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ASSESSMENT OF SOME POLLUTANTS PRODUCED FROM INDUSTRIAL ACTIVITIES AT DAMIETTA GOVERNORATE – EGYPT

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ABSTRACT

The present research concerned with assessing some pollutants produced from industrial activities in Damietta Governorate. Twenty-two sampling sites have been selected representing the aquatic environment at the study area. Representative samples of water and sediment were collected from the different localities and over two seasons, Summer 2004 and Winter 2005. Physico-chemical characteristics as well as heavy metals (Zn, Cu, Pb, Mn and Cd) were analyzed for both water and sediment samples.

Dissolved oxygen concentration ranged between 0 to 9.9 mg/L with an average value of 4.8 ± 0.8 mg/L. The BOD concentrations ranged between 0.9 and 124 mg/L, with a mean value of 35.4 ± 6.3 mg/L. Chemical oxygen demand concentrations ranged from 6.56 to 1685 mg/L, with an average value of 989.3 ± 740.16 mg/L. However, the highest mean value was recorded in Winter (1630.6 ± 44.6 mg/L), meanwhile there is a concentration drop of COD during Summer whereas the values ranged between 6.56 and 1574 mg/L.

The total organic carbon concentration in sediment varied between 0.13 and 15.6 mg/g dry wt., with an average value of 3.53 ± 0.15 mg/g dry wt. The concentration of the studied heavy metals in water followed concentration abundance as Pb > Cd > Zn > Mn >Cu. While, heavy metals concentration in sediment samples were found according to the following order: Zn > Mn > Pb > Cd > Cu. Therefore, an effective pollution control for pollution sources should be implemented in order to prevent environmental deterioration.

INTRODUCTION

The disposal of human wastes has always constituted a serious problem. With the development of urban areas, it becomes necessary, from public health and aesthetic considerations, to provide drainage or sewer system to carry such wastes away from the residential area. The normal respiratory was usually the nearest water course. It soon became apparent that rivers and other receiving bodies of water have a limited ability to handle waste materials without creating nuisance conditions [**Mahida (1983)**].

The disposal of such wastes involves interrelated social and economic problems. Such problems have, therefore, to be solved with due regard to their impact on the overall development and welfare of society. All industrial wastes cannot be treated to the same degree of purification as sewage and a balanced approach to the problem of treatment is necessary [**Gray (1999)**].

Egypt is a semi-arid country with limited water resources. The population growing, urbanization increasing and the rapid growth of agricultural require the development of the available resources. In addition to the scarcity of precipitation and ground water, Egypt depends mainly on very confined share of the surface water of the Nile River. Consequently the conservation of resources is even of greater significance.

Damietta governorate is located in Delta region and consists of four markzes (Administrative district) and covers an area of 1029 Km. The Governorate's population density is 926.56 persons per Km2 and 57% of the land area is inhibited. It occupies a peninsula and is boarded on all sides by Dakahleya Governorate except for its northern border, which faces the Mediterranean sea. The eastern part of the governorate is occupied by lake Manzala, which covers roughly 20% of the governorate surface area. The main air temperature of Damietta is 21.3 °C ranging from a maximum of 36°C in August to a minimum of 8°C in January.

This area is bordered from the south by dense plan trees. Moving in land from the Delta's northern coast, Prairie areas including marsh land and ponds predominate. Roughly 74% of the governorate is cultivated whilst 19% is covered by water. The Nile splits the Governorate in two, carrying water along its eastern branch throw the Delta from Cairo to the Mediterranean Sea. Damietta Governorate Mediterranean coastline extend for some 61 Km from El-Diba in the east to Gamassa in the west. The coastline is part of the Nile Delta which experienced decreased deltaic and related coastal erosion during the early 20th centuary (i.e.,Ras El-Bar) [**El-Banna &Hasaneen (2000) and El-Banna (2004)**].

The Governorate is rich in natural and economic resources, which has led to increased levels of investment in agriculture, urban and industrial development, oil and gas exploration, and refining and tourism. The area also benefits from a growing fishing industry, which obtain most of its catch from the Mediterranean Sea (20.6 %) and to a lesser extend Lake Manzala (4.39 %). Recent coastal developments in the past two decades include:

- The construction of Damietta port and associated developments (e.g., the Union Fenosa and United Company Gas Derivatives Project).
- The establishment of new Damietta city and the international coastal road.
- Mining activities especially for black sand, quarries and exploitation of sand duns.
- Fishing. Fish and shrimp farming and sea water salt extraction.
- Offshore exploratory activities, and
- Tourist development along Damietta's coastal zone (*i.e.*, Ras El-Bar).

However, much of these developments have been poorly planned and unmanaged which has resulted in the insensitive use of coastal zone lands and natural resources including marine areas. As a consequence the zone fragile environment has deteriorated, beaches now suffer from erosion and sedimentation, coastal water sources have seen an increase in salinity levels (from 800 ppm inland to 30000 ppm around the coast) due to salt water intrusion and the rise in ground water levels and discharge from drains and changes in coastal currents has negatively affected the water quality, fish stocks and wildlife habitats. The largest local source of pollution comes from pollution flowing into the Damietta branch of the Nile, which not only affects negatively on fish and water quality but also poses a health impact on communities living close to the river and fish consumers. Most of this derives from unsanitary or unplanned drainage (*i.e.*, sewage, solid waste ... etc.), which flows from cities, villages and tourist resorts which either have partial or non-existent drainage treatment plants.

New Damietta city which is located along the northern coast of the Mediterranean Sea (6500 acres) has been built to accommodate a population of 270000 and includes five residential districts and two industrial zones, as well as land for tourism development. New Damietta city's population is well behind its planned population target of 25500. In 1996, the city had a population of 6520 residents and in 2000 the city's population was estimated at only 7058 residents.

In contrast to slow population growth, development in the city's industrial zones is progressing rapidly. The city has two industrial zones, namely the industrial zone and the new industrial zone extension, both located south of the city. The industrial zone has a total area of 341 acres divided into 308 land subdivisions. As reported in the Damietta Governorate Statistical Year Book (2000), 291 land parcels have been allocated to investors, 134 projects are under constructions, 160 projects are operating, and five have yet to he allocated.

Aim of the work:

The aim of this work is to study the impacts of some industrial activities generally at Damietta Governorate and particularly at a new developing industrial zone (New Damietta Industrial Zone) in a new developing community (New Damietta City), on the surrounding ecosystem. In this study the distribution of heavy metals and physico-chemical characteristics of both water and sediment in some water bodies were detected.

