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Impact of Pollution on Weeds Phytosociology

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THE ASSOCIATED vegetation to some Assiut province farmlands was investigated between two years (2015 and 2016). The recorded flora (82 species belonging to 25 families) revealed general dominance of the annuals (65% of the total flora). Cluster analysis as a classification method yielded two distinct groups (A and B). Stands of group "A" were restricted to the polluted areas and those of group "B" were confined to the non-polluted areas. Fifteen species were confined to the polluted areas (group A), 31 species were in the non-polluted areas (group B) and 36 species were represented in both. Presence (P %) of species within the different groups was used as monitor of ecological success and habitat performance. Those species represented in both areas but with high presence percentages in polluted area (eurytopic species), in addition to species confined to this area can be checked for their potential use in phytoremediation. *Urtica urens* was the most abundant invasive species tolerating serious pollution level. Therefore, it can be considered as an indicator species for polluted areas. The application of DCA and CCA as ordination techniques on the collected data revealed the dependence of group "A" vegetation on heavy metals and group "B" on major nutrients. Preliminary phytosociological studies, however, can provide useful information on the species of potential use in phytoremediation.

Keywords: CCA, DCA, Heavy metals, Phytosociology, Soil pollution, Weeds.

Introduction

Water of suitable quality and quantity is essential to all life forms. Egypt now is facing a water crisis due to the rapid decline of water resources resulting from over-exploitation of groundwater for crop irrigation, decline of incoming water in the Nile River and population explosion (Laraus, 2004). The increasing scarcity of clean and safe water, however, sets the need for appropriate technology and management of the available and already endangered water resources. Industrial and domestic wastewater reuse is now considered as basic component of integrated water management, especially in countries of arid and semiarid regions of the world (Lazarova & Asano, 2005) like most Arab countries.

The application of wastewaters from human habitations to farming areas has been practiced throughout the world for hundreds of years: In England (Folsom, 1876 and Stanbridge, 1976), in the United States, France and Germany (U.S.EPA, 1979 and Reed et al., 1995). In many regions, domestic and industrial sewage water was usually used for irrigation of the agricultural lands without any treatment (Ozdemir & Dursun, 2004). As in many countries, farmers in Egypt, living near the discharge sites of urban wastewater are already reusing non-treated or partially treated sewage water. This causes a high number of transmissible diseases to both humans and animals, and pollutes cultivated fields (Jiménez, 2006 and Mekki et al., 2006). The reuse of sewage in agriculture provides convenient way of discharging this wastewater, while adding valuable plant nutrients and organic matter to the soil. Even in areas where wastewater is not the sole water source for agricultural irrigation, farmers still prefer using sewage water for irrigation for its high content of nutrients, which reduces expenditure on chemical fertilizers (Pescod, 1992 and Lazarova & Asano, 2005). However, irrigation water quality is one of the main factors limiting plant growth and influencing crop quality (Barman et al., 2001 and Muchuweti et al., 2006).

Weeds are defined as plants adapted to man-made habitats and interfered with human impacts (Holzner, 1978). Weeds are important components

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of agroecosystems and their population dynamics. Their diversity and community structure were controlled by different temporal and spatial scales (Marshall et al., 2003). Studies of weed communities by numerical methods, such as cluster and correlation analysis, and multivariate technique such as canonical correspondence analysis can be a useful tool to show relationships between weed species and crops (Salonen, 1993; Kenkel et al., 2002 and Salama et al., 2017), but using these computerized tools to assess the correlation between weeds communities and the degree of pollution is still lacking. The crop rotation influences the composition of arable weeds and their seed banks and represents a possible method for weed control (Shaltout & El Fahar, 1991).

Many studies were conducted to understand the effect of industrial and domestic wastewater and sludge application to agricultural land. Most of these studies focused on the effect of heavy metals on the cultivated plants (Mapanda et al., 2005; Ramadan et al., 2003 and 2005; Karatas et al., 2006 and Zeid & Abou El Ghate, 2007), however, still there are many unresolved questions. Untreated wastewater may contain propagules of different plants that do not belong to the discharging area, and what species will succeed to invade the polluted area will be the first question need to resolve. Parallel to this, there are some existing species which will be not capable to cope with changes caused by pollution and completely disappear or their abundance will reduced. The spreading and dominance of the new invading plants also will be important to study. The aims of this work are to identify the difference in the natural flora prevailing in polluted and non-polluted farmlands, to recognize the pollution-weed relationships and to assess the role of different polluting factors on the distribution and composition of the weed flora in each area.

Materials and Methods

Area of study

Assiut province is located about 375km south of the capital. The total area of the governorate covers about 1550km^2 extends for about 120km along the banks of the Nile. Assiut lies in an arid area with temperature ranging between 31ºC in August and 12.5ºC in January. Relative humidity ranging between 61% in December and 27% in May. Generally the wind velocity seems to be high in winter and spring and fluctuates between 7.5km.h^{-1} in April and 12.5km.h^{-1} in July and August.

Data collection

During 2015 and 2016, vegetation was sampled from 26 stands in 4 sites along N-S line across the Western side of the Nile Valley in Assiut Province to cover as much as possible the main two types of farmlands (polluted and non-polluted). It comprises the white clover, wheat and maize farmlands on western side of the Nile Valley located between 27°17′-27°10′N and 31°01′-31°12′ E (Fig. 1). The first seven stands (farmlands) irrigated from El-Mallah canal (site 1) which supplied with wastewater came from Arab El-Madabegh sewage lifting station. Meanwhile, stands 8 to 13 irrigated with polluted water of El-Zennar drainage canal (site 2). On the other hand; site 3 (stands 14-20) and site 4 (stands 21-26) irrigated with non-polluted water from El-Ibrahimia Canal (Fig. 1). Two pollution regimes were recognized in this study; 13 stands in farmlands irrigated with non-polluted water and the other 13 stands laid in farmlands irrigated with polluted water. Specimens were collected of each species recorded, and then identified according to Boulos (1999–2005) and deposited as voucher specimens at the Assiut University Herbarium (ASTU). The chorotype of each of the recorded species were cited according to Zohary (1966) and Wickens (1976). Life forms of species were assigned according to El-Sheikh (2005) used to classify these species according to their life forms..

