, 2009).

Table 9: Effect of seaweeds application on some soil properties at different rates after harvesting.

Seaweed treatments (ton fed^{-1})	pH soil past	Ec dSm^{-1}	OM %	CEC meq100 g soil^{-1}	$CaCO_3$ %	Sp %	F.C. %	K cm h^{-1}	B.D. g cm^{-3}
1-Contaminated soil(Control)	7.73	1.29	2.51	18.91	44.10	31.5	25.6	1.25	52.83
2-Contaminated soil with Ulva 0.1	7.64	1.13	2.63	18.92	48.6	32.7	26.8	1.13	57.35
3-Contaminated soil with Ulva 0.2	7.62	1.19	2.73	18.96	49.8	32.8	26.9	1.04	60.75
4-Contaminated soil with Ulva 0.3	7.58	1.19	2.82	19.30	50.1	33.6	27.3	1.02	61.50
5-Contaminated soil with Ulva 0.4	7.54	1.20	2.90	19.31	51.2	34.3	27.8	1.01	61.80
6-Contaminated soil with Gelidium 0.1	7.63	1.12	2.65	18.92	48.7	32.6	26.6	1.14	56.98
7-Contaminated soil with Gelidium 0.2	7.61	1.15	2.74	18.97	49.9	32.7	26.8	1.11	58.11
8-Contaminated soil with Gelidium 0.3	7.58	1.15	2.83	19.31	50.7	33.8	27.9	1.05	60.37
9-Contaminated soil with Gelidium 0.4	7.53	1.17	2.91	19.32	51.3	34.9	27.9	1.00	62.26
10-Contaminated soil with mixed 0.1	7.62	1.14	2.67	18.93	48.9	33.3	26.9	1.14	56.98
11-Contaminated soil with mixed 0.2	7.60	1.15	2.75	18.95	49.3	33.6	27.8	1.07	59.62
12-Contaminated soil with mixed 0.3	7.57	1.16	2.81	19.40	52.7	34.7	28.6	1.04	60.75
13-Contaminated soil with mixed 0.4	7.55	1.18	2.91	19.45	52.9	34.8	29.8	1.02	61.50

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معالجة الارض الملوثة بالفلزات الثقيلة باستخدام بعض الأعشاب البحرية

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معالجة الأراضى وتقييد حركة العناصر بها ضرورة لتجنب مخاطرها على البيئة وصحة الإنسان- لذا فان هذه الدراسة تهدف إلى تقييم تأثير بعض الاعشاب البحرية فى تقليل حركة وتيسر بعض الفلزات الثقيلة فى تربة ملوثة حيث استخدم نوعين من الاعشاب البحرية (الطحالب الخضراء بمفردها والطحالب الحمراء بمفردها ثم خلط كلاً منهما) بعد تجفيفها فى الفرن على درجة 60درجة مئوى تحت مستويات مختلفة(0.1، 0.2، 0.3، 0.4 طن/فدان) مع عينات التربه السطحية التى جمعت من مزرعة الجبل الأصفر شمال غرب القاهرة ثم بعد ذلك زرعت فى تجربة أصص بمزرعة كلية الزراعة جامعة الازهر بالقاهرة حيث تم زراعة نبات الفجل الأحمر (*Raphanussativus L.*) فى صيف 2014م وذلك لمتابعة حركة وتيسر العناصر فى التربة والنبات وتشير أهم النتائج إلى:

- أن كلاً من الأعشاب البحرية (الطحالب الخضراء بمفردها والطحالب الحمراء بمفردها) قد نجحا فى خفض تيسر وتقييد حركة العناصر (الزنك، الرصاص، المنجنيز، النحاس) فى التربة الملوثة حيث اظهر المحتوى الميسر من تلك العناصر إتجاهاً متناقصاً بزيادة مستويات الإضافة خاصة عند معاملات الخلط بين الطحالب الخضراء والحمراء عند استخدام 0.3، 0.4 طن/فدان بالمقارنة بالطحالب بمفردها والكنترول على التوالى.
- أهمية اضافة الأعشاب البحرية للتربة الملوثة حيث عملت على تحسين الخواص الكيماوية والطبيعية للتربة الملوثة وزادت من احتفاظ التربة للماء وتقييد حركة وتيسر العناصر الثقيلة فى التربة وخفض الكمية الممتصة منها فى الأنسجة النباتية خاصة فى المجموع الخضرى عن المجموع الجذرى وعليه فان سمية هذه العناصر للنباتات النامية تناقصت بزيادة مستويات الاضافة عند معاملات الخلط بين الطحالب الخضراء والحمراء عند استخدام 0.3، 0.4 طن/فدان بالمقارنة بالطحالب بمفردها والكنترول على التوالى.