Int. J. Environ. Res., 7(3):779-784,Summer 2013
ISSN: 1735-6865

Effect of Trace Metals Levels in Wastewater Discharges, Sediment and *Euchelus Asper* in Kuwait Marine Environment

Bu-Olayan, A.H.* and Thomas,B.V.

POB 5969, Department of Chemistry, KuwaitUniversity, Safat13060, Kuwait

Received 10 Aug. 2012; Revised 25 Dec. 2012; Accepted 2 March 2013

ABSTRACT: This study assesses the effect of major trace metals levels in wastewater discharges and sediment from twenty four permanent and five semi-permanent wastewater drain outlets into the Kuwait coast. The effect of trace metals levels released from untreated wastewater discharges to *Euchelus asper*, gastropod was also determined. Results showed high trace metal levels in *E. asper* tissues, followed by sediment and in wastewater during winter than in summer irrespectively of the sampled areas. Regionally, distributed wastewater drain outlets in six Kuwait Governorates (GI-GVI) revealed high trace metal levels in GI due to industrialization and occasional untreated wastewater discharges into the marine environment. High Zn and Cr in the gastropod, sediment and wastewater samples indicated the effect of oil spills and untreated wastewater discharged into the sea. Results of our study exceeding the standards pollution limits could be validated as a tool to undertake precautionary measures to similar polluted areas elsewhere in the globe.

Key words: Trace metals, drainagewater, sediment, mollusc, KuwaitCoast

INTRODUCTION

Wastewater generated from various anthropogenic sources form a natural sink in the sea. Wastes from urban, industrial, and agricultural sources have been disposed into the sea. Wastes from urban areas are classified to municipal wastes, a combination of residential, commercial establishments and storm water (Al-Enezi *et al.*, 2004; Abd El-Gawad, 2009). FAO anticipates the total volume of 40 bcm.yr-1 of domestic wastewater by the year 2015 (FAO, 2003). Toxic heavy metals were found associated with industrial and domestic effluents (Zarazua, *et al.*, 2006; Carletti *et al.*, 2008). Metals found in wastewater are commonly elevated because of its anthropogenic use. Therefore, metals are used as tracers of wastewater in the ocean (Matthai and Birch, 2000). Marine organisms that live near the wastewater discharge points are food source for many organisms and humans. They are high in inorganic and organic constituents and thus, bioaccumulation in flora and fauna is common (Lewis *et al.*, 2008; Ra *et al.*, 2008; Kiziloglu *et al.*, 2008; Ramadan and Bream, 2010).

In Kuwait, the estimated annual volume of wastewater ranges between 206 and 254 Mm^3. Approximately, 62% of the total wastewater treated (208,000cu.m d-1) is reused for agriculture, landscape and roadside irrigation and the rest is discharged into the sea (Al-Zubari, 1997). The recent increase in population and rapid industrialization has led voluminous discharge of domestic and industrial wastewater including frequent discharge of untreated wastewater into the sea (UNEP, 2001). Wastewater containing inorganic and organic pollutants and fluctuating seawater variables (temperature, D.O., salinity) are some factors that lead to environmental stress in Kuwait marine ecosystem. Marine gastropods are found to accumulate high metal concentrations in their body tissues. *Euchelus asper*, is a marine gastropod molluscs inhabiting the lower rocky shores. They are tolerant to trace metals exposures. Although a large volume of wastewater is let out into the sea, seldom evidences exists concerning their synergistic effect upon water, sediment, hydrological and physical variables. Therefore, the present study determined: (1) trace metals levels in the wastewater discharged into the Kuwait Coast, (2) trace metals levels in sediment deposited near the mouth of the drain outlets, (3) trace metals levels in gastropod mollusc, *E. asper* and (4) the relationship between the seasonal trace metals levels and the hydrological variables in samples collected from the drain outlets of Kuwait marine ecosystem.

*Corresponding author E-mail:buolayan@yahoo.com

MATERIALS & METHODS

Sampling sites

During the years 2009-2011, we chose twenty four functional and permanent concrete drain outlets that spread across six Kuwait Governorates (GI-GVI) Coast. Seasonally, samples were analyzed from each Governorate that represented four drain outlets (DT1-DT4). These drains let the major domestic and industrial wastewater into the Kuwait's marine environment throughout the year (Fig. 1). Five semi-permanent drains (SD) located in the southern region of Kuwait were also observed in this study (Fig. 1).

