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ROLE OF *Moringa oleifera* SEEDS EXTRACT IN ELIMINATING SOIL AND WATER CONTAMINATION USING LETTUCE PLANTS AS INDICATOR

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ABSTRACT: A pot experiment was carried out on lettuce (*Lactuca sativa* L.) for growing 2021 season to study the effect of various water sources *i.e.,* fresh water (FW), agricultural drainage (ADW), sewage (SW) and industrial drainage (IDW) after treated with moringa seed extract (MSE) on remove water and soils contamination and its effect on yield and heavy metals content of lettuce plants. The lowest values of SSP, SAR, SCAR, RSC, RSBC, PI, PS, KR and MAR were obtaind in fresh water followed by industrial drainage water, sewage water and agricultural drainage water when treated with MSE. The classification of all water sources indicates before treated with MSE of high salinity-low sodicity (C4S1) and moderate low sodicity (C2S1) after treated with MSE. Addition of MSE to water soureces reduced water turbidity, NO_3-N, BOD, COD, DO and heavy metals compared with untreated water. The highest values of fresh and dry weight, N, P and K- uptake of lettuce plants obtainted in different water sources treated with MSE. Addition of MSE to different water sources gave the lowest accumulation of Pb, Cd, Ni, Fe, Cu, Zn and Mn in soil and lettuce plants compared to untreated water.

Key words: Wastewater, *Moringa oleifera* seeds, water propareties, heavy metals.

INTRODUCTION

Water is an important resource for life. Entire living organisms on earth need water for life. However, water can be problematic if it is not available in the right conditions (**Barnes, 2014).** Water is used by human for various purposes, therefore the cleanliness of water consumed is very important since water is known to affect the health. Today, the quality of water becomes a major problem that needs serious attention (**MWRI, 2005).**

Wastewater may by inherently toxic due to the presence of complex chemical mixtures and thus may mimic diverse modes of action in biological systems. However, instrumental analytical techniques alone may provide little or no information on the potential biological effects of complex environmental mixtures (**Arora *et al.,* 2008; Almeelbi *et al.,* 2014).** Heavy metals contamination in soil and wastewater irrigated crops have been reported in a number of previous studies in Egypt and other developing countries (**Al-Shammiri *et al.,* 2005; Muchuweti *et al.,* 2006** and **Alghobar *et al.,* 2014).** Some of these metals transferred to food chain which can affect food quality and cause serious health hazarded to human being and animals **(FAO, 2014**).

Several findings from previous research in (**Postnote, 2002)** demonstrated the use of synthetic materials for water purification can be severely hazardous to health if something goes wrong in their treatment during processing. Besides synthetic chemicals, there are natural ingredients that can be derived from tropical

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plants which can be used as coagulants, including moringa seeds (*Moringa oleifera*). **Hassanein *et al.*, (2017**) reported that moringa defatted seeds powder had conferred protection against cadmium toxicity in wheat. Upon defatted seeds pre-treatments, Cd accumulation has diminished by 3 and 2-folds in shoots and roots, respectively and wheat growth and physiological parameters have improved spectacularly. *Moringa oleifera (*MO) is potential as organic pollutant absorber in simulation solution. MO reported able to eliminate the turbidity and dissolved organic matters of river water (**Akhtar *et al.*, 2007). Damayanti *et al.* (2011)** made a membrane consisted of MO and zeolite for palm oil effluent treatment.

MSE exhibited high efficiency in the reduction and prevention of the bacterial growth in both wastewater and ''Sungai baluk'' river samples. The turbidity was removed up to 85–94% and dissolved oxygen (DO) was improved from 2.58 to 4.0 mg/L. However, there is no significant difference in pH, EC and total dissolved solids after treatment. Heavy metals such as iron, copper and lead were eliminated by 100, 98 and 78%, respectively **(Shan *et al.*, 2017; James and Zikankuba, 2017).** Natural resources have been used in water treatment since ancient times but still need to be applied on a large scale. Presently increased interest in the use of plant materials as coagulants and disinfectants in water treatment. Among these plant species, Moringa is the most widely cultivated species in terms of its nutritional value and its use as coagulation in water purification (**Mataka *et al.*, 2010; Madrona *et al.*, 2010; Anwar and Rashid, 2007).** The effectiveness over using both natural and synthetic coagulants in turbidity removal was studied. It shows about 70 and 75% removal efficiency for moringa seed and alum respectively with respect to its varying parameters (**Abirami and Rohini, 2017**). The present work aims to study the role of moringa seed extract in elimination soil and water contamination and its effect on yield and heavy metals uptake of lettuce palnts.

