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Heavy Metal Concentration in Seawater at Villa Beach, Iloilo City, Philippines

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ABSTRACT

This study was conducted due to the dearth of studies on heavy metals at Villa Beach, Iloilo City. It aimed to determine the presence and quantities of available heavy metals specifically cadmium, chromium and lead in the water column (surface, middle and bottom). Water physiochemical parameters were determined such as pH, salinity and temperature. Five sampling areas were identified in the shores of Villa Beach. One liter was collected in each layer of each sampling area for a total of 15 seawater samples and was immediately transported to the College of Arts and Sciences-Analytical Service Laboratory of the University of the Philippines Visayas, Miag-ao, Iloilo for the quantification of heavy metals through flame atomic absorption spectrophotometer (FAAS). The pH values range from 7.513-7.933, 10.6-11.566 ppm for salinity and 27.5-31.233 °C for five sampling areas. Average dissolved chromium and lead were highest at station four with 0.545 mg/L and 0.771 mg/L, respectively. Average cadmium was highest at station one with 0.021 mg/L. The mean of Pb > Cr > Cd < Pb in the water column of the five sampling areas but was not significant. Available cadmium, chromium and lead exceeded the permissive value set by

DENR AO No. 34 (1990). This study provides information and awareness to the public about the present available heavy metals in Villa Beach, Iloilo City.

KEYWORDS

Heavy metals, cadmium, chromium, lead, flame atomic absorption spectrophotometry, Philippines

INTRODUCTION

Metal pollution found in seawater and sediments are widely explored since early 1980's (Arifin, Puspitasari, & Miyazaki, 2012). Heavy metals such as lead, cadmium, zinc, copper, manganese, iron, mercury, arsenic and barium are usually measured because these metals are ubiquitous and the concentrations are measurable in marine samples (Ansari, Marr, & Tariq, 2004). The fate of heavy metals in the marine environment is thus found in seawater, sediment and marine organisms. Heavy metals in seawater could be in the solute form or could bind to any suspended particles or sediments such as phytoplankton, zooplankton, debris, clay, and silts (Arifin et al., 2012).

These heavy metals are toxic substances because they could damage the lungs, kidneys and bones (Ansari et al., 2004; Boran & Altinok, 2010) and has the tendency to accumulate in the food chain (Boran & Altinok, 2010; Cuong, Karuppiah, & Obbard, 2008; Tabari, Saravi, Bandany, Dehghan, & Shokrzadeh, 2010).

In this study, cadmium, chromium and lead are determined as heavy metal pollutants. Cadmium (Cd) is not an essential element but it could support the photosynthetic activities of phytoplankton as well as growth but up to 100 mg/L of concentration only (Ansari et al., 2004). Chromium (Cr) on the other hand, is a carcinogenic metal specifically Chromium VI because it could cause death to flatfish at a concentration of more than 5 mg/L (Krejpcio, 2001). Lead is also a toxic and major hazard animals and humans because it could cause physiological and neurological effects most especially to humans (Ansari et al., 2004). In addition, cadmium and lead are indeed toxic because they both bind to cell membranes causing hindrance in the transport processes in plant's cell wall (Manahan, 1999). Boran and Altinok (2010) mentioned that the existence of heavy metals could exacerbate microbial diseases in marine organisms.

Ideriah, David-Omiema, and Ogbonna (2012) revealed that the presence of heavy metals in the water and sediment of Abonnema shoreline at Nigeria are attributed to low pH, high commercial activities, wastes, tidal and wave actions. Meanwhile, Poikane, Carstensen, Dahllof and Aigars (2005) reported that riverine inputs, wastewater discharges, and resumption of contaminated bottom sediments contribute to the presence of trace metals in the water column and nepheloid layer in the Gulf of Riga. Qari and Siddiqui (2008) added that domestic and sewage, factories discharges, industrial effluents, dredging, cargo handling, dumping of ship waste and other coastal activities contributes to the presence of heavy metals in the coastal seawater of Nathia Gali, Karachi, Pakistan. Chan-Won and Young-Tack (1994) believed that the enclosed coastal sea is a good source of heavy metal deposition.