Soil sampling and analysis

Three soil samples were collected from each of 26 stands at the root distribution zone of plants, then they were oven dried at 105ºC till reaching constant weight. Soil:water extracts (1:5) were prepared according to Richards (1954) to measure the soil pH and electrical conductivity (EC) using a glass electrode pH90 WTW meter and conductance meter AQUALYTIC model CD20, respectively. The total soluble salt (TSS) were then estimated as described by Jackson (1958). Sodium and potassium ions were determined by flame photometry Model M7D according to Lundegardh (1936). Calcium and magnesium ions were determined volumetrically by titration against versene (Biedermann & Schwarzenbach, 1948). Chlorides were determined by direct titration against $AgNO_3$ (Jackson, 2005). Sulphates were determined according to Bardsley

& Lancaster (1965) by a turbidimetric technique with barium chloride and acidic sodium chloride solution using spectrophotometer (Unicam/uv-vis, Helios Gamma). Phosphates were determined colorimetrically as phospho-molybdate according to Murphy & Riley (1962). Nitrates were also determined colorimetrically according to the method modified by Larsson et al. (1989) after reduction to nitrite. The wet digestion method of Allen et al. (1974) was used for preparing the soil extracts for heavy metals (Ni, Cd, Cu and Zn) which were determined using an atomic absorption spectrophotometer BUCK Scientific Model 210 VGP.

Vegetation analysis

Presence-absence data matrix (26 stands × 82 species) was firstly subjected to cluster analysis as a classification technique using a Bray-cartis-similarity index (Ludwig & Reynolds, 1988). Then ordination procedures were performed with CANOCO software version 4.5 (ter Braak, 1988, 1990). Detrended correspondence analysis (DCA) was made by applying the default options of the DCA in the CANOCO program, to check the magnitude of change in species composition along the first ordination axis according to gradient length in standard deviation units (SD) (Hill & Gauch, 1980). Also, CCA was applied using the same software to determine the association between species composition of these vegetation groups and their soil variables. Fourteen soil variables were included: Soil reaction (pH), TSS, Na, K, Ca, Mg, Cu, Cd, Zn, Ni, Cl, NO_3, SO_4 and PO_4 represented in data matrix.

Species diversity

Species diversity within each separated VG was assessed using two different indices expressing species richness and diversity. Species richness (alpha-diversity) was used for measure the species turnover between different areas and calculated as the average number of species per stand (Magurran, 2013). While species diversity was calculated as the Shannon-Wiener index:

$$H' = -\sum_{i=1}^{R} \text{Pi Ln Pi}$$

where R is the total number of species and Pi is the relative cover of the species that reflects species distribution in the different habitats in the study area (Pielou, 1975).

Statistical analysis

The variation in the soil variables and species diversity was assessed by Independent Samples *t Test* to test the statistical differences between the two VGs using SPSS software (version 21).

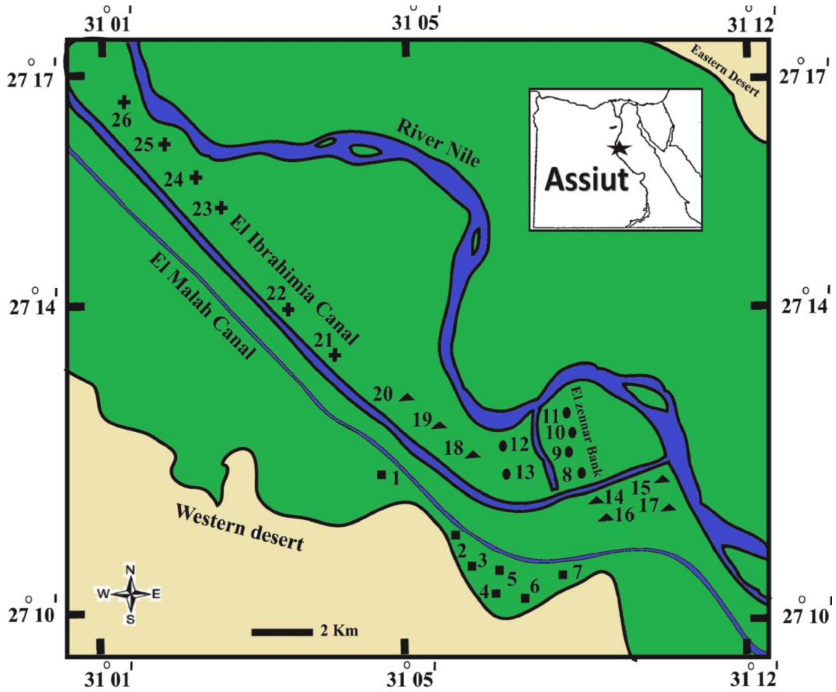

Fig. 1. Map of the Assiut province of Egypt showing the 26 locations in four sites of the study area; squares= site 1, circles= site2, triangles= site 3, plus signs= site 4.

Results

Taxonomic pattern

Total of 82 vascular plants belonging to 67 genera and 25 families were recorded (Table 1). Poaceae was the most represented family with 26 species (31.7%) of the total flora, followed by Asteraceae (7 species; 8.5%), Euphorbiaceae, Fabaceae (6 for each), Brassicaceae, Chenopodiaceae (5 for each), Amaranthaceae (4 species), Polygonaceae (3 species), Asclepiadaceae, Convovulaceae and Solanaceae (2 species for each). Meanwhile the rest of 14 families considered as monospecific ones (Fig. 2A).

