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Ecological performance of *Ludwigia stolonifera* (Guill . & Perr.) P.H. Raven under different pollution loads

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ABSTRACT

This study was conducted to assess the ecological performance of the aquatic macrophyte *Ludwigia stolonifera* (Guill . Perr.) P.H., family Onagraceae in three water habitats under different pollution loads. This emergent hydrophyte can grow and tolerate a wide range of habitats with different pollution levels (ecological plasticity) and produces high biomass (458g.dry wt. /m^2) in autumn at site C and (400 g. dry wt. /m^2) at site A, this indicated the survival in autumn across the year, while the lowest biomass was produced in winter season at site A (180 g. dry wt. /m^2). The plant can absorb and accumulate heavy metals in its tissues with high concentrations, especially in spring and so it could be taken as a good bioindicator for pollution and used in bioremoval of heavy metals from polluted water.

INTRODUCTION

Increasing developments of industrial activities near coastal areas have caused more concerns regarding risks to human health resulting of environmental pollution (Shreadah *et al.*, 2006; Younis & Nafea 2012; Younis *et al.*, 2014; El Zokm *et al.*, 2015; Okbah *et al.*, 2015; Younis *et al.*; 2016; Soliman *et al.*, 2018; Younis, 2018; Amin *et al.*, 2018). Aquatic pollution has globally received tremendous attention due to its toxicity, abundance, persistence and consequent accumulation (Younis *et al.*, 2015; Soliman *et al.*, 2019; El-Naggar *et al.*,2019; Saleh *et al.*,2019).

The genus *Ludwigia (*L.) is represented by two species, *L. stolonifera* (Guill. & Perr.) P.H. Raven and *L. erecta* (L.) Hara. *L. stolonifera* became one of the dominant aquatic macrophytes in water canals and drains (Tackholm,:1974; Boulus,: 2000, 2002& 2009 & Hamed, 2016). Meanwhile, *L. erecta* is very rare in Nile Valley and canal banks (Tackholmi,1974; Boulos, 2000). *L. stolonifera* belongs to sect. *Jussiaea* (L.) Hoch, W.L. Wagner & P.H. Raven comb. nov., which is characterized by a cosmopolitan distribution and polyploidy. The plant is rooted in sediments on the canal banks as it can be called emergent hydrophytes and the shoot system can creep across the water surface in fresh and drainage water body as well as the waste polluted water formed dense growth of plant biomass .

Lodwegia stolonifera can be used for water bioremediation and purification from many pollutants leading to improve quality of drinking water (Larson, 1999); its roots and shoots could be used also as biofilters for heavy metals (Elifantz & Tel-or 2002). Many pharmacologists reported the clinical uses of *L. stolonifera,:* as hepatoprotective, anti-inflammatory, antidiabetic, antibacterial and fibrinolytic; its aerial parts are composed of metabolites including rutin, kaempferol, quercetin, terpenes and triterpenes. (Firoj *et al*., 2005; Barik & Banerjee, 2003; Ghani, 2003).The hydrophytes have great affinity towards the improve water quality of polluted areas (Abd El-Rasheed,: 2011; Dandelot *et al*., 2005).

The plant was found in many habitats in Egypt whether it's in fresh water or brackish, salt affected wetlands and even in marine drains habitats according to its environmental plasticity (Amer *et al.*, 2016) .The plant has genetic plasticity and different genetic structure in different habitats with different range of salinities. The karyotype features and molecular diversity between the seven *L. stolonifera* morphotypes collected from different habitats of Egypt may reflect the influence of habitat on genetic diversity of *L. stolonifera* morphotypes and explain the expansion of *L. stolonifera* in Egyptian habitats and the interspecific plasticity is genetically depend on the environmental variables (Khalifa *et al*., 2017).

The major concern of this study is to assess the ecological performances of *L. stolonifera* in three water habitats under different pollution loads and evaluate the uses of this plant in bioremediation and pollution control.

MATERIALS AND METHODS

The present study was carried at three Governorate namely EL Dakahlia. Damietta and Kafr EL-sheikh, where regular visits to the different water bodies in the studied areas were done and three types of water bodies were selected, namely, El Mansoura large irrigation canal in El-Dakahlia, Elanania canal large irrigation and drainage canal in Damietta and Kotskiener large drainage canal in Kafr elshiekh (Figure 1).

