Marine Pollution Bulletin 111 (2016) 268–276

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Chemical and biological assessment of sediments and water of Khalid Khor, Sharjah, United Arab Emirates

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ARTICLE INFO

Article history:
Received 18 February 2016
Received in revised form 17 June 2016
Accepted 28 June 2016
Available online 2 July 2016

Keywords:
Khalid Khor
United Arab Emirates
Heavy metal
Polyaromatic hydrocarbons
Water
Sediment

ABSTRACT

Water and sediments were collected on March 2013 and April 2014 from Khalid Khor creek area in United Arab Emirates to assess their quality parameters. The pH and alkalinity of the water samples were measured and their values were similar to those of shallow saltwater ecosystems. In addition, elemental analyses and organic compounds were done using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) and Gas Chromatography—Mass Spectroscopy (GC–MS), respectively. The concentration of heavy and trace metals in the water samples were within the acceptable limits except for lead which showed high values, while the concentrations of metals in the sediment samples were relatively high and ranged from 6517 to 13,768 mg/kg. GC–MS analysis showed the presence of polyaromatic heterocyclic (PAHs) compounds in sediments near the shipping area and in amounts classified as highly carcinogenic; however, no polychlorinated biphenyls (PCB) were identified. Moreover, fecal bacterial contamination in water was detected in concentrations that range between 300 and 10,140 organisms/100 mL.

1. Introduction

Over the last two decades, the United Arab of Emirates (UAE) has gone through rapid urbanization especially in the main states of Abu Dhabi, Dubai, and Sharjah. However, the country's development is accompanied by several environmental challenges. For instance, the coastal gulf region requires special consideration due to its semi-enclosed sea, shallowness of its shores, its high evaporation rates and poor flushing characteristics (Sheppard et al., 2010). The elevated temperatures, high salinity and long UV exposure contributed to the negative effects on the UAE ecosystems. One of the impacted areas is Khalid Khor which is a creek and pool system located in the heart of Sharjah. Furthermore, it is one of the tourist destinations in Sharjah due its attractive fountain (Government of Sharjah, 2011). In addition, Khalid Khor is used for recreational fishing and commercial shipping for fish and other products into Sharjah. As a result, its water quality monitoring plays an important role in ensuring the safety and health of the residents of Sharjah.

Environmental deterioration is known to have adverse negative effects on public health; especially with variables associated with the qualities of air, waste disposal, waste water management and treatment, drinking water and ground water (US EPA, 2012; Bee'ah, 2009; Rashed, 2001). Several sources of pollution are known to contribute to the contamination of the Khalid Khor that include improperly treated waste water runoff, chemicals from industries as well as oil leakages from the ships entering the port. Such sources are known to highly affect the quality of water and the living organisms in its water body (US EPA, 2012). Oil leakages are known to be the major sources of the Khalid Khor pollution with their chemical composition which is rich in organic compounds and heavy metals. The metals can be accumulated in sediments and water which will eventually be absorbed by the fish resulting in adverse health effects on both the fish and other marine organisms. It is known that the amount of metals uptake by fish depends upon the chemistry of the water, speciation and the binding state of the metals (Dalinger et al., 1987). Heavy metals and trace metals, such as cadmium (Cd), cobalt (Co), chromium (Cr), iron (Fe), nickel (Ni), vanadium (V), selenium (Se), zinc (Zn) and lead (Pb), can cause adverse health effects for human including cancer, organ damage, bone damage, neurological problems, and developmental problems that would lead to death (Jarup, 2003).

Moreover, sediments act as a storage area with high capacity for metals and play an important role in metal transformation. Unlike many organic compounds, heavy metals can't be decomposed by natural processes; therefore, they will be stored in sediments in various forms leading to a high risk of release during the occasional dredging to maintain shipping lines (Peng et al., 2009).

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http://dx.doi.org/10.1016/j.marpolbul.2016.06.107
0025-326X/

Organic pollution is a major problem that can cause harm to the environment and human health. Most of the hydrophobic organic compounds do not degrade easily in the environment and result in bioaccumulation in the organisms (Jones and de Voogt, 1999). Once these pollutants enter the food chain, they may accumulate in the tissues of organisms and then biomagnify through the food chain. Persistent Organic Pollutants (POP) could result in serious health effects that include disruption of endocrine, reproductive and immune systems in addition to neurological problems and even cancer (ATSDR, 1995). POPs are commonly introduced in the waste water discharges. They can suffocate fish and cause an increase in algae growth due to the introduction of excessive amounts of nitrogen and phosphorous pollutants and depletion of oxygen. Some of the POPs, heavy metals and toxic compounds, persist in sediments and fish and accumulate over a period of time (Revenga and Mock, 2000). Bacterial contamination is another concern in Khalid Khor. Different types of bacteria might find their way to the water body from various sources including waste water discharges from ships in addition to fecal matter from living organisms. Coliform bacteria are a common type that consists of several kinds of bacteria; some of which are harmful to human health, such as *Escherichia coli* (Khan and Ahmad, 2012). Although not all are pathogenic, many are known to cause mild to severe gastrointestinal issues such as diarrhea and they are also used as indicators of the presence of fecal matter, which may have more difficult to analyze pathogenic microbes, and therefore fecal coliforms are a good indicator for overall fecal matter contamination (Dhanya et al., 2013; US EPA, 2013a; Lamka et al., 1980). Several publications in the literature suggested that the presence of heavy metals and organic matter in sediments increase with industrial activities and urbanization (Honglei et al., 2008; Van et al., 2007; Nowrouzi et al., 2012). Although urbanization improves the economy of the country, it may also have a negative impact on its environment. Increased anthropogenic activities pollute water, air and ecosystem in addition to the regions' aesthetic characteristics; therefore, constant monitoring of the quality of water and sediments at Khalid Khor is important to ensure environmental safety and public health. The objective of this research was to characterize the water quality in Khalid Khor, by evaluating the presence of both inorganic and organic contaminants in water and sediments. The study conducted a health assessment of the presence of such contaminants on human health. In addition, important water quality parameters such as pH, conductivity, alkalinity and bacterial contamination were measured.