Saravanamurugan, Karthikeyan and Subramaniyan (2013) found a concentration of 0.14 – 0.18 μg/l cadmium in the Kalpakkan Region, southeast coast of India using the inductively coupled plasma optical emission spectrometer while Ideria et al. (2012) determined heavy metals along Abonemma shoreline at Nigeria using the GBC Avanta flame atomic adsorption spectrophotometer and recorded less than 0.001 – 0.0628 mg/l for cadmium and 0.0632 – 0.1836 for chromium which exceeded the permissive limits set by River State Ministry of Environment, Federal Environmental Protection Agency and World Health Organization. Meanwhile, Sarinas et al., (2013) revealed that heavy metals in the seawater column of Iloilo-Guimaras Jetty Port (Parola Wharf), Philippines exceeded the Department of Environment and Natural Resources AO No. 34 (1990) permissive value. Su et al. (2009) studied the heavy metals in seawater of Manila Bay, Philippines and contrasted wet and dry seasons. The findings were as follows: total cadmium (wet- 44. 995 mg/l, dry- 2.192 mg/l), total chromium (wet- 0.312 mg/l, dry- 0.171 mg/l) and total lead (wet- 0.628 mg/l, dry- 0.31 mg/l). Interestingly, Cuong et al. (2008) studied the distribution of heavy metals in seawater and sediment in the coast of Singapore. They found out that the concentrations of cadmium, chromium and lead for station 1 and station 2 are as follows: cadmium (0.13 – 0.109 μg/l and 0.014 – 0.044 μg/l), chromium (0.07 – 0.35 μg/l and 0.16 – 0.35 μg/l) and lead (0.009 – 0.062 μg/l and 0.022 – 0.059 μg/l). Boran and Altinok (2010) found the following concentrations of metals in the seawater of Western Black Sea shore of Turkey: cadmium (1, 686 μg/l), chromium (5, 824 μg/l) and lead (8, 081 μg/l). In terms of year comparison, Daniszewski (2013) compared the concentrations of heavy metals in the seawater of Miedzyzdroje (Baltic Sea) in 2008 and 2009. In 2008, cadmium was 0.44 ppm, chromium was 2.67 and lead was 0.06 ppm. In 2009, cadmium was 0.46 ppm, chromium was 2.64 and lead was 0.05 ppm. Only chromium exceeded the permissive limit on inland surface water. Qari and Siddiqui (2008) studied the surface seawater and tide pools seawater of Nathia Gali coast of Karachi, Pakistan. The heavy metal concentrations for surface seawater and tide pools seawater are as follows: cadmium (0.03 – 0.15 mg/l and 0.04 – 0.2 mg/l), chromium (0.33 – 1.04 mg/l and 0.045 – 0.54 mg/l) and lead (0.43 – 0.62 mg/l and 0.49 – 0.6 mg/l). On the other hand, Kumar, Jaikumar, Robin, Karthikeyan, and Kumar (2013) recorded the following heavy metal concentrations in the seawater at southeast coast of India: cadmium (8.15 – 24.18 μg/g; mean of 14.55 ± 4.42 μg/g), chromium (11.60 – 15.75 μg/g; mean of 14.13 ± 1.44 μg/g) and lead (4.10 – 6.20 μg/g; mean of 4.93 ± 0.77 μg/g). In Antarctica, Jiabin, Yunna, and Zhongping (1996) conducted a study of heavy metals in seawater of Great Wall Bay. They revealed the following heavy metal concentration: cadmium (≤ 0.09 – 0.10 μg/l), chromium (0.51 – 2.74 μg/l) and lead (0.36 – 3.86 μg/l). Asha et al. (2010) determined the heavy metal concentration in seawater, sediment and bvalves of Tuticorin coast, India. They revealed the following heavy metal concentrations for station 1, 2 and 3, respectively: cadmium (0.55 ± 0.1 μg/l, 1.01 ± 0.7 μg/l and 0.28 ± 0.0 μg/l) and lead (7.23 ± 1.5 μg/l, 10.0 ± 3.2 μg/l and 11.2 ± 6.8 μg/l). In Korea, Kim et al, (2010) determined the distribution of heavy metals in the surface seawater of Saemangeum. Cadmium range from 0.002 – 0.048 μg/l (mean of 0.037 μg/l) while lead range from 0.007 0.0053 μg/l (mean of 0.015 μg/l).

There was no study about the presence of heavy metals conducted in Villa Beach, Iloilo City. Thus, this survey was conducted to assess the presence of available heavy metals in Villa Beach, Iloilo City such as cadmium, chromium and lead. In addition, significant difference was also determined in terms of heavy metal concentration (mg/L) among the five sampling areas.

