International Soil and Water Conservation Research xx (xxxx) xxxx–xxxx

HOSTED BY

ELSEVIER

Contents lists available at ScienceDirect

International Soil and Water Conservation Research

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

Original Research Article

Spatial distribution of heavy metals in the middle nile delta of Egypt☆

Mohamed S. Shokr[a,b,*], Ahmed A. El Baroudy[a], Michael A. Fullen[b], Talaat R. El-beshbeshy[a], Ali R. Ramadan[c], A. Abd El Halim[a], Antonio J.T. Guerra[d], Maria C.O. Jorge[d]

[a] Soils and Water Department, Faculty of Agriculture, Tanta University, Tanta, Egypt
[b] The University of Wolverhampton, Wolverhampton WV1 1LY, UK
[c] Soils and Water Use Department, National Research Centre, Giza, Egypt
[d] Department of Geography, Federal University of Rio de Janeiro, Brazil

ARTICLE INFO

Keywords:
El-Gharbia Governorate
Egypt
Soil contamination
X-ray fluorescence spectrometry
Remote sensing
Geographical information systems
Indices calculations

ABSTRACT

Heavy metal contamination in the El-Gharbia Governorate (District) of Egypt was identified by using remote sensing, Geographical Information Systems (GIS), and X-ray fluorescence (XRF) spectrometry as the main research tools. Digital Elevation Model (DEM), Landsat 8 and contour map images were used to map the landforms. Different physiographic units in the study area are represented by nine soil profiles. X-ray fluorescence spectrometry (XRF) was used for geochemical analysis of 33 soil samples. Vanadium (V), nickel (Ni), chromium (Cr), copper (Cu) and zinc (Zn) concentrations were measured and they all exceeded the average global concentrations identified by Wedepohl (1995). Ni and Cr concentrations exceeded recommended values in all soil profile horizons (Canadian Soil Quality Guidelines, 2007), while Cu had a variable distribution. Zn concentrations are under recommended concentration limits in most soil samples. Contamination Factor, Pollution Load Index and Degree of Contamination indices were used to assess the environmental risks of heavy metal contamination from the soils. All analysed metals pose some potential hazard and pollution levels were particularly high near industrial and urban areas.

1. Introduction

Heavy metals are considered as one of the most critical contaminants in the environment, because of their toxicity, persistence and bioaccumulation. These elements can bio-accumulate in plants, animals and humans via the food chain (Abrahams, 2002). The Nile Delta is one of the oldest intensely cultivated areas on earth and is very densely populated, with ≤1,600 inhabitants per square kilometre (Zeydan, 2005). Agricultural development, industrial activities and inadequate rural sanitation have considerable impacts on eutrophication and contamination status, ecological value and environmental conditions on the Nile Delta (Zeydan, 2005).

Natural and anthropogenic activities are two important sources of heavy metals in soil. Natural sources of heavy metals include weathering and other pedogenic processes acting on rock fragments, and are usually at relatively low concentrations (Baltrėnas, Jankaitė, & Kazlauskienė, 2008; Anikwe & Mbah 2010). Commercial fertilizers, liming materials, agrochemicals and other materials used as soil amendments, irrigation water and atmospheric decomposition are the main anthropogenic sources of heavy metals in soils (Baldassarre, Radina, Senesi, & Senesi, 1999; Filippidis, Michailidis, Mladenova, & Sofianska, 2013). The continuous application of mineral fertilizers which contain high heavy metal concentrations pose potential health threats (Abdelhafez et al., 2012).

Heavy metals become soil contaminants for several reasons. Firstly, their rates of generation by human activities are more rapid than natural ones. Secondly, the chemical form of metal in the receiving environmental system usually make it more bioavailable. Thirdly, where higher potential of direct exposure occurs they can be transferred from sources (usually mines) to diffuse environmental locations (Al-Abed, D'Amore, Ryan, Scheckel & 2005). Heavy metals are usually adsorbed by soil, firstly by initial rapid reactions for minutes or hours, followed by slow adsorption reactions for days or years. Thus, heavy metals can be redistributed into different chemical forms, with associated variations in bioavailability, mobility and toxicity (Buekers, 2007). Heavy metals in soil due to human activities are usually more mobile compared with pedogenic or lithogenic forms (Kaasalainen & Yli-Halla, 2003).

The use of Geographical Information Systems (GIS) is one of the most efficient tools for studying environmental geochemistry (Jiao, Lu,

Peer review under responsibility of International Research and Training Centre on Erosion and Sedimentation and China Water and Power Press.
* Corresponding author.
E-mail address: m.s012@yahoo.com (M.S. Shokr).

http://dx.doi.org/10.1016/j.iswcr.2016.10.003
Received 4 September 2016; Received in revised form 30 October 2016; Accepted 31 October 2016
Available online xxxx

Please cite this article as: Shokr, M., International Soil and Water Conservation Research (2016), http://dx.doi.org/10.1016/j.iswcr.2016.10.003