Study Area:

The sampling locations were chosen to represent the probahly affected areas by discharging of the industrial wastewater from different industrial plants at the New Damietta Industrial Zone.

Twenty-two sampling sites were selected representing the aquatic environment at the study area as shown in Fig (1). These sites are divided into three segments. Sesegment one extends from Mediterranean sea coast at New Damietta City in the East to Mediterranean Sea Coast at Gammassa in the west. Segment two extends from Kafer El-Batikh in the south to the Navigation canal in the north passing through Sanania village. Segment three extends from Meet El-Khouly Abdella village to El-Zarka city.

MATERIAL AND METHODS

All chemicals used were of analytical reagent grade quality. Representative samples of water and sediment were collected from different localities at two seasons, summer 2004 and winter 2005. Water and sediment samples from different sites were analyzed for physico- chemical characteristics which include: pH, Total Dissolved Solids (TDS), Conductivity, Turbidity, Total Hardness, Calcium Hardness, Sulfate, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorus (TP), Total Nitrogen (TN), Nitrite, Nitrate and Ammonia. Heavy metals concentration (Cd, Cu, Mn, Pb, Zn) were determined according to Standard Method [**APHA (1992)**].

RESULTS AND DISCUSSION

Physico-chemical characteristics of water:

The pH is an important factor in the chemical and biological systems of natural waters. It is greatly affected by photosynthetic activity of aquatic flora, temperature and the amount of organic constituents [**Hutchinson (1970)**]. AS shown in fig. (2), pH values ranged from 6.9 to 8.4 during Summer 2004. The highest mean value of pH was recorded at site 9 (8.2 ± 0.23) while the lowest value was recorded at site 21 (7.1±0.21). The increase in pH value is accompanied by a flourishing of photosynthesis organisms [**Rippy & Rippy (1986)**]. The lowest pH value is attributed to the effect of pollution by domestic sewage poured into the drain which led to the liberation of CO_2 and H_2S during the decomposition of the organic matter [**Abbas *et al.*, (2001)**]. This variations in pH (within a narrow range) may be a result of decrease in decomposition of organic matter or due to the reduction of oxygen content at these sites. Present results agreed with the previously recorded results [**Saad (1983); Abdel-Baky & El-Ghobashi (1991) and Dorgham (1999)**].

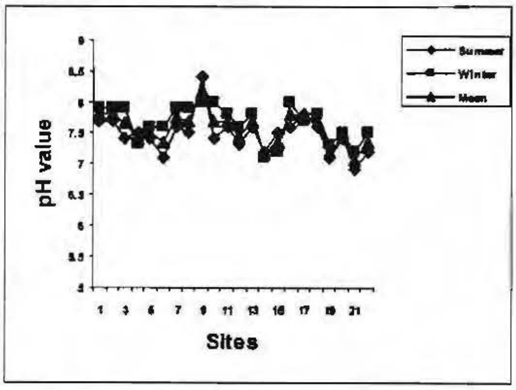

Fig. (2): Site and variation of hydrogen concentration (pH) in water of the study area.

The turbidity values at the studied environment were greatly varied. They ranged between 3.2 NTU to 135 NTU with an average value of 26.3±4.3 NTU. The highest mean value was recorded at both sites 6 and 10 (97±53.7NTU). This is may attributed to the sewage and agricultural discharge into these drains [**Zyadah (1997)**]. Summer represented the highest value of turbidity (29.4±29.8 NTU), these high values may correlated with the photosynthesis processes and high standing crop of plankton organisms (primary productivity) [**Abdel-Baky & El-Ghobashi (1991)**].

The mean value of TDS concentration was 10577.4±1188.4 mg/L. The values recorded at new Damietta coast (site 1 and 2) and Gamassa coast (site 13) were lower than observed by [**Aysen *et al.*, (1988)**] at Turky coastal water (38650mg/L) and [**Said & Karam (1990)**] in Alexandria coast (39000 mg/L). High value of TDS was recorded during Summer, this is due to the high degree of both temperature and evaporation [**Squiras & Saowrd (1986)**]. Lowest values were recorded during Winter, this is attributed to the high rate of drainage water from rain precipitation, in addition to the low rate of evaporation during this season. Sites 1, 2 and 13 recorded the highest values of TDS because of sea water characteristics, while the lowest values of TDS were recorded at sites 14 and 22, which may be due to the high amount of fresh water, agriculture drainage and sewage water which reduce TDS values.

The recorded values of TDS at the present study agree with other results recorded by [**Zyadah (1997)**] in Damietta estuary (32000 mg/L) and [**Khater (2001)**] in Mediterranean sea (26372 mg/L). Moreover, site 18 recorded high value of TDS which may be attributed to the amount of saline water invading this drain from the Mediterranean sea and the degree of mixing between them.

Electrical conductivity (EC) followed the same trend as TDS, and consequently, the highest values were recorded at sites 1, 2, 13 and 18, while the lowest values were observed at sites 14 and 22. However, the relative increase of electrical conductivity during Summer (high temperature and low pH values) may be ascribed to the hydrolysis and redissolution of insoluble salts, and desorption of these salts in the water. Meanwhile, the relative decrease of EC during Winter was consistent with the low temperature and high pH values [**Awadallah & Moalla (1996)**].

Sites 1, 2, 13 and 18 bave nearly high values of sulfate, while, sites 14, 19, 20, 21 and 22 recorded the lowest values. Increased of sulfate values at the mentioned sites may be attributed to the high values of TDS and hardness as suggested by [**Sawyer & McCarty (1978)**] who stated that sulfate was found to be increased with increasing of salinity and alkalinity, whereas the depression in sulfate values at the above site may be due to the decreasing of TDS and calcium hardness at these sites. This is in agreement with the results recorded by [**Khater (2001) and Madkour (2004)**]. On the other hand, the maximum value of sulfate in Summer may be attributed to industrial effluent discharged into these sites and water turbulence which may cause aerobic condition of sulfur, sulfur dioxide and sulfite which are oxidized to sulfate by aerobic bacteria [**Sawyer & McCarty (1978)**]. However, the relative decrease of sulfate concentration in bottom water may be attributed to reduction into sulfide as a result of the considerable effect of reducing bacteria, protein synthesis and subsequent precipitation of detrital organic matter and its decomposition into hydrogen sulfide (H_2S) and insoluble sulfides [**Beauchamp (1953)**]. Sulfur is very important for protein structure, for stabilization of enzyme geometry and for cell division [**Goldman & Horne (1983)**].