MATERIALS AND METHODS

The experiment was carried out to study the role of moringa seed extract in elimination soil and water contamination and its effect on yield and heavy metals content of lettuce plants (*Lactuca sativa* L.). Four sources of water were collected in October 2021. Fresh water (FW) sample were taken from moies canal. Sewage water (SW) samples were taken from Bahr El-Baqar drain, Egypt. Industrial daainage water (IDW) samples were taken from the Abu-Zaabal Company for Fertilizers and Chemical Industries. Agricultural drainage water (ADW) sample were taken from Bilbeis drain, Egypt. The volum of the samples were about 200 liters of each source. Precaution was taken to avoid sample contamination. Two liters of samples were filtered immediately and stored in plastic bottles at 4^{o} Celsius until analysis. Samples were analyzed in the laboratory for the major ions chemistry **(APHA, 1995).** Criteria for judging the validity of water were; soluble sodium percentage (SSP), sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), sodium to calcium activity ratio (SCAR), residual sodium carbonate (RSC), residual sodium bicarbonate (RSBC), permeability index (PI), potential salinity (PS), Kelly ratio (KR) and magnesium adsorption ratio (MAR). The results of the analyses were interpreted using graphical representations like United States Salinity Laboratory (USSL).

A pot experiment was carried out on lettuce (*Lactuca sativa* L.) for growing 2021 season, under greenhouse conditions to study the effect of Moringa seed extract in reducing water and soil contaminates and its effect on plant growth and heavy metals uptake. Pots (PVC) were 33 cm inner diameter and 25 cm deep. Each pot contained 10 kg of air dried loamy soil (Table 1), soil properties were analyzed according to **Piper (1951), Black *et al.* (1965) and Jackson (1973)**.

Moringa oleifera (MO) seeds used in this study were collected from farm of National Research Centre, Egypt. The seeds were de-shelled to remove the kernels. Seed kernels were further dried at ambient temperatures for a period of five days. The chemical compositions of MO seedS were investigated using **Abdulkarim *et al.* (2005); El Sohaimy *et al.* (2015) and Ijarotimi *et al.* (2013**), Tables 2 and 3. The white kernels were milled into a fine powder using a mill (at 3000 rpm) and sieved (using 200-250μm). 20 g

Table 1. Some physical and chemical properties of the investigated soil

Soil characteristic	Values
Soil particles distribution	
Sand ,%	25.6
Silt,%	45.5
Clay,%	28.9
Textural class	Loam
Field capacity (FC),%	18.9
$CaCO_3$, (g kg^{-1})	10.7
Organic matter,(g kg^{-1})	5.8
pH*	7.94
EC,(dSm^{-1}) **	1.45
Available macronutrients (mg kg^{-1}soil)	
N	43.7
P	14.2
K	185

* Soil-water suspension 1: 2.5 ** Soil paste extract

Table 2. The different chemical compounds found in *Moringa oleifera* seed

Chemical	
2,4-Methylene-Cholesterol	4-(Alpha-L-Rhamnosyloxy)-Benzylglucosinolate
Beta-Carotene	28-Isoavenasterol
Campestanol	Alpha-Tocopherol
Ash 4-(Alpha-L-Rhamnosyloxy)-	Benzylisothiocyanate
Brassicasterol	Behenic-Acid
Carbohydrates	Beta-Sitosterol
Fat	Cholesterol
Glucosinolates	Fiber
Palmitic-Acid	Oleic-Acid
Stearic-Acid	Protein
Arachidic-Acid	

Adapted from **Abdulkarim *et al.* (2005)**

Table 3. Amino acid profile in *Moringa oleifera* seeds (mg/100g)

Amino acid	Concentration , mg $100g^{-1}$
Lysine*	312
Histidine*	1930
Valine*	1080
Leucine*	3830
Isoleucine*	4230
Threonine*	3020
Alanine	5160
Aspartic acid	1570
Serine	3060
Proline	2180
Glutamic acid	17870
Glycine	2370
Arginine*	8280
Cysteine	1680
Tyrosine	1970
Methionine*	310
Phenylalanine*	3270

key: asterisk * = indicate essential amino acids. Adopted from **El Sohaimy *et al.* (2015) and Ijarotimi *et al.* (2013)**

of the powder were dispersed in 1000 mL of distilled water. The suspension was stirred during 1 hour, settled during 1 hour and filtered of supernatant through Wattman pleated filter collected **(Gidde *et al*., 2012**). Five liters of the moringa seed extract, were added to 100 liters water of each source and mixed freshand left for 24 hours, then used for irrigation. Two liters of water after adding MSE were stored in plastic bottles at 4^o Celsius until analysis. Samples were analyzed in the laboratory for the major ions chemistry employing standard method (**APHA, 1995**).

The experiment was done in a randomized complete block, in 5 replicates. The soil watering treatments were applied as percentages of the soil's water holding capacity (WHC). Three seedlings pot^{-1} were cultivated and 2 weeks after sowing, seedlings were thinned to two $plants^{-1}$. Nitrogen was added as ammonium sulphate (205 g N kg^{-1}) at 50 mg N kg^{-1} soil, in 3 equal splits; the first was before the 1st irrigation while the second and third splits were 20 and 35 days respectively after the first. P was in a form of ordinary super phosphate, 65 g P kg^{-1}, added at 15 mg P kg^{-1} soil, and K was in a form of potassium sulphate, 410 g K kg^{-1} added at 40 mg K kg^{-1} soil. P and K were added during soil preparation. Pots were weighted daily and the needed amounts of irrigation water were added for each source.

