Mediterranean Marine Science

Vol 7, No 1 (2006)

Contribution of Nutrients and some Trace Metals from a Huge Egyptian Drain to the SE-Mediterranean Sea, west of Alexandria

O.A. EL-RAYIS, M.A.M. ABDALLAH

doi: [10.12681/mms.179](https://doi.org/10.12681/mms.179)

Mediterranean Marine Science
Volume 7/1, 2006, 79-86

Contribution of Nutrients and some Trace Metals from a Huge Egyptian Drain to the SE-Mediterranean Sea, west of Alexandria

O. A. EL-RAYIS[1] and M.A. ABDALLAH[2]

[1] Department of Oceanography, Faculty of science, Alexandria University, Egypt
[2] National Institute of Oceanography and Fisheries, Alexandria, Egypt

e-mail: mahaahmed72007@Yahoo.com

Abstract

In 2003 the MAP Technical Report Series 141, mentioned the lack of data concerning the flux of water, sediments and pollutants from North-African rivers and from the land-based sources to the Mediterranean Sea.

In Egypt, the Omoum drain, after the construction of the Aswan High Dam and the controlling of the Nile River water flow, has become one of the main land-based sources regularly discharging its waters (flow rate 2547.7 x 10^6 m^3/year) directly into the Mediterranean Sea at EL-Mex Bay, west of Alexandria. Downstream, before it reaches the sea, its water mixes with water effluent (surplus water) from a neighboring sewage-polluted lake called Lake Maryout, rate 262.8 x 10^6 m^3 /year.

The present work is a monthly study over a year of levels of concentration of some mainly trace elements (nutrients and some heavy metals) in the proper water of the drain before mixing and in the effluent from the lake, and calculations of both the concentrations and the corresponding expected loads of these elements contributed by the drain to the sea. The results revealed that the respective loads to the sea are 77380 ton/year for total suspended matter, 823 tons/year for dissolved PO_4 -P, 4745 tons/year for inorganic N, 23.7 tons/year for Fe, 3.28 tons/year for Mn, 5.84 tons/year for Cu, 2.9 ton/year for Cd, and 24 tons/year for Zn. The elements loaded by the lake effluent represent values ranging between 8 and 57.5% of the total load contributed by the drain to the sea. The plant nutrients (ammonia and reactive phosphorus) are of values exceeding 44%.

Keywords: Agricultural drain; Lake Maryout; Nutrients; Trace elements; Mediterranean Sea; Egypt.

Introduction

The Rosetta and Damietta branches of the Nile River as well as some agricultural drains discharge into the Mediterranean Sea via several land-based point sources in the north of Egypt and contribute fresh and brackish waters containing trace elements to the sea. EL-RAYIS & SAAD (1984); ABDEL-MOATI (1990) ; EL-RAYIS & SAAD (1992) ; UNEP/MAP/MED POL (2003) have mentioned that the information about the amount of the inputs of some trace elements from the land-based sources to the Mediterranean Sea still appears to be insufficient for budget quantitative work.

The Omoum drain is an huge, Egyptian, agricultural drain that opens directly into the sea at El-Mex Bay, west of Alexandria (Figs 1a and b). Its average flow rate is ~6.6 million m^3/day (2547.7 x 10^6 m^3/year) all year round (EL-RAYIS & EL-SABROUTI, 1997). The

