2014 5th International Conference on Environmental Science and Technology
IPCBEE vol.69 (2014) © (2014) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2014. V69. 1

Environmental Hazards and Pollution from Liquid Waste Lagoons

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Abstract. In Oman, many dumping sites are used as lagoons for liquid waste and landfills for solid waste. In this study, an attempt was made to survey one lagoon for hazardous liquid waste. Common hazardous industrial chemicals were analyzed which include major ions, heavy metals and organic pollutants. The chemicals were analyzed using mass spectrometers, gas chromatography and ion inductive plasma (GC/MS and ICP/MS). The results indicate that there is serious pollution problem caused by liquid waste. In general, sediment samples contained significant levels of major ions, heavy metals and organic pollutants. Similar pollutants were also found in liquid waste at lower concentrations which is evidence of a contamination source. The surrounding soil samples were less contaminated from sediment samples. If this environmental pollution continues, it will eventually seep to underground water and cause soil deterioration, which will lead to serious health problems.

Keywords: Environment, pollution, hazard, liquid waste.

1. Introduction

Waste products are major problems facing environmental and health authorities in Middle Eastern countries due to the high rate of urbanization, industrialization, population growth, migration, and economic development. The Middle East is considered to be the highest waste per capita worldwide which rose recently to more than 150 million tons annually, causing serious environmental and public health problems. For example, currently Oman is generating one of the world's highest waste production, approximately 1.6kg/day per capita. Different types of waste are produced such as undegradable and bio-degradable materials. Some highly hazardous and toxic products are incinerated, buried in landfills or dumped in liquid waste lagoons, leaching into the soil. Also, hazardous pollutants contaminate valuable underground water resources, specifically in arid regions such as Oman [1]-[3]. There are tremendous efforts to rectify these serious environmental conditions by the authorities.

The population of Oman is expanding rapidly. In 1971 it was only 654 thousand, but increased significantly to more than 3 million at present. There were no modern industries. According to 2010 data more than 800 industries have been established in industrial areas throughout the country. Oman produces more than 80 thousand tons of waste annually. For comparison, the amount of industrial waste in 2001 was about 30,000 tons and about 350 landfills [4]. Estimation of hazardous waste quantity on Gross Domestic Product (GDP) based in 2006 was approximately 3.6 million USD. The estimated total waste by 2020 is expected to be more than 4 million tons (Ministry of Regional Municipality, Muscat Municipality, Dhofar Municipality and Ministry of Economy-statistic Year Book).

Most of the liquid waste is dumped in lagoons which contaminate air, soil and underground water. Liquid waste consequently changes soil pH depending on basic or acidic chemical pollutants. The deteriorated soil leads to erosion and desertification. Most contents in liquid waste are recyclable and can

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prevent environmental pollution. So far, there are few recycling institutions in Oman which involve recycling hazardous liquid waste. This is insufficient to meet the generated demand of the tremendous amount of liquid waste.

2. Materials and Methods

A total of 60 samples (20 sediments, 20 effluents and 20 soil samples) were collected from the liquid waste lagoon and stored in a cool box and transferred shortly to the lab for analysis. Samples were collected weekly over a period of two months. The effluents were collected and analysed according to the standard methods [5]. Each effluent sample was collected in 1L of sterile glass bottle for heavy metal analysis [6].

Sediment and soil samples were dried at 105 ^{o}C for 3 h. 0.2 g of dried sediment and soil samples were treated with 4ml of concentrated nitric acid and 0.5ml of hydrofluoric acid in a microwave for 40 min. All samples were diluted to 100 ml with water to a final concentration of 1 g/l [7]. The effluent samples were filtered and analysed for Ca, Cd, Cr, Cu, K, Mg, Na, Ni, Pb and Zn using inductively coupled plasma optical emission spectrometer (ICP-OES) type Perkin Elmer 3300 DV ICP (USA). Blank and certified reference materials were used as controls.

Some organic compounds were selected for this study due to their relevant usage in Oman (Table 1).

Gas chromatography-mass spectrometry (GC-MS) was used for detection of organic compounds following the EPA methodologies (EPA).

Table 1: Organic compounds commonly found in Oman. Information of health sources are based on U.S. Environmental Protection Agency (2013).