The relative increase of total hardness and calcium hardness during winter may be attributed to the increase of $CaCO_3$ solubility with the decrease of water temperature in Winter, and the upwelling of bottom water containing high Ca and Mg concentration to the overlaying water layers by the influence of the stirring winds and induced current in Winter. Moreover, the relative decrease of Ca and Mg contents in surface water in summer may be ascribed to the decreasing $CaCO_3$ and $MgCO_3$ solubility as a result of temperature increase and loss of CO_2 or may be due to their uptake by microorganisms and fish living in the water, photosynthesis, carbohydrate metabolism, fatty acids and chlorophyll syntheses. Present results agreed with the results obtained by [**Awadalla &Moalla (1996) and Awadalla *et al.*, (1993)**].

Dissolved oxygen concentration ranged between 0 and 9.9 mg/L with average value of 4.8±0.8 mg/L. The highest values of DO were recorded at sites 9, 16 and 17 (9.9±0.1, 9.4±0.4 and 9.8±0.14 mg/L, respectively), while sites 5, 6 and 15 have the lowest recorded values (0, 0.25±0.32 and 0.6±0.8 mg/L, respectively). The variations in DO values may be related to the water temperature, penetration of light and photosynthesis [**FWBA (1976)**], concurrent changes of the formation and decomposition of organic compounds, and the uptake of inorganic carbon and release of nutrient to the high rate of biosynthesis of oxygen, penetration of light energy accompanied by the uptake of inorganic carbon, photosynthetic production of hydrocarbons, humic acid and carbohydrates by utilization of CO_2 [$CO_2+H_2O \rightarrow CH_2O + O_2$] and nutrient ions [**Hurst (1950)**]. The lowest value of DO recorded in Summer may be ascribed to the raise of water temperature which led to DO release [**Sawyer & McCarty (1978) and APHA (1989 & 1992)**]. In addition, the isolation of the tropholytic zone from the upper water, the decrease of penetration of light energy from the surface to the bottom, the consumption of DO by respiration of phytoplankton and fish; and the decay of the aerobic bacteria [**Cole (1979)**] were also factors having decreasing effects. The higher values of DO obtained at sites 1, 2 and 13 may be as a results of the high salinity at these sites, also may be due to the great wind action in the open sea which increase the solubility of water oxygen [**Broecker & Peng (1982) and Stefansson *et al.*, (1987)**].

The lowest values of DO recorded at sites 5 and 6 may be attributed to increase quantity of industrial drainage wastewater from industrial zone at New Damietta city and sewage drainage water which decrease the DO at these sites. The present average value of DO was less than other reported data by [**Aysen *et al.*, (1988)**] at eastern Mediterranean Sea (7.7 mg/L) and [**Aboul-Kassim & Dwidar (1990)**] at Alexandria coast (7.24 mg/L). Also, it is more than the reported results by [**El-Hebyawi (1986)**] at Alexandria coastal water and [**Said *et al.*, (1990)**] (3.35 mg/L). The present study showed that the values of DO were in agreement with the obtained results by [**Khater (2001)**] at Mediterranean Sea (6.26 mg/L). and [**Madkour (2004)**] at the eastern region of Delta coast at Damietta (5.89 mg/L).

It is worth to mention that, Summer showed higher values of the biological oxygen demand (BOD) than that recorded during Winter fig. (3). The increase of BOD value may be attributed to pollution where there is a respiratory activity of microorganisms during this time, in addition, sewage, industrial and agricultural effluents in both sea and brackish water cause an increase of organisms which need

DO for an oxidizing the organic compounds [**Lowe (1970); Sawyer &McCarty (1978) and Aboul Kassim (1990)**]. BOD values in the present work were higher than other studies in Alexandria coastal water (4.3 mg/L by [**El-Hehyawi (1986) and Aboul-Kassim & Dowidar (1990)**] at eastern coast of Alexandria (3.9 mg/L). However, there are certain important limitations of BOD as an indicator of organic pollution. When small amount of toxic metallic ions are present in samples, a deceptively low BOD value is observed owing to the inhibition of bacterial activity. For example, as little as 0.01 mg/L of copper materially depresses the result of the BOD test. Some bactericides such as phenols, free chlorine, cyanides, formaldehyde, etc., introduced into sewers by the admission of trade wastes in town sewers, also have a definite suppressing effect on the BOD [**Mahida (1983)**].

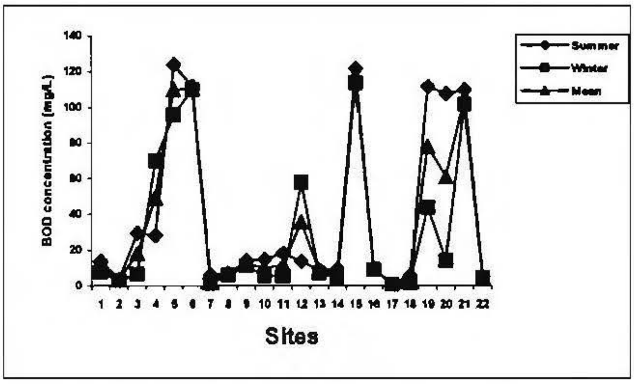

Fig. (3): Site and variation of biological oxygen demand (BOD) concentration in water of the study area.

However, that is indicated the reasons for lowering BOD values when compared to COD values fig. (4) at the same sites of the present work, while there were concentration of toxic metals such Cu which may depressed the results of BOD. Furthermore, some toxic wastes have a high chemical demand for oxygen but indicate a comparatively low BOD even in the presence of large organic matter. When toxic constituents are reduced by dilution below the threshold limits, thereby enabling biological activities to be established, an entirely different picture emerges. With increasing dilution, the total oxygen demand may increase, although COD is decreased [**Mahida (1983)**].

