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Background concentrations of elements in surface soils and their changes as affected by agriculture use in the desert-oasis ecotone in the middle of Heihe River Basin, North-west China

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Abstract

The concentrations of twenty four chemical elements in the surface layer of natural desert soils and the cultivated farmland soils were measured at a desert-oasis ecotone in the middle of Heihe river basin, north-west China. Background values were estimated for (a) major elements (Si 335.3 g kg^{-1}, Al 49.4 g kg^{-1}, Fe 19.1 g kg^{-1}, Ca 29.4 g kg^{-1}, Mg 8.9 g kg^{-1}, K 20.1 g kg^{-1}, Na 17.5 g kg^{-1} and P 0.338 g kg^{-1}), (b) heavy metals and non-metals (Cr 55.8 mg kg^{-1}, Mn 404.8 mg kg^{-1}, Ni 17.7 mg kg^{-1}, Cu 5.1 mg kg^{-1}, Zn 33.7 mg kg^{-1}, Pb 15.5 mg kg^{-1} and As 5.2 mg kg^{-1}) and (c) other trace elements (Ti 2.0 mg kg^{-1}, V 55.3 mg kg^{-1}, Co 5.7 mg kg^{-1}, Rb 82.4 mg kg^{-1}, Sr 232.9 mg kg^{-1}, Y 14.7 mg kg^{-1}, Zr 194.9 mg kg^{-1}, Nb 7.8 mg kg^{-1} and Ba 720.6 mg kg^{-1}). After natural desert soil was cultivated for agricultural use, significant changes in element concentrations occurred under tillage, irrigation and fertilisation management. Compared to natural soil, the for the levels of Si, K, Na, Sr, Zr and Ba decreased, and no changes were observed for Rb, while the values of the other 17 elements increase in agricultural soil from 1.2 to 3.5 times. However, their absolute concentrations are still low, suggesting that the arable soil in this region remains comparatively a clean soil. The increased silt, clay and organic carbon content, under long-term irrigation, enriched the fine-grained materials, and application of fertilisers and manure contributed to the accumulation of most elements in arable soil. The accumulation of elements in agricultural soil increased with increasing cultivation years and extent of soil development.
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Keywords: Background concentrations; Desert soil; Land cultivation; Agricultural use; Desert-oasis ecotone

1. Introduction

Background concentrations of elements in soil may reflect basic information and interrelationships within a given period and spatial scale (Chen, 2005). As a reference level for estimating the degree and extent of soil contamination, the estimation of background values is crucial for establishing soil environmental quality standards, assessing the impacts of agricultural use of solid wastes, and the long-term application of fertilisers and pesticides on soil environmental quality, as well as guiding soil micro-nutrients application (Chen et al., 2004).

Background concentrations of elements in soil are highly dependent on the mineralogical composition of the parent material and on the weathering processes that have led to its formation (Tack et al., 1997; De Temmerman et al., 2003), but also on soil particle size, clay and organic matter content (Salminen and Tarvainen, 1997; Tack et al., 1997, Tume et al., 2006). Consequently, the natural concentration of elements in soil varies widely, making it inappropriate to use universal background levels for assessing the extent and risks of trace metal contamination in a specific soil type (Horckmans et al., 2005). Therefore, although natural background concentrations in soil have been investigated in many countries and have laid the foundations for understanding natural element variation and in assessing soil contamination, such as Poland (Anderson et al., 1994) and many countries in Europe (Salminen et al., 2005; De Vos et al., 2006), the USA (Holmgren et al., 1993; Bradford et al., 1996; Ma et al., 1997) and China (Chen et al., 1991), it is still necessary to estimate local background concentrations and

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spatial distribution characteristics of elements in soil, and the factors affecting their evolution in a specific area, since local element concentrations in a specific soil type may exceed or be lower than listed ranges.

Anthropogenic activities, such as agricultural practices, can strongly influence element concentrations in soil (De Temmerman et al., 2003; Ikem et al., in press). Mineral fertilisers, primarily phosphate fertilisers, and animal manure, can increase the levels of certain elements in soil. Moreover, addition of sewage sludge and some types of compost may cause the enrichment of heavy metals in soil (De Temmerman et al., 2003). The impact of agricultural activities on the accumulation of elements, especially heavy metals in arable soil is of great concern, because of the potential transfer of heavy metals through crops to animals and humans.

