Arabian Journal of Chemistry (2015) 8, 240–245

King Saud University

Arabian Journal of Chemistry

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Assessment of the levels of some heavy metals in water in Alahsa Oasis farms, Saudi Arabia, with analysis by atomic absorption spectrophotometry

Fahad N. Assubaie *

Department of Chemistry, College of Science, King Faisal University, P.O. Box 400, Hofuf 31982, Saudi Arabia

Received 12 May 2011; accepted 20 August 2011
Available online 3 September 2011

KEYWORDS

Heavy metals;
Groundwater;
Irrigation water;
Wastewater

Abstract For the first time, the levels of some heavy metals in water in Alahsa farms, Saudi Arabia were examined. Three types of water were analyzed including groundwater, mixed water and wastewater. The total contents of Mn, Fe, Cu, Zn, Cd and Pb were determined using graphite-furnace atomic absorption spectrophotometry. The results obtained were verified through the analysis of a certified reference material, the results of which are in good agreement with the certified consensus values. As recommended by the Food and Agriculture Organization, the level of heavy metals in groundwater and mixed water have been found to be suitable for irrigation purpose. However, the occurrence of some heavy metals that discharged directly from man-made activities without treatment could result in some environmental problems in the future. On the other hand, the spatial distribution of Mn and Fe has been found to increase from southeast to northwest.

1. Introduction

The accelerated industrialization process in combination with rapid population growth and agricultural activities has brought the risk of increasing the pollution index in natural environments, such as water, soil, air, etc. (Morrison et al., 1990; Dawson and Macklin, 1998; Ekpo and Ibok, 1998; Hassanzadeh et al., 2011; Mandour and Azab, 2011). For its multipurpose usage, persistence in the environment, bioaccumulation and high toxicity, heavy metals are considered as one of the most serious pollutants in the environment. Heavy metals are involved in various industrial processes, agricultural activities, domestic waste and vehicles emission. On the other hand, heavy metals that originated from anthropogenic sources could be found in all components of the environment (Idris et al., 2007; Idris, 2008; Ayni et al., 2011). Due to the increasing anthropogenic contribution by heavy metals, more attention has been devoted to the investigation on those pollutants in the environment (Edmund et al., 2003; Marengo et al., 2006; Al-Hobaib et al., in press). Low efficiency in industrial production processes (e.g. energy power plants, petrochemical and chemical industries, etc.) and the unsuitable handling and management of industrial wastes have been recognized as pollution sources, which are responsible for

* Fax: +966 3 5886 437.
E-mail address: fnassubaie@yahoo.com.

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.arabjc.2011.08.018
1878-5352

producing considerable load of heavy metals to the environment (Charlesworth and Lees, 1999; Hashisho and El-Fadel, 2004; Kuang et al., 2004; Mireles et al., 2004; Banat et al., 2004; Namaghi et al., 2011).

Nearly, all types of water contain heavy metals, many of which result from the natural weathering of the earth's surface (Newcomb and Rimstidt, 2002). In addition, wastewater used for irrigation land, besides effluent from city sewage and industrial wastewater, could significantly affect water quality. Heavy metals from anthropogenic activities could migrate or infiltrate into aquifers and interact with groundwater (Dawson and Macklin, 1998; Charlesworth and Lees, 1999).

A number of heavy metals in irrigation water cause toxic reaction in plants and, therefore, limit its use for irrigation. Many reports that recommended maximum allowable levels of heavy metals in water used for irrigation for a short and long time are available elsewhere (Todd, 1980; FAO, 1985; Rowe and Abdel-Magid, 1995; Chapman, 1997). Rowe and Abdel-Magid (1995) reported on the toxicity of some heavy metals to plants. For example, lead at high concentration can inhibit plant cell growth. In addition, manganese is toxic to a number of crops at few-tenths to a few mg/L, but usually only in acid soils. On the other hand, iron is not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Moreover, copper is toxic to a number of plants at the levels from 0.1 to 1.0 mg/L in nutrient solutions. Furthermore, zinc is toxic to many plants at widely varying concentrations. Zinc toxicity is reduced at $pH > 6.0$ in fine textured or organic soils. Cadmium is also toxic to beans, beets and turnips at concentrations as low as 0.1 mg/L in nutrient solutions. However, such heavy metals as manganese, zinc and copper in trace levels are important for the physiological functions of living tissue and regulate many biochemical processes.

In Al-Ahssa Oasis, Saudi Arabia, the main source of water or almost the single source is groundwater since rivers are not available and rainfalls are scarce. The groundwater in that area is distributed into three aquifers: (a) Neogen is the upper one with a depth of up to 180 m, (b) Khobar is the middle one with a depth ranging from 180 to 250 m and (c) Umm-Arradma is the bottom one with a depth ranging from 280 to 240 m. Al-Ahssa Oasis is the largest irrigated agricultural area in Saudi Arabia. It includes date palm farms, the product of which is the main popular nutritional food, besides many other farms that produce vegetables and fruits.

The increasing demand of water for agricultural, industrial and domestic purposes in the area under study leads to reuse the wastewater. Wastewater includes emission of industries, domestic sewage and drainage water (the unconsumed part of the irrigation water). Unfortunately, wastewater is directly mixed with groundwater at a ratio of 1–3, respectively, with no treatment. Not least but more, most of industries in that area emit wastes without management.

On the other hand, atomic absorption spectrophotometry (AAS) is widely used as a routine technique for elemental analysis in water samples. In this issue, the extensive worldwide use of AAS is attributed to its popularity, familiarity, ease of use and cost-effectiveness comparing with other elemental techniques such as inductively coupled plasma. Moreover, AAS is a sensitive technique, which can detect elements in up to ng/mL levels especially when graphite furnace mode is used for atomization. Furthermore, AAS enjoys good selectivity, which is due to the use of selective irradiation source.

There is lack of studies on water quality in Alahsa Oasis with the exception of a report on nitrate and nitrite levels in groundwater (Assubaie, 2004). Therefore, it has been proposed in the current study to achieve the following objectives. (i) To determine the levels of some heavy metals, namely Mn, Fe, Cu, Zn, Cd and Pb, in water samples using AAS-GF. Three types of samples including groundwater, mixed water and wastewater in Alahsa Oasis will be examined. (ii) To examine the spatial distribution of the levels of Mn and Fe in the groundwater. (iii) To identify the sources of heavy metals in groundwater and finally. (iv) To assess the irrigation water quality.

2. Methodology

2.1. Study area

Al-Ahssa Oasis, Saudi Arabia, is one of the largest oases in the world. It forms an "L" shape that covers 320 km^2 with about 150 m above the sea level. It is situated between 25°21′ and 25°37′ northern latitude with 49°33′ and 49°46′ eastern longitude. The area is located between the rock desert of As-Summan Plateau in the west and sand dunes covering the plain as far as the east border. The climate belongs to the subtropical arid zone of the northern hemisphere. This area includes two cities Al-Hofuf and Al-Mubaraz, which are densely populated and industrialized, besides more than fifty villages (Fig. 1). The population increased from 741,000 in 1980 (Team of Staff, 1995) to 1,408,000 in 2000. Now they are more than 2 millions (Central Department of Statistics Information, 2011).

Figure 1 Saudi Arabia map showing Al-Hufuf city.