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Impact of industrial wastewater disposal on surface water bodies in Mostord area, North Greater Cairo

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Abstract: The studied area (Shoubra El-Khima, Bahteem and Mostorod) lies in the industrial area north of Greater Cairo. The area suffers from several environmental problems such as sewage and disposal of pollutants from the surrounding factories into the surface water pathways in the area. Water samples were collected seasonally from different waterways found in the area, domestic and or industrial liquid wastes from 12 discharge tubes of different factories (as a point source of pollution). Chemical characteristics of different water samples and its heavy metals content were determined using ion coupled plasma technique (ICP). Results indicate that industrial and domestic wastewater samples contain several toxic levels of tested heavy metals (Cd, Co, Pb and Ni) which have a serious impact on surface waterways in the area. Shebin El-Qanater collector drain samples exhibited the highest levels of Cd, Co, Pb and Ni compared to other tested water bodies. Mostorod collector drain samples showed the highest levels of Zn and Cu. Industrial effluent samples collected from Cairo Company for Fabric industry had the highest amounts of total Zn Cu, Cd, Co and Pb, while Delta steel company discharges the highest amounts of total Fe and Mn. Al-Ahleya Plastic Company discharges the highest amounts of total-Ni. Generally, it is necessary to impose the environmental laws and its regulation regarding the industrial wastewater treatments and disposals to minimize the risk of the adverse effects of these pollutants.

Keywords: industrial wastewater; disposal; north Greater Cairo; Egypt

Introduction

The use of wastewater in agriculture is of supreme importance in arid and semi-arid countries. In such countries water is becoming an increasingly scare resource and planners are forced to consider any source of water which might be used economically and effectively to promote further development. Whenever good water quality is scare, water of marginal quality will have to be considered for use in agriculture. However, marginal quality water requires more complex management practices and more stringent monitoring procedures to avoid the hazardous effects of possible industrial effluents discharge to the public sewers or open water pathways. The principal health hazards associated with the chemical constituents of wastewaters arise from the contamination of soils, crops and /or groundwater's.

In accordance with the limited water resources in Egypt and under the increasing need of water for agricultural development, wastewater is becoming a supplementary supply of irrigation in particular parts of the country. Unofficial wastewater reuse is taken place in many locations, where it increases towards the north and the Delta Fringes. During peak demand periods the farmers tend to use wastewater as soon as they fell pressing need to irrigate. Industrial wastewater effluents may contain a number of toxic elements, including heavy metals, which may have a serious impact on the surrounding environment. Under practical conditions wastes from many small and informal industrial sites are directly discharging their industrial wastewater into the common sewer system and /or water bodies. Attention to particular concern to cumulative poison should be drown, principally heavy metals (Abdel-Sabour, 1997), and carcinogens, mainly organic chemicals. The aim of the present study is to investigate the levels of heavy metals in the industrial wastewater as pollution point sources of heavy metals, (i. g. Fe, Mn, Zn, Cd, Co, Pb and Ni). Also, the pollution of surface water bodies passing through the region by industrial wastewater dumping.

1 Materials and methods

The studied area (Fig.1) include Shoubra El-Khhima, Bahteem and Mostorod area is about 24.5 km^2 and lies in the industrial area North of Greater Cairo. Three drains namely; Shebin El-Qanater and Mostorod collector drains which are being used for the disposal of all types of wastes (liquid and solid industrial wastes and sewage effluents) and agricultural laza drain.

1.1 Water sampling

Water samples were collected seasonally according to the standard methods of (USDI, 1960; FAO, 1985) during the period from Oct. 1993 to May 1995. The selected water sampling sites are shown in Fig. 1. Water samples were divided to three categories namely, Drains water, Domestic sewage effluent, and industrial wastewater.

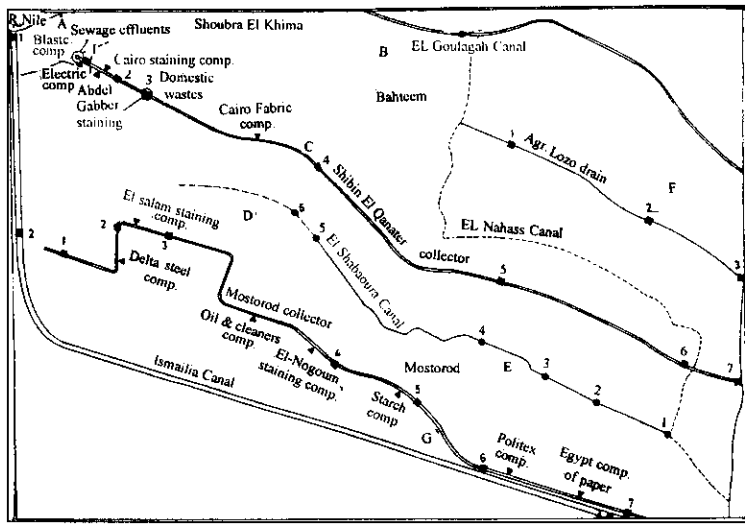

Fig.1 Location of water samples

● canals water samples; ■ collectors wastewater samples; ▼ factories samples; @ sewage and domestic wastes samples