Wastewater sample collection

A horizontal polycarbonate point water sampler (2.2 L) was employed to collect wastewater samples from three loci at the entry point of each drain outlet. Water from the sampler was allowed to settle in a sediment settleometer and filtered using a 0.45µm membrane filter. The settled deposits and filtrate were separately weighed and analyzed for residual trace metals. The average wastewater velocity (ft.sec^{-1}) discharged from each drain outlet (DT1-DT4) of the respective Kuwait Governorates (GI-GVI) was measured by using a (5-15ft) digitalized open channel flow probe (FP211, Global water, US). Physical variables such as temperature, salinity, pH and dissolved oxygen from each drain outlet (DT1-DT4) were measured at discharge outlets using a portable multiport water checker (Hach Inc., USA).

Sediment sample collection

Using a Van Veen Grab sampler (5Kg capacity), three sediment replicates (50g) near the surrounding mouth of each DT bed was collected and stored in polyethylene container. Samples were dried in an oven (GallenKamp II, USA) at 45°C until dryness, ground to homogenized powder and sieved using a 1mm mesh. Powdered sediment (0.2g) was used to analyze trace metals levels.

Gastropod, Euchelus asper collection

Gastropod, *Euchelus asper* was found abundantly on either side at low water level of the rocky embankment near the drain outlets. They were transported in sterile plastic bags to the lab. They were cleaned in deionized distilled water and the tissues removed from the shell. Ten replicates of the whole tissues (10g) from each drain outlets were analyzed for trace metals.

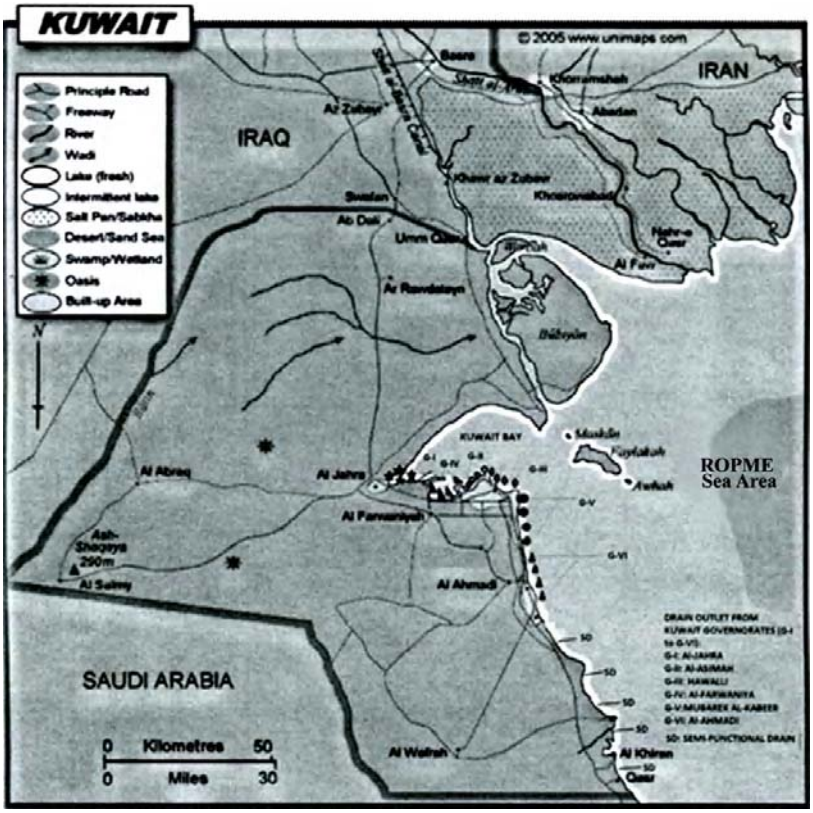

Fig. 1. Wastewater discharges from drain outlets of Kuwait Governorates

Determination of trace metals in wastewater

Two-liter filtered wastewater from each drain was preconcentrated for trace metals following the organic elution method described in APHA (1998). The resultant solute was analyzed in ICP-MS and the concentration of trace metals measured. Quality control and assurance method described in APHA (1998) were carried out using the respective trace metals standards (ICP grade), blanks, Certified and Standard Reference Materials (CRM-403 and SRM-2702:marine water and sediment respectively).