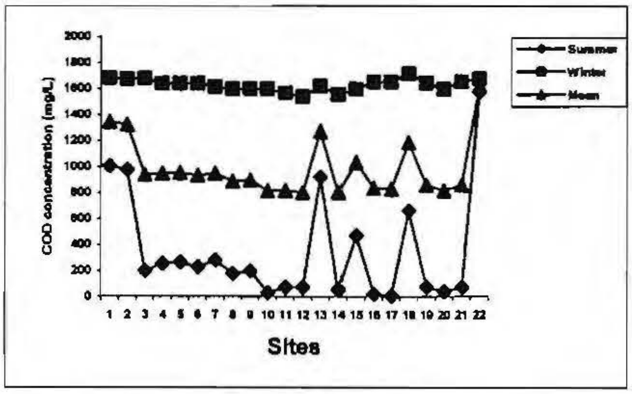

Fig. (4): Site and variation of chemical oxygen demand (COD) concentration in water of the study area.

The environmental significance of phosphorous arises out of its role as a major nutrient for both plants and microorganisms **[Valoon & Duffy (2000)]**. Phosphorous is the limiting nutrient for eutrophication and it is considered as a pollutant if it presents at a high concentration than the normal value **[Saad (1976)]**. The investigations of the present study revealed that high concentration of TP fig. (5) was recorded at sites 5 and 6 (11.8 and 13.04 mg/L, respectively). This may be as a result of high amount of agricultural effluent where phosphorous is an essential element in fertilizers. However, it also may be due to the domestic sewage disposal at these sites, moreover, elevated phosphorous concentrations are related to the pollutants and other nutrient elements at these sites. The decreased value of TP may be attributed to the higher rate of decay of phytoplankton and release of the adsorbed phosphate from the sediment of the waterway bed. Moreover, the decrease and depletion of phosphorous may be related to its adsorption on hydrous Fe_2O_3 and Al_2O_3, its consumption by algae, bacteria or aquatic weeds **[Kramer *et al.*, (1972) and Harvey (1955)]**. The present study are in agreement with **[Khater (2001)]**.

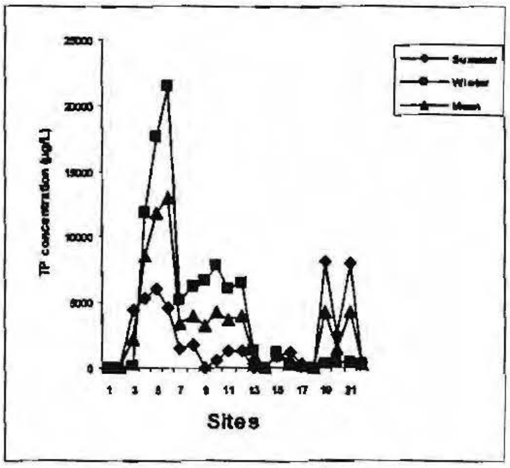

Fig. (5): Site and variation of total phosphorus (TP) concentration in water of the study area.

Fig. (6) showed that total nitrogen fluctuated within a wide range (0.6 to 27.9 mg/L, with an average of 9.68±1.6 mg/L). Maximum nitrogen values were recorded at sites 11 and 12 (27.02±1.25 and 26.64±0.8 mg N/L), while the lowest value was observed at site 14 (0.73±0.1 mg N/L). Fluctuation of nitrogen was inversely associated with the fluctuation dissolved oxygen, this may be attributed to the high rate of bacterial activity associated with high nitrogen content and may also due to the flowing drainage water to these waterways which contain a high concentration of the nutrients [**El-Fayoumi (1994)**; **Zyadah (1997) and Abdel-Baky & Zyadah (1998)**].

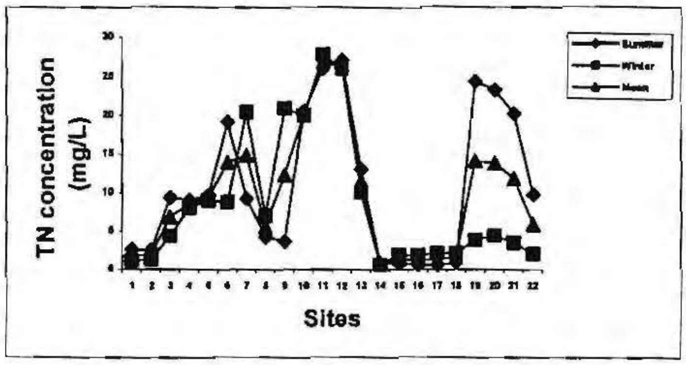

Fig. (6): Site and variation of total nitrogen (TN) concentration in water of the study area

The slight increase in nitrate concentration in winter at different sites of the study area may be ascribed to nitrification of NH_3 and NO_2^- produced by the biochemical decomposition of descending dead plankton by the nitrate nitrifying bacteria, and transformation of organic nitrogen to ammonia and nitrifying ammonia to nitrate. The decrease in nitrate concentration in Summer may be attributed to biological uptake in the photic zone and recycling from the hyplimnion [**Goldman & Horn (1983)**]. Because nitrate is considered the principle source of fixed nitrogen in marine ecology, thus the concentration of nitrate-nitrogen in sea water may vary from 0.001 to 0.05 mg/L [**Mario (1974)**]. Also, the highest values of nitrate may be attributed to high amount of organic matter that was due to the discharge of sewage and agricultural drainage water contains nitrate. Nitrate concentrations at the present work are higher than those obtained by [**El-Hehyawi (1986)**] at Alexandria coast (0.0001-0.00045 mg/L). Nitrite is an intermediated step in the process of converting organic matter into a stable form. Nitrites are, however, not stable and may be reduced to ammonia or oxidized to nitrate; their presence generally indicated that changes are in progress [**Mahida (1983)**]. Nitrite was produced and increased as a result of nitrate reduction by enzyme reductase, increase of nitrification of free ammonia into nitrite, and denitrification of nitrate into nitrite by bacteria existing in water. The decrease of nitrite content may be principally due to the increase of its oxidation to nitrate and reduction of nitrate to ammonia as well as its uptake by plankton [**Awadallah & Moalla (1996)**].The nitrite concentrations found to be high in sites 7, 19 and 21, which may be attributed to the use of ammonium containing fertilizers, and consequently is a source of ammonium ion in water.

The highest mean value of ammonia was recorded during winter (3.84±5.5 mg/L) and may be attributed to increase rate of pollution by drainage water discharged into the waterway, while the low ammonia concentration is due to the increase of plankton population where the phytoplankton utilize ammonium ions in preference to other inorganic nitrogen.

