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Association Between Water Courses lining, Water Quality and Aquatic Vegetation in Two Egyptian Governorates

Nahed M. Ismail * ; Bayoumy B. Mostafa; Khalil M. El-Said; Ahmed M. Azzam; Asmaa Abdel-Motleb and Hoda M. Abu Taleb

Environmental research department, Theodor Bilharz research Institute, Imbaba, Egypt.

* Corresponding author: dnahed2000@yahoo.com

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ABSTRACT

The pattern of association between water canals lining, water quality and aquatic vegetation in Beheira and Giza governorates was studied. Samples of water and Aquatic plants were collected from the examining sites during four seasons in two successive years. Results showed that water conductivity and total dissolved salts in lined sites were significantly lower than those of unlined ones ($P<0.01$& $P<0.05$) in both governorates. In Beheira, Zn, Fe and Cd in lined and unlined sites were significantly increased ($p<0.001$, $p<0.01$& $p<0.05$) during summer comparing with the other seasons. In contrast, in Giza, the highest values of Zn, Pb, Cu, Fe and Cd were recorded in autumn in both lined and unlined sites. The percentage of occurrence and density of the plants were highly significant ($p<0.01$, $p< 0.001$) higher in unlined sites compared to the lined ones during all seasons in both governorates. In Beheira, *Eichhornia crassipes* plant was completely absent during all seasons in lined sites compared to the unlined ones. In Giza, *E. crassipes* (83.3%) and *C. demersum* (50%) was highly significant ($p< 0.001$) higher in unlined sites compared to the lined ones (50% and 0.0, respectively) during summer. The correlation coefficients depicted very good associations between plants and heavy metals in lined sites during spring for more than 50% and more than75% in summer ($r=0.58; p<0.05$). A strong positive correlation for all metals studied, Cd (0.658), Cu (0.758), Fe (0.589), and Pb (0.781) was observed. It can be concluded that watercourses lining may reduce the distribution of aquatic vegetation which rendered the current of water and preserving water with a good quality. There was a strong inverse correlation between the plants and heavy metals in lined canals.

INTRODUCTION

Water is a critical resource necessary for improving the living conditions. It is vital for all socio- economic development and for maintaining healthy ecosystem. Water quality monitoring is one of the highest priorities in environmental protection policy. The hydrodynamics of the ecosystem varied with soils, topography, climate, hydrology, water chemistry, vegetation and other factors including human disturbance **(Rameshkumar *et***

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***al.* ,2019).** One of the environmental modification is the lining of water courses to avoid seepage of water. So, canals lining with suitable materials (e.g concrete; concrete blocks, bricks or stone sand, cement; plastic and rubber) in order to increase flow velocities and reduce aquatic weed growth is required (**Ismail *et al*., 2016; Abdel-Motleb *et al*., 2020)**. Many authors describe the possible benefits of canal lining which includes: water conservation, no seepage of water, reduction in maintenance cost, minimize the growth of aquatic vegetation (**Leigh and Fipps, 2006; Arshad *et al.*, 2009; Ismail, 2009, Memon *et al*., 2013, Chatha *et al.*, 2014 and Khalil *et al*., 2017).** It was estimated that after concrete lining, the annual groundwater recharge in the irrigated areas will be reduced by approximately 50%. This saves a substantial amount of water that can be used to extend the irrigation area so more people can benefit from the available irrigation water **(Maijer *et al*, 2006; Marei, 2013). Memon *et al*. (2013)** stated that as a result of proposed lining of the Dadu canal in Pakistan, seepage losses, water logging, silting and maintenance cost of canal can be significantly decreased, consequently, flow velocity, conveyance efficiency and cropping intensity can be increased. They added that the initial investments over canal lining seem to be very high, but canal lining is a sustain- able step which proves to be very economical in terms of long term benefits. **Solangi (2018)** found that the average water loss was of about 13% from unlined sections compared to only of about 1% from lined sections of watercourses in Pakistan. Similarly average conveyance efficiency was increased by about 12% that resulted average annual water saving of 10.32 hectare-m which could be utilized to bring more land under cultivation for wheat and cotton crops during spring and autumn seasons respectively. Moreover, lined materials play a role for reducing the bacterial growth and metals concentration, therefore the lining of canal helps in preventing the discharge of sewage pollution into canal. Lining of main watercourses also attempts to save water of a good quality for better effectiveness and sustainable water management (**Azzam *et al.*, 2016**). On the other hand, **Ismail (2009)** found that most lined sites contained plants with lower density comparing with the unlined ones. **El-Khayat *et.al.*(2009)** stated in their study on the association between fresh water snails, macrophytes and water quality in different water courses in Egypt that the sites free from both plants and snails characterized by the highest concentrations of cadmium, lead, mercury, sodium, and potassium. Sites containing plants only were characterized with the highest concentrations of dissolved oxygen.

Thus, the aim of the present study is to evaluate the association pattern between water canals lining, water quality and aquatic vegetations in lined and unlined water courses in Beheira and Giza governorates during different seasons of two successive years.

MATERIALS AND METHODS

***A- Study area*:**

This study was carried out in different lined and unlined water courses in two governorates (Beheira and Giza) in a total of 14 sites during four seasons in two successive years (Fig. 1):

1- **Beheira Governorate** is a coastal governorate in Egypt. Located in the northern part of the country in the Nile Delta, its capital is Damanhur.