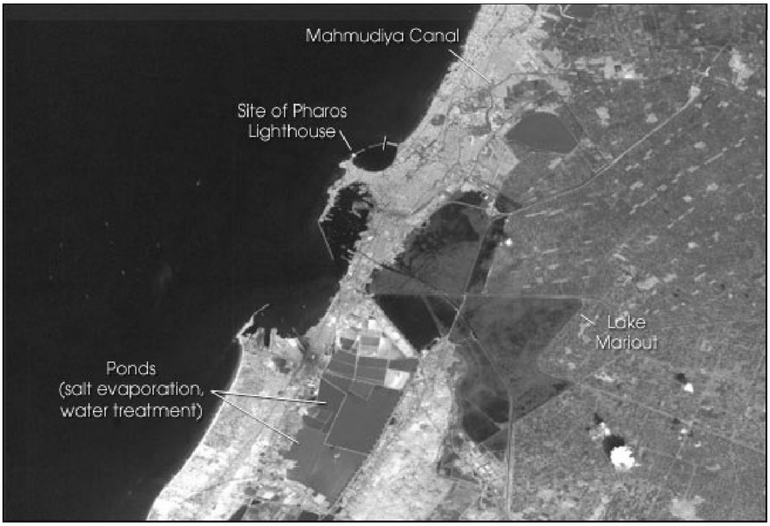
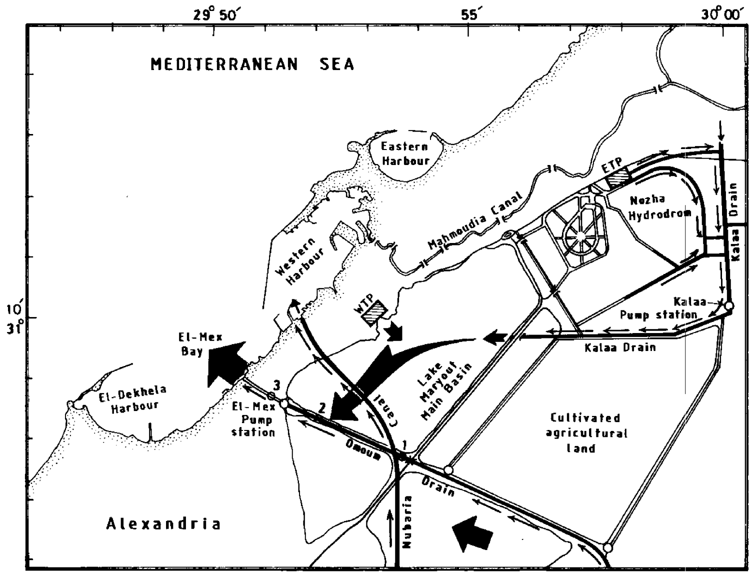


Fig. 1a: A space image of Alexandria City and its Lake Maryout (Main Basin), Omoum Drain, and Mex Bay.



1,2,3 = Position of the sampling station. Water flow direction

Fig. 1b: Study area showing Omoum Drain, Lake Maryout and its surplus water effluent to the downstream part of the drain before pumping to the sea at El-Mex Bay besides positions of the sampling stations (u and d are up- and down-.stream respectively and e = Lake effluent).

drain water is slightly brackish with salinity of about S‰ ~3.3, (HOSSAM & PETRAS, 1998), and is composed mainly of agricultural drainage water drained from cultivated fields in the northwest part of the Nile Delta (Bohaira and a part of the Alexandria provinces). The drain- during its way down to the sea- borders Lake Maryout (Main Basin) on its west side. This lake lies close to the city of Alexandria on its southern side. The bank between the drain and the lake, however, contains several breaches that allow for surplus water from the lake to flow and mix with the drainage water in the drain before discharging to the sea. The surplus water from the lake flows at a rate of ~720,000 m^3/day, and is derived mainly from discharges of wastewaters from two of Alexandria's primary sewage treatment plants (Eastern and Western Treatment Plants, EL-RAYIS *et al.*, 1998). The wastewater in the overflowing water from the lake (site e, Fig.1b) represents about 10.8% of the water at the downstream part of the drain at site d. These calculations depend on the volumes of each of the discharged wastewater from the treatment plants, the agricultural drainage waters which contribute to the lake from the Kalaa drain, and the flow rate at the upper part of the Omoum drain. The dilution factor (8.2) for polluted effluent is then calculated using the following equation:

Dilution factor (n) = the ratio of the daily volume of the proper drainage water (upstream of the Omoum drain) with respect to that of the lake effluent.

Material and Methods

Surface water samples were collected bimonthly during the course of a year (2004-2005) from the upstream part (site u) of Omoum drain before it mixed with the effluent from the lake and from the lake effluent itself to the drain (site e, Fig.1b), in addition to one sample from the drain course just before discharging into the sea. In these samples the concentrations of the following parameters were determined: N-forms (NO_3, NO_2, NH4 and TN), P-forms (DIP and TP) and the metals Cu, Zn, Cd, Fe and Mn (in their dissolved state). Both chlorosity (Clv) and total suspended matter (TSM) contents were also measured in the water sample using the conventional Mohar method and gravimetry, respectively. BOD and COD were measured according to APHA (1995). The nutrients were determined colorimetrically using a spectrophotometer (Shumadzu double beam UV-150-02) according to APHA (1995) and Koroleff's methods cited in Grasshoff (1976). The trace metals in 2-5 liter filtered water samples were pre-concentrated first, using chelating resin (Chelex-100) according to the procedure mentioned by Abdullah and Royle, (1974) before measuring using Flame-Atomic Absorption Spectro-photometer (AAS-Varian Techtron-Model 10 plus). The values are expressed as (µg/l).

Precision of metal analysis represented by coefficient of variation (CV) is of values ranging between 21 and 25%. Recovery from metal free waters using the standard addition technique is 97 + 5% of the standard values of trace metals.