Organic compound	Uses	Health effects
Dichlorobenzene	Control of insects, intermediate production of chemicals	Irritation of eyes, nose, throat, skin; sore throat; drowsiness, liver, kidney damage
Dichloromethane (Methylene chloride)	Paint remover, metal degreasing, adhesives products, polyurethane production, and polycarbonate resin production	Carcinogen, mental confusion, and headache, eye and respiratory tract irritation
Ethylbenzene	Styrene production, solvent, production of synthetic rubber and cellulose acetate	Drowsiness, fatigue, headache and mild eye and respiratory irritation
m-Xylene	Uses as solvents	Irritation eyes, nose, throat. Gastrointestinal effects, neurological and central nervous system, cardiovascular, and kidney effects
Trymethylbenzene	Occurs naturally in crude oil. Used in certain paints and cleaners	Reproductive system and fetal development
Vinyl Chloride	Used for production of polyvinyl chloride (PVC) plastic and vinyl products	Effect central nervous system, liver damage and cancer

3. Results

The major ions found in the sediment, liquid and soil samples were Ca, Na, K and Mg. These ions were significantly found ($p<0.001$) in sediment followed by liquid and soil. Ca levels were significantly higher followed by K, Na and Mg in all samples (Fig. 1).

The most contaminated samples by the heavy metals were sediment followed by liquid samples ($p<0.001$). Zn levels were significantly higher than the other metals in all samples taken from sediment liquid and soil. Ni levels were significantly lower than Zn but higher than the rest of the heavy metals followed by Cr and Cu (Fig. 2).

The most dominant organic pollutant was vinyl chloride ($p<0.001$) followed by trymethylbenzene. m-xylene was significantly higher in soil samples ($p<0.001$) compare to other organic compounds. Other organic compound pollutants in soil were found at low levels (Fig. 3).

4. Discussion

During the last 4 decades, there has been a significant increase in industry and agriculture linked to the population explosion in Oman. These conditions led to an increase in terrestrial and aquatic pollution. Unfortunately, little attention was focused on the environment. As a result environmental pollutants gradually infiltrated into the environment contaminating ecological niches in the region [1]-[3], [8]-[12].

These ecological pollutants resulted from a significant increase in dumping sites, such as lagoons liquid waste and landfills solid waste.

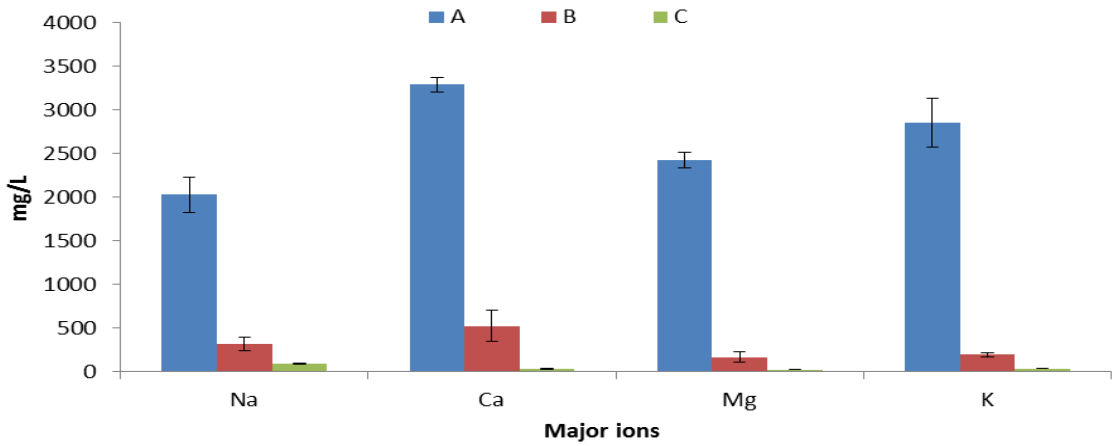

Fig. 1: Distribution of major ion in A=sediment, B=liquid waste and C=soil in Oman.

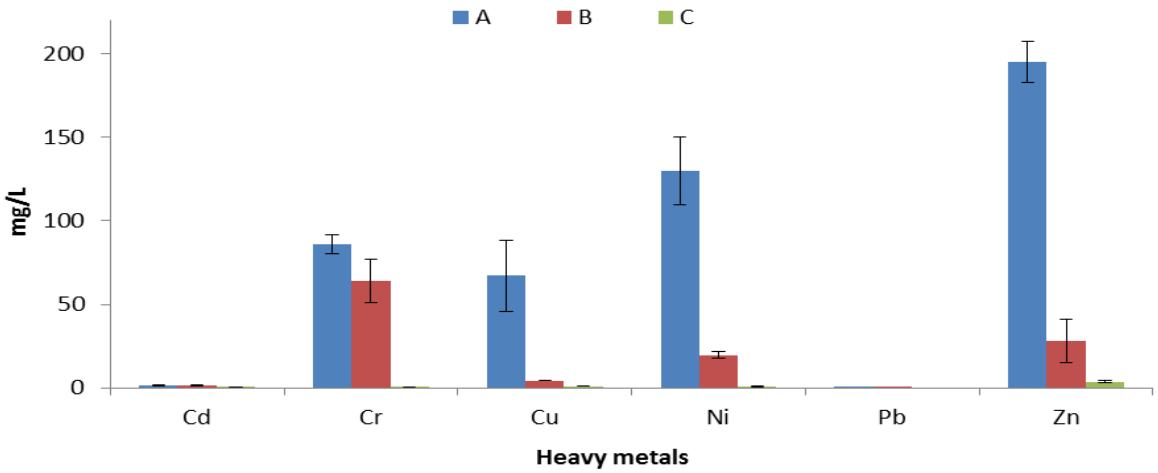

Fig. 2: Distribution of heavy metal in A=sediment, B=liquid waste and C=soil in Oman.