The oasis in the middle of Hexi Corridor region, located in Gansu province, north-west China, is an important area for grain production. In recent years, this region has become one of the main planting areas of wine-making grape, ketchup-making tomato, and vegetables, due to its typical desert climatic conditions. Application of large amounts of chemical fertilisers and pesticides contributed to the high yields of these crops. However, little information is available about soil environmental quality in this region. On the other hand, it is one of the main sandy desertification areas induced by wind action and one of the source regions of sandstorms in North China (Research Group of Study on Combating Desertification/Land degradation in China, 1998). A better understanding of the concentration and distribution of elements in soil may provide a reference for determining the source region of sandstorms. The objective of the present study is to estimate the background concentration levels in the surface layer of desert soil and to examine the changes of elements in soil, following land cultivation and, subsequently, agricultural use, and finally to discuss the influence of agricultural practices on the soil environment.

2. Materials and methods

2.1. Study area description

The study area, covering the marginal oasis and adjacent desert area of Gaotai and Linze counties in the middle of Hexi Corridor region of Gansu province, is located between 39°18′–39°25′N and 99°34′–100°37′E, with an altitude ranging from 1330–1420 m. The area is classified as a typical temperate desert and a desert-oasis ecosystem (Fig. 1). The landscape consists of the relatively flat Gobi desert, covered by gravels and the undulate denudation terrain of sand dunes. The vegetative cover is 5%–15% in the Gobi desert, and the main plant species consists of some sub-shrubs, including *Nitraria sphaerocarpa* (Maxim.) and *Reaumria soongorica* (Pall. Maxim.), and a few annual desert species, such as *Suaeda glauca* (Bge.) and (*Sillium mongolicum* Rgl.). There is *Nitraria sibirca* and *Phragmites communis* (Trin.) population, distributed in the inter-dune lowland of the residual desert. The marginal oasis belongs to young oasis, which is exploited in recent decades. This region has a typical temperate desert climate: dry and hot in summer, cold in winter, ample sunshine, very little precipitation, strong winds, and frequent drifting sands. The annual mean air temperature is about is 7.6 °C, with an absolute maximum and minimum of 39.1 °C, and −27 °C respectively. The normal annual precipitation is 117 mm. Mean annual pan-evaporation is around 2390 mm, twenty times greater than the annual precipitation. The frost-free season lasts

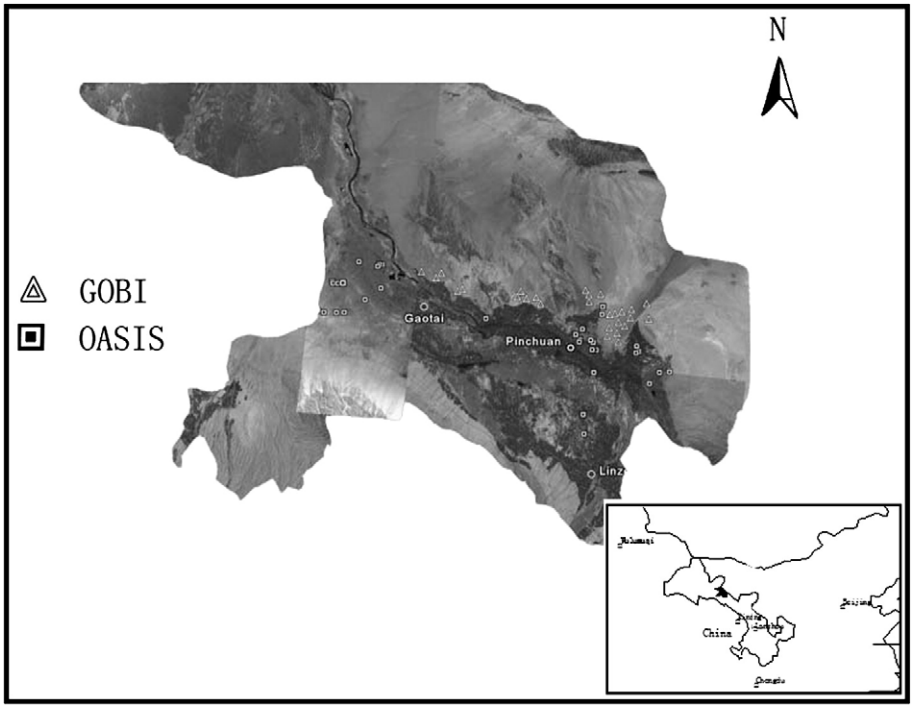

Fig. 1. Study location map and soil sample sites.

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