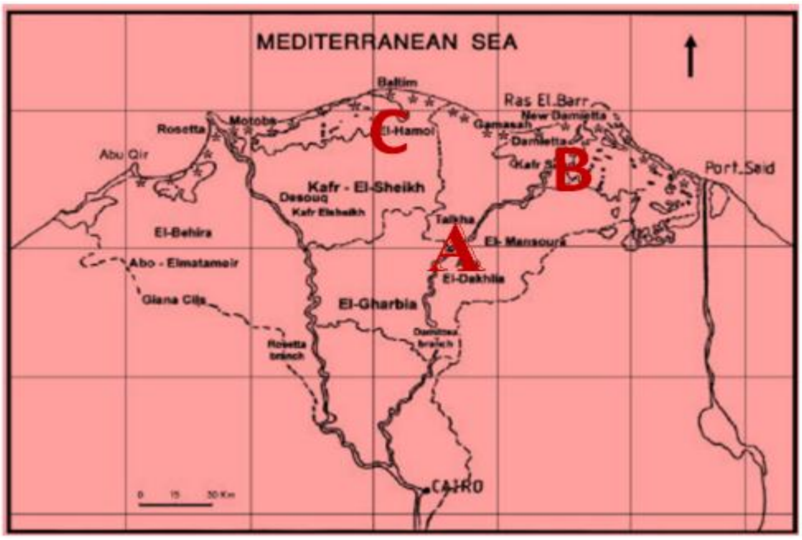


Fig. 1: Map showng the study area, A Mansoura, B Damietta and C kafr sheik

15 sampled stands were selected in each site of the study area representing the various water bodies. In each stand, all plants species were recorded in five plots area (25 m2 each). The identification and nomenclature of the recorded species were according to (Täckholm,:1974; Boulos, 1999, 2000, 2002&2009). The presence absence estimates were detected for the recorded plant species in the studied localities. The water, soil and plant (Root and shoot) samples were collected from 15

stations in each habitat for salinity , heavy metals and biomass determination in the four seasons of the year according to (APA,1998, 1999).

RESULTS AND DISCUSSION

Vegetation

74 seventy four species belonging to: 57 genera and 25 families were recorded. Among them 39 annuals, 2 biennales and 33 perennials (Table 1). The Large drainage canal site C at Kafr Elsheikh showed the richest habitat in species number (70 species), while large irrigation canal site A at Mansoura recorded the lowest species number (42 species) habitat. It was observed that 2 species were recorded only in the site A while one species recorded at site B and 7 species were recorded only in site C, this variation of species distribution may be :attributed to the variation in environmental variables like salinity where the salinity differences between habitats varied greatly as it was higher at sites: B and C than site A .Also it was found that 24 species were recorded in site B and C only and this may be due to the similar environmental variables like salinity levels in both sites, Fig. (2).

Table 1: The presence absence estimates (P %) of the vegetation of the study area A=Mansoura irrigation canal B=Damietta canal C= Kafr elsheik drainage canal

Family	Species	Life span	studied sites			P%
			A	B	C	
Amaranthaceae	*Amaranthus graezicans* L.	Ann	+	+	+	100
	Amaranthus hybridus L.	Ann	-	+	+	66
	Amaranthus lividus L.	Ann	+	+	+	100
Asclepiadaceous	*Cynanchum acutum* L.	Per	-	+	+	66
Chenopodiaceae	*Bassia indica* (Weight)A.J.Scott.	Ann	-	+	+	66
	Suaeda vera Forssk .J.F.Gmel	Per	-	-	+	33
	Suaeda pruinosa Lang.	Per	-	-	+	33
	Chenopodium album L.	Ann	+	+	+	100
	Chenopodium murale L.	Ann	+	+	+	100
	Chenopodium ambrosoides L.	Bie	-	+	+	66
	Beta vulgaris L.	Ann	+	+	+	100
Asteraceae	*Urospermum picroides*(L.)F.W.Schmidt	Ann	-	-	+	33
	Senecio vulgaris L.	Ann	-	+	+	66
	Senecio gluaca L.	Ann	-	+	+	66
	Sonchus oleraceus L.	Ann	+	+	+	100
	Silybum marianum L	Ann	-	-	+	33
	Cichorium endivia L.	Ann	+	+	+	100
	Conyza aegyptiaca (L.)Dyand	Ann	-	+	+	66
	Pluchea dioscoroides(L.)DC.	Per	+	+	+	100
Convolvulaceae	*Convolvulus arvensis* L.	Per	+	+	+	100
	Cressa cretica L.	Per	-	+	+	66
Brassicaceae	*Brassica tournifortii* Gouam	Ann	-	+	+	66
	Brassica rapa L.	Ann	-	+	+	66
	Sisymbrium irio (L.Gaertin	Ann	-	+	+	66
	Capssella bursa-pastoris (L.)Medik	Ann	+	-	+	66
	Cronopus didymus (L.)Sm.	Ann	+	-	+	66
	Cyperus alopecuroides L.	per	+	+	+	100
	Cyperus laevigatus L.	Per	-	-	+	33
Cyperaceae	*Cyperus rotundus* L.	Per	+	+	+	100
	Euphorbia peplus L.	Ann	+	+	+	100
Euphorbiacea	*Euphorbia prostrata* Aiton.	Ann	+	+	+	100
	Avena fatua L.	Ann	+	+	+	100
	Cynodon dactylon(L.)Pers	Per	+	+	+	100
	Echinocloa colona (L.) Link.	Ann	+	-	+	66
	Echinocloa stagnina L.	per	-	+	+	66
	Denibera retroflexa (Vahl.)Panz..	Ann	-	+	+	66
	Phragmites australis(Cav.).Trin.Steud.	Per	+	+	+	100
	Lolium perenne L.	Per	-	+	+	66
	Phalaris minor Retz	Ann	+	+	-	66

