J. Egypt. Acad. Soc. Environ. Develop., 19 (1): 177-184 (2018) **(D-Environmental Studies)**
E.mail: easedjournal_egypt@yahoo.com **ISSN 1110-8770**
www.eased.byethost13.com **eISSN 2314-5471 (online)**

Distribution dynamics of some heavy metal concentration in the sediments of Damietta and Rosetta branches, River Nile, Egypt

A.A. Elewa[1], M.E. Goher[1], L.F. Mohamed[2], H.S. Bekheet[2] and G.S. Abd El Aziz[1*]
[1] National Institute of Oceanography and Fisheries
[2] Faculty of Science (Girls), Al-Azhar University
*D.ghada_salah@yahoo.com

ABSTRACT

Sediments are the major compartments for many materials of toxic or nutrient concern in aquatic environment. So the studies of the distribution dynamics of heavy metals in the sediments are very important. The aim of the present study is to illustrate the factors affecting on the rate of accumulation of the sediments in Damietta and Rosetta branches during the period 2010-2011. The recent sediments were collected by Ekman dredge from 24 stations represent different localities along the extent of the two branches during four seasons. The present results show that the Rosetta branch was highly polluted compared with Damietta branch.

Keywords: Heavy metals, Damietta branch, Rosetta branches, accumulation of metals, sediments.

INTRODUCTION

The River Nile is the dominating features of northeastern parts of Africa Affecting several African countries. From Aswan to Cairo, the Nile runs for about 975 Km. North of Cairo at Delta barrage the Nile bifurcate into Rosetta and Damietta branches. On the other hand, the two branches are subjected to several types of pollution due to the different industrial wastes as a direct results from neibouring several factories in addition to domestic and Agriculture waste effluents normally contaminated with heavy metals, depending on the quantity and quality of the effluents inputs (Essa*et al*., 2014; Elewa & Goher (2016), Ali 2013) show that most chemical concentrations in Damietta branch increased northward due to the extensive industrial, agricultural and domestics wastes thermal pollution by the cooling system of Talkha and Kafr Saad electric power stations and to the excretion of fish from fish cages dispersed in the area between El-Serw and Faraskour cities. Therefore the sediment existing at the bottom play a major role in the pollution of the two branches ecosystem by heavy metals. Also, the sediment reflects the current quality of the water body by heavy metals (Bauomy *et al*., 2017).Therefore, the analysis of heavy metals in the sediments. Number of studies have been conducted on the role of heavy metals in water and sediment of the rivers in the world where the bottom sediment act as accumulator for these metals and the rate of accumulation depends on the environmental conditions (Elewa *et al.*, 2015; Goher *et al.,* 2017; Hagag, 2017 ; Bayomy, 2017).

The purpose of the present study is to determine the pattern of some heavy metals in the sediments of Damietta and Rosetta branches and the factors affecting on the precipitation and dissolution of these metals during the period 2010-2011.

MATERIALS AND METHODS

Damietta branch is about 220 Km and Rosetta branch 125 Km in Lengths. These two branches are the main sources for drinking and irrigation water for the Governorates of Delta Zone.

Sampling program

Sediment samples were collected seasonally from 24 stations along the extent of the two branches (Table 1, Fig. 1). The recent sediments from different areas using Ekman dredge sampler sediment samples were collected from 24 location along the two branches to cover different environmental conditions (following table) complete digestion of sediment was done according to Kouadiol and Trefry (1987) and the studied heavy metals were analyzed by atomic absorption spectrophotometer Model Perkin Elmer 3150 and the concentration were determined by using of calibration curve express in (µg/g).