Plants Samples of were taken after 55 days to record plant vegetative charachters, fresh and dry weight. At harvest, plants per pot were taken and recorded plant height, fresh weight and dried at 70 ˚C for 72 hours. Plant material were digested and analyzed for N, P and K **(Chapman and Pratt, 1961)**. Total phosphorus in plant was determined colourmetrically using ascorbic acid method (**Watanabe and Olsen**

1965). Soil samples were taken after harvesting and heavy metals were determined using atomic absorption spectrophotometry according to **AOAC (1984**).

RESULTS AND DISCUSSION

Role of Moringa Seed Extract on Chemical Properties of Water

Table 4 shows EC, pH and the ionic composition of water sources *i.e.* fresh, agricultural drainage, sewage and industrial drainage water before and after treatment with MSE. The EC and pH ranged from 0.19 to 4.63 dsm^{-1} and 7.21 to 7.87, respectively for different water sources. The highest EC, pH were obtained with ADW before treated with MSE, while the lowest EC, pH were obtained with freshwater after treated with MSE (**Abdel-Fattah and Helmy, 2015; Tantawy *et al.*, 2015*;* Hendrawati *et al.*, 2016; Al-Hamid *et al.*, 2017).**

According to **USDA (1954)**, salinity classes ranged from low to very high. Water in ADW , SW and IDW before treated with MSE is high salinity (C4), which should not be used on soils with restricted agricultural drainage age and if used, special management for salinity control should be done and salt tolerant plants should be used. Water in ADW, SW and IDW after treated with MSE is of moderate salinity (C3), which should can be used for can be used for all but extremely salt-sensitive crops when grown on soils of high to medium permeability. these soils of low permeability, some leaching and times growing moderate salt tolerant crops are necessary. Relative abundance of cations in water of FW, ADW, SW and IDW was Na^{+}> Ca^{+2} >Mg^{+2}>K^{+}, respectively. Regarding anions abundance in water of FW, ADW, SW and IDW was SO_4^{-2} > Cl^{-} > HCO_3^{-} > CO_3^{-} , respectively.

Data recorded in Table 4 show that pH of water sources was not significantly changed after treatment with MSE. "The main use of pH in a water analysis is for detecting abnormal waters. The normal pH range for irrigation water is from 6.5 to 8.5" **(WHO, 2006)**. An abnormal value is a warning that the water needs further evaluation. Irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion (**FAO, 2014).** This result agreed with the findings of **Abdel-Fattah and Helmy (2015); Al-Hamid *et al.*, 2017; Amagloh and Benang 2009; Arnoldsson *et al.*, 2008).**

Role of Moringa Seed Extract on Water Quality Parameters

Table 5 shows soluble sodium percentage (SSP), sodium adsorption ratio (SAR), sodium to calcium activity ratio (SCAR), residual sodium carbonate (RSC), residual sodium bicarbonate (RSBC), permeability index (PI), potential salinity (PS), Kelly ratio (KR) and magnesium adsorption ratio (MAR) in water sources as affected by MSE. The lowest values of SSP, SAR, SCAR, RSC, RSBC, PI, PS, KR and MAR were observed in FW followed by IDW, SW and ADW after treated with MSE. The classification of water i.e. ADW, SW and IDW indicates that all water source have waters of high salinity-low sodicity (C4S1) before treated with MSE, and moderate low sodicity (C3S1) after treated with MSE according to **USDA (1954)** classification which could used safely for irrigation purposes since RSC values are less than 1.25.

According to classification of **Gupta (1990)** , waters of different sources is considered non-alkaline water, could be used on almost all soils for all crops for indefinitely long periods without any problem. Different water sources are of good quality for irrigation purposes since PI values are lower than 75, except ADW. The PI ranges from 42.3% to 85.25%, which comes under class -I of Doneen’s chart. The PS values water samples in the study area were 1.59 , 17.25, 11.0 and 8.76 $mmol_c$ /L for FW, ADW, SW and IDW ،respectively after treated with MSE. Therefore, the tested water falls under recommended permissible. According to the classification of KI, waters in different sources have KI of < 1.0; therefore, they could be used for irrigation except ADW. MAR values were 6, 73, 34. 2, 27.15 and 97.43 for FW, ADW, SW and IDW, respectively after treated with MSE, respectively. Therefore, the water is suitable for use in irrigation since the values are <50 in waters of the three agricultural drainage s. This result agreed with the findings of (**El Sohaimy *et al.*, 2015; Tantawy *et al.*, 2015 and Hendrawati *et al.*, 2016 and Merwad, 2019).**