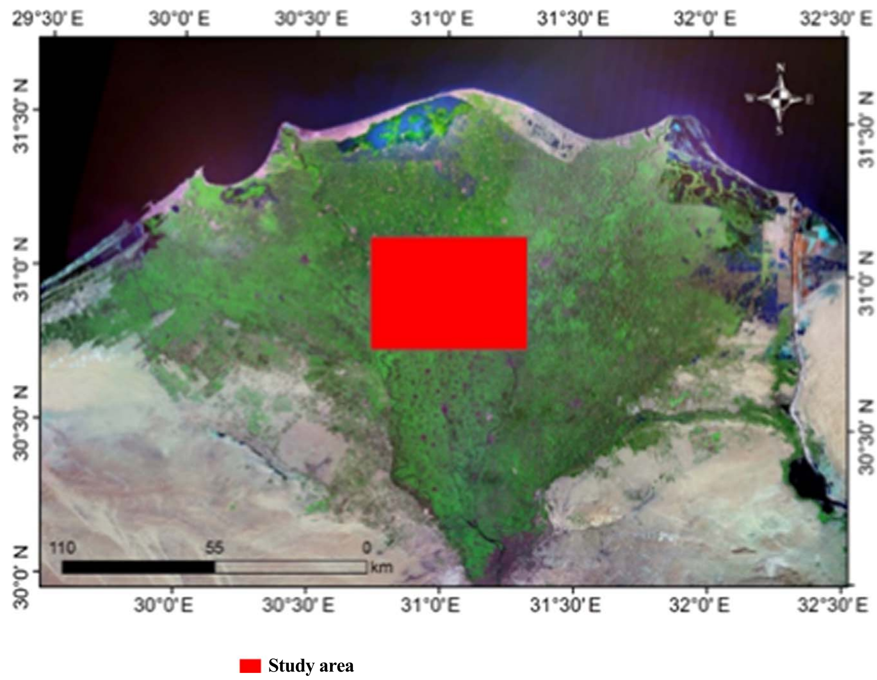

Fig. 1. Location of the study area in the middle Nile Delta of Egypt.

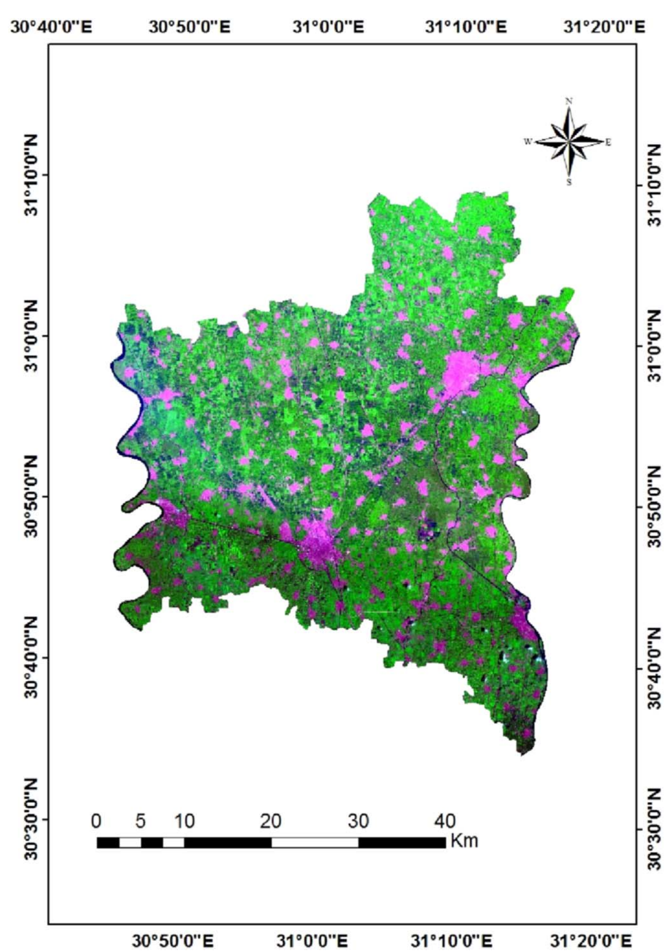

Fig. 2. Landsat 8 mosaic of the study area.

Teng, Wu & Wang, 2014). Spatial distribution is essential for assessment of effects of heavy metals on soil and to delineate contamination zones (El Razek & Omran, 2012). The use of inverse distance weight (IDW) procedures can assist spatial interpolation of heavy metal distribution patterns (Zheng, 2006).

The spatial interpolation of IDW can produce maps of heavy metal distributions and quantify the probability of heavy metal concentrations higher than their guide values (Bhalli, Ghaffar, Parveen & Shirazi, 2012). The identification of appropriate reference values for uncontaminated soil conditions is a major methodological problem associated with correctly assessing soil contamination, as all quantitative assessment methods rely on reference values exceeding background concentrations (Desaules, 2012). The most common reference values used for soil contamination assessment are background, crustal and regulatory reference values.

Both quantitative and qualitative methods are used for soil contamination assessment. Qualitative methods are inferential and indicative and multivariate analyses require that each variable is normally distributed and that the whole data-set has a multivariate normal distribution (de Caritat & Reimann, 2000). The Contamination Factor (CF) is one of the most commonly used quantitative methods used to evaluate the severity of heavy metal contamination. CF has been applied to assess the roles of anthropogenic sources in contaminating sediments with heavy metals in the Jinix River Catchment of China (Abdelhafez & Li, 2014).

The main aim of the present study is to identify the distribution of selected heavy metals in El-Gharbia Governorate, using remote sensing, Geographical Information Systems (GIS) and X-ray fluorescence (XRF) spectrometry.

2. Materials and methods

2.1. Study area

The study area is the Middle part of the Nile Delta of Egypt (30°45′20″–31°10′50″E;30°35′10″–31°10′05″N) and covers an area