MATERIALS AND METHODS

Sampling Areas

The five sampling areas of Villa Beach, Iloilo City, a Class SB marine water classified by DENR AO No. 34 (1990) are located in the shores of Adelfa's Beach Resort, Sto. Niño Sur Elementary School, JBLFMU-Arevalo, between Tatoy's Seafoods and Breakthrough Restaurant and another area going to Sto. Niño Norte with a total distance of 1.876 km from Sampling Area 1 to Sampling Area 5. Figure 1 shows the map of the five sampling areas from Google Map as well as the distances between sampling areas and their global positioning system (GPS).

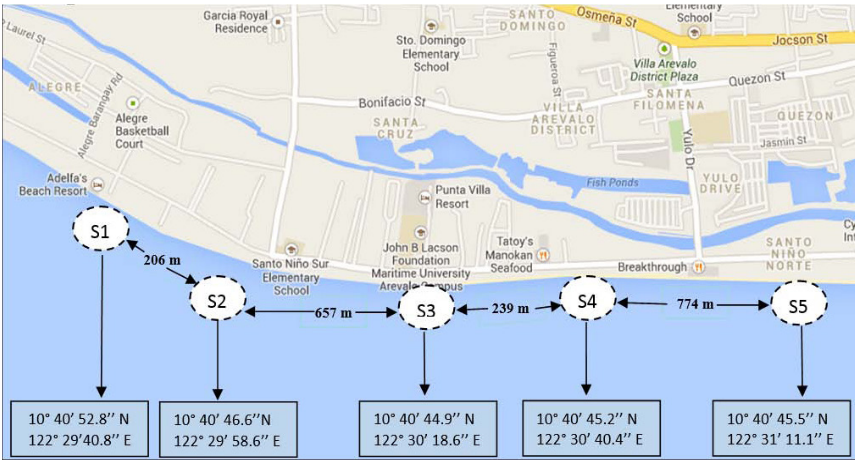

Figure 1. Sampling areas (from Google map) as well as the distances between sampling areas

Materials

The materials used were 15 sterilized bottles (1000 ml), distilled water, pH meter, thermometer, salinometer, GPS positioning device, 10 m length rope, tape measure, bottle with cover, and the flame atomic absorption spectrophotometer (Varian Model 55B) owned by the College of Arts and Sciences-Analytical Service Laboratory, University of the Philippines Visayas, Miag-ao, Iloilo where the samples were analyzed using this instrument.

Collection of Water Samples

The researchers collected the seawater samples using the improvised bottle with cover and transferred in the sterilized bottles.

The seawater was collected at the surface, middle and bottom of the water column. Three liters of seawater samples (one liter per sampling point) were collected approximately 10 m from the shoreline.

The seawater collected at the surface and bottom levels were about 0.5 inch (1.27 cm). Figure 2 shows the depth of each water column for each sampling area.

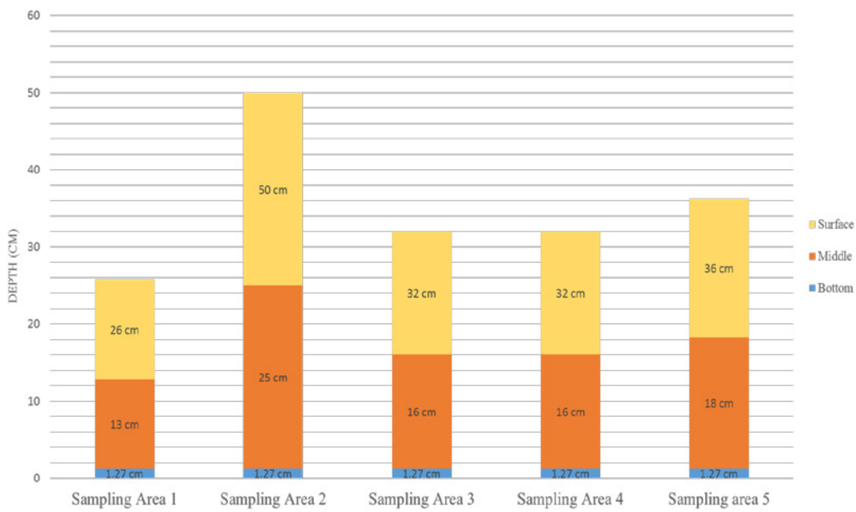

Figure 2. Depth of each water column for five sampling areas

Analysis of water physicochemical characteristics

Temperature, salinity and pH were measured in three readings per water column for the five sampling areas.