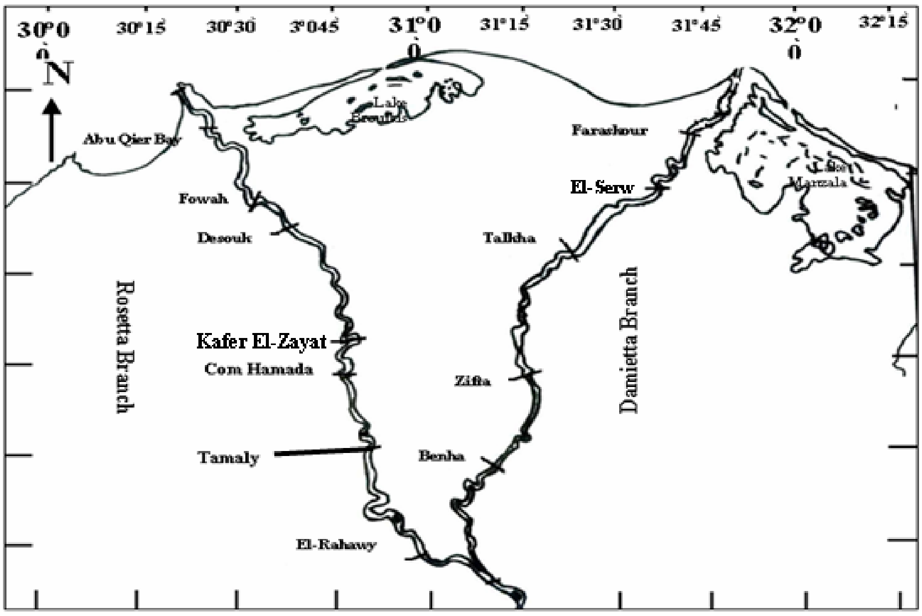

Fig. 1. Map of Damietta and Rosetta branches illustrates the selected stations

Table1. Feature of the location of the sampling sites along the extend of Damietta and Rosetta branches

	No.	Code	Features of station	Position	
				Latitude	Longitude
Damietta Branch	1	D1E	Eastern bank at Benha City	30° 27.58′	31° 10.61′
	2	D1M	Main Channel at Benha City		
	3	D2E	Eastern bank at Zefta City	30° 43.08′	31° 24.31′
	4	D2M	The main Channel at Zefta city		
	5	D3W	At discharge point of cooling water of Talkha Electric Power Station	31° 04.00′	31° 24.31′
	6	D3M	The main channel at Talkha city		
	7	D4E	Eastern bank at El-Serw city		
	8	D4M	The main channel at El-Serw city	31° 14.43′	31° 14.43′
	9	D5W	Weastern bank at Faraskor city		
	10	D5M	In the main channel at Faraskor city	31° 21.35′	31° 46.95′
Rosetta Branch	11	R1up	In main channel (upstream of El-Rahawy Drain)	30° 12.44′	31° 01.99′
	12	R1M	In main channel at El-Rahawy		
	13	R1E	Eastern bank (downstream of El-Rahawy Drain)		
	14	R2E	Eastern bank at atTamalay bridge	30° 30.46′	30° 50.03′
	15	R2M	The main channel at Tamalay bridge		
	16	R3W	Weastern bank at Kom Hamada city	30° 42.89′	30° 45.69′
	17	R3M	The main channel at Kom Hamada city		
	18	R4E	Eastern bank at Kafr El-Zayat city	30° 49.56′	30° 48.43′
	19	R4M	The main channel at Kafr El-Zayat city		
	20	R5W	Weastern bank at Dosouk city	31° 08.16′	30° 38.16′
	21	R5M	The main channel at Dosouk city		
	22	R6W	Weastern bank at Fauwa city	31° 12.00′	30° 33.17′
	23	R6M	The main channel at Fauwa city		
	24	El-Rahawy	At discharge point of El-Rahawy Drain		

D: Damietta branch R: Rosetta branch

Pollution Load Index (PLI)

The extent of pollution by metals has been assessed by Appling the Pollution Load Index (PLI). This parameter express as PLI = $(CF_1 \times CF_2 \times CF_3 \dots CF_n)^{1/n}$ where n is the number of the metals and CF is the contamination factor where CF=metal concentration in the sediment/metal back ground value. The background concentration express in (µg/g) of Fe (4670), Mn (950), Zn (95) Cu (45), Pb (20) and Cd (0.3) in the standard shale according to Turekian and Wedpohl (1961). The obtain values in the sediment to quantify the degree of metal pollution (Cevik *et al.*, 2009; Nobi *et al.*, 2010; Ong *et al.*, 2013). The PLI value > 1 indicate that the sediment is polluted whereas PLI< 1 indicate that no pollution (Tomlinson *et al.,* 1980).