Industrial wastewater samples: Liquid waste samples (48 samples) were collected seasonally from the discharge tubes of the following factories: Group A: El-Ahleya Plastic Factory, Electric Company, Abdel Gabbar Factory for staining, and Cairo Company for Fabric. These factories discharge their liquid wastes directly into Shebin El-Qanater collector (Fig 1). Group B: Delta Company for Steel, El-Salam Company for Staining, Nile Company for Oil and Cleaners, El-Nogoum Company for Staining, Egyptian Company for Starch and Glucose, Politex Company for Staining. Egyptian Company for Paper. These factories discharge their liquid wastes directly into Mostorod collector drain (Fig.1).

Drains water samples: Water samples (28 samples) were taken seasonally from seven selected sites along Shebin El-Qanater collector drain (Fig. 1). This drain is used for collecting agricultural domestic and industrial wastewater. Often farmers irrigate their agricultural fields from this wastewater due to the lack of fresh irrigation water. Another twenty eight water samples along Mostorod collector drain from seven sites were collected seasonally. The latter drain is heavily loaded by industrial wastewater and is being used in irrigation. Another twelve water samples were collected seasonally from the agricultural Laza drain (Sites 1,2 and 3; Fig.1).

Domestic and sewage effluent samples: A sewage discharge tube at the far Western area dumps its load (at rate of 50 m^3/h) to Shibin El-Qanater collector. Four sewage effluent samples were collected seasonally from this wastewater.

1.2 Water samples analyses

All liquid wastes and water samples were transported immediately to the laboratory then filtrated through filter paper No. 44 (Slow ash-less). Both filtrate and suspended matter were kept for analyses. A 500 ml of the filtrate were pre-concentrated (on water bath) to 50 ml for determination of soluble heavy metals. The suspended matter retained on the filter paper was oven dried (105℃), then a known weight was wet digested with $HF/HClO_4$ acids (Jackson, 1969) for determination of heavy metals (Fe, Mn, Zn, Cu, Co, Cd, Pb and Ni) using ion coupled plasma (ICP) technique.

2 Results and discussions

2.1 Industrial and domestic wastes of the studied area

The studied area includes several different industrial activities such as plastic, steel, fabric, staining, paper oil and cleaners industries which discharge their liquid wastes into different water bodies. Also, there are various small factories and workshops, which discharge their wastewater into the sewer system or transport their solid and liquid wastes by trucks to the previous water bodies. Another pollution sources, sewage effluents and domestic wastes are discharged to water bodies through many pipes at different sites. Wastewater samples were collected seasonally from sewage effluents discharging into the beginning of Shebin El-Qanater collector and domestic wastes transported by trucks to the site 3 of this collector and the outlet of some industrial factories. i.e. Ahleya Plastic, Electric Company, Abdel-Gabbar Staining, Cairo Staining, Cairo Fabric, Delta Steel, El-Salam Staining Nile Co. of Oil and Cleaners, El-Nogoum Staining, Egyptian Co. for starch, Politex Staining Company and Egyptian Co. for Paper. These wastewater samples were analyzed for heavy metals. Data in Table 1 showed the concentrations ($\mu g/L$) of Fe, Mn, Zn, Cu, Cd, Co, Pb and Ni in these wastewaters. The amount of wastewater discharged annually from different factories and their content of heavy metals (kg/a) are presented in Table 2. The highest values of Fe concentration were found in the wastewater of Delta Steel Company (21936 $\mu g/L$) while the lowest concentrations were observed in the wastewater of Ahleyah Plasitic Company and Egyptian Company of Starch. Also, the highest amounts of Fe

Table 1 General mean values of total concentrations (μg/L) of heavy metals in the liquid wastes of some industrial factories and domestic wastes during the period of 1993 – 1995 in the studied area