Zinc concentration at the study area ranged between 0.001to 0.0815 mg/L with an average of 0.122±0.05 mg/L fig. (7). Thus, the Zn concentrations lied within the allowable limit (1 mg/L). However, a peak value was observed at site 11(0.74±0.1 mg/L), another high value was recorded at site 21 (0.44±0.54 mg/L), while the highest mean value was recorded during Summer (0.159±0.3 mg/L). This may be due to great amounts of agricultural drainage water that discharging into these waterways. In addition, water-sediment exchange may affect those metal concentrations [**Sonnen (1965)**]. In the present study, zinc was lower than that recorded by [**El-Adel (2000)**] at Gamassa drain (9.05 mg/L). From the hydrobiological point of view, the relative decrease in zinc concentration may be attributed to the decrease in the decomposition rate of organic matter with lower temperature [**Aboul-Naga (2000)**] and due to the consumption of Zn by phytoplankton [**Salah (1960)**]. The highest values of Zn are also coincided with the highest values of salinity. It was found that the potential pollutants resulting from industrial drainage, domestic sewage, agricultural drainage and urban runoff lead to the increase of heavy metal concentration in water.

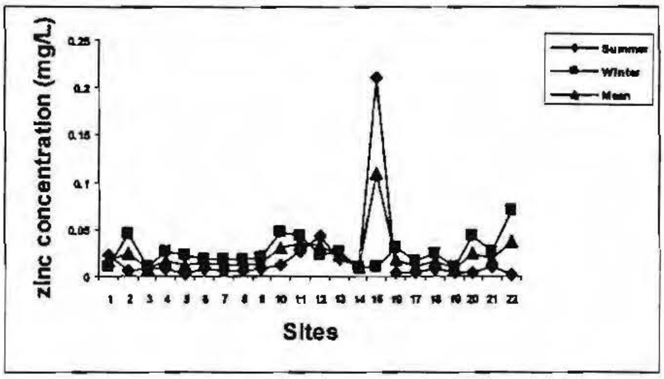

Fig (7): Site and variation of zinc concentration in water of the study area.

It is clear from fig. (8) that the mean value of cadmium concentration was 0.13±0.04 mg/L, while the highest values were recorded at sites 1, 5and 18 (0.27±0.3, 0.26±0.17 and 0.26±0.16 mg/L, respectively). However, these values exceed the allowable limits of cadmium (0.01 mg/L).The highest value was recorded in Summer (0.16±0.15 mg/L), however, this may be due to agricultural, domestic and industrial wastewaters discharged into these sites. It is found that 70-90% of Cd in a freshwater stream was present as the free hydrated ion or other liable complexes. In general, a high proportional of Cd is usually associated with organic matter, particularly humic acid [Giller *et al.*, (1998)].

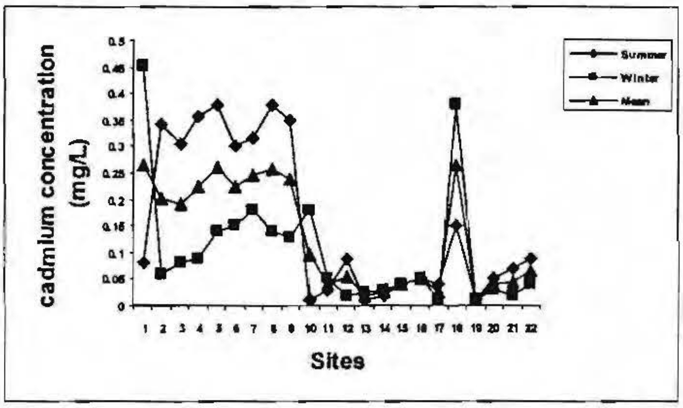

Fig. (8): Site and variation of cadmium concentration in water of the study area.

The mean concentration of lead in water of the study area was 0.5±0.3 mg/L exceed the allowable limit by 10 fold (0.05 mg/L) as shown in fig. (9).The highest value were recorded at sites 12, 13 and 17 (0.85± 0.2, 0.88±0.05 and 0.88±0.01mg/L, respectively). These higher levels may be due to the higher amounts of agricultural and domestic wastewaters discharged into these waterways. Comparing the present results with other recorded results in different locations revealed that, it was higher than recorded by **[Zyadah (1995)]** in Lake Manzalah (0.343-1.185mg/L).

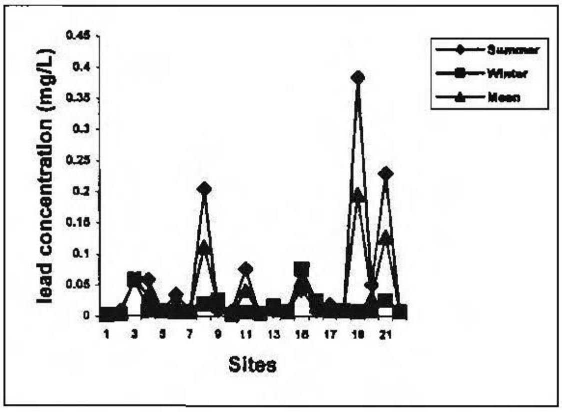

Fig. (9): Site and variation of lead concentration in water of the study area.

[UNEP/FAO (1986)] demonstrated that, the mean copper concentration of Mediterranean Sea ranged between 0.0003-0.003 mg/L. Consequently, as shown in fig. (10), the results of the present study increased seven fold than the recorded by **[UNEP/FAO (1986)]**. The mean value of Cu concentration was 0.023± 0.004mg/L. Site variation indicated that one peak was observed at site 15 (0.11±0.14mg/L), whereas, the lowest values of Cu concentration in water were found at sites 3 and 19(0.008± 0.001 and 0.007± 0.003mg/L, respectively). However, the mean value recorded during Winter was higher than that recorded during Summer (0.026± 0.015 and 0.02± 0.043 mg/L, respectively). This may be due to the mixed drainage water from sewage and agricultural activities. On the other hand, the decrease of Cu concentration may be due to the tendency of Cu to form complexes with organic legends and humic matter **[McKnight *et al.*, (1983) and Kendrick *et al.*, (1992)]**. According to **[Mance (1987)]**, the Cu concentration of the present study did not exceed the allowable limit (1 mg/L).