According to the type of environments, 15 species (18.29 %) were restricted to the polluted stands, 31 species (37.8 %) were confined to the non-polluted stands and the other 36 species (43.9 %) were recorded in both areas (Table 1). Notably, *Convolvulus arvensis, Sonchus oleraceus, Cyperus rotundus, Portulaca oleraceae, Cynodon dactylon, Malva parviflora, Corchorus olitorius* and *Echinochloa colona* wildly flourish and equally cover both environments with presence values (P%) ranged between 53.9 - 92.3%.

The species of Poaceae and Chenopodiaceae were represented in both environmental regimes. *Cynodon dactylon* (P = 76.9% - 69.2% in non-polluted and polluted stands, respectively), followed by *Poa annua* (P = 38.5-100%), *Phragmites australis* (100-30.8%), *Echinochloa colona* (69-53%), *Brachiaria reptans* (61.5-30.8%) and *Digitaria sanguinalis* (46.2-7.8%) were best grasses dominated both areas (Table 1). On the other hand, grasses were better represented in the non-polluted areas (12 species; 39% of the non-polluted areas flora) and they include *Imperata cylindrica, Avena fatua, Desmostachya bipinnata, Polypogon monspeliensis, P. viridis, Sorghum halepense* and *Arundo donax*. However the polluted stands included only 5 Poaceae (e.g. *Brachiaria eruciformis, Dactyloctenium aegyptium* and *Setaria verticillata*).

Chenopodiaceae generally represented in all the study area but seem to prefer the non-polluted areas and this clear in the presence of *Chenopodium ambrosioides* (P = 53.9%) in this environment and the complete absence of *C. album* from the polluted ones. Also members of Euphorbiaceae and Fabaceae take similar way in preferring the less polluted areas. For Fabaceae; *Melilotus indicus* and *Alhagi graecorum* were represented in both areas while *Trifolium resupinatum, Acacia nilotica, Sesbania sesban and Trigonella hamosa* were prevented from the growth in polluted ones as whole. Also, there are four Euphorbiaceae elements (*Euphorbia peplus, E. helioscopia, E. indica* and *E. prostrata*) grown in the unpolluted areas only.

Urticaceae, Lamiaceae, Typhaceae and Verbenaceae were only represented in the polluted stands with one species for each. Notably, that *Urtica urens* recorded in all these stands (P = 100%). On the other hand *Ammi majus* (Apiaceae) and *Plantago major* (Plantaginaceae) cannot grow in non-polluted soils.

Life forms

Annual herbs represented about 46.3% of the recorded flora followed by perennial grasses (16%) and annual grasses (14.6%) while the least frequent species was the perennial herbs (7.32%), tree (4.9%), shrub and annual forb (3.7% for each), sedges (2.4%) and parasite (1.2%). Further, there was no drastic difference in life forms between those from the polluted sites and non-polluted sites although marked differences were found in the number of life forms in each site.

Figure 2B revealed the predominance of annual herbs, especially those represented in both areas (50%) followed by 32% for those restricted to the clear stands. While the grasses either perennial or annual (Poaceae genera) ones and annual forbs (Fabaceae genera) may prefer to avoid pollution.

Chorological affinities

Chorological analysis revealed the predominance of wide range distributed species (cosmopolitan, palaeotropical and pantropical elements) and represented by 49% of the total flora followed by the Mediterranean elements (33%) as monoregional (M), biregional and pluriregional formed of combinations of the five monoregional phytochoria: M, SA, IT, SZ and ES.

More than half of the Mediterranean elements (59%) were restricted to the non-polluted stands, meanwhile it was reduced in the polluted stands to 15%. Same trend was noticed in case of cosmopolitan species (N = 44% and P = 6%). On the other hand, these polluted areas contained up 36% of pantropical elements (Fig. 2C).

TABLE 1. Recorded species, families, presence percentage in polluted sites (P% in Pol.), presence percentage in non-polluted sites (P% in Non.), life form (LF) and chorotypes (CT) of the recorded species in the study area.