Examining sites:

Lined sites: Site 1: El-Schiek Zaied canal (cement lining), Site 2: El-Seddik Yousif canal (cement lining), Site 3: Al-Shouhada village canals (cement lining) and Site 4: Main canal and branches of Al-Nubaryia city (cement lining).

Unlined sites: Site 5: Naser canal (sandy soil) and Site 6: Nagah Sultan canal in Janakliz (sandy soil).

2- Giza Governorate : It is in the center of the country, situated on the west bank of the Nile River opposite Cairo. Its capital is the city of Giza. It includes a stretch of the left bank of the Nile Valley around Giza, and acquired a large stretch of desert, including Bahariya Oasis.

Examining sites:

Lined sites: Site 1: Kafer Hakkim; branch of Abo-Shenina canal (bricks and stone lining), Site 2: Bani Magdoul canal (cement lining), Site 3: Branch of Bani Magdoul canal (rubber lining), Site 4: El-Malek Idress canal (bricks and stone lining) and Site 5: Kobry El-Balah canal (bricks and stone lining).

Unlined sites: Site 6: Kafer Hakkim; Abo-Shenina canal, Site 7: Bani Magdoul; El-Masoudia drain and Site 8: Al-Mansuria canal.

***B- Ecological survey*:**

A regular survey of the banks was carried out in sampling sites during autumn, winter, spring and summer (two visits/each season) in two successive years (2014-2016). The survey was done across the lined and unlined canals at the examining sites. Sampling was carried out at fixed points, about 150m apart. The ecological conditions were recorded at each site during samples collection (Field sheets were designed for information for each site of water bodies under study). Aquatic plants in the various sampling sites were collected and transferred to the laboratory. They were identified (**Boulos *et al.* 1994; Zahran and Willis, 2009; Abdel-Motleb *et al.*, 2020)** and the density of each plant species was estimated quantitatively by scores [+, ++, +++] **(Ismail, 2009)**.

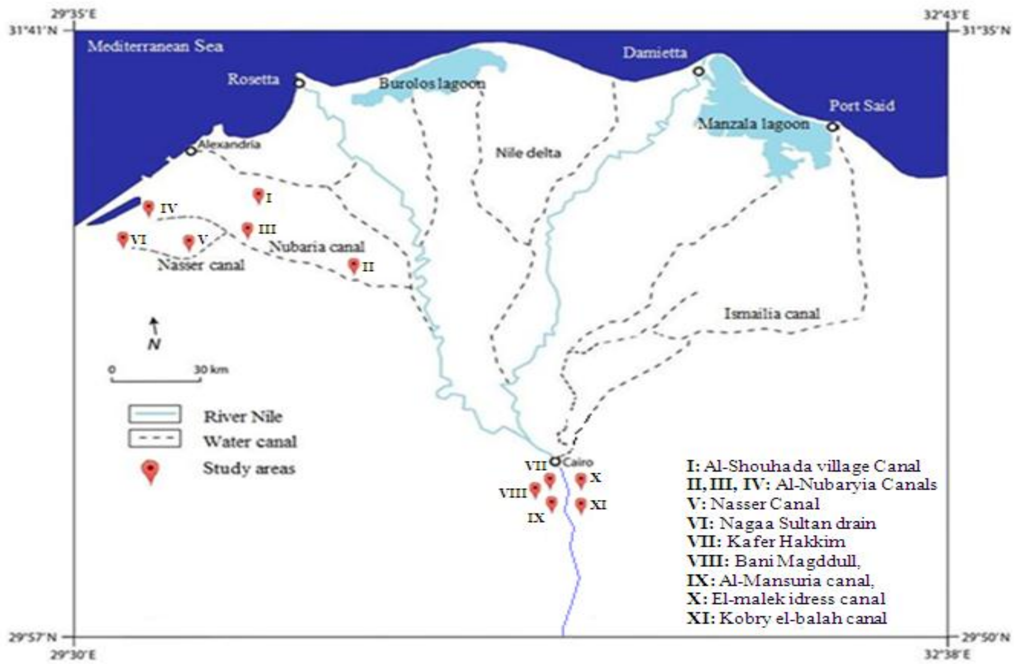

Fig. 1 A map of the study area.

C- Meteorological data and habitat measurements:

The main ecological parameters were recorded in the sampling sites during the study period. Thus, the water temperature, Electrical conductivity (µmhos) and TDS (Total dissolved salts) were measured using a portable conductivity meter (HI 9635),where pH was measured using a portable pH meter (HI 9024) and dissolved oxygen (D.O) was measured using a portable D.O meter (HI 8543). All measurements were taken on spot at midday, at 20 cm under the water surface between 9:00 am and 3:00 pm. All these parameters were recorded in the field sheets, using procedures in APHA (American Public Health Association) (**Clesceri, *et.al.* 1998**).

For chemical assessment, water samples were collected in 1 liter polyethylene bottles from each examined site. At the laboratory, water samples were filtered and the levels of some heavy metals; Zn, Cu, Pb, Fe, Cd were determined by atomic absorption spectrophotometer. The mean value of each element for each site was calculated seasonally. Determination of heavy metals in water samples were performed according to **A.O.A.C. (1995)** by using the atomic absorption spectrophotometer (Solar M 600531 v1.27) at Central Agricultural Pesticides Laboratory, Agricultural Research Center (ARC), Dokki, Giza, Egypt. The current, wavelength and slit band width of each element were adjusted automatically by the instrument software.