Statistical analysis

One-way Anova analysis was applied identify significant differences for metals among different seasons and stations for sediment samples, significance levels of tests were taken as P< 0.05 and highly significance levels of tests were taken as P<0.05 and highly significance as P<0.01. Pearson's correlation analysis was performed to evaluate the potential relationships between the measured variables. Anova tests and correlation coefficient (r) between the studied elements were undertaken using Excel-stat software.

RESULTS AND DISCUSSION

The seasonal variations of the studied heavy metals are presented in Table (1). The present results indicate that no significant differences (P< 0.05) in metals concentrations were observed in the sediments of Damietta branch during summer expect Co and Cd (r = 0.59) and Fe with Pb (r=0.58) and Pb with Ni, Co, Zn (r = 0.55-0.64) between Fe and Cu and Mn with Zn during Autumn. In winter there is significance positively correlation between Nicle and Cu (r=0.64) and Co(r=0.72) and there is negative correlation exists between Mn and Cu (r= 0.58) during spring, there is positively significance correlation between Cu and Pb (r= 0.84) and between Co and Cu and Zn (r= 0.76).

In Rosetta branch, there is highly significance (r=0.86) between Cu and Zn and modernly significance (r = 0.64) between Mn and Co and between Co and Cd (r = 0.58) during summer. During autumn , the results show that no significant differences (P> 0.05) in metals content were observed in the sediment along the extent of the branch may be due to the localized pollution during winter, there was highly significance (P<0.01) between Cu and Zn (r = 0.94), this indicted that, these two element oxides exist together with clay minerals or adsorption of both Cu and Zn on hydrated iron and Manganese oxides. This was confirmed by Abdelsatar and Elewa (2001) and Abdo (2013). During spring there was a highly significance (r = 0.86)between Zn and Co. The present results show that there is highly significance (P<0.01) between iron and Ni(r = 0.94)and the correlation Fe and Zn and (r = 0.92) between and Mn and (r = 0.64) (r = 0.78) and (r = 0.72) between Fe and Pb during summer. This indicate that iron is considered as one of the Geochemical support phase of these elements (Abdo *et al.* (2017) iron occur in sediments in different forms including oxides, hydroxides, phosphates and sulphides (Erely *et al.,*1991). In Damietta and Rosetta branches it fluctuated in the ranges (7.4-9.7) and 6.2-10.7 mg/g respectively. The deposition of iron from the water to the sediment was high oxygen content an pH value and organic matter (Elewa *et al.,* 1997).

The maximum concentration of Mn 261.2 and 399.5µg/L measured at Damietta and Rosetta branch. The increase in Mn content may be due to the precipitation of Mn as MnO_2 under anaerobic condition (Abdelsattar and Elewa 2001). On the other side, the lowest values of Mn were 165.1 and 148.9 µg/L recorded during winter in Damietta and in summer at Rosetta branch. This decrease in Mn contents may be due to the mobilization of Mn from sediment to the overlying water due to the decomposition of organic matter (0.8-8%), (0.6-7.5%) (Abdo, 2013).

Nickel is precipitated with hydroxide, phosphate, carbonates and silicate. Also, Ni adsorbed by silicate clays and from insoluble and soluble complexes with the soil organic matter (Baker & Chison 1975). The results of Ni show the ranges of 2.6-46.7 and 0.5-96.9 µg/g in Damietta and Rosetta branches. A wide fluctuation in Co content (5.9-21.6) and 5.4-36.1 µg/L for the proceeding branches respectively, which is depending on the sediment types, the settling of Co rich organic matter and the dynamics of adsorption on clay minerals and assimilation by aquatic macrophytes.

Lead present in the form of $PbSO_4$ and $PbCo_3$ and adsorbed by minerals in sediments. The increase of Pb (86.5 µg/g) and 89.7 µg/g in Rosetta and Damietta branches may be related to the settling of Pb rich plankton to the sediment (Abdelsatar *et al.*, 2003). The decrease of lead concentration (19.6-26.2 µg/g) during summer may be due to the Remobilization of Pb from sediments to overlying water is mainly affected lowering in pH and changes in Redox conditions (Sayed, 2002) cadmium is sorbet to sedimentary organic matter and its binding intensity is very sensitive to pH (Rudd *et al.*, 986). The present results show an increase in Cd concentration during 3.98 and 4.96 µg/L in Damietta and Rosetta branches may be the effluents of El-Rahany drain (station (3) and Easter bank of Zefat city due to the effluents at station (3) of domestric and industrial wastes. On the other hand, the decrease of Cd 0.45 µg/g and 0.88 µg/g may be related to the mobilization of Cd from sediment to the above water (Goher *et al.*, 2017).