Table 4. Effect of moringa seed extract on chemical composition of water sources

Factor of study		EC	pH	Cations, mmolc l^{-1}				Anions, mmolc l^{-1}			
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
Effect of water source (a)											
FW		0.39d	7.66ab	1.43	1.08d	0.72d	0.72c	0.00	1.63d	0.86d	1.45d
ADW		3.29a	7.73a	4.54	4.56c	22.74a	0.67d	0.00	10.62a	12.60a	9.29c
SW		2.21b	7.63c	6.06	5.39a	9.10 b	0.96a	0.00	5.15 b	5.64b	10.72a
IDW		1.75c	7.21d	5.99b	5.0 ab	5.11c	0.85b	0.00	3.19c	3.70c	10.12ab
Effect of MSE (b)											
With out		2.74a	7.51a	6.26a	5.48a	8.41a	0.99a	0.00	7.68a	8.09a	11.22a
With		1.07b	7.63b	2.74b	2.56b	4.57b	0.60b	0.00	2.61b	3.31b	4.56b
Effect of Interaction (a*b)											
FW	With out	0.59g	7.77b	2.10g	1.76f	1.16g	0.98c	0.00	2.56e	1.01g	2.39g
	With	0.19h	7.63d	0.76h	0.40g	0.28h	0.46g	0.0	0.69h	0.71h	0.50h
ADW	With out	4.63a	7.87a	5.45c	5.18c	34.59a	0.78d	0.00	15.70a	17.54a	12.76c
	With	1.94d	7.68c	3.62d	3.94d	10.89c	0.55f	0.00	5.53c	7.65c	5.82e
SW	With out	3.17b	7.65d	8.63b	7.90a	13.29b	1.18a	0.00	7.92b	8.54b	14.54b
	With	1.25e	7.60f	3.48e	2.87e	4.91e	0.74d	0.00	2.37f	2.73e	6.90d
IDW	With out	2.58c	7.60f	8.87a	7.09b	8.01d	1.03b	0.0	4.54d	5.26d	15.20a
	With	0.91f	7.55g	3.11f	3.03e	2.20f	0.66e	0.00	1.83g	2.14f	5.03f

Note: FW= Freshwater**, ADW=** Agricultural drainage water**, SW=** Sewage water**, IDW=** Industria drainage water, MSE= Moringa seed extract

Table 5. Effect of moringa seed extract on water quality parameters

Factor of study		SSP	SAR	SCAR	RSC	RSBC	PI	PS	KI	MAR	USSL Index
Effect of water source (a)											
FW		17.04d	0.60d	0.56d	-0.89d	0.20b	61.61b	1.59d	0.29d	18.03d	C2S1
ADW		66.26a	10.30a	10.27a	1.22 a	6.08 a	81.63a	17.25a	2.50a	45.92 c	C4S2
SW		41.89b	3.69b	3.58b	-6.30b	-0.91d	55.28c	11.00b	0.79b	48.47b	C3S1
IDW		28.24c	2.05c	1.97c	-7.87c	-2.81c	42.64d	8.76c	0.46c	84.47a	C3S1
Effect of MSE (b)											
With out		42.36a	5.82a	5.71a	-4.07b	1.42a	55.48b	13.70a	0.72b	62.13b	C4S1
With		34.35b	2.50b	2.48 b	-2.70a	-0.14b	62.61a	5.59b	0.86a	93.43a	C2S1
Effect of Interaction (a*b)											
FW	**With out**	19.33g	0.83g	0.80f	-1.30c	0.46c	54.98e	2.21g	0.30g	70.40b	C2S1
	With	14.74h	0.37h	0.32g	-0.47b	-0.07d	74.08b	0.96h	0.24g	6.73h	C1S1
ADW	**With out**	75.20a	15.00a	14.82a	5.07a	10.25a	85.25a	23.92a	3.25a	55.17e	C4S2
	With	57.32b	5.60b	5.72 b	-2.03d	1.91 b	71.76c	10.56d	1.44b	34.20f	C3S1
SW	**With out**	42.87c	4.62c	4.52c	-8.61g	-0.71e	53.99f	15.81b	0.80c	68.70c	C4S1
	With	40.92d	2.76e	2.63d	-3.98e	-1.11f	58.26d	6.18e	0.77d	27.15g	C3S1
IDW	**With out**	32.04e	2.84d	2.69d	-11.42h	-4.33h	42.30g	12.86c	0.50e	59.58d	C4S1
	With	24.44f	1.26f	1.25e	-4.31f	-1.28g	42.57g	4.66f	0.36f	97.43a	C3S1

Note: FW= Fresh water**, DW=** Agricultural drainage water**, SW=** Sewage water**, IW=** Industrial drainage water, MSE= Moringa seed extract**,** SSP = Soluble sodium percentage, SAR = Sodium Adsorption Ratio, SCAR = Sodium to Calcium Activity Ratio, RSC = Residual Sodium Carbonate, RSBC = Residual Sodium Bicarbonate, PI = Permeability Index, PS = Potential Salinity, KR = Kelly Ratio and MAR = Magnesium Adsorption Ratio.