The values of the studied elements in the downstream part of the drain are calculated using the conventional dilution equation:

$$Sd = [Su + (Se/n)] / [1 + (1/n)]$$

where Sd, Su and Se are the concentrations of the element downstream and in the upstream or proper drain and in the effluent from the lake, respectively. While n =8.2 is the dilution factor calculated above, which is the ratio of the volumetric flow of water in the Omoum drain before mixing with that of the effluent.

Results and Discussion

The concentrations of the studied nutrients and trace metals as well as Clv , TSM, BOD and COD in the effluent (Se) of Lake Maryout and in the upstream part of the Omoum drain (Su) and that calculated in the downstream part of the discharge point (Sd) are listed in Table 1.

The daily total load of each of these elements contributed by the lake (Te) and that dis-

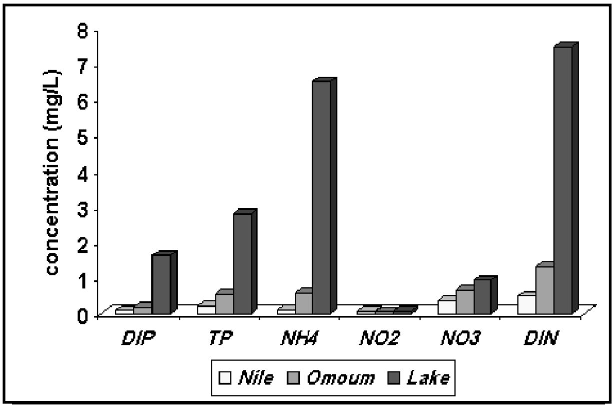
Table 1
Average concentration of studied parameters in the lake effluent and in Omoum Drain upstream and downstream of the discharge point after 1993, as well as permissible Levels of some pollutants according to Egyptian Law for Environmental Protection (Law 4/1994).

Element	Unit	Lake effluent (Se)* measured	Omoum Drain		Permissible level (Law 4/ 1994)
			Upstream part (Su)*,measured	Downstream part (Sd)*,calculated	
Flow rate (m^3/d)		720,000	5,930,000	**6,650,000**	
Cl_v	mg/L	1226±24	1675±76	**1626.2**	-
TSM	"	48.0±26	30.0±7	**31.95**	60
BOD	mg O_2/L	45.2±14	12.7±8	**16.23**	60
COD	"	91.2±18	65.0±13	**67.8**	100
DIP	mg P/L	1.63±0.6	0.18±0.0	**0.34**	1.63
TP	"	2.79±1.0	0.54±0.2	**0.78**	-
NH_4	mg N/L	6.48±4.5	0.58±1.2	**1.22**	3
NO_2	"	0.06±0.0	0.06±0.0	**0.06**	-
NO_3	"	0.94±0.8	0.67±0.6	**0.69**	9
DIN	"	7.48±3.6	1.31±0.4	**1.97**	-
TN	"	35±6.0	16.9±8.0	**18.87**	-
DIN/DIP		4.59	7.28	**5.79**	
Fe	µg/L	12.9±6.5	9.6±5.0	**9.9**	1500
Mn	"	3.52±2.3	1.5±0.8	**1.4**	1000
Cu	"	2.9±1.5	2.5±1.2	**2.5**	1500
Cd	"	1.2±0.6	1.17±0.4	**1.2**	50
Zn	"	17.7±12	9.1±5.8	**10.03**	5000

**Bimonthly average (2004-2005)*
The values at the downstream part are calculated according to the dilution equation.

charged into the sea (Td), in addition to their ratio are shown in Table 2. The abundance of the concentration level for each of the studied parameters in each of the upstream parts of the drain (proper agricultural drainage water), and in the effluent from the lake, besides that in Nile River water (as background levels, after Awad, 1993) are shown in Figure 2.

From Table 1, it is easy to notice that the concentration levels of Cu, Cd, NO2 and NO_3 in the lake effluent are quite close to their counterparts in the upstream part of the drain (proper agricultural drainage water), with the exception of the plant nutrients (DIP and DIN), Zn, Fe, Mn and TSM. These are of concentration levels considerably higher than those in the proper drain water (by 9, 5.7, 1.9, 1.3, 2.3 and 1.6 times respectively). At the same time the elements DIP, TP, NH4, DIN, Zn and TSM are more than those in the proper Nile River water (Awad, 1993) by 18.8, 13.2, 58.9, 14.9, 2.2 and 3.3 times respectively. On the other hand, the higher concentrations of BOD and COD in the lake effluent than those in the upstream part of the drain refer to how this polluted water contains high amounts of



