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# Urban street dust bound 24 potentially toxic metal/metalloids (PTMs) from Xining valley-city, NW China: Spatial occurrences, sources and health risks

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ABSTRACT

Street dusts (SDs) were a significant tracer to understand the pollution status of potentially toxic metal/metalloids (PTMs) in local environment. In this study, a total of 157 SDs were collected in the valley-city of Xining, NW China, with the objective to systematically investigate the spatial occurrences, sources and health risk status of 24 PTMs bound in SDs. The basic datasets of pH and size-fractions showed that the SDs with PTMs were more alkaline and dominated with the coarse particle sizes between PM10–50, respectively. Results of concentration levels and spatial status of 24 PTMs processed with multi-statistical tools well established the sources identification in monitored local areas. It was suggested that the principal elements, Al, Fe, Si, K, Ca, Na, Mg, coupled with the trace elements Bi, Ga, Nb, Ni, Rb, Sr, Th, U, Y, Zr, As, Mn, Ti, V, Ce and La would be possiblely predominated by geogenic source or nature material, whereas contamination of Ba, Cu, Pb and Zn was clearly related to traffic-related sources. Peculiar associations among Cr and Co were possiblely enriched in SDs very close to the alloy industries. However, Sb and Sn differed from other observed PTMs, which appeared to derive predominantly from the coal combustion other than sources of electronic and mechanical industries. Compared to the integrated potential ecological risk index (PERI) of all PTMs with considerable contamination level and ecological risk, the single PTM of Sb posed very high risk. Calculated Hazard Index (HI) suggested ingestion as the most important exposure pathway for the majority of PTMs in children and adults, and no significant health risks of non-carcinogenic to children and adults were found except Cr (2.78) exposured to children. However, the evaluated cancerous risk was in the acceptable range both to children and adults except for the case of Cr exposure to adults (1.55E-06) compared to other PTMs. Although the carcinogenic risk was found no significant level, the maps of spatial carcinogenic risks above the threshold for children and adults were observed in some local monitoring areas, which should be attention and not to be always ignored.

## 1. Introduction

Street dust (SD), which consists of soil, deposited airborne particulates, construction material, soot and fume discharged from the industry and vehicles, etc, is one of the most important host media of environmental pollutants. To certain degree, street dust is a more pertinent indicator to urban environmental quality than single compartmental monitoring of air, water and soil, because it reflects pollutants from the multi-media (Sharareh et al., 2017; Wong et al., 2006).

Potentially toxic metal/metalloids (PTMs) are considered to be a major source of environmental pollution in urban areas (Al-Khashman, 2004; Batjargal et al., 2010; Sharareh et al., 2017). Street dust is a main reservoir for urban PTMs from surrounding areas (Tang et al., 2013), and its bound PTMs are a subject of growing concern because of their severe toxicity, nonbiodegradability, and bioaccumulation. It is widely considered to be a sink for trace metal/metalloids from various sources, including industrial activities such as power plants, coal combustion, metallurgical industry, auto repair shop (Zheng et al., 2010), transportations (Wei and Yang, 2010), mining and smelting operations, and municipal waste disposal emitted by vehicle exhaust, brake wear, consumer products like lead paint (Farfel et al., 2005; Grigoratos and Martini, 2015; Gunawardana et al., 2012).

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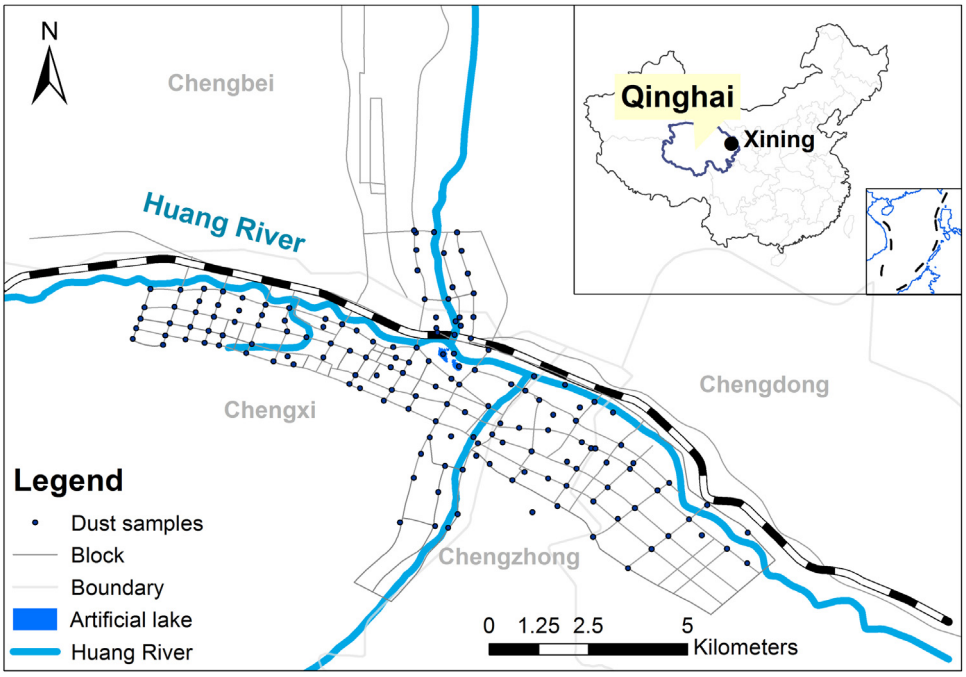