Species	Family	P% in Non.	P% in Pol.	CT	LF
Species represented in polluted and non-polluted areas					
Convolvulus arvensis L.	Convolvulaceae	92.31	76.92	PAL	PH
Sonchus oleraceus L.	Asteraceae	76.92	84.62	COSM	AH
Cyperus rotundus L.	Cyperaceae	76.92	76.92	PAN	SD
Portulaca oleraceae L.	Portulacaceae	53.85	92.31	COSM	AH
Cynodon dactylon (L.) Pers.	Poaceae	76.92	69.23	COSM	PG
Malva parviflora L.	Malvaceae	53.85	84.62	M+IT	AH
Poa annua L.	Poaceae	38.46	100	M+IT+ES	PG
Cichorium endivia L.	Asteraceae	30.77	100	M+IT	AH
Phragmites australis (Cav.) Trin. ex Steud.	Poaceae	100	30.77	PAN	PG
Corchorus olitorius L.	Tiliaceae	69.23	53.85	PAN	AH
Echinochloa colona (L.) Link	Poaceae	69.23	53.85	PAN	AG
Solanum nigrum L.	Solanaceae	23.08	92.31	COSM	AH
Chenopodium murale L.	Chenopodiaceae	23.08	84.62	COSM	AH
Pluchea dioscoridis (L.) DC.	Asteraceae	76.92	30.77	SA+SZ	PS
Trianthema portulacastrum L.	Aizoaceae	15.38	84.62	Am	AH
Brachiaria reptans (L.) C.A. Gardner & C.E. Hubb.	Poaceae	61.54	30.77	PAL	AG
Melilotus indicus (L.) All.	Fabaceae	53.85	23.08	PAL	AF
Fumaria parviflora Lam.	Fumariaceae	7.69	69.23	M+IT+ES	AH
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	69.23	7.69	SA	PT
Chenopodium ambrosioides L.	Chenopodiaceae	53.85	7.69	COSM	AH
Oxalis corniculata L.	Oxalidaceae	15.38	46.15	COSM	AH
Panicum repens L.	Poaceae	38.46	15.38	PAN	PH
Digitaria sanguinalis (L.) Scop.	Poaceae	46.15	7.69	PAL	AG
Ricinus communis L.	Euphorbiaceae	46.15	7.69	PAL	TR
Amaranthus viridis L.	Amaranthaceae	15.38	30.77	COSM	AH
Amaranthus graecizans L.	Amaranthaceae	7.69	30.77	PAL	AH
Amaranthus lividus L.	Amaranthaceae	7.69	30.77	M+IT	AH
Eclipta prostrata (L.) L.	Asteraceae	30.77	7.69	PAN	AH
Phragmites mauritianus Kunth	Poaceae	23.08	15.38	PAL	PG
Euphorbia heterophylla L.	Euphorbiaceae	23.08	7.69	PAN	AH
Alhagi graecorum Boiss.	Fabaceae	15.38	7.69	SA+IT	PS
Beta vulgaris L.	Chenopodiaceae	15.38	7.69	M+IT+ES	AH
Conyza bonariensis (L.) Cronquist	Asteraceae	15.38	7.69	Am	AH
Cynanchum acutum L.	Asclepiadaceae	7.69	15.38	SA	PH
Paspalum distichum L.	Poaceae	15.38	7.69	PAN	PG
Bidens pilosa L.	Asteraceae	7.69	7.69	M+IT+ES	AH
Species represented only in non-polluted area					
Imperata cylindrica (L.) Raeusch.	Poaceae	69.23		M+SA+IT	PG
Oxystelma esculentum (L.f.) R. Br.	Asclepiadaceae	69.23		SZ	PH
Avena fatua L.	Poaceae	53.85		COSM	AG
Desmostachya bipinnata (L.) Stapf	Poaceae	53.85		SA	PG
Phalaris paradoxa L.	Poaceae	53.85		M+IT	PG
Amaranthus hybridus L.	Amaranthaceae	38.46		COSM	AH

TABLE 1. Cont.

Species	Family	P% in Non.	P% in Pol.	CT	LF
Polypogon monspeliensis (L.) Desf.	Poaceae	38.46		COSM	AG
Polypogon viridis (Gouan) Breistr.	Poaceae	38.46		M+IT	AG
Phalaris minor Retz.	Poaceae	30.77		M+IT+SA	AG
Rumex dentatus L.	Polygonaceae	30.77		M+IT+ES	AH
Sisymbrium irio L.	Brassicaceae	30.77		COSM	AH
Trifolium resupinatum L.	Fabaceae	30.77		M+IT	AF
Ammi majus L.	Apiaceae	23.08		M	AH
Chenopodium album L.	Chenopodiaceae	23.08		COSM	AH
Dichanthium annulatum (Forssk.) Stapf	Poaceae	23.08		PAL	PG
Euphorbia peplus L.	Euphorbiaceae	23.08		M+IT+ES	AH
Sorghum halepense (L.) Pers.	Poaceae	23.08		PAN	PG
Acacia nilotica (L.) Delile	Fabaceae	15.38		SA	TR
Eruca sativa Mill.	Brassicaceae	15.38		M+IT	AH
Plantago major L.	Plantaginaceae	15.38		M+IT+ES	PH
Pseudognaphalium luteoalbum L.	Asteraceae	15.38		COSM	AH
Arundo donax L.	Poaceae	15.38		M+IT+SA	PG
Sesbania sesban (L.) Merr.	Fabaceae	15.38		SZ	TR
Avena barbata Pott ex Link	Poaceae	7.69		M+IT+ES	AG
Brassica nigra (L.) Koch	Brassicaceae	7.69		COSM	AH
Bromus catharticus Vahl	Poaceae	7.69		M+IT+ES	PG
Cuscuta pedicellata Ledeb.	Convolvulaceae	7.69		SA	PAR
Euphorbia helioscopia L.	Euphorbiaceae	7.69		M+IT+ES	AH
Euphorbia indica Lam.	Euphorbiaceae	7.69		AM	AH
Euphorbia prostrata Aiton	Euphorbiaceae	7.69		M+IT+ES	AH
Trigonella hamosa L.	Fabaceae	7.69		M+SA+SZ	AF
Species represented only in polluted area					
Urtica urens L.	Urticaceae		100	M+IT+ES	AH
Coronopus didymus (L.) Sm.	Brassicaceae		53.85	PAN	AH
Emex spinosa (L.) Campd.	Polygonaceae		38.46	M+SA	AH
Brachiaria eruciformis (Sm.) Griseb.	Poaceae		30.77	PAN	AG
Brassica rapa L.	Brassicaceae		15.38	M+ES	AH
Dactyloctenium aegyptium (L.) Wild.	Poaceae		15.38	PAL	AG
Lamium amplexicaule L.	Lamiaceae		15.38	IT	AH
Phyla nodiflora (L.) Greene	Verbenaceae		15.38	PAN	PH
Setaria verticillata (L.) P. Beauv.	Poaceae		15.38	COSM	AG
Datura innoxia Mill.	Solanaceae		7.69	PAN	AH
Digitaria ciliaris (Retz.) Koeler	Poaceae		7.69	PAL	AG
Paspalum dilatatum Poir.	Poaceae		7.69	AM	PG
Persicaria salicifolia (Brouss.ex Willd.) Assenov	Polygonaceae		7.69	M+IT	AH
Salsola imbricata Forssk.	Chenopodiaceae		7.69	SA	PS
Typha domingensis (Pers.) Poir. ex Steud.	Typhaceae		7.69	PAN	SD

Life forms abbreviations: AF= Annual forb, AG= Annual grass, AH= Annual herb, PG= Perennial grass, PH= Perennial herb, PS= Perennial shrub, SD= Sedge and rush, TR= Tree. Chorotypes abbreviations: Am= American, SA= Saharo-Arabian, PAL= Palaeotropical, SZ= Sudano-Zambezian, ES= Euro-Siberian, PAN= Pantropical, COSM= Cosmopolitan, IT= Irano-Turanian, M= Mediterranean.