Standards: metals stock standards of Cd, Cu, Fe, Pb and Zn were obtained from Merck, Darmstadt, Germany (Merck's ampoules; 1000 mg). Water samples (200ml) were digested with 5ml of di-acid mixture (9 HNO_3: 4 $HCIO_4$) on a hot plate and filtered by Whatman No. 42 filter paper and add double distilled water to make the volume up to 50 ml (**Abd el-Kader *et al*.2016).**

Statistical Analysis:

The mean values of heavy metals concentrations were calculated and subjected to Analysis of Variance (ANOVA) using non-randomized block design and Least Significant Difference method(LSD) on the SPSS 24.0 for windows program after analysis of the homogeneity of variance according to Cochran's test (**Winer, 1981**). Correlation between parameters was performed using Spearman´s rank Correlation coefficient.

RESULTS

Chemical analysis of water samples:

Physico-chemical parameters

The results of physicochemical measurements indicated that the statistical analysis showed no significant difference in temperature and pH of water between the two tested habitats (lined and unlined water bodies) during the four seasons in both Governorates. It was found that in Beheira the mean value of water conductivity and TDS (total dissolved salts) in lined water bodies was significantly lower than those of unlined ones ($p<0.01$) during summer, autumn, winter and spring (540.7±66.6, 579.9±74.04, 578.5±67.5 and 549.9±46.8µmhos, respectively for conductivity) and (389.6±41.2, 403.4±51.8, 384.4±47.8 and 385.5±32.8 ppm, respectively for TDS), (Table 1). The same pattern was found in Giza Governorate, in which the mean value of water conductivity and TDS in lined water bodies was significantly lower than those of unlined ones ($p<0.01$& $p<0.05$) during all seasons (Table 2). It was found that the dissolved oxygen (D.O) in unlined sites during spring was highly significant increase than summer, autumn and winter ($p<0.01$) in both governorates (14.04±5.04 and 8.76±1.88mg/l in Beheira and Giza, respectively).

Results of the chemical analysis of some heavy metals (Zn, Cd, Pb, Cu and Fe) in water samples from new reclaimed areas at Beheira and Giza governorates during the four seasons are given in tables (3) and (4). No significant difference between lined and unlined water courses was observed in both governorates. At Beheira, it was found that Zn, Cd and Fe were highly significant increased ($p<0.001$, $p<0.01$& $p<0.05$) in summer than autumn, winter and spring in lined and unlined sites. Unlined sites showed that the value of Pb was highly significantly increased ($p<0.01$) in summer than autumn and spring, and it significantly increased ($p<0.05$) in winter than autumn. Cu was significantly increased ($p<0.05$) in autumn than spring and summer. It completely absent in summer in lined sites and in summer and spring in unlined ones (Table 3).

Regarding Giza governorate, the lined sites showed that during autumn, Zn was significantly increased ($p<0.05$) than winter; Pb and Cd were significantly increased ($p<0.01$ & $p<0.05$) than spring, summer and winter. While Fe was significantly increased ($p<0.01$) in summer than winter. The highest values of Zn, Pb, Cu and Cd were recorded in autumn (Table 4). In unlined sites, Pb and Cd were significantly increased (p<0.01 & p<0.05) than spring, winter and summer. It was found that the highest values of Zn, Pb, Fe and Cd were recorded in autumn whereas, Cu concentration was the highest in spring and completely absent in summer. The results indicated that Pb was disappeared in summer and spring in both lined and unlined sites (Table 4).

Table 1. Physicochemical parameters of different sites representing lined and unlined water bodies in new reclaimed areas in Beheira governorate (El-Nubaryia & Cairo–Alexandria road farms) during different seasons in two successive years.

Seasons	**Lined water bodies**				**Unlined water bodies**			
Parameters.	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
Tempratur. (C^o)	٢٦.٥٢ ±0.٥٦	24.82 ±0.67	22.13 ±0.56**,*	25.53 ±0.60	٢٦.٤٥ ±0.٦٠	23.17 ±1.35*	23.9 ±0.88*	24.75 ±0.44
Cond.^{b} (µ mhos/cm)	٥٤٠.٧١ ±٦٦.٥٨	579.87 ±74.04	578.50 ±67.48	549.88 ±46.84	١٩٣٠.5 ±6٧٤.١	1756.25 ±553.76	1344.75 ±346.41	592 ±167.86
TDS^{c} (mg/L)	٣٨٩.٥٧ ±٤١.٢٢	403.38 ±51.84	384.38 ±47.80	385.5 ±32.77	١٣٩٩.٠ ±٥١٢.٩٥	1191.0 ±324.96	997.5 ±280.42	1419.25 ±633.34
pH	٧.٦٩ ±٠.١٣	8.03 ±0.31	7.92 ±0.18	8.32 ±0.17	٧.٨٨ ±٠.٠٩	8.23 ±0.11	8.11 ±0.18	8.18 ±0.11
DO(mg/L)	٣.٩ ±١.٢	3.86 ±0.79	3.96 ±0.40	5.77 ±3.33	2.91 ±1.69	4.34 ±0.44	4.18 ±0.54	14.05 ±5.04^{a}

