Heavy metals and metalloid contamination in Louisiana Lake Pontchartrain Estuary along I-10 Bridge

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ABSTRACT

In this study, HMs concentration in sediments and water from the Lake Pontchartrain estuary along the I-10 Bridge were investigated in two seasons to evaluate the level of contamination and to assess the effect of vehicular traffic. Vehicular traffic has led to HMs such as As, Cd, Cr, Pb, Zn, Ni, and Cu accumulation in sediments along the bridge. The HMs content in water especially in summer increased due to high temperature which led to release of HMs from the sediments. The level of pollution attributed to anthropogenic activities was evaluated using several pollution indicators. The overall HMs bioavailability and EFs was mostly high in summer and the concentration of the HMs in both sediments and water was highly influenced by the season and the distance from the highways. The content of As and Cd in lake sediments were higher than the background values (BGV) for both seasons (spring and summer), and Cr and Pb in sediments were higher than the BGV in most sampling points in the spring. According to Sediments Quality Guidelines (SQGs), heavy metals except for As have low biotoxicity, and As could potentially result in harmful effects on the aquatic organisms. The relationship between As and vehicular traffic is less studied so our finding stress the need for further study on source of As in Lake Pontchartrain sediments.

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Introduction

Heavy metals (HMs) contamination is a subject of continuous interest within the scientific community, due to the toxic effects on the entire biosphere (atmosphere, hydrosphere, lithosphere and pedosphere) (Varol, 2011; Morselli et al., 2003). Anthropogenic activities is one of the most important source of HMs pollution. Vehicular traffic is human induced activity and a major source of contaminants release into the natural environment (Duong and Lee, 2011; Sezgin et al., 2004). The worldwide high vehicular traffic density has led to accelerate emission rates, causing contamination of roadside soils (Modrzewska and Wyszkowski, 2014; Kummer et al., 2009). HMs emitted from motor vehicle transportation remain suspended in air and deposited along the roadside soil (Yu et al., 2014). Cadmium, chromium, nickel, lead and arsenic are mainly released from car exhaust, worn tires and engine parts, brake pads, rust, used antifreeze, road paint and pavement degradation (Rijkenberg and Depree, 2010; Nixon and Saphores, 2007; WHO, 2000; Wei et al., 2009). HMs exposure can cause different diseases such as malformation, kidney damage, cancer, and abortion (Alomary and Belhadj, 2007). According to US

EPA (1996), half of suspended solids and one sixth of hydrocarbons reaching streams are originated from freeways. Specifically, tire treads and tire dust contain significant concentration of Zn, brake linings and rubber have high content of Cd, Cu, Fe, Ni, Pb and Zn (San Miguel et al., 2002; Lindgren, 1996). High level of HMs such as Cd, Co, Cr, Cu, Fe, Pb and Zn have also been reported in many articles, due to the consumption of gasoline, motor oil or grease and antifreeze (Nixon and Saphores, 2007; Liu et al., 2012; Kummer et al., 2009).

Recent studies of HMs contamination by vehicular traffic focus on soil pollution along the roadside and adjacent areas. The infiltration of road runoff and dust deposition, leads to elevated metal concentrations in the roadside soils. Furthermore, leaching of galvanized crash barriers and road signs by rain and splashing water releases the significant concentration of metals (Van Bohemen and Janssen Van De Laak, 2003). Soil metal contamination typically decreases with increasing depth and distance from the road edge (Modrzewska and Wyszkowski, 2014; Golwer, 1995). However, to our knowledge, there are limited studies conducted on vehicular traffic effects on HMs accumulation in water and sediments along the road (especially the bridge).

Sediments are ecologically important components of aquatic habitat. Sediments show a great capacity to accumulate contaminants, and most pollutants adsorbed on the sediments are not bioavailable (Nemati et al., 2011; Singh et al., 1997). However, some processes such as sediments resuspension, desorption, redox reactions or degradation of the sorptive substance may induce pollutants release into water column. Therefore, sediments not only act as a reservoir, but also the potential source of pollutants in the aquatic system (Varol, 2011; Nemati et al., 2011). For the important role of sediments in water body, the analysis of metals in sediments are vital to assess the degree of pollution in the aquatic environment (Alomary and Belhadj, 2007).

The I-10 highways is one of the most important roads in the Southern United States and I-10 Bridge (Pontchartrain Expressway) in Lake Pontchartrain is a parallel 6-lane section of interstate 10 and U.S. Route 90 in New Orleans, Louisiana. The expressway follows I-10 into the Central Business District of New Orleans, and the length of the bridge is 10.5 km. As the main traffic artery through New Orleans, the traffic flow on I-10 is rather high. In this paper, we are reporting the first comprehensive study on the distribution of HMs in water and sediments along the I-10 Bridge. The objectives of this study were: (1) to determine the spatial and temporal distributions of HMs in water and sediments along the bridge, (2) to investigate the bioavailability of HMs by using EDTA extraction and modified BCR extraction methods, (3) to explore the degree of HMs contamination in the sediments using contamination indices, and (4) to assess the environmental risks of HMs in the study area by comparing with Sediments Quality Guidelines (SQGs).

Methodology

Sampling sites

The study area is located in the Southwestern part of the Lake Pontchartrain basin. The Lake Pontchartrain is the second largest shallow estuary in America with a surface area of 1630 km^2, and an average depth of 3.7–4.3 m. It is connected to the Gulf of Mexico by open channels on the southeast side and the water quality is brackish. Fig. 1 shows the locations of sampling sites. Sample of water and sediments were collected from 8 and 10 sites, along the I-10 Bridge in the spring and summer, respectively. The distance from the bridge to the location 8 in spring is 0.1 km. The distance from the bridge to location 7, 8, 9 and 10 in summer is 0.13, 0.06, 0.8 and 0.05 km, respectively. All the remaining sampling sites are under or between the two bridges. Samples from site-9 were collected at a greater distance from the bridge for background measurement. Due to tidal and wind disturbance, sampling points were not in the same position, but they were relatively restrained in a limited scope.

Sample collection and pretreatment

Water and sediments samples were collected using a self-made water sampler and a mechanical dipper on February 19, 2009 and July 16, 2009, representing spring and summer samples, respectively. After sampling, water samples were stored in an insulated cooler containing ice and delivered to the laboratory immediately and stored at 4 °C prior to further analysis. Sediments were freeze-dried, homogenized, crushed and sifted passed through a 75 μm stainless steel sieve and then stored in polyethylene bottles for heavy metal analysis.

Water sample analysis

The lake water physicochemical parameters, such as pH, electrical conductivity (EC), DO, and temperature at 10 cm depth were measured *in situ* with a hand-held YSI (Model556, YSI Incorporated, USA). Other water samples were passed through a 0.45 μm pore size membrane filter and determined in the laboratory. Turbidity was analyzed using a Hach Turbidimeter. TOC and DOC were determined using a Shimadzu TOC-V vch Total Organic Carbon Analyzer. The dissolved anions were analyzed by a Dionex ICS 2000 Ion Chromatograph. The dissolved HMs were analyzed by a PERKIN ELMER SCIEX ELAN 9000 ICP-MS after HNO_3 acidification.