	Setaria verticillata (L)P.Beauv..	Ann	+	-	+	66
	Imperata cylindrical L.	Per	-	+	+	66
	Hordeum vulgare L.	Ann	-	+	+	66
	Hordeum marinum L.	Ann	-	+	+	66
Poaceae	*Setaria viridis*(L.)Beauv.	Ann	-	+	+	66
	Arundo donax L.	Per	+	+	+	100
	Polypogon monspeliensis L.	Ann	+	+	+	100
Fabaceae	*Alhagi graecorum* Bioss.	Per	-	-	+	33
	Medicago polymorpha L.	Ann	+	+	+	100
	Medicago hispida L.	Ann	-	+	+	66
	Medicago sativa L.	Ann	-	+	+	66
	Melilotus indicus L.	Ann	+	+	+	100
	Sesbania sesban L.	per	-	+	+	66
Malvaceae	*Malva parviflora* L.	Ann	+	+	+	100
	Sida alba L.	Bie	+	+	+	100
Plantaginaceae	*Plantago major* L.	Per	+	+	+	100
Polygonaceae	*Rumex dentatus L.*	Ann	+	+	+	100
	Persicaria salicifolia L.	per	+	+	+	100
	Polygonum equisetiforme Sm.	Per	-	+	+	66
Portulacaceae	*Portulaca oleracea L.*	Ann	+	+	+	100
Pontadariaceae	*Eichhornia crassipes*	per	+	+	+	100
Ceratophyllaceae	*Ceratophyllum demersum*	per	+	+	+	100
Araceae	*Pistia stratiotes L.*	per	-	+	-	33
Azollaceae	*Azolla filiculoides*	Ann	-	+	+	66
Lamiaceae	*Mentha longifolia L.*	per.	+	-	+	66
Lemnaceae	*Lemna gibba L.*	per	-	+	+	66
Haloragaceae	*Myriophyllum spicatum L.*	per.	+	+	+	100
Onagraceae	*Ludwegia stolonifera L. CAV.*	per	+	+	+	100
Typhaceae	*Typha domingensis L.*	per	+	+	+	100
Solanaceae	*Solanum nigrum* L.	Ann	+	+	+	100
	Ipomea carnea L.	per	+	+	+	100
	Wathania somonifera(L) Dunal.	per	+	-	+	66
Potamogetonaceae	*Potamogeton pectinatus L.*	per	+	+	+	100
	Potamogeton nodosus Poir.	per	+	-	-	33
	Potamogeton crispus	per	+	-	-	33
Total	74 species	74				

Water and soil salinity

The mean water and soil salinty of the studied habitats were represented in Figs. (2&3), indicate that is a clear differences between sites A,B and C in water and soil salinities ,where sites B and C are closely related to each other in salinity values. High salinity values were recorded in summer season in all sites and the lower salinities levels recorded in winter season.

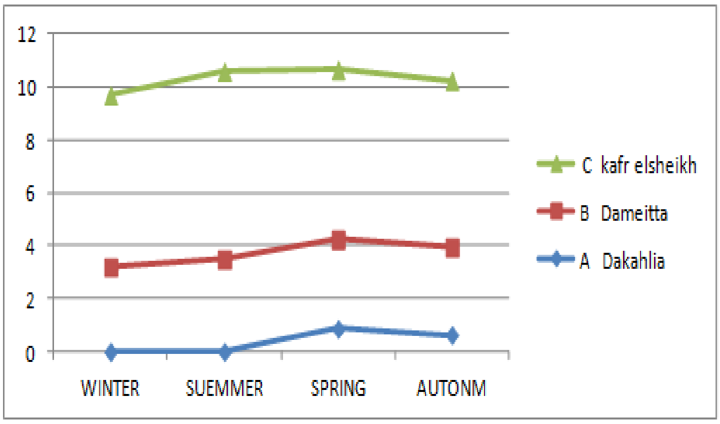


Fig. 2: The mean seasonal variation in water salinity in the studied habitats.