All values mean± standard error (SE). ***Lined***; ***p<0.01 significant decrease than summer and spring;* **p<0.05 significant decrease than autumn;* ***Unlined sites:*** **p<0.05 significant decrease than summer;* ^{a}*p<0.01 significant increase than summer, autumn and winter.* ***Lined vs unlined:*** ^{b}*p<0.01: Conductivity, significantly decreased in lined than unlined sites;* ^{c}*p<0.01: TDS significant decreased in lined than unlined sites.*

The survey study revealed that 12 plant species were collected and identified from the examined water courses (lined and unlined) in both governorates in autumn, winter, spring and summer during two successive years (Tables 5,6). These plants represented by *Eichhornia crassipes*, *Ceratophyllum demersum*, *Jussias repens*, *Lemma giba*, *Polygonum serr*, *Potamogeton nodosus*, *Cyperus alopecuroides*, *Zanichellia* sp, *Panicum repens*, *Nymphea* Sp, *Azzolla azzolla* and *Potamogeon crispus*. The percentage of sites containing various types of plants in both examined water courses (lined and unlined) in new reclaimed areas (Al-Nubaryia) at Beheira governorate are given in table (5) and figure (2). It was observed that the percentage of abundance and density of these plants were highly significant (p<0.01, p< 0.001) higher in unlined sites compared to the lined ones, in which 8 plant species were collected during all seasons from unlined sites compared to only five species from the lined ones.

Table 2. Physicochemical parameters of different sites representing lined and unlined water bodies in Giza governorate during different seasons in two successive years.

Seasons / **Parameters.**	**Lined water bodies**				**Unlined water bodies**			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
Tempratur. (C°).	25.38± 0.48	24.46± 0.44	22.49± 0.51[**]	25.78± 0.67	25.04± 0.59	24.16± 0.39	23.27± 0.004[a]	24.09± 0.35
Cond.[f] (µ mhos/cm)	708.19± 46.31	731.81± 43.09	687.54± 40.39	588.05± 66.58	1187.90± 163.4	975.22± 109.2	938.65± 94.71	647.59± 40.47[b,c]
TDS[f] (mg/L)	717.19± 174.19	532.33± 40.11	526.90± 81.65	523.41± 31.87	860.52± 120.8	753.07± 78.18	835.94± 119.5	753.90± 123.85
pH	7.64 ± 0.13[d]	7.44± 3.55	8.04± 0.09	8.07± 0.50	7.65± 0.11[d]	8.21± 0.06	8.05± 0.67	7.91± 0.07
D.O.[g] (mg/L)	3.61 ± 0.48	3.50± 0.20	2.77± 0.32	2.93± 1.06	3.97± 0.45	4.04± 0.35	1.87±0.35	8.76± 1.88[e]

All values mean± standard error (SE). ***Lined :*** *[**]p<0.01 significant decrease than spring, summer and autumn; [d]p<0.01 significant decrease than winter, spring.* ***Unlined :*** *[a]p=0.01 significant decrease than summer; [b]p<0.05 significant decrease than winter; [c]p<0.01 significant decrease than summer and autumn; [e]p<0.01 significant increase than winter, summer and autumn; [d]p<0.01 significant decrease than winter, spring and autumn.*
Unlined vs lined: *[f]p=0.01 significant increase; [g]p=0.05 significant increase during spring, autumn and summer.*

The results showed that the plant *E. crassipes* was completely absent during all seasons in the lined sites compared to the unlined ones where found in all seasons in 50% of the examined sites during winter, spring and summer, 25% in autumn. Also, *C. demersum* present in 50% of the examined lined sites during spring and summer and found in lower percentage of sites during autumn and winter. Whereas, it was found in 75% of the unlined sites during spring & summer and 50% in autumn & winter.

The associations pattern between heavy metals and plants were statistically significant at $p<0.05$ level linear association in lined sites during spring. These correlation coefficients depicted very good associations for more than 50% of the relationships ($r=0.58; p<0.05$). The coefficient of correlation values between the metal levels (Cd, Cu, Fe and Pb) and plants from Sperman correlation coefficient indicated that the correlation coefficients between heavy metals and plants in summer reflected very good associations for more than75% of the relationships. A strong positive correlation for all studied metals, Cd (0.658), Cu (0.758), Fe (0.589), and Pb (0.781) was observed.

Table 3. The chemical analysis of some heavy metals in water samples from new reclaimed areas in Beheira governorate (El-Nubaryia & Cairo–Alexandria road farms) during the four seasons in two successive years.

Seasons / Elements	Lined water bodies				Unlined water bodies			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
Zn (μg/L)	0.64±0.20[a]	0.13±0.012	0.017±0.003	0.12±0.03	0.4±0.07[e]	0.24±0.10	0.03±0.003	0.13±0.04
Cu (μg/L)	0.0	0.04±0.012	0.05±0.01	0.08±0.07	0.0	0.04±0.02[f]	0.01±0.01	0.0
Pb (μg/L)	0.15±0.03	0.19±0.12	0.15±0.02	0.01±0.01	0.19 ± 0.01[**]	0.05±0.01	0.18±0.02[*]	0.0
Fe (mg/L)	14.26 ±3.57[b]	9.14±3.57[c]	0.32±0.06	1.55±1.27	10.95 ± 1.36[#]	0.99±0.67	0.25±0.03	0.54±0.26
Cd (μg/L)	0.65 ± 0.16[d]	0.03±0.03	0.02±0.003	0.03±0.02	0.82 ± 0.01[#]	0.07±0.0014	0.03±0.003	0.006±0.001