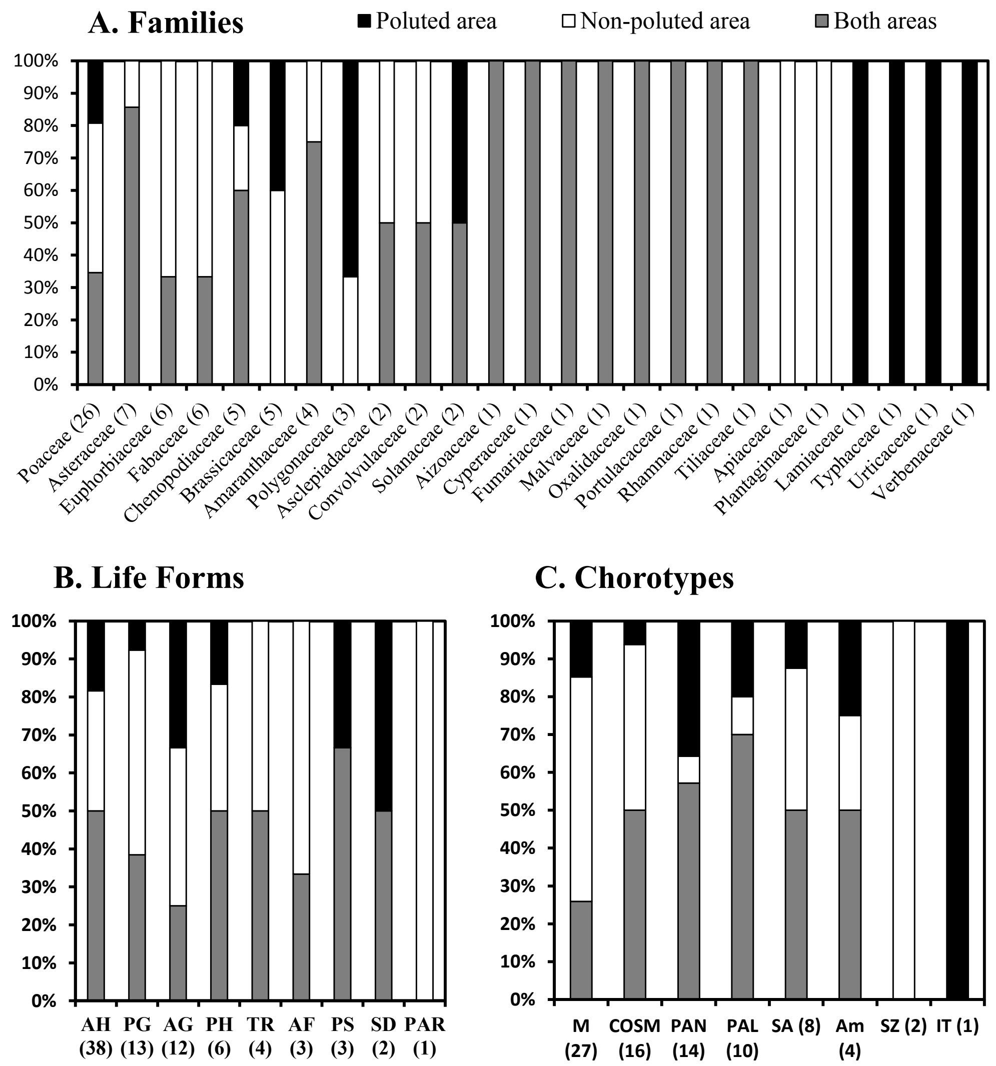

Fig. 2. A- Percentages of species in the represented families in polluted area only (P), in non-polluted area only (N), in both polluted and non-polluted areas (B); B- Percentages of species in the different life form types and C- Percentages of species in the different floristic regions . Numbers between bracts represent the number of species.

Classification of the vegetation

Classification of the presence/absence dataset of 82 species recorded in 13 polluted and 13 non-polluted stands using cluster analysis yielded 2 vegetation groups A and B (Fig. 3A); comprised a set of stands which are similar in their floristic composition. Inspection to Fig. 3A indicated that stands of group A located in farmlands irrigated with waste-water, while the group B stands had the flora of natural water-irrigated farmlands.

Group A included 51 species in 13 stands, and dominated by 11 species such as *Cichorium pumilum, Poa annua, Urtica urens* (P= 100%), *Portulaca oleraceae, Solanum nigrum* (P= 92%), *Malva parviflora, Trianthema portulacastrum, Sonchus oleraceus, Chenopodium murale* (P= 85%), *Cynodon dactylon* and *Fumaria parviflora* (P= 69%). This group had lower species richness (18.53± 0.79 stand^{-1}) and Shannon-Wiener index (2.90 ± 0.04). Macronutrients of this group soils were significantly lower than those of group B. On the contrary, its trace elements were higher by 100-200 folds than the other (Table 2).