Role of Moringa Seed Extract on Dissolved Oxygen, Biological and Chemical Oxygen Demand, NO_3-N and Heavy Metals Remove

Table 6 shows turbidity, NO_3-N, BOD, COD, DO, concentration of B, Fe, Zn, Cu, Mn, Pb, Ni and Cd in water sources as affected by MSE. MSE coagulant has better coagulation capability to reduce water turbidity compared with untreated water that was able to reduce turbidity by 70.8, 81.0, 82.9 and 81.4% in FW, ADW, SW and IDW, respectively. Turbidity in the water is caused by suspended solids, both organic and inorganic substances. Inorganic substances include crack of rock, sand, mud, and dissolved metals. Organic matters originating from domestic and industrial waste could serve as good environment for bacteria to grow. Besides microorganisms, algae and plankton can also cause cloudiness in the water **(WHO, 2006)**.

From the data presented in Table 6 results showed that the application of MSE gave lower values of NO_3-N, B, metals i*.e.*, Fe, Zn, Cu, Mn, Pb, Ni and Cd in FW, ADW, SW and IDW than those water untreated. These decreases represent 26,29, 48, 38, 25, 37, 0, 0 and 0 % for FW, respectively ; 62, 45, 51, 57, 57, 48, 55, 35, and 61% for ADW, respectively; 58, 44, 60, 55, 57, 55, 60, 75 and 83%, respectively for SW and 59, 32, 54, 52, 52, 51, 62, 74 and 81%, respectively for IDW. Thus, these findings agreed with what was deduced by **Subramanium *et al.* (2011).** High levels of heavy metals are typically associated with severe health effects (**Meneghel *et al.*, 2013; Vikashni *et al.*, 2012).** MO seed cake acts as natural adsorbent to remove the heavy metals from water samples. MSE reduced 98.6% turbidity of wastewater, 10.8% of its conductivity, 11.7% of its BOD and removed its metal contents (Cd, Cr, Mn). When applied to Industrial water, MSE removed the turbidity of Industrial water as much as 97.5%, while reduced the conductivity and BOD of Industrial water 53.4% and 18%, respectively (**Hendrawati *et al.*, 2016; Maina *et al.*, 2016).** In this study, the increasing MSE concentration showed high efficiency in the removal of the heavy metals from the ‘‘Sungai baluk’’ river samples. **Subramanium *et al.* (2011)** reported that MO seed cake has been able to remove copper (Cu) up to 90%. The concentration of Cu after the treatment was in the range of the standard drinking water. Obviously, more than 90% of Cd was removed. The result was similar with what was found by **Meneghel *et al.* (2013).** However, **Vikashni *et al.* (2012)** confirmed that only 60% of Cd could be remove by using MSE. The level of Fe was fully removed by MSE. This result totally agreed with what was concluded by **Sajidu e*t al.* (2005)**. Regarding Pb level, although MSE showed some reduction of Pb in the treated water, the result was not good enough to meet the drinking water standards (**WHO, 2006) .** Pb has been reduced up to 0.537 mg/L; however, this value was considered higher than the acceptable concentration of Pb which should be less than 0.05 mg/L. The percentage of the removed Pb at our study was 70%, whereas it had been 89 and 80%, respectively in the studies carried out by **Subramanium *et al.* (2011).**

Impact of Vareious Water Sources Treated With Moringa Seed Extract on Yield and Npk-Uptake of Lettuce Plants

Data presented in Table 7 show that plant height, chlorophyll a, b, carotenoids, fresh and dry weight, N, P and K- uptake of lettuce plants were clearly affected by the interaction between the different water sources and MSE. The highest values were observed at the treatment of sewage water in the presence of MSE, while the lowest one were obtained with agricultural drainage water in absences of MSE . Fresh and dry weight yield of lettuce plants ranged from 431 to 688 and 25.5 to 109 g plant^{-1}, respectively. These results are agreement with those obtained by **Munirat *et al.* (2016).** The beneficial effects of sewage water application may be due to the greater capacity of sewage to supply nutrients to the plant and to improve soil properties. These nutrients may activate the hydrolytic enzymes during planting, which in turn increase the amount of hydrolyzeates e.g. glucose and amino acids, which are required for growth of embryo axes (**Sulaiman *et al.*, 2017).**

Results showed that application of MSE to different water sources increased fresh and dry weight, N, P and K- uptake of lettuce plants compared to the untreated waters. These increases represent 4, 14, 16, 19.8 and 13.4% for FW, respectively; 10, 33, 19, 24 and 17% for ADW, respectively; 11, 26, 34, 27 and 27%, respectively

Table 6. Impact of moringa seed extract on turbidity, NO_3-N, BOD, COD, DO and remove heavy metals