All values mean± standard error (SE); rows with different letters were significant .
Non significant difference between lined and Unlined sites. Lined: [a]$p<0.001$ *significantly increase than autumn, winter and spring;* [b]$p<0.01$ *significant increase than winter and spring;* [c]$p<0.05$ *significant increase than winter and spring;* [d]$p<0.001$*significant increase than Autumn, winter and spring.* Unlined: [e]$p<0.05$ *significant increase than autumn, winter and spring;* [f]$p<0.05$*significant increase than spring and summer;*[**]$p<0.01$ *significant increase than autumn and spring;*[*]$p<0.05$ *significant increase than autumn;* [#]$p<0.01$ *significant increase than autumn, winter and spring.*

Regarding, the results of the percentage of sites containing various types of vegetation in the lined and unlined water bodies in Giza governorate are presented in table (6) and figure (3) in all seasons during two successive years. It was found that during summer, the percentage of sites containing the two plants *E. crassipes* (83.3%) and *C. demersum* (50%) was highly significant ($p< 0.001$) higher in unlined sites compared to the lined ones which represented by 50% and 0.0 for the two plants, respectively. Whereas, the plant species *Jussias repens*, *Polygonum serr*, *Panicum repens* and *Nymphea sp* were infested with a lower percentage (ranging between 10% and 20%) of the examined lined sites and completely absent from the unlined ones in this season. Very strong associations were observed between concentrations of Cu (- 0.68) & Fe (- 0.74) and the plant *Eichhornia crassipes.* Moderate associations were observed between Pb and *Lemma giba* (-0.65) and *Cyperus alopecuroides* (-0.81) in lined sites. There was a strong inverse correlation between the presence of plants and the increase of heavy metals (Table 7).

Table 4. The chemical analysis of some heavy metals in water samples collected from different lined and unlined sites in Giza Governorate during the four seasons in two successive years.

Seasons / Elements	Lined water bodies				Unlined water bodies			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Zn (µg/L)	0.06±0.003	0.23±0.11^{a}	0.01±0.004	0.11±0.07	0.06 ± 0.003	0.18±0.05	0.011±0.005	0.03±0.005
Cu (µg/L)	0.0	1.41±1.05	0.0	0.04±0.02	0.0	0.24±0.15	0.003±0.003	0.56±0.018
Pb (µg/L)	0.0	0.32±0.14^{b,c}	0.09±0.01	0.0	0.0	0.46±0.22$^{f,\#}$	0.10±0.009	0.0
Fe (mg/L)	4.87±2.57^{d}	2.76±1.04	0.27±0.06	1.8±0.95	2.52 ± 0.83	15.16±13.02	0.39±0.18	1.07±0.90
Cd (µg/L)	0.007±0.001	0.13±0.05^{e}	0.02±0.006	0.003±0.001	0.008 ± 0.001	0.12±0.06$^{f,\#}$	0.02±0.006	0.004±0.001

All values mean± standard error (SE); rows with different letters were significant.
No significant difference between lined and Unlined
Lined : ^{a}*p<0.05significant increase than winter;*^{b}*p<0.01 significant increase than spring and summer;* ^{c}*p<0.05 significant increase than winter, spring and summer;* ^{d}*p<0.01significant increase than winter;* ^{e}*p<0.01 significant increase than summer, winter and spring.*
Unlined : ^{f}*p<0.01significant increase than spring;*$^{\#}$*p<0.05significant increase than winter and summer*

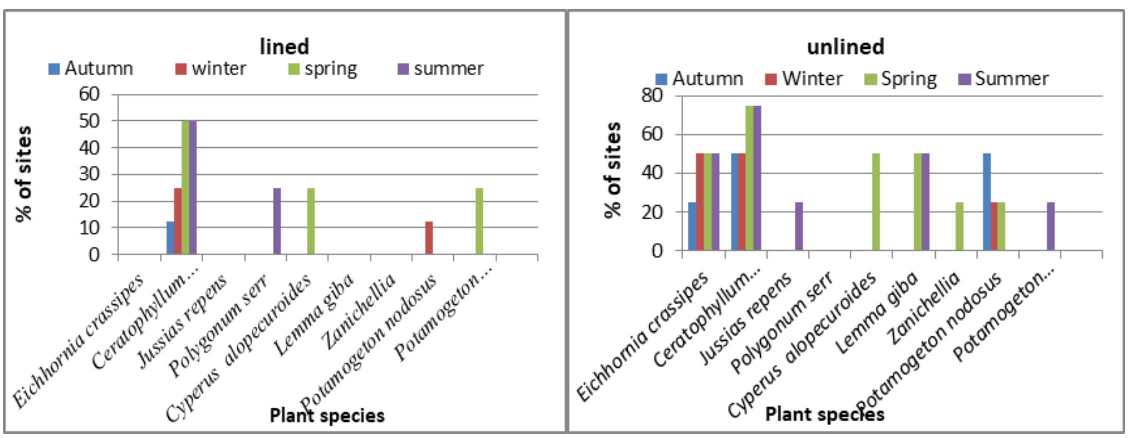

Fig. 2 Distribution and abundance of aquatic plants in the examined lined and unlined water courses in new reclaimed areas at Beheira Governorate in different seasons during two successive years.