In the following is a matching of the present results of heavy metals with those of standard shale express in (µg/g) as reported by Turekilan and Wedpohl (1961).

Table 2. Comparison of the metal concentration with standard shale (µg/g).

	Fe	Mn	Cu	Zn	Pb	Cd
Present work	6202-10655	149-399	18.7-91	14.5-176.9	19.6-86.5	0.9-5
Sayed (2002)	7390	923	76	679	155	26
Standard shale	4670	850	45	95	20	0.3

The results show that the heavy metal concentrations at El-Rahawy branch are highly enriched in the sediment in the studied region due to the highly polluted by the intensive sewage effluents. These results were confirmed by studies of the contamination of factors (CF) and Pollution Lad Index (PLI) as represented in Table (3).

Table 3. Metals contamination factors (CF) and Pollution Lad Index (PLI)

Metals	Damietta branch	Rosetta branch
Fe	1.6-2.1	1.3-2.3
Mn	0.2-0.3	0.2-0.5
Cu	0.3-1.2	0.5-2.3
Zn	0.1-1.2	0.2-1.9
Pb	1.3-4.5	1.0-4.3
Cd	1.7-13.3	2.9-16.7
PLI	0.5-1.9	0.7-2.7

The value of PLI > 1 indicate that Rosetta branch is more contaminated.

Accumulation factor of heavy metals in sediments:

The accumulation factor of the studies heavy metals can be calculated from the following equation. AF = (metal concentration in the sediment/metal concentration in the water). The present studies of AF (Table 4) show that Fe content is the highest metal for precipitation followed by Mn and the least was Nicle.

In conclusion, the present results indicate the Rosetta branch is highly polluted by heavy metals due to the different effluents drains to the branch without any chemical or biological treatment lead to an extremely had variations in the aquatic environment. Hence the distribution dynamics of the studies heavy metal mainly depends on the type of these effluents discharge into the branches.

Table 4. Accumulation Factor of Heavy metal in sediments of Damietta and Rosetta branches.

Sample Element	Station code	Iron (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Cobalt (Co)	Nickel (Ni)	Lead (Pb)	Cadmium (Cd)
1	D1E	24.693	6.480	3.051	3.448	1.900	0.995	3.255	0.998
2	D1M	31.497	7.228	1.854	0.823	1.389	0.678	2.114	1.296
3	D2E	29.145	6.877	3.262	2.113	1.777	0.722	2.933	1.762
4	D2M	27.883	7.019	2.748	2.809	2.276	0.871	1.919	0.940
5	D3W	20.936	6.389	2.280	3.123	2.927	0.600	2.413	1.094
6	D3M	23.700	5.919	2.326	2.394	3.626	1.491	1.465	1.814
7	D4E	23.153	4.124	2.810	3.636	2.276	2.122	1.919	0.702
8	D4M	27.692	5.220	2.609	1.836	2.896	1.763	1.019	0.811
9	D5E	23.037	5.180	2.211	3.563	2.835	1.414	4.123	0.730
10	D5M	24.172	6.051	2.075	1.352	2.155	1.367	2.634	0.770
11	R1E	19.952	8.470	2.758	0.944	1.929	1.087	6.600	1.298
12	R1M	26.728	7.602	2.015	0.693	1.291	0.947	4.639	1.487
13	R1D1	10.568	2.685	3.123	0.305	1.340	0.325	1.096	1.062
14	R2E	15.029	5.376	2.621	0.953	1.824	0.350	2.241	1.604
15	R2M	22.916	6.018	2.297	0.737	1.366	1.626	1.048	1.897
16	R3E	22.721	6.078	3.026	0.808	1.096	0.581	2.101	1.501
17	R3M	23.868	9.359	3.873	1.293	2.247	0.825	1.135	1.244
18	R4E	17.582	3.583	1.667	1.194	1.967	0.591	0.448	0.993
19	R4M	17.242	4.322	3.866	1.605	2.528	1.490	1.675	1.255
20	R5E	17.545	4.787	3.087	2.469	1.870	1.104	3.679	0.930
21	R5M	19.073	4.905	5.247	2.000	2.542	1.167	4.733	1.051
22	R6W	22.471	4.034	3.529	1.753	2.793	1.263	1.155	1.874
23	R6M	21.903	5.399	5.431	1.663	3.105	1.357	3.578	1.215
24	الرهاوى	6.264	0.943	3.116	0.810	0.178	0.207	2.338	0.421