Analysis of seawater samples

The seawater samples were transported and analyzed at CAS-ASL of University of the Philippines Visayas, Miag-ao, Iloilo to determine the mean concentrations of available cadmium (Cd), chromium (Cr) and lead (Pb) through flame atomic absorption spectrophotometer (FAAS).

Data Analysis

One-way ANOVA set at .05 level of significance was used to test for significant difference of available cadmium (Cd), chromium (Cr), and lead (Pb) among the five sampling areas.

RESULTS AND DISCUSSION

Determination of water physicochemical characteristics

The pH level of the surface seawater samples in the five sampling areas range from 7.513 - 7.95 which has been found as basic or alkaline. Consecutively, the pH level of the middle seawater samples range from 7.533 - 7.923 while the bottom seawater samples range from 7.58 - 7.933.

In the surface level of the five sampling areas, the salinity (ppm) of the water stretches from 10.6 ppm - 11.966 ppm. On the other hand, the salinity level at the middle lies between 10.966 ppm - 11.566 ppm. At the bottom, salinity level ranges from 10.6 ppm - 11.333 ppm.

Meanwhile, the temperature of the water in the surface of the five sampling areas measures from 27.833 °C - 31.233 °C. At the middle, temperature extends from 28.033 °C - 30.166 °C. Moreover, temperature ranges from 27.5 °C - 31.133 °C at the bottom. Table 1 shows the results.

Table 1. Water physicochemical characteristics of the five sampling areas

Water Column	Physicochemical Characteristics	Sampling Areas				
		1	2	3	4	5
	pH	7.843	7.95	7.703	7.643	7.513
Surface	Salinity (ppm)	11.033	11.5	10.6	11	11.966
	Temperature (°C)	29.933	27.833	30.533	31	31.233
	pH	7.856	7.923	7.636	7.65	7.533
Middle	Salinity (ppm)	11.5	11.566	10.966	11	11
	Temperature (°C)	30	30.166	28.3	28.533	28.033
	pH	7.856	7.933	7.666	7.59	7.58
Bottom	Salinity (ppm)	11.333	11	10.6	11	10.966
	Temperature (°C)	27.5	30	29.933	31.133	30.833

Concentrations of available cadmium, chromium and lead

As shown in Figure 3, the mean concentrations of Cd in Sampling Areas 1, 3 and 4 exceeded the permissive level of 0.01 mg/L set by DENR AO No. 34 (1990) but have lower quantities as compared to the study of Sarinas et al. (2013). For Sampling Area 1, the mean concentration of Cd was 0.02 mg/L; Sampling Area 2 has 0.01 mg/L; Sampling Area 3 has 0.02 mg/L; Sampling Area 4 has 0.02 mg/L and Sampling Area 5 was 0.01 mg/L.

Alternatively, the mean concentrations of available Cr in Sampling Area 1 was measured to be 0.43 mg/L; for Sampling Area 2 was 0.48 mg/L; for Sampling Area 3 was 0.50 mg/L; for Sampling Area 4 was 0.55 mg/L; and for Sampling Area 5 was 0.55 mg/L. Hence, the mean concentrations of Cr are found higher than 0.1 mg/L set by DENR AO No. 34 (1990) but have lower quantities as compared to the study of Sarinas et al. (2013).

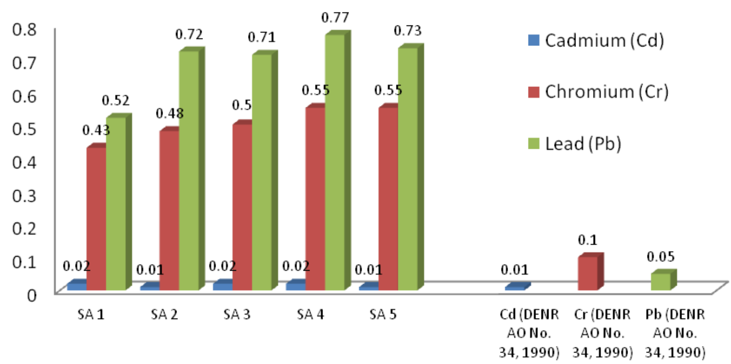

Figure 3. Mean quantities of available Cd, Cr and Pb of this study as compared to standards set by DENR AO No. 34 (1990)