Table 5. Percentage of sites containing various types of vegetation in the sampling sites the lined and unlined water bodies in Beharia governorate during different seasons in two successive years.

		lined sites					**unlined sites**				
Seasons	**Plant species**	**% of total sites**	Plant density				**% of total sites**	Plant density			
			Absent	+	++	+++		Absent	+	++	+++
Autumn	*Eichhornia . crassipes*	-	absent	-	-	-	25***	-	-	25	-
	Ceratophyllum . demersum	12.5	-	-	-	12.5	50***	-	25	25	-
	Potamogeton nodosus	-	absent	-	-	-	50***	-	25	25	-
Winter	*E. crassipes*	-	absent	-	-	-	50***	-	-	-	50
	C. demersum	25	-	-	12.5	12.5	50***	-	25	-	25
	P. nodosus	12.5	-	12.5	-	-	25*	-	-	-	25
Spring	*E. crassipes*	-	absent	-	-	-	50***	-	-	-	50
	C. demersum	50	-	25	12.5	12.5	75***	-	25	-	50
	P. nodosus	-	absent	-	-	-	25***	-	25	-	-
	Potamogeton perfoliatus	25***	-	-	-	25	-	absent	-	-	-
	Cyperus alopecuroides	25	-	25	-	-	50***	-	50	-	-
	Lemma giba	-	absent	-	-	-	50***	-	-	-	50
	Zanichellia	-	absent	-	-	-	25***	-	-	-	25
Summer	*E. crassipes*	-	absent	-	-	-	50***	-	-	-	50
	C. demersum	50	-	25	25	-	75***	-	-	50	25
	Jussias repen	-	absent	-	-	-	25***	-	-	-	25
	Polygonum serr	25***	-	25	-	-	-	absent	-	25	-
	P. perfoliatus	-	absent	-	-	-	25***	-	-	-	-
	Lemma giba	-	absent	-	-	-	50***	-	-	-	50

+ = low density, ++ = medium density, +++ = high density.
** highly significant (p<0.01).
*** more highly significant (p< 0.001).

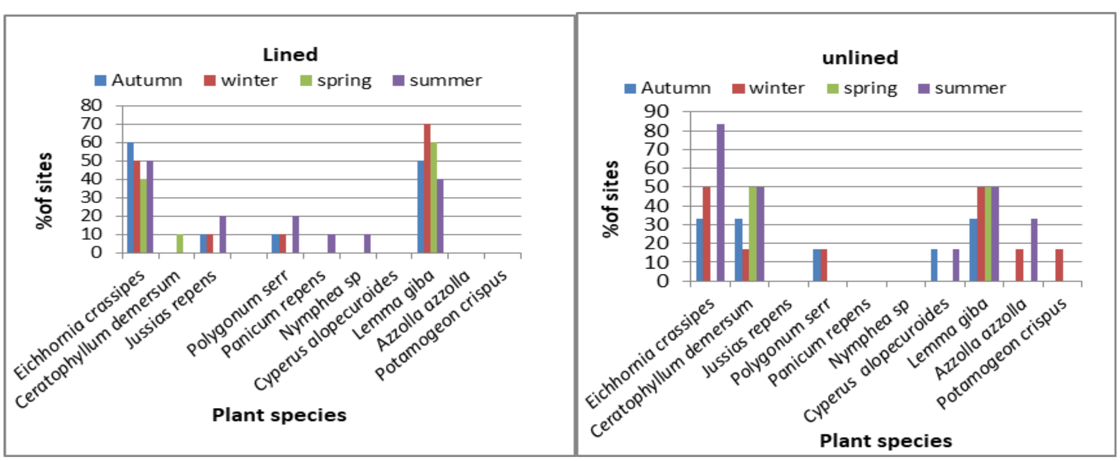

Fig. 3 Distribution and abundance of aquatic plants in the examined lined and unlined water courses in Giza governorate in different seasons during two successive years.

Table 6. Percentage of sites containing various types of vegetation in the sampling sites the lined and unlined water bodies in Giza governorate during different seasons in two successive years.

Seasons	Plant species	lined sites					unlined sites				
		% of total sites	Plant density				**% of total sites**	Plant density			
			Absent	+	++	+++		Absent	+	++	+++
Autumn	*E. crassipes*	60	-	10	-	50	33.3^{***}	-	-	16.7	16.6
	C. demersum	-	absent	-	-	-	33.3^{***}	-	16.7	16.7	-
	Jussias repens	10^{**}	-	-	-	10	-	absent	-	-	-
	Polygonum serr	10	-	10	-	-	$16.7^{n.s}$	-	16.7	-	-
	Cyperus	-	absent	-	-	-	16.8^{***}	-	16.8	-	-
	alopecuroides	50	-	20	-	30	33.3^{*}	-	-	-	33.3
	Lemma giba										
Winter	*E.crassipes*	50	-	10	-	40	50	-	16.7	-	33.3
	C.demersum	-	absent	-	-	-	16.7^{***}	-	-	-	16.7
	Jussias repens	10^{**}	-	-	10	-	-	absent	-	-	-
	Polygonum serr	10	-	10	-	-	16.7	-	-	-	16.7
	Potamogeon crispus	-	absent	-	-	-	16.7^{***}	-	-	-	16.7
	Lemma giba	70	-	30	10	30	50^{**}	-	16.7	-	33.3
	Azzolla azzolla	-	absent	-	-	-	16.7^{***}	-	-	-	16.7
Spring	*E. crassipes*	40^{***}	-	20	-	20	-	absent	-	-	-
	C. demersum	10	-	10	-	-	50^{***}	-	50	-	-
	Lemma giba	60	-	20	20	20	$50^{n.s}$	-	16.7	-	33.3
Summer	*E.crassipes*	50	-	-	10	40	83.3^{***}	-	50	16.7	16.7
	C.demersum	-	absent	-	-	-	50^{***}	-	-	16.7	33.3
	Jussias repen	20^{***}	-	-	-	20	-	absent	-	-	-
	Polygonum serr	20^{***}	-	10	-	10	-	absent	-	-	-
	Panicum repens	10^{**}	-	-	-	10	-	absent	-	-	-
	Nymphea sp	10^{**}	-	-	10	-	-	absent	-	-	-
	Cyperus alopecuroides	-	absent	-	-	-	16.7^{***}	-	16.7	-	-
	Azzolla azzolla	-	absent	-	-	-	33.3^{***}	-	-	-	33.3
	Lemma giba	40	-	10	-	30	$50^{n.s}$	-	16.7	-	33.3