Factory	Fe	Mn	Zn	Cu	Cd	Co	Pb	Ni
Ahleya Blastic Company(A)	309	104	1320	41	48	9	228	299
Electric Company (B)	385	36	1130	69	10	12	162	24
Abdel-Gabbar Staining Co.(C)	3203	334	248	47	9	24	156	42
Cairo Co. for Staining (D)	5167	395	588	282	111	128	466	233
Cairo Co. for Fabric (E)	3319	257	2683	210	34	92	190	46
Delta Co. for Steel (F)	21936	1650	5363	475	17	20	224	100
EL-Salam Staining Co. (G)	2737	304	7812	99	38	69	374	66
Nile Co. for Oil and Cleaners (H)	4103	1592	571	112	13	57	299	73
EL-Nogoum Staining Co. (I)	4261	724	3536	136	24	81	122	55
Egypt Co. of Starch (J)	973	120	470	41	3	4	40	15
Politex Staining Co. (K)	2863	182	2634	99	46	89	135	45
Egypt Co. for Paper (L)	4597	281	8771	190	43	75	367	68
Sewage Effluents (M)	7225	1137	1130	220	22	39	252	109
Domestic Wastes (N)	10123	1761	528	249	49	18	148	525

Table 2 Amounts heavy metals (kg/a) in liquid wastes of different industrial factories and domestic wastes during the period of 1993 – 1995 in the studied area

Factory	Amount of wastewater, million m^3/a	Fe	Mn	Zn	Cu	Cd	Co	Pb	Ni
A	4.40	1360	458	5808	180	211	40	1003	1316
B	0.10	39	4	113	7	1	1.2	16.2	2.4
C	0.12	385	40	30	5.6	1.1	2.9	18.7	5
D	0.99	5115	391	582	279	110	127	462	231
E	5.12	16993	1316	14659	1075	1740	471	973	236
F	4.30	51325	7095	23061	2043	73	86	963	430
G	0.18	493	55	1406	18	6.8	12	67	12
H	2.20	9027	3502	1226	246	28.6	125	658	161
I	0.16	682	116	566	22	3.8	12.9	20	9
J	2.60	2530	312	1222	107	7.8	9.2	104	39
K	0.85	2434	155	2239	84	39	75.7	115	38
L	3.60	16549	1012	31576	684	155	270	1321	245
M	0.37	2637	415	412	80	8	14.2	92	40
N	0.075	759	132	40	19	3.7	1.4	11	40

discharged annually were recorded in the wastewater of Delta Steel (51325 kg/a), while the lowest values were observed in the wastewater of Electric Company (39.0 kg/a). The highest values of Mn concentration were observed in the wastewater of domestic wastes (1761 μg/L), while the lowest values were found in the wastewater of Electric Company (36 μg/L). Concerning the amounts of Mn discharged annually, Delta steel recorded the highest values (7095 kg/a). The highest values of Zn concentration were recorded in the wastewater of Egyptian Company of Paper (8771 μg/L) and the lowest values were recorded in Egypt Company for Starch (470 μg/L). Concerning the amounts of Zn discharged annually, Egyptian Company for Paper recorded the highest values (31576 kg/a). The lowest values were recorded in samples from Abdel-Gabbar staining Co.

(30 kg/a). The highest values of Cu concentration were recorded in the wastewater of Delta Steel Company (475 μg/L). The lowest values were recorded in Egyptian Company of Starch and Ahleyah Plastic (41 μg/L). Concerning the amounts of Cu discharged annually, Delta Steel Company recorded the highest values (2043 kg/a). The highest values of Cd concentration were recorded in the wastewater from Cairo Co. for staining (111 μg/L). The lowest values were recorded in Egypt. Comp. of starch (3 μg/L). Concerning the amounts of Cd discharged annually, Cairo Fabric Co. recorded the highest values (1740 kg/year) followed by Ahleyah Plastic (211 kg/a). The lowest values were observed in Electric Co. (1.0 kg/a).

The highest values of Co concentration were recorded in the wastewater of Cairo Staining Co. (128 μg/L). The lowest values were observed in the Egyptian Company for Starch (4 μg/L). Concerning the amounts of Co discharged annually, Cairo Fabric recorded the highest values (471 kg/a) followed by Egyptian Company for Paper (270 kg/a). The lowest values were recorded in the Electric Company wastewater (1.2 kg/a). The highest values of Pb concentration were recorded in the wastewater of Cairo Staining (466 μg/L). The lowest values were observed in Egyptian Company of Starch (40 μg/L). Concerning the amounts of Pb discharged annually, Egyptian Company of Paper had the highest values (1321 kg/a). The lowest values were observed in domestic waste samples (11.0 kg/a). The highest values of Ni concentration were recorded in domestic wastes (525 μg/L) followed by wastewater of Ahleyah Plastic (299 μg/L) and the lowest values were observed in Egypt Co. (15 μg/L). Concerning the amounts of Ni discharged annually, Ahleyah Blastic recorded the highest value (1316 kg/a) and the lowest values were observed in samples of Electric Company (2.4 kg/a). In general, Cairo Company for Fabric seems to discharge the highest annual load of Zn, Cu, Cd, Co and Pb while Delta company for steel discharges the highest total Fe and Mn. Al-Ahlya Blastic company discharges the highest Ni annual load.