Factor of study		Turbidity (NTU)	Mg L^{-1}											
			BOD	**COD**	**DO**	**NO_3-N**	**B**	**Fe**	**Zn**	**Cu**	**Mn**	**Pb**	**Cd**	**Ni**
Effect of water source (a)														
FW		9.63d	18.02d	107.73 d	6.05 d	4.13 d	0.46 d	17.46d	1.12 d	0.85d	8.50 d	0.00	0.00	0.00
ADW		86.67c	48.94c	236.73 c	8.72 c	22.00 c	1.35c	33.74c	1.57c	1.47c	12.07c	0.99c	0.62c	0.60c
SW		100 b	55.18b	274 b	9.91b	27.90b	1.80b	41.52b	1.64ba	1.58b	13.33b	1.44b	1.02b	0.83b
IDW		177.07a	99.87a	313	11.50a	29.59 a	2.46 a	53.92a	1.70	1.65a	16.48a	3.45a	2.47a	1.99a
Effect of MSE (b)														
With out		144a	111a	332a	12.48a	29.84a	2.62a	62.39a	2.16a	2.06a	19.76a	3.83a	2.81a	2.17a
With		26.21b	20.64b	130b	7.84b	12.41b	1.60b	28.12b	1.03b	0.99b	9.82b	1.51b	0.84b	0.45b
Effect of Interaction (a*b)														
FW	With out	14.92f	25.78f	125f	7.45e	4.75f	0.54g	23.07f	1.38d	0.97f	10.48e	0.00	0.00	0.00
	With	4.34g	10.25g	90.45g	4.64g	3.51g	0.38g	11.84g	0.85g	0.72g	6.52g	0.00	0.00	0.00
ADW	With out	169b	87.63c	383b	12.8c	40.49b	2.31d	55.63c	2.29c	2.21c	17.62c	1.98e	1.23d	1.19c
	With	32.13e	22.73f	165d	7.02f	15.3d	1.28f	27.41f	0.99g	0.94f	9.04f	0.89f	0.80f	0.47e
SW	With out	322a	177a	461a	15.98a	43.87a	3.64b	80.43b	2.40b	2.36b	23.91b	6.01b	4.14b	3.50b
	With	55.07d	33.62d	140e	11.32d	18.35d	2.03e	32.48e	1.07f	1.02e	10.75e	2.43d	1.04e	0.58e
IDW	With out	70.12c	155b	357c	13.7b	30.23c	3.98a	90.45a	2.56a	2.69a	27.04a	7.34a	5.87a	3.98a
	With	13.28f	16.02e	127f	8.39e	12.46e	2.69c	40.76d	1.22e	1.29d	12.98d	2.73c	1.51c	0.76d

Note: FW= Fresh water**, DW=** Agricultural drainage water**, SW=** Sewage water**, IW=** Industrial **drainage** water, MSE= Moringa seed extract, BOD= Biological Oxygen Demand, COD= Chemical Oxygen Demand, DO= Dissolved Oxygen

Table 7. Impact of different water sources as affected by moringa seed extract on yield and NPK-uptake of lettuce plants

Factor of study		Plant height (cm)	Fresh weight g $plant^{-1}$	Dry weight g $plant^{-1}$	Nutrient uptake (mg $plant^{-1}$)		
					N	P	K
Effect of water source (a)							
FW		25.50b	577b	74.21b	1632b	312b	1433b
ADW		13.17d	453d	29.77d	558d	78.7d	506d
SW		31.18a	652a	97.67a	2542a	477a	2225a
IDW		19.50c	505c	56.31c	896c	108c	879c
Effect of MSE (b)							
With out		20.58b	526 b	57.60 b	1174 b	195 b	1066 b
With		24.08a	568a	71.37a	1640a	293a	1455a
Effect of Interaction (a*b)							
FW	With out	24.67c	566d	69.23d	1435d	270c	1287d
	With	26.34c	589c	79.19c	1829c	355b	1578c
ADW	With out	11.33g	431g	25.50h	448g	60.67f	415h
	With	15.02f	475f	34.04g	667f	96.33e	598g
SW	With out	29.33b	616b	86.34b	2051b	374b	1825b
	With	33.01a	688a	109a	3034a	581a	2626a
IDW	With out	17.03e	490f	49.35f	764f	77.67ef	739f
	With	22.02d	521e	63.26e	1028e	139d	1018e

See footnote of Table 4

for SW and 6, 28, 21, 49 and 19%, respectively for IDW. These results are in agreement with those of **(Elgharably and Mohamed 2016; Sulaiman *et al.*, 2017; Hassanein *et al.*, 2017; Merwad, 2019).** The positive effects of irrigation with sewage water might be due to the increase in the nutrients of the soil under sewage water irrigation. These nutrients may improve the physical and nutrient contents of the soil, hence significantly increased the total chlorophyll and carotene and established good growth and increased biomass and yield of the crop. This justification is supported by many in dependent studies **(Senyigit *et al.*, 2011 and Zavadil, 2009).**

Impact of Vareious Water Sources Treated With Moringa Seed Extract on Heavy Metals Accumulation of Lettuce Plants