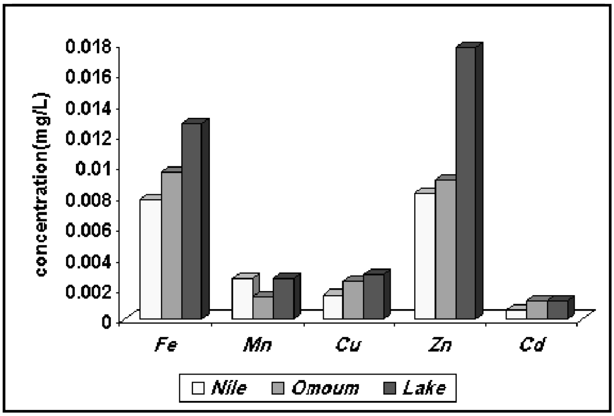


Fig. 2: A comparison between the concentration levels of the studied elements in the upstream part of the Omoum Drain, the lake effluent and of the River Nile water (as background).

bio- and non-biodegradable organic matter. Table 2 shows that the lake contributes between 8 and 57.5% of the total amount of the elements discharged into the sea. It also shows that NH4 and DIP exceed the permissible level (Law 4/1994); these are the most polluting elements in the discharge. Obviously the high concentration level of N and P compounds in the lake effluent reflects the role of disposal of the wastewater effluents from the two Alexandria treatment plants.

Table 1 also shows that the DIN/DIP ratio in the lake effluent (4.59) is considerably lower than that in the proper drain water (7.28). The normal N/P ratio in human excrement is almost 5.3 (Wetzel, 2001). On the other hand, the level of NO_3 and NO_2 in the lake effluent is comparatively low (for example it is lower than the DIP). Elimination of these inorganic N compounds, especially NO3, from such an aquatic medium (oxygen depleted) is to be expected and is mostly due to de-nitrification processes and formation of molecular N_2O and N_2 (CARPENTER & CAPONE, 1983 & YOSHIDA, 1988).

Table 3 shows the change in current load of some studied elements from the drain to the sea before and after the construction of the treatment plants in 1993. It is noticeable that there is an increase in the load contributed to the sea for DIP, NH_4, NO_2 and DIN. The increase in levels noted in the discharged waters is several times that previously recorded before 1993 by EL-RAYIS & SAAD (1992).

Table 2
Calculated daily load of pollutants discharged with the effluent (e) from Lake Maryout and with the Omoum Drain down-stream part (d) and their percentage ratios.

Element	Unit	Effluent load **(Te)**	**Load at the Downstream of Omoum Drain(Td)**	Te-load % / Td-load
Flow rate (m^3/d)		**720,000**	**6,650,000**	10.8
Cl_v	**ton/d**	882.7	**10814.2**	8.16
TSM	"	34.56	**212.5**	16.26
BOD	"	32.54	**107.9**	30.15
COD	"	65.66	**450.8**	14.56
DIP	"	1.17	**2.26**	51.7
TP	"	2.01	**5.19**	38.74
NH_4	"	4.66	**8.1**	**57.53**
NO_2	"	0.04	**0.40**	10.0
NO_3	"	0.68	**4.59**	14.81
TN	"	25.20	**125.48**	20.08
Fe	**kg/d**	9.29	**65.83**	14.11
Mn	"	2.02	**9.31**	21.69
Cu	"	2.09	**16.62**	12.57
Cd	"	0.86	**7.98**	10.77
Zn	"	12.74	**66.69**	19.10

Table 3
Load (ton/day) of some constituents contributed by Omoum Drain to the sea before and after the construction of the Alexandria two sewage treatment plants in 1993.

Constituent	Before 1993*		After 1993		**State after** 1993
	Before 87	**After 87**	(1995)	**(2005)** **	
Flow rate ($x10^6$) (m^3/d)	6.350	6.650	6.650	**6.980**	**Increase**
Cl_v ($x10^3$)	9.84	10.824+	10.81+	**10.40+**	~ Constant
TSM (x10)	19.32	21.54+	21.25	**9.7**	Decrease***
DIP	1.46	2.30	2.61	**4.19+**	**Increase**
TP (Diss.)	4.36	6.21	4.31	-	Variable
TP (Diss. + Part)	-	-	5.19	**5.69+**	
NH_4-N	2.19	2.50	8.10	**10.41+**	**Increase**
NO_2-N	0.33	0.44	0.40	**1.46+**	**Increase**
NO_3-N	1.64	1.93	4.59+	**3.08**	**Increase**
DIN	4.16	4.87	13.09	**14.9+**	**Increase**
TN (Diss. + Part)	-	-	125.5+	**38.12**	Decrease***