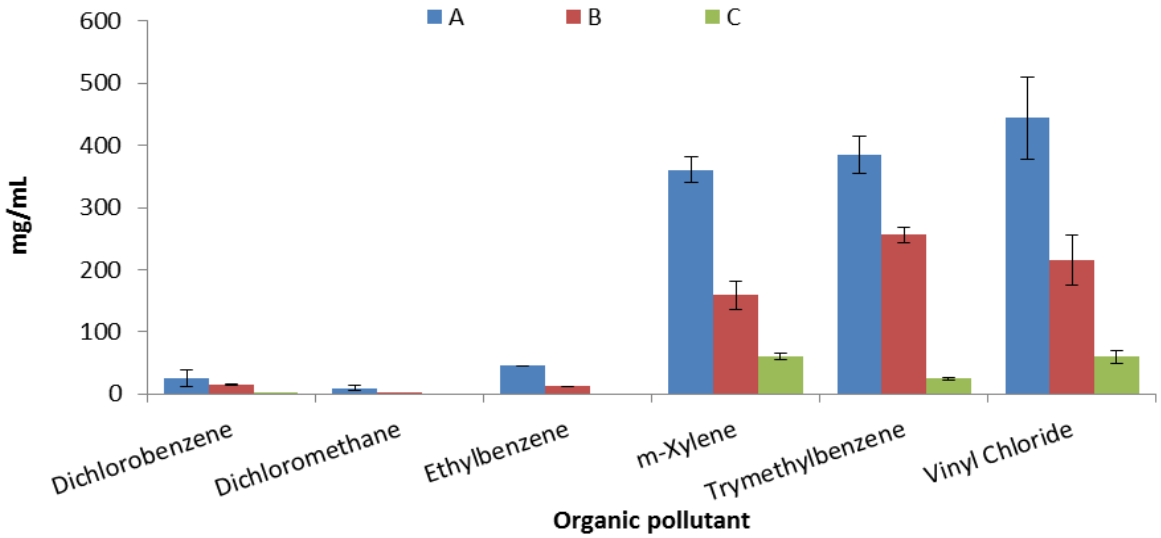

Fig. 3: Distribution of organic pollutants in A=sediment, B=liquid waste and C=soil in Oman.

In this study, a lagoon dumping site was chosen to analyse major ions, heavy metals and organic pollutants in liquid waste, sediment and soil. As expected, the three sample sites were contaminated; however, the sediment is the most heavily contaminated.

In other studies regarding heavy metal pollution in Oman, revealed that sewage effluents from industrial sources were responsible for coastal contamination affecting fish population in the area [12]. The contaminated effluents were also responsible for agriculture soil pollution [11]. The heavy metal pollution was reported to be from the industrial sewage treatment plants infiltrating underground water [2].

Heavy metals, Co, Hg, Pb and Sn, accumulation is gradually increasing in wild life [13]. Toxicity of heavy metals in living organisms is due to accumulate and bind biomolecules such as proteins. It was reported that heavy metal toxicity caused a decline in various wild life [14]-[16]. Overtime, high concentrations of heavy metals may ultimately become fatal [17].

Contaminated effluents may play an important role in polluting the environment, detrimental to human and wild life. Consumption of contaminated food and drinking water containing high concentration of pollutants may lead to a variety of chronic diseases such as renal failure, anaemia, liver cirrhosis, and cancers [18], [19].

In this study, several organic compounds were found in the three sites with the highest concentration of sediment. The main source of the pollutants is from effluents originated from industries established in Oman in recent years. During the last few years, there has been a steady increase in the systemic diseases and cancers probably, resulting from the spread of pollutants in habitats, particularly in underground water and farmland. If this trend continues without environmental management, the pollutants will increase progressively, infiltrating and contaminating habitats such as soil and waterbeds, which is one of the main sources of drinking water and agriculture [1]-[3], [8]-[12]. These environmental conditions will consequently inflict serious health problems in the region.

Recently, the authorities and responsible citizens begin to realize the seriousness of the environmental contamination in Oman. There is great expectation that environmental programs will strengthen in the future to lessen serious environmental contamination and prevent serious consequences.

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