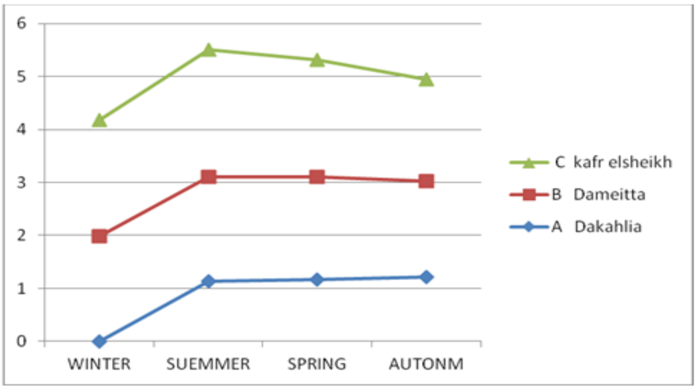
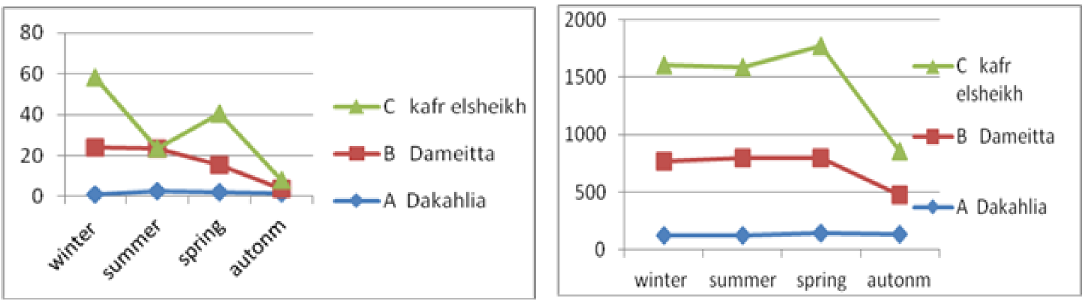


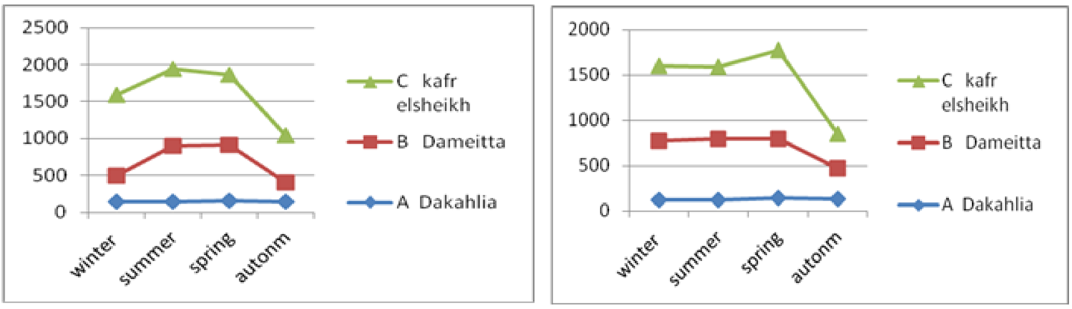
Fig. 3: The mean seasonal variation in soil salinity at the studied habitats.

Haevy metals analysis

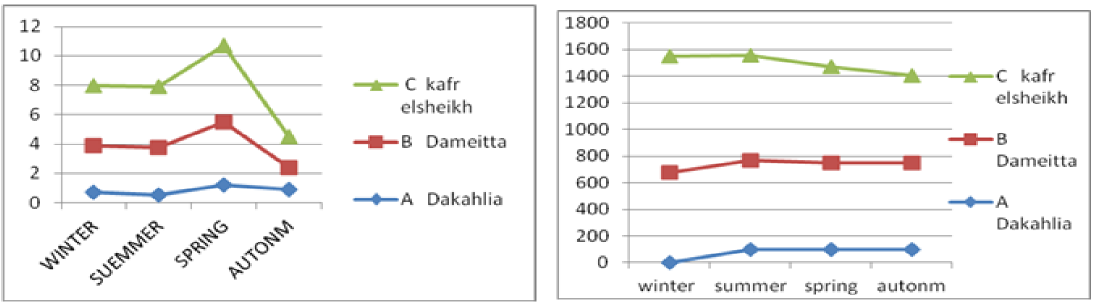
From Fig. (4) it was observed that heavy metals in water varied from site to site and from season to season, where site A in general was had very low concentration of heavy metals except in Cd and Mn whose were high at spring season. In sites B and C the heavy metals were with high concentrations in spring and low at summer.