2.2 Industrial wastewater collector drains

Two wastewater collectors were found in the studied area namely; Shebin El-Qanater and Mostorod collector drains. Seven sites of sampling for each collector were selected to reflect the potential pollution point sources. As it would be expected, the sites near the industrial or sewage discharge sources show higher heavy metals concentrations in their water

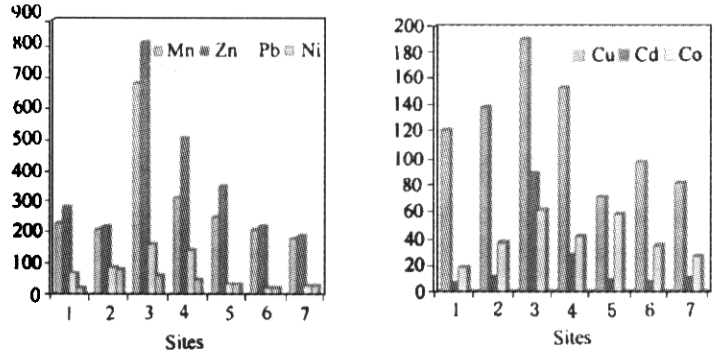

Fig.2 Heavy metals content in Shebin wastewater drain at seven selected sites during 1993 – 1995

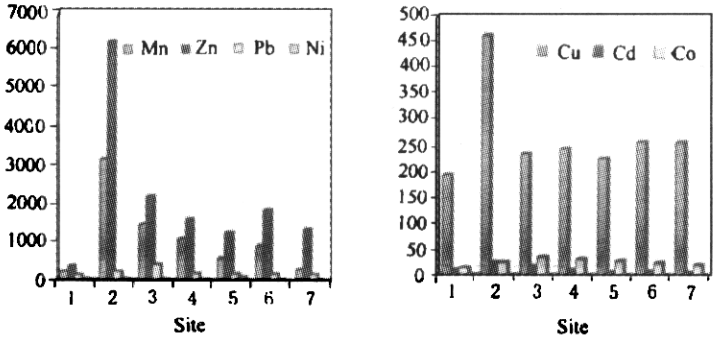

Fig.3 Heavy metal content in Mostorod drain wastewater at different selected sites during 1993 – 1995

samples. As shown in Fig.2, sites 3 & 4 for Shebin El-Qanater collector drain had the highest levels of heavy metals. This is due to discharging wastewater into this collector from the outlets of several factories such as Ahleya Plastic Company, Electric Company, Abdel-Gabbar Company for Staining, Cairo Company for Staining and Cairo Company for Fabric. Site 3 receives another load of dumping wastes by many wastes loaded trucks (liquid and solid wastes) from different small factories,

sewage and domestic garbage. On the other hand, sites 5, 6, 7 which are far from polluted sources (5 – 10 km) showed the lowest levels of dissolved Fe, Mn, Zn, Cu, Cd, Co, Pb and Ni metals. Concerning Mostorod collector drain, site 2 (Fig. 3) showed the highest concentration of Fe, Mn, Zn and Cu (2087, 236, 1881 and 80 μg/L, respectively). This is due to the major effect of Delta Company of Steel which discharge its wastewater at this site. As shown in Table 3, the general mean concentrations of dissolved Fe, Mn, Zn, Cu, Cd, Co, Pb and Ni in Shebin El-Qanater collector drain are 1633, 293, 555, 74, 10, 21.3, 149 and 172 μg/L, respectively, while those in Mostorod collector drain are 695, 137, 1657, 88, 7, 14, 67 and 49 μg/L, respectively. Levels of Fe, Mn, Cd, Co, Pb and Ni in wastewater of Shebin El-Qanater collector drain were higher than their levels in wastewater of Mostorod collector drain. On the other hand, the concentrations of Zn and Cu in wastewater of the latter collector are higher than Shebin El-Qanater collector drain.