Data presented in Table 8 show that vareious water sources treated with MSE significantly decreased in heavy metals content of lettuce plants as compared to untreated water. This finding stands in agreement with those of (**Elgharably *et al.*, 2014; Sulaiman *et al.*, 2017; Merwad, 2019).** Regarding the impact of vareious water sources, data obtainted that the addition of water sources to soil *i.e.* ADW, SW and IDW gave the highest content of heavy metals of lettuce plants compared to freshwater. Main effect of water sources are as follows SW > ADW > IDW> FW. The highest levels of Pb, Cd, Ni, Fe, Cu, Zn and Mn uptake of lettuce plants were observed with application of industrial water without MSE (0.95, 0.58, 1.67, 95.7, 5.2, 45.7, and 40.5 mg plant^{-1}, respectively, while the lowest one (0.01, 0.0, 0.01, 25, 0.68, 7.8 and 6.8 mg plant^{-1}, were found under irrigated with freshwater in the presence of MSE. From statistical analysis, results showed that application of MSE to vareious water sources gave significant decrease in Pb, Cd, Ni, Fe, Cu, Zn and Mn accumulation of lettuce plants compared to untreated water. These decreases represent 50, 100, 50, 31, 26,7 and 55%, respectively for FW; 62, 83, 76, 42, 53, 48 and 63, respectively for ADW; 78, 75, 85, 35. 56, 57 and 61, respectively for SW and, 81, 79, 89, 39, 64, 64 and 60%, respectively for IDW. With industrial wastewater irrigation concentrations of Fe, Mn, Zn and Cu in all crops are optimal for wheat, bean and onion growth, but that of Cd and Pb were high (**Munirat *et al.*, 2016; Elgharably *et al.*, 2014; Sulaiman *et al.*, 2017).**

The plants grown on the soil irrigated with industrial wastewater contained higher concentrations of heavy metals than that grown in soils irrigated with freshwater. The use of industrial wastewater in crop irrigation at the all 6 sites increased the uptake and accumulations of heavy metals in the plants. The concentrations observed in this study were higher than those reported by other workers **Abdellah (1995), Adhikari *et al*. (2004) and Kawatra and Bakhetia (2008)** who have examined vegetation from heavy-metals contaminated sites. Concentrations of Fe, Mn, Zn and Cu in the studied crops are within the acceptable limits for plant growth as freshas consumption by humans and animals. Data obtained reveal that in the IW-irrigated soils, all crops contained concentrations of heavy metals above the permissible levels for consumption by humans, or animals (**Ahme and Al-Hajri, 2009; Merwad, 2019).**

Impact of Vareious Water Sources Treated with Moringa Seed Extract on Accumulation of Heavy Metals in Soil

Results presented in Table 9 show that the soil irrigated with vareious water sources *i.e.* agricultural drainage water , sewage water and industrial water without MSE contained higher values of heavy metals than that soil irrigated with FW. This finding stands in agreement with those of **Abdel Salam (2002) and Merwad (2019).** The contennt of Fe, Mn, Zn, Cu, Pb, Cd and Ni are present at high values in the soils irrigated with sewage water comparted to that irrigated with Industrial water **(Lghobar *et al.*, 2014).** Data showed that the soil irrigated with agricultural drainage, sewage water and industrial water gave higher levels of accumulation heavy metals compared to soil irrigated with fresh water. Main effect of water sources are as follows IDW> SW > ADW > FW. The higher values of accumulation Pb, Cd, Ni, Fe, Cu, Zn and Mn in soil were obtained with addition of industrial water in the apsent of MSE (2.27, 1.24, 1.94, 2073, 3.06, 79.63 and 736 mg kg^{-1}, respectively, while the lowest value (0.08, 0.03, 0.11, 835, 0.48, 10.6 and 82 mg kg^{-1}, were found under irrigated with fresh water in the presence

Table 8. Impact of different water sources as affected by moringa seed extract on heavy metals accumulation of lettuce plants

Factor of study		Pb	Cd	Ni	Fe	Cu	Zn	Mn
Effect of water source (a)								
FW		0.006d	0.01d	0.02d	16.86d	0.62c	6.18d	6.39d
ADW		0.054c	0.04c	0.11c	31.06c	0.80c	7.72c	11.07c
SW		0.444b	0.28b	0.66b	59.70b	2.73b	22.56b	17.62b
IDW		0.564a	0.35a	0.93a	76.97a	3.52a	31.08a	28.42a
Effect of MSE (b)								
With out		0.442a	0.28a	0.75a	56.68a	2.69a	23.40a	22.69a
With		0.092b	0.06b	0.10b	35.61b	1.14b	10.37b	9.06b
Effect of Interaction (a*b)								
FW	With out	0.005d	0.017e	0.02d	36.76e	0.92d	8.02de	15.31cd
	With	0.008d	0.005e	0.01d	25.36f	0.68de	7.41de	6.83ef
ADW	With out	0.081cd	0.06de	0.17c	21.44fg	0.84d	8.14d	9.38def
	With	0.027d	0.014e	0.04d	12.27g	0.39e	4.21e	3.39f
SW	With out	0.727 b	0.45b	1.15b	72.73b	3.81b	31.71b	25.52b
	With	0.175c	0.11cd	0.17c	46.67d	1.65c	13.41c	9.71de
	With out	0.953a	0.58a	1.67a	95.79a	5.18 a	45.71a	40.54a
IDW	With	0.162c	0.12c	0.18c	58.14c	1.85c	16.44c	16.30c