a-Conc. of Pb in water

b-Conc. of Zn in water


c-Conc. of Fe in water

d-Conc. of Cu in water


e-Conc. of Cd in water

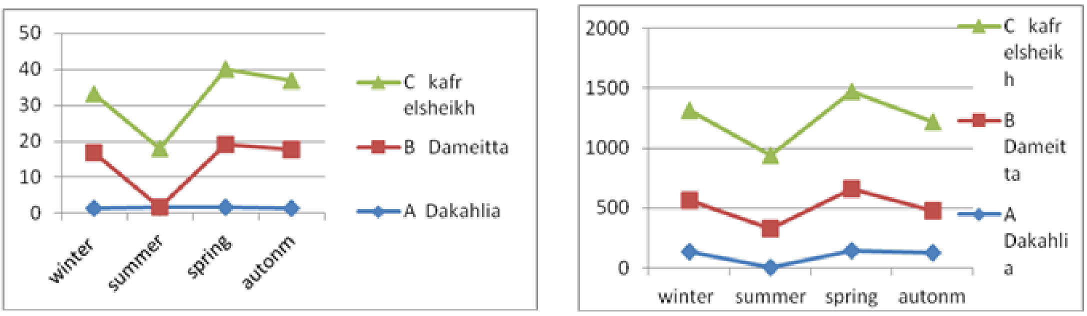
f-Conc. of Mn in water

Fig. 4: Seasonal variation of heavy metals concentration µg/l in water at the study area

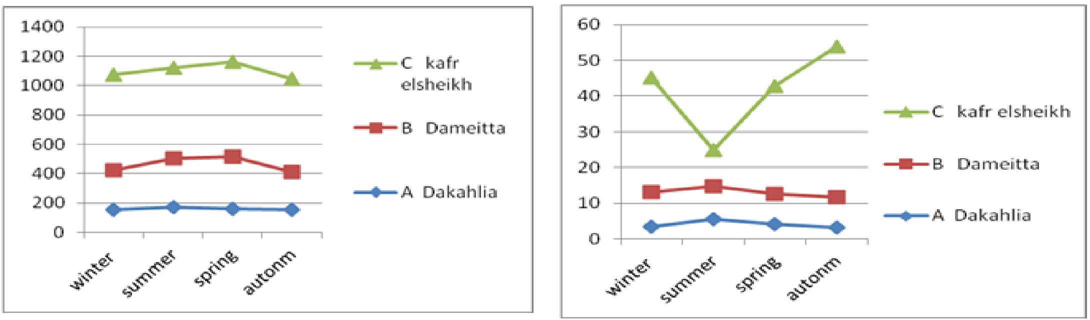
Site C show higher concentrations of heavy metals than the other sites and it may be due to pollution and it receive agriculture, industrial and sewage water with heavy metals (Nafea , 2005; Nafea & Zyada, 2015) where sites and A are irrigation canals with less polluted water.

From Fig. (5) it was observed that heavy metals concentrations in soil showed seasonal variation from site to site and from season to season, here site A showed very low concentration in comparison with sites and C .Also site C showed a highest concentrations than sites and B. It was noted that high concentrations of heavy metals were recorded at spring season, while the lower were recorded at summer season. This was confirmed by the findings of (Nafea & Zyada, 2015) that indicated that the sources of soil heavy metals were, from the industrial and drainage water and from agriculture and aquaculture systems.