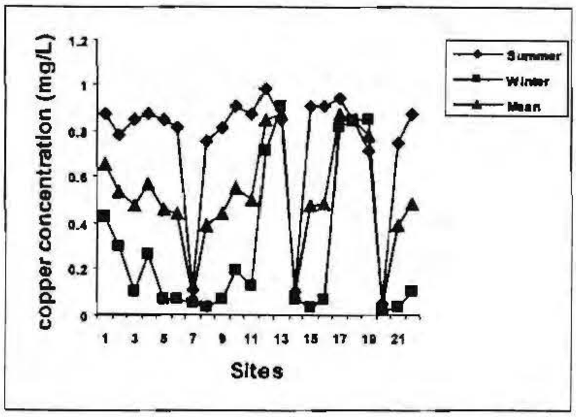

Fig. (10): Site and variation of copper concentration in water of the study area.

Physico-Chemical characteristics In Sediment:

The sediment reflects the pollution in water column, where it tends to concentrate the heavy metals and other organic pollutants particularly organic matter [**Guerrin *et al.*, (1990)**].

The mean value of hydrogen ion concentration in sediment was 7.6±0.26. All pH values at the different sites of the study area were slightly alkaline, however, the highest mean value was recorded at site 2 (8.05±0.96), whereas the lowest value was observed at site 14 (7.3±0.18). These pH values may be due to agricultural, sewage and industrial wastewaters discharged into these areas that lead to increase of organic matter and pH value. Generally, the activity of bacteria is at its best in mineral soil at intermediate and higher pH values but get depressed when the pH falls below 5.5. A pH ranged from 6 to7.5 is about the most satisfactory biological environment. Nitrification takes place vigorously in soil when the pH is about 6 and above. However, pH range of 6.5 to 7.5 approximately, is conducive to the availability of most plant nutrients. There are some correlation between pH and soil environments, the availability of nutrients, the activity of micro-organisms and the toxicity of certain solutions [**Mahida (1983)**].

The highest value of total dissolved solids in sediment was recorded at site 4 (42580±3563.8 mg/L), this may be attributed to the nature of this site, where there is a drainage pumping station of Sanania and all the industrial and domestic wastewater of New Dimietta city and the industrial effluents of New Damietta industrial zone were accumulated at this site and consequently, there are a huge accumulation of pollutants. However, Summer recorded the highest mean value of TDS, this may be due to the increased amount of wastewater pumped during Summer, because of increasing recreation activities and may be attributed to high rate of evaporation.

The electrical conductivity values in sediment show that, the highest mean value was recorded at site 1 (28.78±21.81 µmhos/cm) and the lowest value was observed at site 11 (1.2±0.5 µmhos/cm). Because EC is considered as an indication of soil salinity and site 1 is the Mediterranean Sea coast of Damietta, so its sediment contains great amount of salts that are hydrolyzed and redissoluted causing the high value of EC. The decrease of EC in Winter may be due to the low temperature.

The highest values of ammonia, nitrate and nitrite in sediment were recorded in Summer (140±240, 26.7±51.2 and 17.73±33.12 mg/kg dry wt., respectively). It was found that, site 21 had the highest ammonia concentration, while the nitrate and nitrite concentration at the same site were low, this may be attributed to the transformation of organic nitrogen to ammonia and to increase of nitrite oxidation to nitrate and reduction of nitrate to ammonia. That reasonably happened after discharging of high amount of sewage and agricultural effluents to this drain. It is obvious that, the ammonia concentration at all sites of the study area were higher than those of nitrate and nitrite and the above processes were though to be happened also at all site. However, ammonification is dependent on microbes and the enzymes they produce. Most microbes can decompose organic matter; ammonification therefore takes place rapidly when conditions favour microbial activity in general. Favorable conditions include a moist warm soil well supplied with nutrient and organic matter. The process slows down when the soil becomes dry or the temperature drops toward freezing [**Thompson & Troeh (1982)**]. Moreover, the nitrite concentration was lower than the nitrate at the same site that may be due to the increase of nitrite oxidation to nitrate. The concentration of ammonia, nitrite and nitrate were the highest during Summer, this may be attributed to the high amount nitrogen fertilizers and the agricultural activities during this season.

The mean value of total phosphorous concentration in sediment at the study area was 4.97±2.67mg/g dry wt fig. (11) with a highest value recorded in Winter (6.85mg/g dry wt.). This may be ascribed to the introducing of phosphate fertilizers washed down from the cultivated lands and reached to these drains. These results are in agreement with [**Nafea (2005)**]. The high concentration of TP at section three may be attributed to sewage wastewater reached also to these drains [**Ramzy (1994)**]. Phosphorous in the sediment may be adsorbed to particles, bount to calcium, chemisorbed by ironoxyhydroxides, and contained in organics [**Krom & Berner (1981) and Blazer (1986)**]. The efficiency of phosphorous utilization is generally low, organic matter plays an important role in increasing the availability of this element. Decomposition of organic matter results in the release of phosphates from the decomposed material. As the organic matter is decomposed by microorganism, phosphorous is mineralized and released. Organic matter and microorganisms materially affect the availability of inorganic phosphorous [**Mahida (1983)**]. However, soil microorganisms generate large quantities of carbon dioxide. Carbonated water acting on tricalcium phosphate leads to the formation of soluble phosphates.

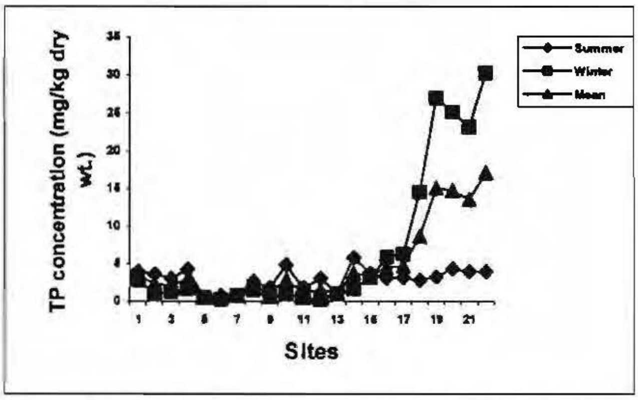

Fig (11): Site and variation of total phosphorus (TP) concentration in sediment of the study area.

The total organic carbon varied between 0.13 and 10.66 mg/g dry wt. with an average value of 3.53±0.153 mg/g dry wt. fig. (12). The highest value was recorded at site 6 (10.66±6.99 mg/g dry wt.). That may be due to sewage discharge which reached this drain, in addition to the rotten dead freshwater plants that sink and decay on the substratum at these sites. [**Shimp *et al.*, (1971)**] found a good correlation between the concentration of heavy metals and concentration of organic carbon in sediment.