Group B included 67 species in the other 13 stands. It was dominated by 17 species including *Phragmites australis* (100%), *Convolvulus arvensis* (92%), *Cynodon dactylon, Pluchea dioscoridis* and *Sonchus oleraceus* (77%), *Corchorus olitorius, Echinochloa colona, Imperata cylindrica*, *Oxystelma esculentum* and *Ziziphus spina-christi*

(69%), *Brachiaria reptans* (62%), *Avena fatua*, *Chenopodium ambrosioides, Desmostachya bipinnata, Malva parviflora, Melilotus indicus* and *Phalaris paradoxa* (54%). This group exhibited a relatively high species richness (22.5 ± 1.16 stand^{-1}) and Shannon-Wiener index (3.09 ± 0.06). The soil chemistry for this group was safer for the plant life where the trace elements ranged between 0.11 µg g^{-1} dry soil for Cd to 63.5 µg g^{-1} dry soil for Zn. Generally soil pH, heavy metals (Cu, Cd, Zn, Ni), nutrients (K, Ca, Mg, SO_4 and PO_4) showed clear significant differences between groups A and B (Table 2).

Stand ordination

Ordination technique of Detrended Component Analysis (DCA, Fig. 3B) separates these two groups along its two axes. This application revealed the high significant difference between the floristic compositions of these groups. The eigenvalue for the first DCA axis was relatively high (Eigenvalue = 0.438) indicating that it captured the greater proportion of the variations in species composition among stands, followed by the second axis (Eigenvalue= 0.239). The cumulative percentage variance of species data of the first two DCA axes was 39.4%.

Soil-vegetation relationships

The relationship between the vegetation and soil variables was studied using Canonical correspondence analysis (CCA). Figure 3C showed the significant correlations between group A stands with the soil heavy metals while those of group B showed a correlation with pH, TSS and most of the estimated major nutrients.

The inter-set correlations resulted from Canonical Correspondence Analysis (CCA) of the examined soil variables were displayed in Table 3. The cumulative percentage variance of species-environment correlation was 37.9% for the first two axes. CCA axis 1 was highly positively correlated with Cadmium and highly negatively correlated with Magnesium. So, this axis can be interpreted as coarse Cd-Mg gradient. CCA axis 2 was highly positively correlated with soil-solution reactions and highly negative correlated with chlorides. Thus, this axis can be interpreted as pH-Cl gradient.

TABLE 2. Mean values ± SE and t-test statistic of the soil variables, species richness and species diversity in the polluted and non-polluted vegetation groups (A and B) of Assiut weeds.

Soil factors		**Vegetation groups**		**F-value**
		A	**B**	
pH		7.81 ± 0.20	8.74 ± 0.04	20.31 **
TSS %		0.17 ± 0.01	0.35 ± 0.07	6.02*
Cu		107.69 ± 8.96	0.56 ± 0.01	142.91**
Cd	µg g^{-1}dry soil	10.98 ± 0.45	0.11 ± 0.00	582.14**
Zn		190.04 ± 17.65	63.45 ± 0.93	51.30**
Ni		59.37 ± 5.41	0.40 ± 0.01	118.69**
PO_4		77.70 ± 4.78	13.37 ± 1.64	161.79**
SO_4		27.14 ± 3.67	84.85 ± 24.18	5.56*
K		0.04 ± 0.01	0.09 ± 0.02	9.084**
Na	mg g^{-1}dry soil	0.61 ± 0.36	0.80 ± 0.13	0.24
Ca		1.00 ± 0.04	3.57 ± 0.54	22.58**
Mg		0.58 ± 0.02	1.70 ± 0.17	41.16**
NO_3		0.68 ± 0.09	0.51 ± 0.04	2.96
Cl		0.72 ± 0.36	1.34 ± 0.06	2.92
SR (Spp. Stand)		18.53 ± 0.79	22.5 ± 1.16	7.83**
H’		2.90 ± 0.04	3.09 ± 0.06	6.79*