Table 5. Heavy metals concentration (µg/g) in the sediments of Damietta and Rosetta branches.

		Mina	Station	Season	Max.	Station	Season
Fe	D	7400.5	4	Autumn	9658.9	8	Spring
	R	6201.9	11	Summer	10654.9	13	Summer
Mn	D	165.1	7	Winter	261.2	1	Winter
	R	148.9	19	Summer	399.5	13	Spring
Cu	D	12.2	2	Spring	49	7	Spring
	R	18.7	14	Summer	90.9	19	Spring
Zn	D	13.4	2	Spring	116.2	5	Winter
	R	14.5	15	Summer	176.9	18	Winter
Co	D	5.9	2	Winter	21.6	8	Winter
	R	5.4	12	Autumn	36.1	18	Winter
Ni	D	2.6	2	Autumn	46.7	8	Autumn
	R	0.54	14	Autumn	96.9	15	Autumn
Pb	D	26.2	9	Summer	89.7	7	Aut/sp.
	R	14.6	22	Summer	86.5	13	Summer
Cd	D	0.45	8	Summer	3.98	3	Winter
	R	0.88	17	Autumn	4.96	13	Winter

D: Damietta branch R: Rosetta branch

J. Egypt. Acad. Soc. Environ. Develop., 19 (1): 177-184 (2018) (D-Environmental Studies)
E.mail: easedjournal_egypt@yahoo.com ISSN 1110-8770
www.eased.byethost13.com eISSN 2314-5471 (online)

REFERENCES

Abdelsatar, A.M. and Goher M.E. (2015). Heavy metals, fractionation and risk assessment in surface sediments of Qarun and wadi El-Rayanlakes , Egypt. Environ. Monit. Assess., 187-346.

Abdelsatar, A.M.; Goher M.E. and Sayed, M.F. (2010). Recent environmental changes in water and sediment quality of lake Qarun, Egypt, J. Fish. Aquat. Sc.,5(2):56-69.

Abdo, M.H. (2002). Environmental studies on Rosetta branch and some chemical application at the area extends from El-Kanater El-Khyria to Kafr El-Zayat city. Ph.D. Thesis, Fac. Science, Ain Shams University pp. 466.

Abdo, M.H.; Goher M.E.; Amin, A.E. and El-Degwy, A.A. (1917). Evaluation of some heavy metals in water and sediment of El-Sharkawia canal, River Nile, Egypt. Conf. Fac. Sci. Benha University.

Ahmed, N.A.M.(2013). Biochemical studies on pollution of the River Nile at Delta barrage, Egypt. Ph.D. Thesis, Fac. Agri. Benha Univ. Egypt.

American Public Health Assocition APHA (1998).Standard methods for examination of water and wastewater. New York 1193.

Bauomy, M.F.F.; Elewa, A.A.; Toyel, S.I.; El-Kasheif M.A. and El-Zeer, M.E. (2017). Toxicological studies of water with a particular references to its effect on *Clarias gariepinus* fish at Bahr El-Phasaony drain, El-Menoufiya Governorate , Egypt. J. Biosci. Appl. Res., 3(3):265-272.

Campbell, P.G.C and Tessier, A. (1986). Inorganic Pb in aquatic sediments. Geochemical partitiougand bioavailability pathway, cycling and transformation of Pb in environment P.M. stokes, eds the Royal society of Canada, 33-170.

Cevik, F.; Göksu, M.Z.; Derici, O.B. and F,ŷnd,ŷk, O. (2009). An assessment of metal pollution in surface sediments of seyhan dam by using enrichment factor, geoaccumultion index and statistical analysis. Environ. Monit. Assess., 152(1-4): 309-317.