a-Conc. of Pb in soil b-Conc. of Zn in soil



c-Conc. of Fe in soil d-Conc. of Cu in soil



e-Conc. of Cd in soil f-Conc. of Mn in water soil

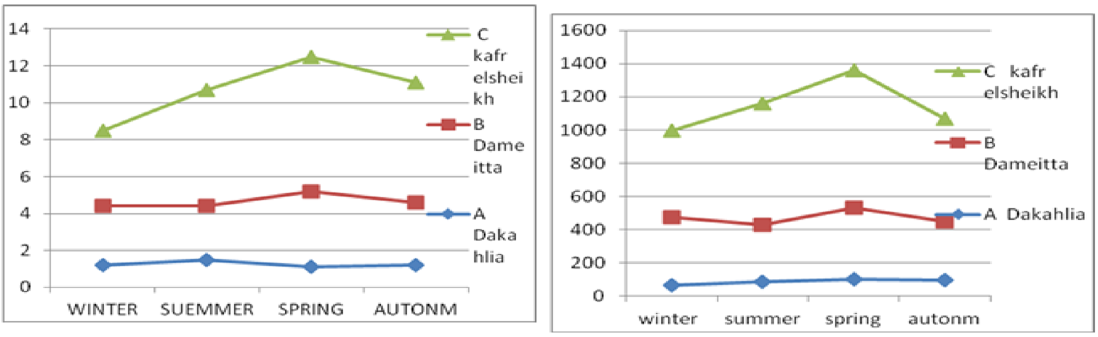
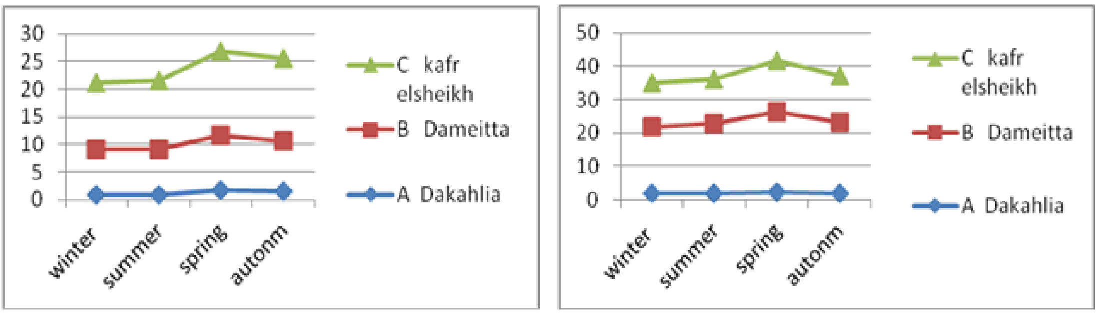
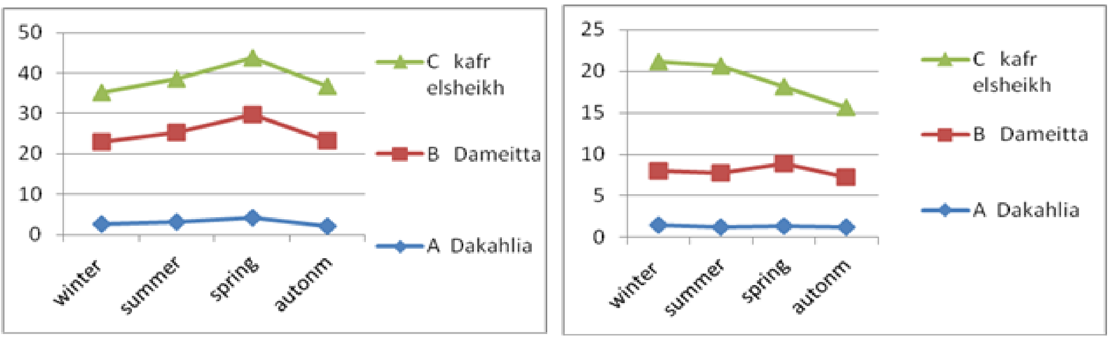


Fig. 5: Seasonal variation of heavy metals concentration µg/g soil in soil at the study area.

The determination of heavy metals in shoot system of the *Ludwegia stolonifera* as in Fig. (6) Showed that *Ludwegia stolonifera* had a great efficiency to word absorption and accumulation of heavy metals in their tissues but the concentration varied from season to season, where spring season recorded the high contents of heavy metals in shoot and the lower was recorded in summer season. It was found that Pb, Zn and Mn were highly recorded in shoot system at the site C more than the sites A and B. and there was a correlation between the concentration of heavy metals in water and soil and their concentration in the plant tissues. So the *Ludwegia stolonifera* can be used as a good tool for bio removal of these metals from water and soil and it could be accumulate it in their shoot by high concentrations (Elifantz & Tel-or, 2002). The hydrophytes have great ability for absorbing heavy metals from water and accumulate them in their tissues with high values leading to bioremediation for the water habitats and biofiltration for pollutants from water (Nafea, 2016; Younis & Nafea, 2015).