Trace metals analysis in sediment and Euchelus asper

Dried sediment and whole tissues of *E. asper* samples (0.2g) were digested with 5ml HNO_3 (v/v, Aristar grade) in a Microwave digester (Ethos1, Milestone, Italy). The resultant samples were diluted and analyzed for trace metals analysis in the ICP-MS. A direct mercury analyzer (DMA-80: Milestone, Italy) determined the mercury levels in wastewater, sediment and *E. asper* tissues.

RESULTS & DISCUSSION

Trace metals concentrations in wastewater, sediment and gastropod, *E. asper* collected from the drain outlets of the six Kuwait Governorates (Fig.1) during the two seasons correlating the water velocity are presented (Fig. 2). The data were logarithmically transformed to correct unequal variation, varied units and express consistency. The semi-permanent drains (SD) located in the southern region of Kuwait (Fig.1) were found dry during most part of the year and hence, not investigated in the present study. Observations showed the sequence of trace metals concentrations in *E. asper*>sediment>wastewater (Fig.2) indicating high metals accumulation in *E. asper* from sediment and wastewater, a result of low water current and flushing wastes in the Kuwait Bay, and secondarily from different waste resources. This phenomenon was found in line with the earlier findings (Al-Enezi *et al.*, 2004; Abd El-Gawad, 2009; Ra *et al.*, 2008; Ramadan and Bream, 2010). Seasonally, high trace metals levels were observed during winter than in summer in all the samples (Fig.2). This observation was found similar to that of the earlier investigators (Abd El-Gawad, 2009; Carletti *et al.*, 2008).

Governorate wise analysis (GI-GVI) showed high trace metals levels in the sequence of GI>GIII>GIV>GII>GV>GVI irrespective of seasons in *E. asper*, sediment and wastewater (Fig.2). Wastewater discharges from thermal, desalination and power plants besides the discharges from construction activities, automobile wash centers, public utility services and few recreational activities attribute to very high trace metals levels in samples collected from GI and GIII.

sediment and *E.asper*

Trace metals levels in GIV and GII were found moderately high due domestic waste discharges into the Kuwait coast. The northern area of GV has moderately populated residential areas with recreational activities. However, the southern part of

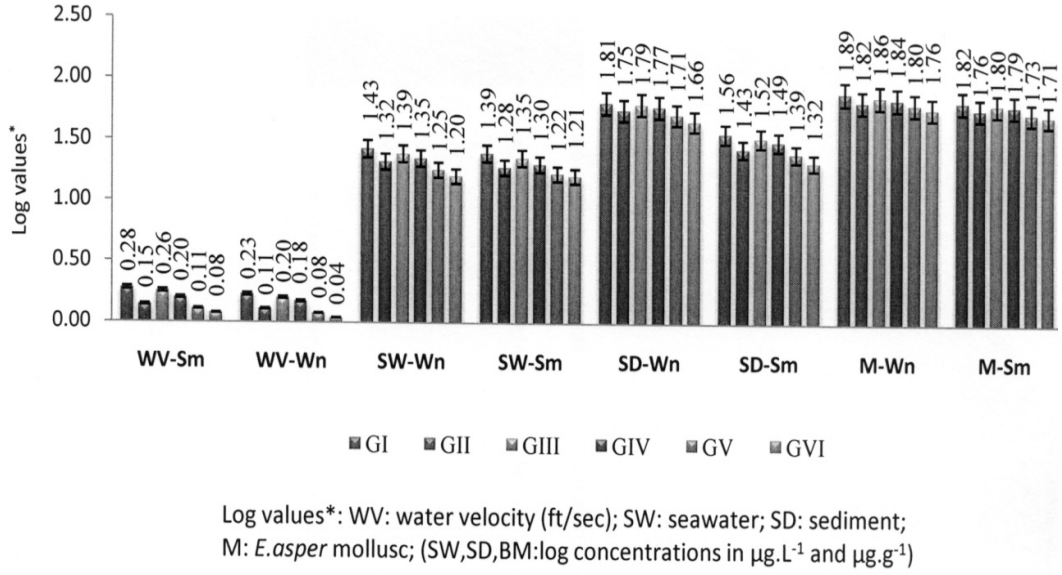

Fig. 2. Logarithmic data on the season-wise water velocity, trace metals concentrations in wastewater