Elewa A.A.; Sayyah, S.M. and Hassona, A.F.A. (1990). Regional symposium Environ. UNARC PP. 382-402, Alexabria.

Elewa, A.A. (1993). Distribution of Mn, Cu, Zn and Cd in water, sediment and aquatic plants and Aswan Reservoir of River Nile at Aswan, Egypt. J. Appl. Sci., 8(2):711-713.

Elewa, A.A. and Goher, M.E.M. 1999. Environmental factors affecting the precipitation and dissolution of Fe, Mn, Zn, Cu, Pb and Cd in River Nile at Damietta branch. Bull. Fac. Sci., Zagazig Univ. 114-136, 21(2).

Ezzat, S.M.; Abd El-Shakour, E.H.; Abostate, M.A.; Mahdy, H.M. and El-Bahnasawy M.A. (2012).Water quality assessment of River Nile Rosetta branch: Impact of drains discharge. Middle. East J. Scientific Res., 12(4):413-423.

Ghannam, H.E.; Talab A. S. and Elewa, A.A. (2015). Impact of seasonal changes on the quality of water and fish from Abu Zabaallake J. Biosci. Appl. Res., 1(4):192-199.

Goher, M.E.; Emara, M.M.; Abdo M. H.; Mahmoud, N.M.; Abdelsatar, A.M. and El-Shamy, A.E. (2017). Cadmium removal from aqueous solution using super paramagnetic iron oxide Nanosorbents on amberlete IR 120 H. J. Applied Sci., 17(6): 296-305.

Hagag Y.H.M. (2017). Environmental and chemical studies on the River Nile pollutants and their relation to water quality at Rosetta branch, Egypt. M.Sc. Thesis, Genetic Engineering and Biotechnology Institute, Sadat city University.

Hassouna M.E.M.; Elewa A.A. and Ibrahim A.M. (2014). Factors affecting heavy metals distribution in the River Nile at greater Cairo, region. Int. J. Bioassays 3(6):3051-3061.

Ibrahim, A.T.A. and Omar, H.M. (2013). Seasonal/variations of heavy metals accumulation in muscles of the African catfish clariasgariepinus, River Nile water and sediments at Assiut governorate, Egypt. J. Biol. Earth Sci., 3(2): 236-248.

Kouadiol, T. and Trefry, J.H. (1987). Sediment trace metal concentration in the Ivory coast, west Africa. Water, air and soil pollution 32:142-154.

Nobi, E.P.; Dilipan, E.; Thangaradjou, T.; Sivakumar, K. and Kannan, L. (2010). Geochemical and Geo-statistical assessment of heavy metal concentrations of sediment of different coastal ecosystems of Andaman Islands, India, estuarine, coastal and self Science, 87(2): 253-264.

Ong, M.C.; Menier, D.; Shazili, N.M. and Kamaruzzaman, B.Y. (2013). Geochemical characteristics of heavy metals concentration in sediments of Quiberon Bay waters, south Brittany, France, oriental J. Chemistry, 29(1):39-45.

Sayed M.F. (2002). Chemical studies on pollution in Rosetta branch of River Nile between Kafr El-Zayat and Rosetta outlet. Ph.D. Thesis, Fac. Sci. Cairo, University P. 404.

Singh, L. and Choudharyn, S.K. (2013). Physico-chemical characteristics river water of Ghana. Int. J. Innovative Research in Science, Engineering and Technology, 2(9): 4349-4357.

Sovobodove, Z.R.; Liod, J.; Machova, M. and Vykusova, C. (1993).Water quality and fish health. ETFAC Tech. Paper (54), FAO Rome, P. 59.

Stumm, W. and Morgan J.J. 1970. Aquatic chemistry, Introduction emphasizing chemical equilibrium natural water. Wiley. Interscience, New York N.Y., 583.

Tomlinson D.L.; Wilson, J.G.; Harris, C.R. and Jeffrey, D.W. (1980). Problems in the assessments of heavy metals levels in estuaries and formation of a pollution index. Helgolmeeresunters, 33:566-575.

Turekian, K.K. and Wedepohl, K.H. (1961). Distribution of the elements in some major of the earth's crust. Geological Soc. Am. Bull., 72(2): 175-192.