See footnote of Table 4

Table 9. Impact of different water sources as affected by moringa seed extract on accumulation of heavy metals in soil after harvesting

Factor of study		Pb	cd	Ni	Fe	Cu	Zn	Mn
Effect of water source (a)								
FW		0.13d	0.05d	0.17d	1188d	0.62d	12.57d	120d
ADW		0.94c	0.40c	0.37c	1914c	1.01c	30.62c	242c
SW		1.25b	0.67b	1.08b	2151b	1.89b	36.93b	415b
IDW		1.56a	0.84a	1.33a	3123a	2.36a	53.72a	477a
Effect of MSE (b)								
With out		1.40a	0.72a	1.09a	2386a	1.96a	47.65a	463a
With		0.54b	0.27b	0.39b	1802b	0.99b	19.26b	164b
Effect of Interaction (a*b)								
FW	With out	0.18g	0.07g	0.23d	1540e	0.76f	14.52g	158e
	With	0.08g	0.03g	0.11e	835f	0.48g	10.61h	82.20f
ADW	With out	1.33c	0.57c	0.63c	2312bc	1.29d	44.43c	324c
	With	0.55f	0.24f	0.11e	1991cde	0.74f	16.80f	160e
SW	With out	1.81b	0.98b	1.55b	2073cd	2.71b	52.03b	635b
	With	0.69e	0.37e	0.61c	1754d	1.06e	21.83e	195de
IDW	With out	2.27a	1.24a	1.94a	3618a	3.06a	79.63a	736a
	With	0.84d	0.43d	0.72c	2627b	1.66c	27.80d	218d

See footnote of Table 4

of MSE. The soil irrigated with wastewater had the highest accumulation of heavy metals *i.e.*, Fe, Hg ،Cd, Pb, Cu, Cr, Zn, Ni and Mn as a result of some industrial activities **(Liang *et al.*, 2014; Sulaiman *et al.*, 2017).** From statistical analysis, results showed that the soil irrigated with vareious water sources with MSE gave significant decrease in accumulation of Pb, Cd, Ni, Fe, Cu, Zn and Mn compared to the soil irrigated with vareious water sources in the apesent of MSE. These decreases represent 55, 57, 52, 46,36, 27 and 48%, respectively for FW; 59, 58, 82, 14, 43, 62 and 51, respectively for ADW ; 61, 62, 61, 27, 27, 60, 58 and 69, respectively for SW and, 62, 65,62 15, 45, 65 and 70%, respectively for IDW. This finding stands in agreement with those of **Bhatia *et al.* (2007), Galal (2015), Asongwe and Yerima (2016) and Hassanein *et al*. (2017).**

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دورمستخلص بذور المورينجا فى تقليل تلوث التربة والماء باستخدام نباتات الخس كدليل

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أجريت تجربة أصص على نبات الخس فى موسم زراعة 2021م لدراسة تأثير مصادر مياه مختلفة وهى المياه العذبة (FW)، الصرف الزراعى (ADW) ، والصرف الصحي (SW) والصرف الصناعي (IDW) مع أو بدون مستخلص بذور المورينجا (MSE) في إزاله تلوث المياه والتربة وتأثيره على محصول ومحتوى المعادن الثقيلة بنباتات الخس. أظهرت النتائج أن أدنى قيم SSP و SAR و SCAR و RSC و RSBC و PI و PS و KR و MAR لوحظت في المياه العذبة تليها مياه الصرف الصناعى والصحى ثم الصرف الزراعى بعد المعالجة بمستخلص بذور المورينجا. يشير تصنيف المياه بجميع المصادر ماعدا المياه العذبة بأنها عالية الملوحة - منخفضة الصودية (C3S1) قبل المعالجة وذات ملوحة متوسطة ونسبة صوديوم منخفضة (C2S1)بعد المعالجة بمستخلص بذور المورينجا. وجد أن مستخلص بذور المورينجا له القدرة على تقليل تعكر الماء وخفض تركيز النترات والأكسجين الذائب فى الماء وتركيز العناصر الثقيلة مقارنة بالمياه غير المعالجة. معالجة جميع مصادر المياه بمستخلص بذور المورينجا أدى لزيادة الوزن الطازج والجاف وتركيز النيتروجين والفوسفور والبوتاسيوم الممتص بواسطة نباتات الخس. أدت إضافة مستخلص بذور المورينجا إلى مصادر المياه المختلفة إلى انخفاض معنوي في امتصاص نباتات الخس للرصاص ، الكادميوم ، النيكل ، الحديد ، النحاس ، الزنك ، والمنجنيز مقارنة بالمياه غير المعالجة وكذلك فى التربة.

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