*$P \leq 0.05$; **$P \leq 0.01$,

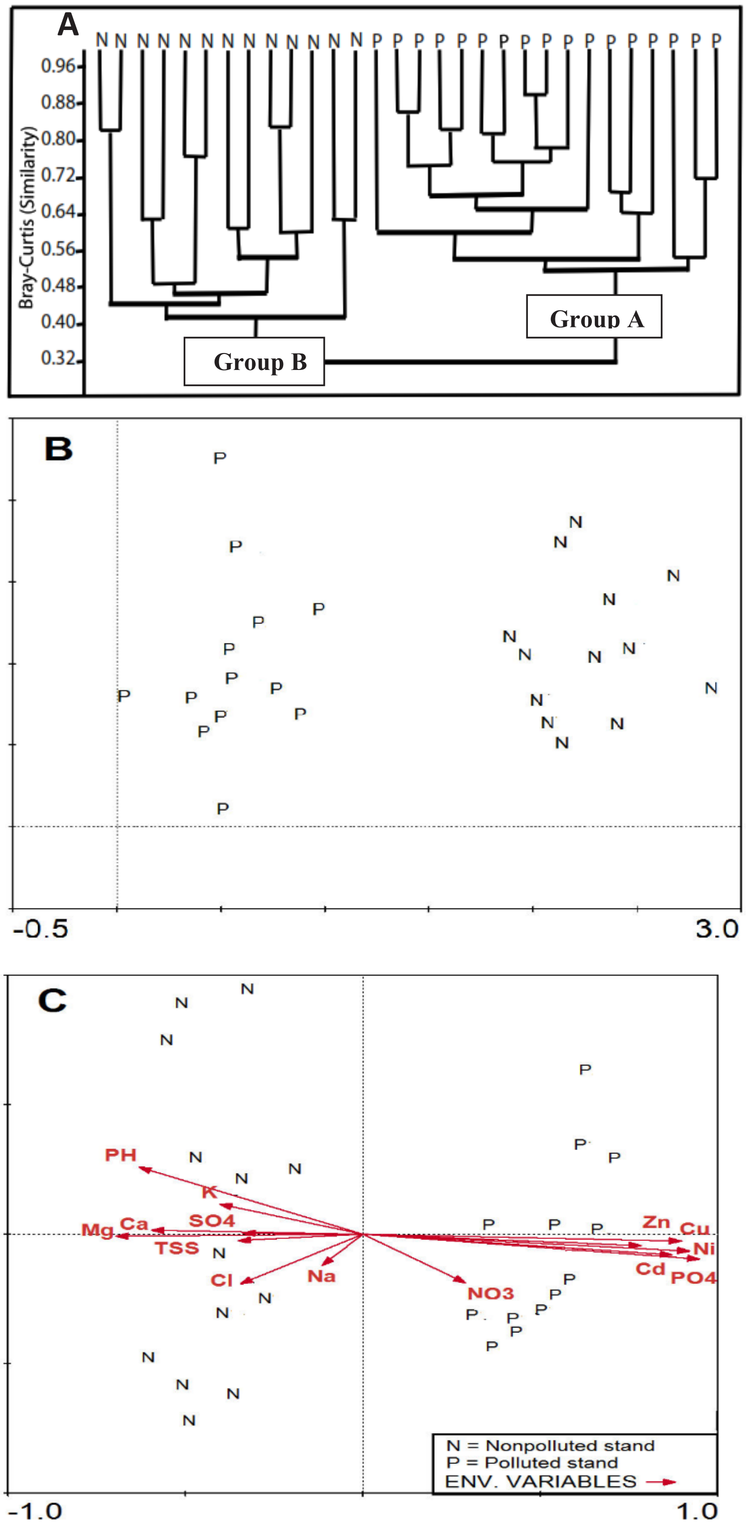

Fig. 3. (A) Bray-Curtis cluster analysis showing the clear separation of sample plots to two groups, (B) DCA separating the stands to their vegetation groups and (C) CCA biplot that distribute these stands in relation to the environmental variables.

TABLE 3. Inter-set correlation of CCA analysis for the soil variables, together with eigenvalues and species–environment correlations in the study area.

Axes	AX1	AX2
Eigenvalues	0.424	0.218
Species-environment correlations	0.989	0.955
Cumulative percentage variance of species data	15.1	22.8
pH	-0.631	0.259
TSS (%)	-0.351	-0.024
NO_3	0.289	-0.188
Cl	-0.345	-0.191
Ca	-0.595	0.016
Mg	-0.695	-0.007
Na	-0.115	-0.121
K	-0.406	0.116
PO_4	0.921	-0.064
SO_4	-0.338	0.005
Zn	0.788	-0.044
Ni	0.872	-0.079
Cu	0.898	-0.026
Cd	0.949	-0.096

Discussion

The eighty two recorded species in this study were belonging to 25 families, with the most common species from the Poaceae and Chenopodiaceae. Collectively, both families comprised 10 species in polluted, 13 in non-polluted and 12 in both areas. Anning & Yeboah-Gyan (2007) mentioned that Poaceae is the most important invasive families in Ashanti Region, Ghana.

It is well known that Poaceae and Chenopodiaceae comprise the highest number of tolerant species and genera, respectively. Also Amaranthaceae, Asclepiadaceae, Asteraceae, Euphorbiaceae, Fabaceae, Brassicaceae, Convolvulaceae and Polygonaceae were represented in all sites. Dazy et al. (2008) observed 8 families in polluted studied areas among them Poaceae (23%), Brassicaceae (4.3%) and Polygonaceae (2.6%). Kazemeini et al. (2013) studied the plant communities of Galali Iran mine polluted site and found that a considerable proportion of species are belonging to Asteraceae, Euphorbiaceae and Chenopodiaceae. However, Aizoaceae, Cyperaceae, Fumariaceae, Malvaceae, Oxalidaceae, Portulacaceae, Rhamnaceae and Tiliaceae do not have a variety of species in all sites (one species for each). Each of Lamiaceae, Typhaceae, Urticaceae and Verbenaceae was represented by only one species in polluted sites, but Apiaceae and Plantaginaceae were represented by one species in non-polluted sites.

Phytogeographically, Egypt is the meeting point of floristic elements belonging to at least four different regions: The African Sudano-Zambezian, the Asiatic Irano-Turanian, the Afro-Asiatic Saharo-Arabian and the Euro-Afro-Asiatic Mediterranean (El-Hadidi, 1993). The chorological analysis of the listed species revealed that the widely distributed species belonging to cosmopolitan (19.51%) followed by pantropical (14.63%) and pluriregional as: M+IT+ES (14.63%), indicating that the floristic structure of the study area is relatively simple as compared with other areas of Egypt, being more affected by human disturbances. The dominance of monoregional over the interregional species (bi and pluriregionals) may be associated with the absence of inter-zonal habitats such as anthropogenic or hydro-, halo- and psammophilous sites. The results indicate that Mediterranean elements predominate the studied area (27 species, 33%), and were represented as mono-regional (1 species, 1.22%), biregional under the influence of Irano-Turanian, Saharo-Arabian, Euro-Siberian regions (10 species, 12.2%) and pluriregional (16 species, 19.51%).

Ecological indices also showed that the plant community found in the non-polluted area (vegetation group B) was more complex and structural than that in the polluted area (group A) with higher values for species richness and Shannon-Weaver diversity. The species richness found in the polluted area (SR = 18.53) was closed to the value (18) that was found by Luzuriaga et al. (2005). In addition, the species diversity (H'= 2.9) were close to the value that had been given by Conesa et al. (2007) who found H' values of 2.5-3 for plant communities growing in sites contaminated by heavy metals. Nevertheless, the decreases in species richness and diversity observed here were supposedly linked to the high contamination of the soils which could exhibit phytotoxic effects on plant species and colonization process.