GV and northern part of GVI comprises of small scale industries and thus, low trace metals levels was observed in wastewater from GVI than in GV. Trace metals levels in GV and GVI was comparatively lower than trace metals in samples collected from the other Kuwait Governorates. Reasons could be attributed to the few drain outlets, influence of open sea that rapidly flushes wastewater to the southern ROPME Sea Area and treatment facilities of domestic wastewater besides the low density of human population in the GVI areas. High trace metals in the sequence of Zn>Cr>Ni>Cu>Fe>Pb>Hg was observed in wastewater collected from four drain outlets (DT) irrespective of the two seasons. Accidental oil spills, automobile wastes, untreated domestic wastewater discharges, plastic wastes, constructional and e-wastes attributes to high Zn, Cr and Ni levels in both the analyzed samples. Such phenomenon was not uncommon, globally (Zarazua *et al.,* 2006; Matthai and Birch, 2000; Kiziloglu *et al.*, 2008; Al-Zubari, 1997; UNEP, 2001). Trace metals sequence in sediment samples was found similar to that of the trace metals sequence observed in wastewater analyzed during summer and winter. However, variation was observed in the trace metals sequence in the gastropod, *E. asper*. These changes may be attributed to efficacy of *E. asper* to accumulate essential trace metals from the sediment deposition, besides the factors governing the trace metals absorption from food and environmental variables such as temperature, salinity, dissolved oxygen (DO), and tidal effects. Such changes were found in agreement with the earlier findings (Lewis and Chancy, 2008).

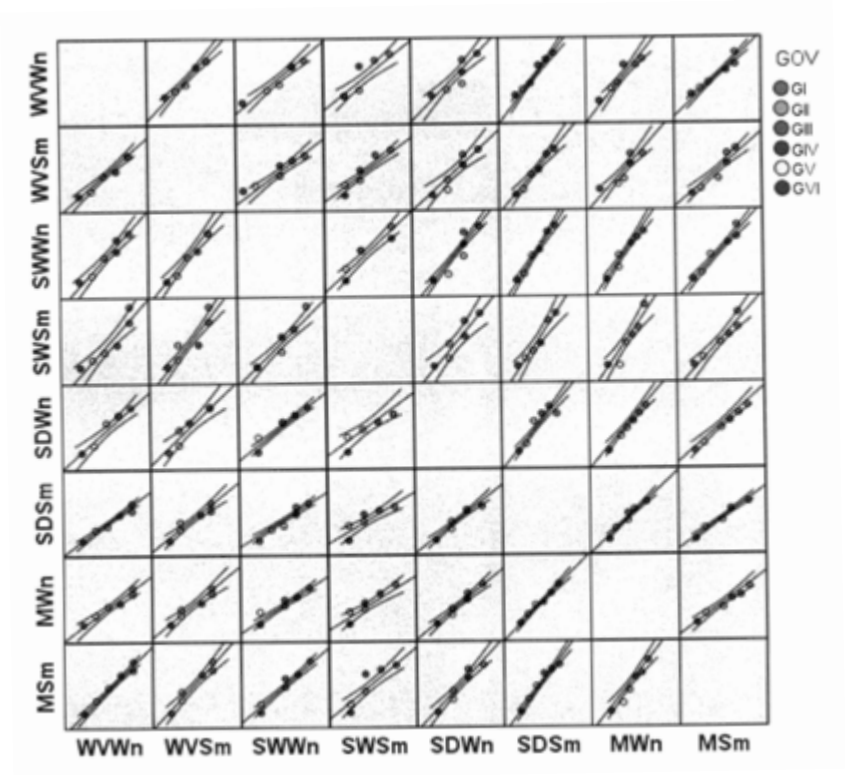

Fig. 3. Governorates -wise correlation coefficient between water velocity, wastewater, sediment and *E. asper* tissue

Table 1. ANOVA between water velocity, wastewater, sediment, *E. asper* and hydrological variables during summer and winter

Variation	df	F	P-Value	F critical Significance
Governorate-wise	5	15.55	<0.004	2.35 *
Season-wise	13	1318.04	<0.0001	1.87 *
Error	65			
Total	83			

Table 2. Mean hydrological variables in Kuwait's wastewater drain outlets

Gov.	DO. Sm (mg/L)	S. Sm (‰)	T. Sm oC	DO.Wn (mg/L)	S. Wn (‰)	T. Wn oC
G-I	5.3	44	42	6.4	36	20
G-II	5.2	41	40	6.4	38	22
G-III	5.4	43	42	6.2	38	25
G-IV	5.3	42	41	6.3	39	27
G-V	5.1	41	40	6.5	39	23
G-VI	5.0	41	40	6.6	37	22

Gov.: Kuwait Governorates (GI-GVI); DO: dissolved oxygen; S: salinity; T: temperature; Sm: summer; Wn: winter; (‰): parts per thousand

Statistical analysis (ANOVA) revealed significance between the velocity of water, trace metals in wastewater, sediment, *E. asper* and hydrological variables from the six Kuwait Governorates during summer and winter (Table 1). Correlation coefficient (SPSS, v.19) revealed significant relationship between the samples collected from the six Kuwait Governorates and the two seasons (Fig.3).