Sedimentation processes may deposits heavy metals contained in anthropogenic particles, together with terrigenous and biogenic material, on the seabed. The processes are very important in river deltas and also in other areas receiving discharges of domestic sewage and industrial effluents, sludge and solid wastes. The concentration of heavy metals in sediments will thus depend not only on pollution inputs, but also on other factors such as the natural background levels of the area and its catchment basin, the geomorphology, the prevailing water circulation, the organic carbon content, the mineralogical characteristics and grain size of sediment components and the sedimentation rates [**UNEP (1993)**].

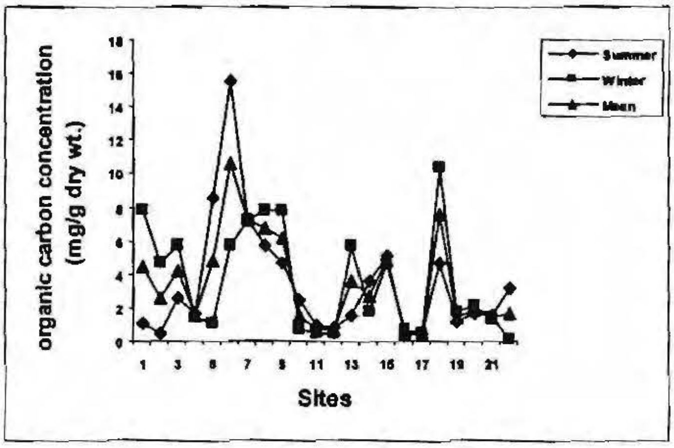

Fig. (12): Site and variation of organic carbon concentration in sediment of the study area.

As shown in fig. (13), the average concentration of zinc was 0.81±0.29mg/kg dry wt. The highest values was recorded in site 22 (2.12±0.91mg/kg dry wt., this may be attributed to the amount of agricultural drainage, domestic wastewater and industrial effluents discharged at this drain. The increase value of Zn concentration in sediment during Summer was related to the highest concentration in water in the same season.

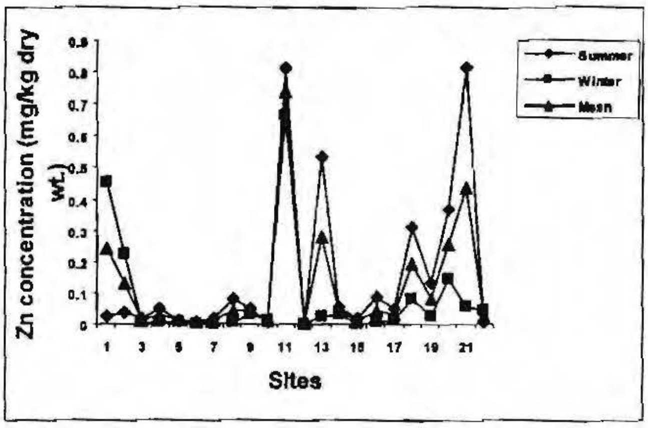

Fig. (13): Site and variation of zinc concentration in sediment of the study area.

The concentration of Zn in surfacial sediment in the present study was lower than the data reported by [**Nasr *et al.*, (1990)**] and [**Mahmoud (1992)**] at Alexandria coastal water (108 mg/kg dry wt.), [**Zyadah (1997)**] at Ezbat El-Borg (406.2-536.3

mg/kg dry wt.) and [**Zyadah (1995)**] and [**Abdel-Baky *et al.*, (1998)**] at Lake Manzalah (5.93-107.54 and 48.42 mg/kg dry wt. respectively).

The cadmium concentration in surfacial sediment fig. (14) ranged between 0.07 and 0.25 mg/kg dry wt., with an average value of 0.13±0.04 mg/kg dry wt.. The highest value was recorded at site 17 (0.19±0.08 mg/kg dry wt.), this may be attributed to sewage effluents, industrial waste and agricultural drainage water. Many authors have found that domestic wastewater can contain a fairly high concentration of heavy metals [**Brindley *et al.*, (1982); Stephenson (1987) and Wong & Chiu (1993)**]. Others found that there is a relation between Cd and nitrogen. This relation may reflect their input sources or their mutual chemical adherence [**Collinson & Shimp (1972) and Pezetta &Iskandar (1975)**].

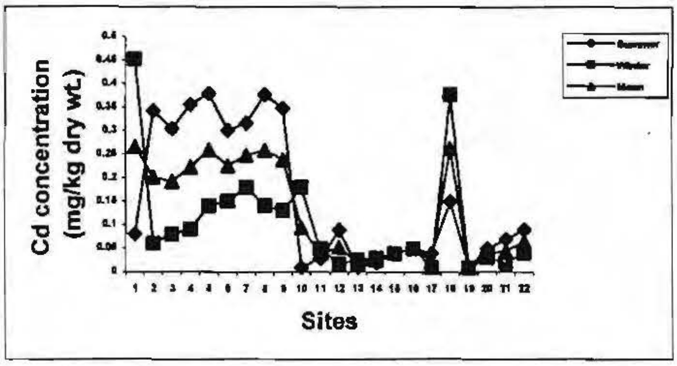

Fig. (14): Site and variation of cadmium concentration in sediment of the study area.

Lead concentration in surfacial sediment was found to exhibit a slight seasonal and site differences fig.(15). The maximum concentration of Pb was recorded at site 22 (0.32±0.09 mg/kg dry wt.), this may be attributed to the industrial effluents, the domestic sewage and agricultural drainage water received by this site. The recorded value of Pb concentration at the present study was lower than indicated by [**Nasr *et al.*, (1990) and Mahmoud (1992)**] of Alexandria coastal water (71.52ppm and 93.9 mg/kg dry wt., respectively); [**Zyadah (1997)**] at Damietta estuary (16.4-20.3 mg/kg dry wt.) and [**Abdel-Baky *et al.*, (1998)**] at Manzalah Lake (14.05 mg/kg dry wt.). In addition, increased value of Pb concentration in sediment may be referred to the sinking of fresh water floated plants which are coming from River Nile, then died in the saline water and down to sediment of the substratum. These plants have a great tendency to accumulate some heavy metals (e.g. Pb) in high values [**Zyadah (1997)**]. The increasing values recorded in Winter may be related to the increase levels of organic carbon, which in sequence, associated and had a tendency to precipitate Pb metal [**Ramzy (1994)**].