Table 3 Mean of dissolved heavy metals content in wastewater samples collected from different drains in tested area

Drain	Heavy metals (μg/L) in wastewater samples							
	Fe	Mn	Zn	Cu	Cd	Co	Pb	Ni
Shbin El-Onater	1667	293	555	74	10	21.3	149	172
Mostord	965	137	966	50	7	14.0	67	29
Laza	652	94	313	23	9	11.0	122	45

Laza agricultural drain: Fig. 4 shows the concentrations of heavy metals in water samples collected from three sites at

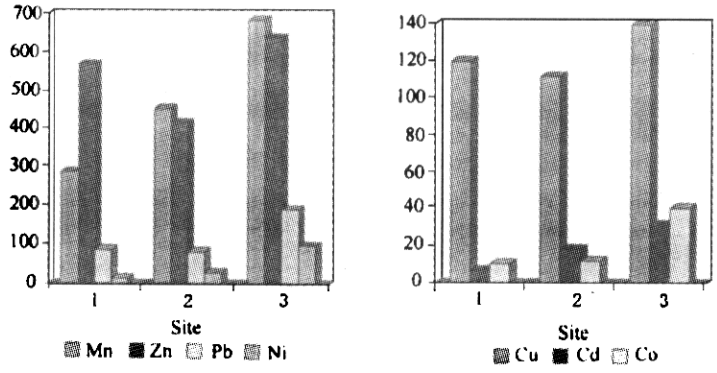

Fig.4 Heavy metals content in Laza drain water at different selected sites during 1993 – 1995

Laza agricultural drain. The general mean concentrations of dissolved Fe, Mn, Zn, Cu, Cd, Co, Pb and Ni in wastewater of this drain are 652, 94, 313, 23, 9.2, 11, 122 and 45 μg/L, respectively. Water quality of different Egyptian drains depend on the nature and amounts of the wastewater load discharged to the drain. The flow-rate of both current stream and discharged waste effluent have a crucial role on drains water quality. Abdel-Shafy and Abdel-Sabour (1995) reviewed heavy metals levels of several Egyptian drains. They pointed out that most potentially responsible metals for water quality impairment are Pb, Cd and Ni for domestic water supply, and Pb and Cd for aquatic uses according to USEPA (1992). The highest values of dissolved Fe were found in Shbin El-Qanater wastewater and Mostorod collector drains specially, in spring and summer seasons, while Laza drain recorded the lowest levels. The highest values of dissolved Mn were found in wastewater of Sbebin El-Qanater collector drain specially in winter season, while Laza drain recorded the lowest levels. Zinc levels in most water samples were high specially, during autumn and winter seasons. The highest values of dissolved Zn were found in the wastewater of Mostorod and Shebin El-Qanater collector drains. The highest values of dissolved Cu were observed during all season in the wastewater of Shebin El-Qanater and Mostorod collector drains. The wastewater of Shebin El-Qanater and Mostorod collectors recorded a high levels of dissolved Cd and Co metals during all seasons. Laza drain recorded the lowest levels of these heavy metals (Cd and Co). The highest levels of both Pb and Ni were found in the wastewater of Shebin El-Qanater collector drains during summer season.

Suspended matter in contaminated water bodies: The average contents of heavy metals in the suspended matter of contaminated water bodies at the studied area are presented in Table 4. The highest amounts of Fe were obtained in the suspended matter of Mostorod and Shebin El-Qanater collectors (26722, 17909 ppm, respectively). While Shebin El-Qanater recorded the highest levels of Mn, Mostorod collector recorded the highest amounts of Zn and Cu (2229 and 234 ppm, respectively). With regard to Cd, Co, Pb and Ni, Shebin El-Qanater recorded the highest levels (47, 61, 380 and 117 ppm, respectively).

Table 4 Mean of total heavy metals content in suspended matter (TSS) of wastewater samples collected from different drains in tested area

Drain	TSS, g/L	Heavy metals in wastewater samples, mg/L							
		Fe	Mn	Zn	Cu	Cd	Co	Pb	Ni
S.Qanater	0.85	17907	1540	684	208	47	61	380	117
Mostord	1.80	26722	982	2229	234	18	30	217	73
Laza	0.28	5134	469	543	124	7	12	161	46

3 Conclusion

Generally, results reveal that industrial wastewater (in tested area) contain number of toxic heavy metals (Cu, Cd, Co, Pb, and Ni) with relatively high levels and may have a serious impact on the surrounding environment, as they do not degrade and when accumulate they cause adverse effect on the environment. To minimize the environmental hazards, waste effluents should be treated on sites where toxic metals originate. Thus, Levels of potentially toxic elements needs to be continuously monitored and should be removed during several treatment processes before the disposal of these wastes.

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