a-Conc. of Pb in shoot b-Conc. of Zn in shoot


c-Conc. of Fe in shoot d-Conc. of Cu in shoot

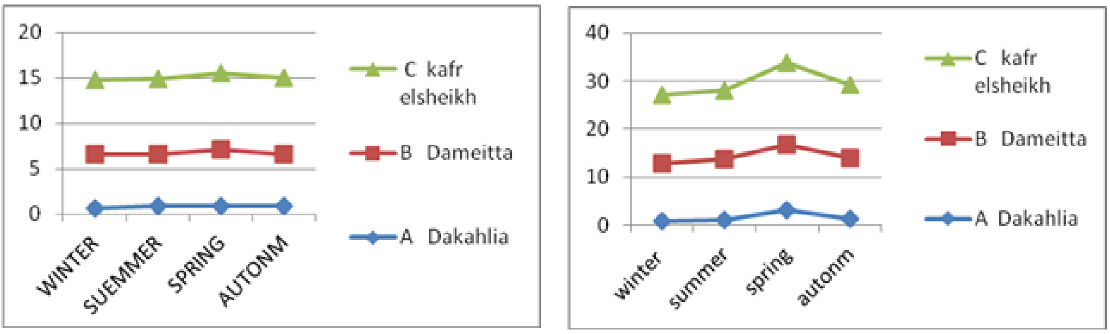
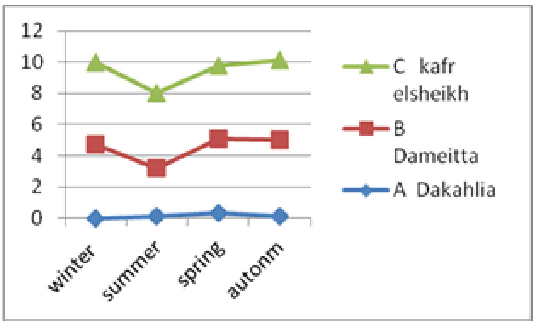

e-Conc. of Cd in water shoot f-Conc. of Mn in water shoot

Fig. 6: Seasonal variation of heavy metals concentration µg/g dry wt. in plant shoot .

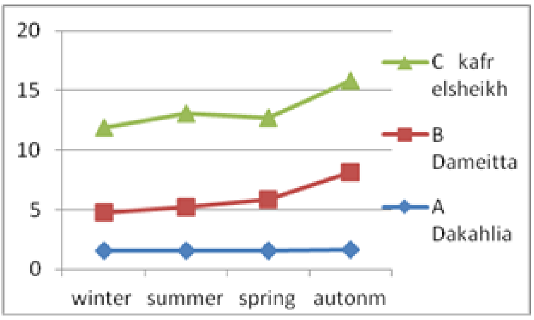
From Fig. (7) it was observed that the root system of the *L. stolonifera* absorbe and accumulate heavy metals from soil by high rate and the spring season was the most effective season in absorbing heavy metals than the other seasons. This plant has a great affinity to ward Cu, Pb, Zn, and Fe absorbing from soil.

The plant could be considered a good biological tool for biosorption and bio removal of heavy metals from soil and water and it could be a suitable candidate for bioremediation of polluted water and soil habitats with different salinity levels as it has an ecological and genetic plasticity in different habitats as mentioned and as iscussed by Amer *et al*. (2016) and Khalifa *et al*. (2017).