** El-Rayis and Saad (1992)*
*** Present work*
+ ve is a maximum value
**** The noticeable decrease in the TSM load obviously reflects the role of the primary treatment process for the raw sewage wastes in the treatment plants.*

The increase in the level of PO_{-4} and DIN species after 1993 is often due to release of these plant nutrients by oxidation of organic matter in the raw wastewater during the primary treatment processes inside the treatment plants, and the aeration process before discharging into the lake and thence to the drain. The level of the pollutants in the current land-based Omoum drain with respect to that of the permissible levels in such sources according to Egyptian law (4/1994) for environmental protection is also shown in Table 1. The impacts of this land-based source on the quality of the neighboring Mediterranean Sea coastal waters (at El-Mex Bay, surface area 19.4 km^2) need to be studied and assessed. Such impacts will be the subject of the forthcoming paper.

Conclusion

The Omoum drain opens directly into the Mediterranean Sea at El-Mex Bay west of Alexandria, the surplus water from Lake Maryout (mainly wastewater) allows flowing and mixing with the drain water before discharging into the sea. The total daily load of each of the studied elements that are discharged into the sea depends mainly on the elements contributed by the lake. The lake contributes between 8 and 57.5% of the total amount of elements discharged into the sea. The level of pollutants in the current land-based Omoum drain with respect to that of the permissible Egyptian levels, shows a decrease in nutrients and an increase in trace metals. The impacts of this land-based source on the quality of the neighboring Mediterranean Sea coastal waters (El-Mex Bay) need to be studied and assessed.

References

ABDEL-MOATI, A.R., 1990. Behavior and fluxes of copper and lead in the Nile River estuary. Estuarine and Coastal Shelf Science. 30:153-165.

ABDULLAH, M.I. and ROYLE, L.G., 1974. A study of the dissolved and particulate trace elements in the Bristol channel. *Journal of Marine Biology Assessment*. UK. 54: 581 - 597.

APHA, 1995. Standard Methods for the Examination of Water and wastewater, 19th Edition, American Public Health Association, Inc., New York.

AWAD, F.K. 1993. Distribution of some trace elements in the River Nile from Isna to Al-Kanater Al-Khyria, Egypt. M.Sc. Thesis, Alexandria University. Egypt, 223 pp.

CARPENTER, E. & CAPONE, D., 1983.Nitrogen in the Marine Environment. Academic Press, N.Y. pp. 105-137.

EL-RAYIS, O. A. & SAAD, M.A.H., 1984. Concentration of Cu, Cd, Zn, Fe and Mn in the River Nile water and its contribution to the Mediterranean Sea. VIIes Jurnees Etud. Pollutions, Lucerne, CIESM, pp.45-52.

EL-RAYIS, O. A. & SAAD, M.A.H., 1992. Sources and concentration of some trace elements of a huge drain lies on the north African desert coast, west of Alexandria, *Proceeds of 2nd International Conference on Environmental protection is a must.* Alex. Univ. & USPD. 24-27 Feb. 1992. pp. 202 - 212.

EL-RAYIS, O. A. & El-SABROUTI, M. A. 1997. Lake Maryout: pollution problems and proposals for restoration. *Fresenius Environmental Bulletin* 6: 598- 604.

EL-RAYIS, O. A., EL-NADY, F.E. & HINCKELY, D., 1998 . Existing environmental conditions in Lake Maryout south of Alexandria, Egypt: 1- water quality. *The 8th Conference on Environmental protec-*

tion is a must. NIFO, VEA, ISA and SFD Alex. Egypt, 5-7 May 1998. pp. 33 -43.
HOSSAM, A.H. & PETRAS, J.L., 1998. Modeling of a drainage system contaminated by wastewater. 24th WEDC Conference Sanitation and Water for All, Islamabad, Pakistan. pp. 161 - 164.
GRASSHOFF, K., 1976. Methods of Seawater Analysis. Vertage. Chemie. Weinheim, New York, pp 317.
UNEP/MAP/MED POL 2003., Riverine transport of water, sediments and pollutants to the Mediterranean Sea. Technical Reports Series No. 141, UNEP/MAP, Athens, 111 p.
WETZEL, R. G. 2001., Limnology. Lake and River Ecosystem, Academic Press. 1108 p.
YOSHIDA, N., 1988. 15 N-depleted N2O as product of nitrification. Nature, 355: 528-529.

Accepted in March 2007