CONCLUSION

Based on the present investigation, we found: (1) *E. asper* could be characterized as an indicator to trace metals, (2) different kinds of wastes influences the level of trace metals contamination, (3) in addition to the water current, flushing rate of wastewater into the marine environment. Furthermore, we suggest meticulous monitoring and treatment of untreated wastewater that is accidently released into the marine environment.

ACKNOWLEDGMENTS

We thank the Research Administration, Kuwait University for their invaluable financial support to our project SC-06/09. We also thank the Vice Dean Research, and General Research Facilities (GRF: GS01/ 05) for extending their analytical support towards this project.

REFERENCES

Al-Enezi, G., Hamoda, M. F.and Fawzi, N. (2004). Heavy metals content of municipal wastewater and sludges in Kuwait. J. Environ. Sc. Health A, **39 (2)**, 397-407.

Al-Zubari, W. (1997). Towards the establishment of a total water cycle management and re-use program in the GCC countries. Presented at the Regional Workshop on the Technologies on Wastewater Treatment and Reuse, Bahrain, 2-4 June.

Abd El-Gawad, S.S.I. (2009). The Mollusk Gastropod *Lanistes carinatus* (Olivier, 1804) as a biomonitor for Some Trace Metals in the Nile River**.**Internat. J. Zool. Res.,**5 (3)**, 115-125.

APHA, (1998). American Public Health Association, Eaton DA, and AWWA (Joint Eds). Standard Methods for the Examination of Water and Wastewater, 20th edition, American Public Health Ass., American Water Works Ass., Water Environmental Federation Joint Publishers, 1015 fifteenth street, NW, Washington, DC, 2005-2605.

Carletti, G., Fatone, F., Bolzonella, D. and Cecchi, F. (2008). Occurrence and fate of heavy metals in large wastewater treatment plants treating municipal and industrial wastewaters. Water Sc. Technol., **57 (9)**, 1329-1336.

FAO, (2003). Sustainable water resources management for food security in the near east region, high-level technical workshop "regional program for food security in the near east: towards sustainable food security and poverty alleviation", Jeddah, 8-9 October 2003, 1-6.

Kiziloglu, F.M., Turan, M., Sahin, U., Kuslu, Y. and Dursun, A. (2008). Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica olerecea L var. botrytis*) and red cabbage (*Brassica oelrecea L var. rubra*) grown on calcareous soil in Turkey. Agricult. Water Mgm., **95 (6)**, 716-724.

Lewis, M. and Chancy, C. (2008). A summary of total mercury concentrations in flora and fauna near common contaminant sources in the Gulf of Mexico. Chemosphere, **70**, 2016-2024.

Matthai, C. and Birch, G.F. (2000). Trace metals and organochlorines in sediments near a major ocean outfall on a high energy continental margin (Sydney, Australia). Environ. Pollut., **110**, 411-423.

Ra, J.S., Lee, B.C., Chang, N.I. and Kim, S.D. (2008). Comparative whole effluent toxicity assessment of wastewater treatment plant effluents using *Daphnia magna*. Bull. Environ. Contamin. Toxicol., **80**, 196-200.

Ramadan, A.S.A. and Bream, A.S. (2010). The Effects of Sewage Discharge on The Marine Gastropod *Gibbula* sp., Collected From The Coast of Al-Hanyaa, Libya.Egypt Acad. J Biol. Sc., **2 (2)**, 47-52.

UNEP, (2001). Overview of the socio-economic aspects related to the management of municipal wastewater in west Asia (including all countries bordering the Red Sea and Gulf

of Aden). UNEP/PERSGA/ROPME Workshop on Municipal Wastewater Management in West Asia, Bahrain, 1-59.

Zarazua, G., Ávila-Pérez, P., Tejeda, S., Barcelo-Quintal, I. and Martínez, T., (2006), Analysis of totaland dissolved heavy metals in surface water of a Mexican polluted river by Total Reflection X-ray Fluorescence Spectrometry, Spectrochimica Acta Part B: Atomic Spectroscopy, **61**, 1180-1184.