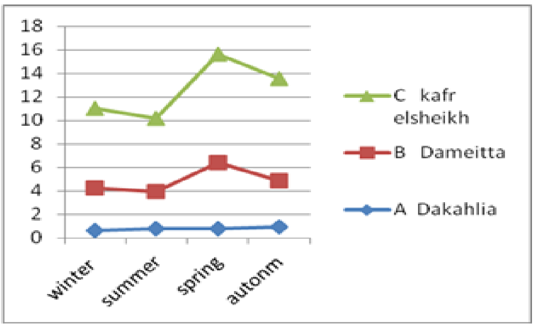
a-Conc. of Pb in root



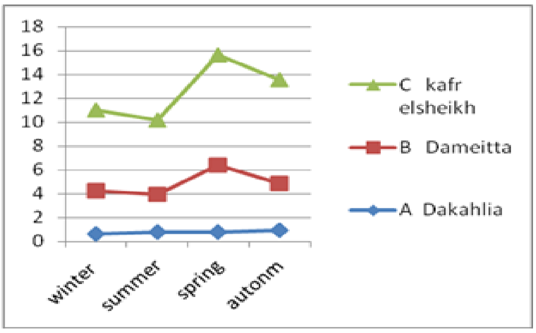
b-Conc. of Zn in root



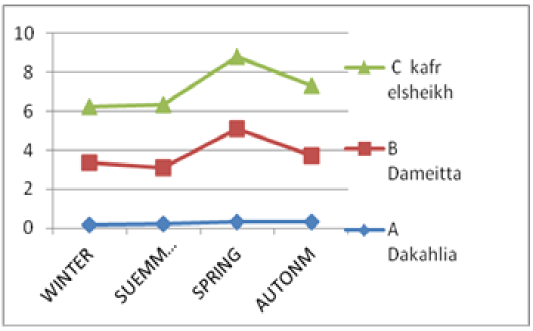
c-Conc. of Fe in root



d-Conc. of Cu in root



e-Conc. of Cd in root



f-Conc. of Mn in root

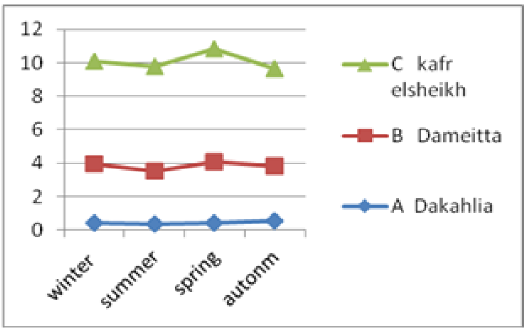


Fig. 7: Seasonal variation of heavy metals concentration µg/g dry wt. in plant Root.

The results of determination of biomass production of *L. stolonifera* as in Fig. (8) indicated that the plant can grow and sustain hard environmental conditions producing high biomass in different habitats with different loads of pollutions and different salinity levels, but at certain limits of pollution it will be stop growth and became dry. The plant Produce high biomass 458g dry wt./m2 , 420 g dry wt./m2 and 400 g dry wt./m2 at sites C,B and A, respectively at autumn season , this may be due to that the plant has a great ecological plasticity and adaptation with different habitats under different pollution loads (Amer *et al.*, 2016) and have an genetic plasticity with different water habitats and environmental variables (Bedoya & Madrinan 2015). The lower biomass produced by the plant was at winter season; 250g dry wt./m2,220 gdry wwt./m2 and 180 g dry wt./m2 at sites, B and A respectively.

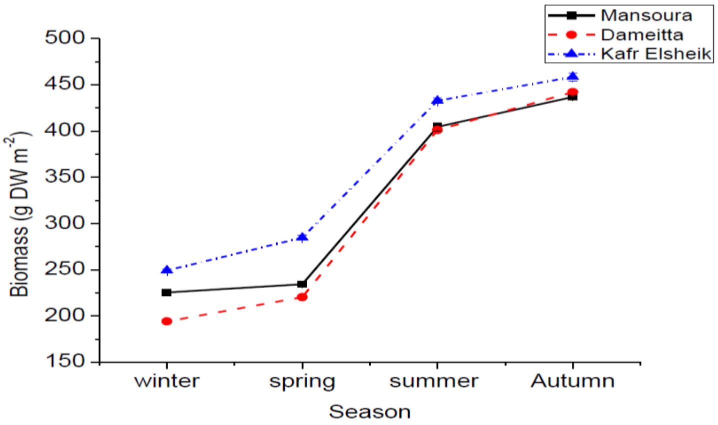


Fig. 8: Seasonal variations in biomass of *Luwdegia stolonifera* in the study area

According to Alpert *et al.*, (2000) the invasive hydrophytes were spread in different habitats and became dominant producing high biomass contents, The produced biomass could be used as biofertilizers in new reclaimed lands and in animal feeding (Firoj *et al*., 2005; Barik & Banerjee, 2003; Ghani, 2003). Also it may be used in the purification of drinking water and improve its quality, this documented by Larson (1999) due to it can filter heavy metals from water and soil leading to improving its quality for animals and human uses (Elifantz & Tel-or, 2002). The environmental variables have great impacts on the hydrophytes and their growth and performances (Younis & Nafea 2012). assess the relationship between the vegetation and the environmental variables and stated that the plants can adapted against the different environmental conditions due to it has an ecological and genetically plasticity (Matesanz *et al*., 2015).

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CONCLUSION

The emerged hydrophytes *Lodwegia stolonifera* can grow in water surface and fixing its root in soil of canal banks and could sustain high pollution concentration and had a great environmental and ecological plasticity which gave it the ability of growth and producing high biomass in most habitats with different pollution loads and could be used in bioremoval and bioremediation of polluted water bodies by heavy metals under different environmental variables and different rates of pollution stress.

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