In this study, *Urtica urens* was the most abundant weed, restricted to the polluted sites, and completely absent in non-polluted stands. The same species was recorded by Belabed et al. (2014) as the dominant species in polluted sites at North West Algeria, and also was identified as one of the main plant communities in the Almadén district of Spain which according to Molina et al. (2006) is considered as one of the most contaminated sites on the Earth. In contrast, *U. urens* was recorded amongst 39 species listed in wetland (clean water) at Pocharam lake, Medak District, Telangana, India by Swamy et al. (2016). In this study, some species such as *P. annua, C. endivia*, *C. murale, F. parviflora, M. parviflora* and *S. nigrum* had high presence values in the polluted area, while others such as *P. australis, D. sanguinalis, P. dioscoridis* and *R. communis* were have high presence values in the non-polluted area. *B. pilosa, C. olitorius, C. rotundus, C. dactylon* and *S. oleraceus* seem eurytopic species which have a wide range of tolerance, so they similarly represented in both polluted and non-polluted stands.

The wide distribution range of some weeds may be related to their wide amplitude (e.g., annual herb) caused by phenotypic plasticity and frequency (Shaltout & El-Din, 1988), while restricted distribution of another can be attributed to the habitat preference phenomenon. In addition, the type of crop, seasonal preferences and contamination level may explain the differences in weeds number listed among different farmlands in the study area.

The dominance of annuals amongst the recorded list of species could be related to their high reproductive capacity, ecological, morphological and genetic plasticity under high level of disorders (Grime, 1979). On the contrary, the low number (26 species; 31% of the total number of species recorded in this study) of perennials (trees, shrubs, grasses and herbs) may be related to the intensive management used in the plantations such as ploughing, sub-soiling, harrowing, leveling and furrowing operations which could affect vegetative growth structures, as well as the life cycles of the perennial weeds (Abd El-Ghani et al., 2013). The life forms of plants in agricultural land may be closely linked with temperature, irrigation sources, type of crop and soil condition. Cultivation allows weeds to survive without human intervention whereas the seeds of target crop must be added each season by the way that the agricultural activities seem to be more suited to weeds than crops. As irrigation by untreated or partially treated wastewater increase the pollution of studied sites, it also increases the rate of invading weeds to the fields while the sensitive species disappear. This study indicates that most of the recorded weeds are sensitive to pollution. However, this explain why there are more weeds in non-polluted area (67 species) while there are new invading weeds (15) in polluted one. Interestingly, the majority of species that were restricted to, or their presence increased in the polluted area belonged to the widely inter-continental range of distribution.

Conclusion

Six species were common in both polluted and non-polluted areas, 7 species their presence percentage greatly increased, and 15 species recorded only in the polluted area. Out of these 15 species, 6 were accidental and recorded only in one stand. However, there are about 16 species (spreading and invading spp. in the polluted area) considered to be indicative opportunists, regardless their affinity to specific metal, and could be implicated for phytoremediation. If the 6 common species implicated, a total of 22 species will be considered for studying and pollutants analysis.

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تأثير التلوث على المجتمعات النباتية للأعشاب

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تمت دراسة الغطاء النباتي المرتبط ببعض الأراضي المنزرعة بمحافظة أسيوط خلال العامين 2015 و 2016م، وقد تم تسجيل 82 نوعاً نباتياً تنتمي إلى 25 عائلة وأوضحت الدراسة سيادة النباتات الحولية عامة والتى شكلت 65% من مجموع النباتات. وبإستخدام التحليل العنقودي كطريقة تصنيف نتج مجموعتان متميزتان من النباتات هما "A" و "B" وقد اقتصرت وقفات المجموعة "A" على المناطق الملوثة، أما وقفات المجموعة "B" فقد اقتصرت على المناطق غير الملوثة. أيضاً أوضحت الدراسة تقيد خمسة عشر نوعاً نباتياً على التواجد فى المناطق الملوثة فقط (المجموعة A) وواحد وثلاثون نوعاً في المناطق غير الملوثة (المجموعة B) وتواجد ستة وثلاثون نوعاً في كلا المنطقتين. تم استخدام نسبة تواجد كل نوع من النباتات داخل المجموعتين كدلالة ليوضح نجاح النوع وتفضيله لموئل ما. هذا وقد بينت الدراسة أنه يمكن تحقيق استخدام جهد تلك الأنواع الممثلة في كلا المنطقتين ولكن بنسبة تواجد عالية في المنطقة الملوثة (الأنواع ذات القدرة الإحتمالية لعديد من العوامل البيئية)، بالإضافة إلى الأنواع المحصور تواجدها على هذه المنطقة فقط في المعالجة النباتية لمثل هذه المناطق الملوثة. كان نبات الحُريق أكثر الأنواع انتشاراً إذ تم تسجيله فى كل الوقفات الملوثة فقط مما يعكس قدرته على تحمل مثل هذه المستويات من التلوث الخطير، ولذلك يمكن اعتباره نوعاً من النباتات الدالة على التلوث. أظهر تطبيق DCA و CCA على البيانات التى تم جمعها ارتباط مجموعة الغطاء النباتي "A" بالمعادن الثقيلة وارتباط المجموعة "B" بالعناصر المغذية الأساسية. وقد خلُص هذا البحث إلى أن الدراسات الأولية على المجتمعات النباتية فى مثل هذه المناطق يمكن أن توفر معلومات مفيدة عن الأنواع المؤثرة التي يمكن استخدامها في المعالجة النباتية.