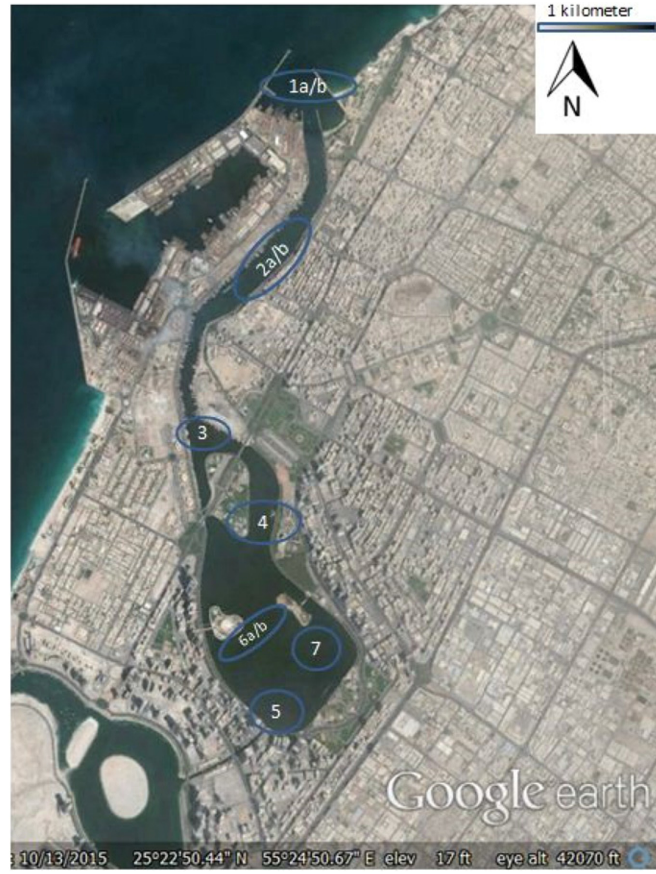

Fig. 1. Maps of the sampling sites in Khalid Khor, Sharjah, United Arab Emirates.

2. Experimentation section

2.1. Water sampling and storage

Samples were collected from Khalid Khor Port during two periods on March 16, 2013 and April 12, 2014, between 9:00 am and 12:00 pm, along the creek and pool areas as shown in Fig. 1. Water samples were collected using a Van Dorn Sampler (ALS Research equipment, Denmark) at two meters depth from the surface. All equipment and dilution water for the IDEXX analysis was steam sterilized using a top loading autoclave (Priorclave, UK) at 121 °C for 15 min. All other samples were taken in nalgene or polypropylene bottles appropriate for their analysis. When available, bottom sediment samples were collected using an Ekman Dredge grab sampler, placed into Ziploc bags. Absence of a sediment sampling suggests minimal sediments at that site. All samples were stored on ice for transport to the laboratory. Upon arrival at the laboratory, sediment samples were placed at −20 °C until air drying for 24 h prior to analysis. Water samples for metals analysis were acidified to pH 2 with concentrated nitric acid and all water samples were stored at 4 °C until analysis if analysis was delayed.

2.2. Water quality parameters

Surface water pH and temperature were measured on site using a HI8424 pH meter (Hanna Instruments, Romania), Dissolved oxygen was measured using a Cyberscan DO 110 (Eutech, United States), and conductivity using an Orion 115A+ Basic Conductivity probe (Thermo Electron Corporation, United States), respectively. Samples were placed in an iced cooler and transported to the laboratory for analysis. Water alkalinity was determined by titration method adapted from Radojevic and Bashkin (2006) using 0.10 M of standardized hydrochloric acid (HCl). Three replicates of 100 mL of each water sample were titrated using methyl orange as indicator. At the equivalence point, the alkalinity was calculated in mg $CaCO_3$/L for each sample.

2.3. Bacterial analysis of water

Immediately upon return to the laboratory, bacterial analysis was performed using a Colilert-18 kit with Quantitray 2000 (IDEXX, USA) with 100× dilution. The diluted samples were added to 100 mL sodium thiosulfate vessels, Colilert 18 indicator was added, the mixture was transfered into the IDEXX Quanti-Tray 2000 tray and placed in an incubator Type 142300 Incubator (Thermodyne, USA) at 30–35 °C for 24 h. The Most Probable Number (MPN) of the total coliforms was determined using the yellow coloration index. A presence/absence test was used on sterile dilution water priorly incubated using Type 142300 Incubator (Thermodyne, USA) at 35 °C to methods were uncontaminated.

2.4. Elemental analysis of the water samples

The metal samples were analyzed using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) (Varion-liberty Australia). Several heavy and trace metals were analyzed that included cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), vanadium (V), selenium (Se), zinc (Zn) and lead (Pb). Calibration standards, in the range of 0.01–5 ppm, were prepared for quantification with 1 M nitric acid. Blank samples and QC Standards