**Fig. 1.** The location map of study area (the right upper) and sampling sites in Xining urban city.

PTMs in SD could be remobilized and enter the ambient environment at certain circumstances, such as being lifted into the air through re-suspension process or being leached out into the water system (Joshi et al., 2009; Martuzevicius et al., 2011). They are usually biomagnified in the body tissues, producing severe health risks, including central nervous system damage, renal effects, bone fractures, immune systems, and decreased intelligence quotient (IQ) for children etc. (Chen et al., 2015; Eqani et al., 2016), for example, some trace metal/metalloids like Pb, As, and Ni are carcinogenic and are considered to play etiological roles in some diseases, especially heart disease, stroke and kidney disease, and blood diseases (Jarup, 2003). As a consequence, the trace metal/metalloids could pose significant risks to human health via ingestion, dermal contact, and inhalation (Acosta et al., 2014; Ferreira and De, 2005), and have received much attentions due to its importance to urban environmental quality and human health.

Urbanization and industrialization in China have taken place at an unprecedented pace in the last three decades. Urban environmental pollution has become a very important issue (Wei and Yang, 2010; Zhao et al., 2006). Due to the property of concealment, persistence and high toxicity, some trace metals and metalloids had been paid extensively endeavors for their pollution status and associated health problems in SD during the past several decades (Day et al., 1975; Duggan, 1980; Li et al., 2001; Shi et al., 2011). While, most studies, especially conducted in China, focused only on a limited numbers of PTMs that with high toxic (such as Pb, Zn, Cd, Cr, As), and the studied areas were usually simple and not complicated in terms of industrial categories. Like Xining, a medium-industrial city in China, is one of these cases, quantitative studies of multi-trace metal/metalloids pollutants in SD have been limited. The contamination levels, pollution status and health risks of multi-trace metal/metalloids have not been systematically gathered and intercompared.

The aim of the present study was systematically: (1) to explore the spatial levels and pollution status of multi-elements (including important 24 PTMs) in SDs in Xining, NW China, and (2) to discriminate potential anthropogenic sources, and (3) to assess the health risk associated. The results of this research would provide an important insight into multi-PTMs in the urban environment, and was conducive to the scientific society, the local enterprises and the policy makers of the municipality. Furhter understanding the sources of multi-PTMs contamination was useful in the development and implementation of effective management strategies for local industrial city (e.g., identifying priority areas to be remediated).

## 2. Materials and methods

### 2.1. Study area

Xining (101°45′E, 36°43′N), the capital of Qinghai province of China, lies in the eastern part of Qinghai-Tibet plateau. As an ancient highland city and a major gateway to the Tibetan Plateau on the Yellow River, Xining once had experienced the extensive development many years ago. Nowadays, with the higher speed of urbanization and industrialization, the urban population of Xining has dramatically grown from 941,000 in 2000–2267,000 in 2013, and the Real Gross Domestic Product (GDP) per capita was 5215 Yuan (RMB, name of chinese currency) in 2000–43,346 Yuan in 2013 due to the contributions of industrial business. Xining is current not only the capital city of Qinghai province, but also becomes the important industrial base on mechanical and chemical engineering, fur and milk products, metallurgy, building material manufacture, pharmacy and electronic industries etc. in northwest of China. Combined with a large number of construction sites, bare soil surfaces and strong wind in Xining urban city, make Xining with serious dust pollution. Compared to western developed countries, the industrial layout in this area obviously lacked well planning, posing a potential risk of multiple pollutant sources.

### 2.2. Samples collection

A total of 157 SD samples were collected from asphalt pavements along the main streets and each road branches in the region of Xining (Fig. 1) in September (dry season), 2014. The weather condition was sunny and windless during the sampling period and no rain had occurred during the two weeks prior to sampling. The sampling sites covered all over the urban area of about 350 $km^2$ including the traffic, industries, commercial, and residential areas et al. At each site, road characteristics, land use, and geographic coordinates were recorded, and about 200 g of SDs were collected by gently sweeping an area of approximately 2–3 $m^2$ adjacent to the curb of the impervious surfaces