+ = low density, ++ = medium density, +++ = high density.

** highly significant ($p<0.01$).

*** more highly significant ($p< 0.001$).

Table 7. Correlation coefficients between heavy metals and plants in lined sites at Giza governorate.

	Eichhornia crassipes	*Lemma giba*	*Cyperus alopecuroides*	*Ceratophyllum demersum*
Cd	*1*			
Cu	*- 0.68*	*1*		
Fe	*- 0.74*	*- 0.78*	*1*	
Pb	*0.40*	*- 0.65*	*- 0.81*	*1*
Zn	*0.35*	*- 0.78*	*0.63*	*0.58*

DISCUSSION

The present work indicated that the statistical analysis showed no significant difference in temperature and pH of water between the two tested habitats (lined and unlined water bodies) during the four seasons in the two governorates. **Patil *et al*.(2016)** stated that the growth rates of terrestrial and aquatic plants are temperature-dependent, with species having optimal growth and competitive ability at particular temperatures, and in particular climates. In addition, within a region, differences in temperature-dependent growth could cause different plant species to be specialized on different portions of the growing season. On the other hand, they added that the soil is affected by higher and lower pH when enter in the soil. Thus, pH does have an effect on plant growth and also it plays an important role in the formation of algal blooms.

In the present study the mean values of Electric conductivity (EC) and total dissolved salts (TDS) of water in lined sites were significantly lower than those of unlined ones ($P<0.01$& $P<0.05$) in both examined governorates in all seasons. These results were fully agreement with those of **Ismail (2009)** who studied the physicochemical parameters of water in lined and unlined water courses in seven governorates of Egypt. She found that no significant difference between the two tested habitats (lined and unlined water bodies) but the conductivity of water in lined water bodies was lower than those of unlined ones. The same results were obtained by **Abdel-Motleb *et al*. (2020)** who indicated that there was no significant difference between physicochemical parameters of the lined and unlined water bodies, however, the EC of water in lined water bodies was lower than that of unlined ones. These results also confirmed those of **Yousif *et al*. (1998)** who found in their study in the two newly reclaimed areas located west and east of Suez Canal, El-Manayef area (earthen water courses) and El-Morra area (cement lined branches) that the major physicochemical parameters of the two areas were almost similar. Present study indicated that the lower EC were recorded during spring and the highest ones during summer, while those recorded in winter showed the average value in the unlined sites in both governorates, however those of the lined sites were approximately the same in all seasons. These results confirmed those of **Abd El-Hady and Hussian (2012)** who showed in his study in Ismailia Canal that winter was the optimum season for water EC. Some evidence referred that the maximum concentration of TDS was in summer while the minimum value was found in winter, probably because of stagnation and settlement of suspended particles. In summer most of the vegetation was decaying which leads to accumulation of dissolved solids in water. High concentration of dissolved solids may create an imbalance for the aquatic life. The high values of TDS may influence the taste, hardness and corrosive properties of the water **(EPA, 1976)**. Also, **Rameshkumar *et al*. (2019)** found that the EC and TDS negatively influenced the aquatic macrophytes. Therefore, there is a need for some adaptation measure to maintain the water quality for more extended period for domestic use. Dissolved oxygen is an indicator for healthy water ecosystem and when its level are depleted, the aquatic animals become stressed and die (**Didonato *et al*., 2003**). It is an important water quality parameter to maintain because of its significant biological and physicochemical property of surrounding water. Also, the DO level indicates the degree of pollution in the water bodies **(Gopalkrushna 2011).** Present study indicated that dissolved oxygen (DO) in unlined sites during spring was highly significant increase than summer, autumn and winter (p<0.01) in both governorates. In comparing the two tested habitats (lined and unlined) in Giza, the values of DO in unlined water courses were significantly (p<0.05) higher than the lined ones during spring, autumn and summer. This may be explained as in the present study, the unlined water bodies showed a diversity of plant species with high density making the habitat richness with oxygen this is due to the presence and activity of the plant *E. crassipes*. **Kotadiya and Acharya (2014)** stated that oxygen enters into the water by aerial diffusion and as a photosynthetic by-product of aquatic plants. Also, the present results confirmed those of **El-Khayat, *et.al.*(2009)** who found in their study on the association between fresh water snails, macrophytes and water quality in different water courses in Egypt that the sites containing plants were characterized with the highest concentrations of dissolved oxygen.