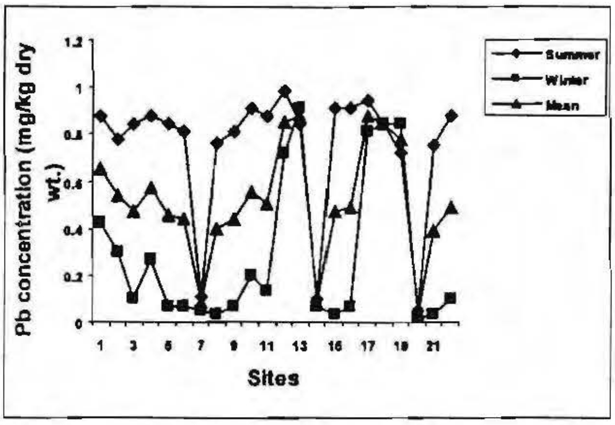

Fig. (15): Site and variation of lead concentration in sediment of the study area.

The mean copper concentration in surfacial sediment at the study area was 0.113±0.004 mg/kg dry wt. fig.(16). Site 20 recorded the highest concentration of Cu during Winter, this may be due to agricultural and sewage effluents discharged into these sites. Copper variation during seasons at different sites in water and sediment may be due to its tendency to form complexes with organic ligands and humic matter [**McKnight *et al.*, (1983) and Kendrick *et al.*,** (1992)], this complication leads to decrease of the portion of free ions in water. It was found that, 90% of Cu in water was complexed by dissolved humic matter [**Mantoura *et al.*,** (1978)]. Copper concentration in surfacial sediment in the present study was lower than that recorded by [**Nasr *et al.*,** (1990)] in Alexandria coast (29.4 mg/kg dry wt.) and [**Mahmoud** (1992)] in Alexandria coast (44.54 mg/kg dry wt.).

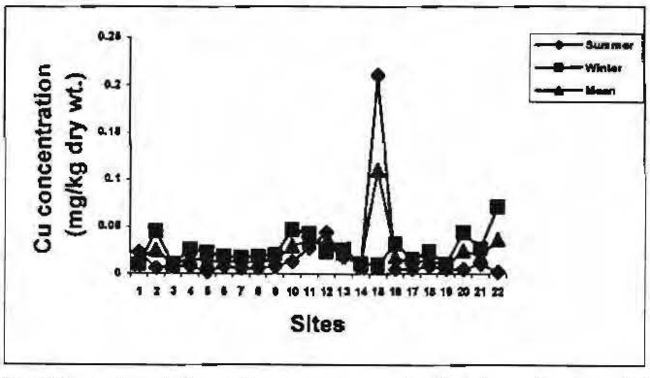

Fig. (16): Site and variation of copper concentration in sediment of the study area.

Comparing the level of heavy metals in the sediment of the present study with their Standard concentrations in the shales (Cu: 45, Zn: 95, Cd:0.3 and Pb: 20 ppm) which were reported by [**Turekian & Wedepohl (1961)**], it can be shown that the surfacial sediments of the studied environment contain lower levels of heavy metals than the standard limit.

RECOMMENDATIONS

It can be concluded that the appropriate ways of controlling the pollution of most investigated drains are as follows:

1. Pretreat the different types of industrial and domestic wastewater before discharged into sewer.
2. Minimize pollution from industrial activities via pollution prevention.
3. Ensure that industrial and hazardous wastes are safely disposed.
4. Provide incentives to industries to encourage them to invest in new pollution abatement equipment.
5. Establish waste transfer stations to control and manage industrial and hazardous waste streams, specially in marine sites.
6. Ensure that large industries introduce necessary pollution abatement equipment to comply with Egyptian environmental law.

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الملخص العربى

تقييم بعض الملوثات الناتجة عن الأنشطة الصناعية في محافظة دمياط – مصر

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يهتم هذا البحث بتقييم بعض الملوثات الناتجة عن الأنشطة الصناعية في محافظة دمياط. وبناءا على ذلك تم اختيار اثنين وعشرين موقعا لتمثل البيئة المائية في منطقة الدراسة. تم تجميع عينات ممثلة للمياه والرسوبيات من المناطق المختلفة خلال موسمي صيف ٢٠٠٤ وشتاء ٢٠٠٥ وتم تحليل الخواص الفيزيائية والكيميائية وبعض العناصر الثقيلة للعينات بالمناطق قيد الدراسة.

وقد أظهرت النتائج أن تركيزات الأكسجين الذائب في المياه قد تراوحت بين صفر إلى ٩,٩ ملليجرام/ لتر بقيمة متوسطة ٤,٨±٠,٨ ملليجرام/ لتر، بينما تراوحت تركيزات الأكسجين الحيوي المستهلك بين ٠,٩ إلى ١٢٤ ملليجرام/ لتر بقيمة متوسطة ٣٥,٤± ٦,٣ ملليجرام / لتر. وبالنسبة لتركيزات الأكسجين الكيميائي المستهلك فقد تراوحت بين ٦,٥٦ إلى ١٦٨٥ ملليجرام/ لتر. وقد سجلت اعلى قيمة في فصل الشتاء (١٦٣٠,٦ ± ٤٤,٦ ملليجرام/ لتر) و قد لوحظ انخفاض في تركيزات الأكسجين الكيميائي المستهلك خلال فصل الصيف وتراوحت القيم بين ٦,٥٦ إلى ١٥٧٤ ملليجرام/ لتر.

وتراوحت قيم الكربون العضوي الكلى في عينات الرسوبيات بين ٠,١٣إلى ١٥,٦ ملليجرام/جم وزن جاف بقيمة متوسطة ٣,٥٣±٠,١٥ ملليجرام/جم وزن جاف. وقد وجد أن تركيزات العناصر الثقيلة في عينات المياه تبعت الترتيب التالي: الرصاص> الكادميوم> الخارصين> المنجنيز> النحاس، بينما كان ترتيبها في عينات الرسوبيات كالتالي: الخارصين>المنجنيز >الرصاص >الكادميوم.

وقد أوضحت نتائج الدراسة أهمية تطبيق طرق ذات كفاءة عالية للتحكم في التلوث الناتج عن الأنشطة الصناعية المختلفة داخل المنشأة وذلك لحماية البيئة الطبيعية.