Legend:

SA1 - Sampling Area 1	SA4 - Sampling Area 4
SA2 - Sampling Area 2	SA5 - Sampling Area 5
SA3 - Sampling Area 3	

Furthermore, the mean concentrations of Pb in the five sampling areas exceeded the permissive level of 0.05 mg/L by DENR AO No. 34 (1990). The concentration of lead in Sampling Area 1 was 0.52 mg/L; 0.72 mg/L for Sampling Area 2; 0.71 mg/L for Sampling Area 3; 0.77 mg/L for Sampling Area 4; and 0.73 mg/L for Sampling Area 5. Therefore, the amount of Pb measured in this study is higher than the permissive level set by DENR AO No. 34 (1990) but at this time, higher quantities as compared to the study of Sarinas et al. (2013).

Generally, there is no significant difference among the mean concentrations of available cadmium, chromium, and lead in the five sampling areas, $F_{(2, 42)}$ = .062, p = .940.

CONCLUSIONS

The quantity of lead was higher than chromium whilst chromium was higher than cadmium and cadmium was higher than lead (Pb > Cr > Cd < Pb) in the five sampling areas. However, there was no significant difference found among the mean concentrations of these heavy metals from the five sampling areas.

Furthermore, the heavy metal concentrations found in this study surpassed the permissive level set by DENR AO No. 34 (1990). Thus, the seawater of Villa Beach, Iloilo City is generally contaminated with cadmium, chromium, and lead during the time of sampling.

Follow-up study should be conducted considering the seasons, ocean current, and tides. Furthermore, other heavy metals should also be analyzed.

This study unlocked other areas of research particularly on the concentrations of other heavy metals present in Villa Beach, Iloilo City including sediments, fishes, algae, and other marine invertebrates.

The residents along Villa Beach shall be advised of the risks of heavy metals present in the waters to avoid health complications caused by heavy metals. Awareness shall be imposed especially to local fishermen who utilize the beach for fishing as well as oyster breeders. Recreational activities shall be regulated if not minimized. Special concerns shall be lifted especially to children in the community who are fond of swimming in the beach as well as the students of JBLFMU-Arevalo who regularly utilize the beach for practical assessments in their physical education subject.

LITERATURE CITED

Ansari, T. M., Marr, L. L., & Tariq, N.
2004 Heavy metals in marine pollution perspective - A mini review. *Journal of Applied Sciences, 4* (1): 1-20. Retrieved on October 15, 2013 from http://goo.gl/pWUgUR

Arifin, Z., Puspitasari, R., & Miyazaki, N.
2012 Heavy metal contamination in Indonesian coastal marine ecosystems: A historical perspective. *Coastal Marine Science, 35* (1): 227-233. Retrieved on October 12, 2013 from http://goo.gl/mJjxyj

Asha, P. S., Krishnakumar, P. K., Kaladharan, P., Prema, D., Diwakar, K., Valsala, K. K., & Bhat, G. S.
2010 Heavy metal concentration in sea water, sediment and bivalves off Tuticorin. *Journal of the Marine Biological Association of India, 52* (1): 48-54. Retrieved on December 5, 2013 from http://goo.gl/SVt27P

Boran, M. & Altinok, I.
2010 A review of heavy metals in water, sediment and living organisms in the Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences, 10*: 565-572. Retrieved on January 12, 2014 from http://goo.gl/FPgAAY

Chan-Won, L. & Young-Tack, K.
1994 Distribution of heavy metals in seawater, sediment and biota of Jinhae Bay, Korea. *Water Science and Technology, 30* (10): 173-177. Retrieved on November 8, 2013 from http://goo.gl/pzIMgf

Cuong, D. T., Karuppiah, S., & Obbard, J. P.
2008 Distribution of heavy metals in the dissolved and suspended phase of the sea-surface microlayer, seawater column and in sediments of Singapore's coastal environment. *Environmental Monitoring Assessment, 138*: 255-272. Retrieved on May 2, 2014 from http://goo.gl/bI9QMl

Daniszewski, P.
2013 Determination of metals in sea water of the Baltic Sea in Miedzyzdroje. *International Letters of Chemistry, Physics and Astronomy, 13*: 13-22. Retrieved on March 16, 2014 from http://goo.gl/dbBNsE