Some physico-chemical parameters (pH, temperature, oxidation reduction potential, dissolved salts, etc.) of surface waters have direct or indirect influence on the incidence, transport and speciation of heavy metals {such as Lead (Pb), Copper (Cu), Iron (Fe), Zinc (Zn) and cadmium (Cd)} and hence on the quality of water. The excessive amounts of these metals can become toxic to the aquatic plants. Some of the direct toxic effects caused by high metal concentration include inhibition of cytoplasmic enzymes and damage to cell structures due to oxidative stress. Thus, the negative influence of heavy metals may indirectly affect the growth of plants (**Patil *et al*., 2016).** Present work of the chemical analysis of some heavy metals (Zn, Cd, Pb, Cu and Fe) in water samples from new reclaimed areas (Al-Nubaryia) at Beheira and Giza governorates during the four seasons indicated that no significant difference between lined and unlined water courses was observed in both governorates. Summer season was characteristic with a high concentrations of Zn, Fe and Cd compared to the other seasons in both lined and unlined sites in Beheira. However, Cu was completely absent in summer in lined sites and in summer and spring in unlined ones. In contrast present study in Giza showed that the highest values of Zn, Pb and Cd were recorded in autumn in lined and unlined sites. Whereas, Cu concentration was the highest in spring in unlined sites and in autumn in lined ones. However, the results indicated that Pb was disappeared in summer and spring in both lined and unlined sites. Some studies suggested that the increase of metal concentrations in water during hot seasons (spring, summer) may be attributed to the liberation of heavy metals from the sediment to the overlying water under the effect of both high temperature and organic matter decomposition due to the fermentation process (**Ali and Abdel-Satar, 2005; Goher *et al*., 2014).** The present obtained results may be explained as there is some other environmental factors may be affecting the presence or disappearance of some heavy metals other than the increases of temperature such as pH, Ec, oxidation reduction potential, dissolved salts, pollution, etc. On the other hand, the present work in Beheira governorate showed that the values of Fe were highly significant higher during summer and autumn in lined sites and during summer in unlined ones compared to those of the other seasons. Also, in Giza governorate this value was the highest during autumn in unlined sites. These may be attributed to the fact that these seasons in Egypt (summer and autumn) are characteristic with high temperature which responsible to liberation of Fe from the sediment to the surface water. These results go well with those of **Azzam *et al*. (2016)** who found in their study in the lined and unlined stations in Nubaria canal in Egypt that the concentration of Fe was found remarkably higher than other metals at all of the examined stations throughout the study period (one year). They added that the iron concentration was high in autumn and low in winter. Also, present results confirmed the investigations of **Ekström *et al*. (2016)** who stated that Elevated air temperature should lead to increasing Fe export from soils to ground and surface waters. They found that the largest increases in Fe concentrations were seen in spring and late summer/fall, which was also when increases in temperature was most pronounced. Moreover, **Wedyan *et al.*(2016)** found in their study that Cd and Fe concentrations increased due to different input of drains and may show a highly significant increase during the end of summer and autumn seasons.

In the present results the percentage of abundance and density of the aquatic plants in Beheira governorate was highly significant (p<0.01, p< 0.001) higher in unlined sites compared to the lined ones. Which 8 plant species were collected during all seasons from unlined sites compared to only five species from the lined ones. Whereas, *Eichhornia. crassipes* was completely absent during all seasons in the lined sites. The two plants *E. crassipes* and *Ceratophyllum. demersum* were the most abundant species in unlined sites during all seasons in the present study. In Giza, the percentage of sites containing the two plants *E. crassipes* and *C. demersum* were highly significant (p<0.001) higher in unlined sites compared to the lined ones during summer. Thus, Most lined sites in both governorates containing plants with lower density compared to the unlined ones where the various plants were presented in various diversity and density ranging from lower up to higher. This may be attributed to the fact that most aquatic plants required a substratum of soil which attached and grow. So, lined sites made the habitat unsuitable for plants life. These results go well with those of **Ismail (2009)** who found that only six plant species were collected from the lined sites belonging to several water courses in Egypt compared to nine species from the unlined ones. She investigated that a highly significant reduction between the percentage of lined sites containing the two plants *E. crassipes* & *J. repens* and those of unlined ones. **Mostafa (2007)** stated that the most common macrophytes present in the nature water courses in Egypt were *E. crassipes*, *C. derersum* and *Lemna gibba*.

In the present study, there was a strong correlation between the presence of plants and the increase of heavy metals. The associations pattern between heavy metals and plants were statistically significant at $p<0.05$ level linear association in lined sites during spring. These correlation coefficients depicted very good associations for more than 50% of the relationships ($r=0.58$; $p<0.05$). The coefficient of correlation values between the metal levels (Cd, Cu, Fe and Pb) and plants from Sperman correlation coefficient indicated that the correlation coefficients between heavy metals and plants in summer reflected very good associations for more than75% of the relationships. A strong positive correlation for all metals studied, Cd (0.658), Cu (0.758), Fe (0.589), and Pb (0.781) was observed. In Giza, very strong inverse correlation were observed between the plant *Eichhornia crassipes* and concentrations of Cu (- 0.68) & Fe (- 0.74). Moderate associations were observed between, Pb and *Lemma giba* (-0.65) and *Cyperus alopecuroides* (-0.81) in lined sites.

In conclusion there was a strong inverse correlation between the plants and heavy metals. Watercourses lining may play a significant role in preserving water with a good quality and reduces the distribution of aquatic vegetation which rendered the current of water.

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