DENR AO No. 34
1990 Revised Water Usage and Classification/Water Quality Criteria Amending Section Nos. 68 And 69, Chapter III of the 1978 NPCC Rules and Regulations. Retrieved June 3, 2014 from http://goo.gl/0SPVq1

Ideriah, T. J. K., David-Omiema, S. & Ogbonna, D. N.
2012 Distribution of heavy metals in water and sediment along Abonnema shoreline, Nigeria. *Resources and Environment, 2* (1): 33-40. Retrieved on December 12, 2013 from http://goo.gl/5axF5d

Jiabin, P., Yunna, F. & Zhongping, L.
1996 Concentration level of heavy metals in the Great Wall Bay, Antarctica in austral summer. *Journal of Environmental Sciences, 8* (1): 173-177. Retrieved on April 25, 2014 from http://goo.gl/MOTKl5

Kim, K. T., Kim, E. S., Cho, S. R., Park, J. K., Ra, K. T. & Lee, J. M.
2010 Distribution of heavy metals in the environmental samples of the Saemangeum coastal area, Korea. *Coastal Environmental and Ecosystem Issues of the East China Sea,* 71-90. TERRAPUB and Nagasaki University. Retrieved on April 13, 2014 from http://goo.gl/KCY2WW

Krejpcio, Z.
2001 Essentiality of chromium for human nutrition and health. *Polish Journal of Environmental Studies, 10* (6): 399-404. Retrieved on February 27, 2013 from http://goo.gl/s5gqqB

Kumar, C. S., Jaikumar, M., Robin, R. S., Karthikeyan, P. & Kumar, C. S.
2013 Heavy metal concentration of sea water and marine organisms in Ennore Creek, Southeast Coast of India. *The Journal of Toxicology and Health. Photon, 103*: 192-201. Retrieved on March 7, 2014 from http://goo.gl/f290Hw

Manahan, S. E.
1999 *Environmental chemistry.* 7th ed. New York, London: Lewis Publishers. Retrieved on May 2, 2014 from http://goo.gl/3h1yZi

Poikane, R., Carstensen, J., Dahllof, I. & Aigars, J.
2005 Distribution patterns of particulate trace metals in the water column and nepheloid layer of the Gulf of Riga. *Chemosphere, 60:* 216-225. Retrieved on January 12, 2014 from http://goo.gl/E2qoVk

Qari, R. & Siddiqui, S. A.
2008 Heavy metal pollution in coastal sea water of Nathia Gali, Karachi (Pakistan). *Journal of Environmental Research and Development, 3* (1): 9-19. Retrieved on November 8, 2013 from http://goo.gl/rVmWO4

Saravanamurugan, R., Karthikeyan, M. M. & Subramaniyan, A.
2013 Heavy metal accumulation on water, sediment and some commercial important fin-fishes from Kalpakkam region, southeast coast of India. *International Journal of Environmental Biology, 3* (3): 118-124. Retrieved on February 27, 2014 from http://goo.gl/xiUskR

Sarinas, B. G. S., Gellada, L. D., Magramo, M. M., Teruñez, M. R., Inocencio, G. C. M., Duero, C. E. S., Cleofas, F. K. J. and Segunla, G. S.
2013 Heavy metals in the water column of Iloilo-Guimaras Jetty Port (Parola Wharf). *IAMURE International Journal of Ecology and Conservation*, *6* (1): 54-67. Retrieved on March 13, 2014 from http://goo.gl/7ug0yp

Su, G. S., Martillano, K. J., Alcantara, T. P. Ragragio, E., De Jesus, J., Hallare, A. & Ramos, G.
2009 Assessing the heavy metals in the waters, fish and macro invertebrates in Manila Bay, Philippines. *Journal of Applied Sciences in Environmental Sanitation, 4*(3): 187-195. Retrieved on October 26, 2013 from http://goo.gl/PUmqAW

Tabari, S., Saravi, S. S. S., Bandany, G. A., Dehghan, A. & Shokrzadeh, M.
2010 Heavy metals (Zn, Pb, Cd and Cr) in fish, water and sediments sampled from southern Caspian Sea, Iran. *Toxicology and Industrial Health, 26* (10): 649-656. Retrieved on December 11, 2013 from http://goo.gl/USrJD8