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Research article

Use of multivariable and redundancy analysis to assess the behavior of metals and arsenic in urban soil and road dust affected by metallic mining as a base for risk assessment

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ABSTRACT

The vicinity of abandoned mining ponds to populated areas may suppose a high environmental and health risk being necessary evaluate unreclaimed ponds as source of metal(loid)s. In order to evaluate the behaviour of metals and arsenic from tailing ponds and their effects in urban areas, 10 mine wastes samples, 10 urban soil and 10 urban road dust samples were collected from two mining districts (La Unión and Mazarrón, SE Spain). Physicochemical properties and total, available and water-soluble concentration of metals (Cd, Co, Cr, Cu, Fe, Ni, Mn, Pb, Zn) and As were analyzed. Results suggest enrichment in Fe, Mn, Pb and Zn of urban soil and road dust in both studied towns. Multivariable analysis indicated that Cd, Mn, Pb and Zn in La Unión urban soil, and As, Cd, Cu, Pb and Zn in soil and Fe in road dust of Mazarrón come from mining districts. In addition, redundancy analysis showed that mobility of metal(loid)s related to mining sources were more influenced by their total concentration, while metals with a lithogeny origin were more affected by physicochemical properties.

1. Introduction

The extractive activity in the southwest of Spain has been an important source of economical incomes from the romans period to the latest nineties as evidence the 85 tailing ponds scattered in La Unión and Mazarrón mining districts. Mainly mined ores were Sphalerite, Pyrite and Galena (Manteca and Ovejero, 1992). Therefore, the tailing ponds are composed by high amounts of Fe-oxyhydroxides, sulphates, and potentially leachable metal(loid)s due to extreme acidic conditions.

It is known that even after mine closure, unrestored tailings ponds are a potential environmental and health risk causing negative impacts in the surrounding areas (Zornoza et al., 2012; Alcolea et al., 2015), particularly in populated areas. Mine wastes containing high sulphide concentrations are one of the most serious sources of environmental pollution (Candeias et al., 2015), which is due to the potential production of acid drainage of mine (ADM) formed by the oxidation of sulphide mineral, commonly Pyrite (Galán et al., 2003; Garcia-Lorenzo et al., 2016). Also, under semiarid conditions metal(loids)s can be suspended in the air bound to particulate matter and redistributed into the environment (Castillo et al., 2013; Yun et al., 2016). The inherent toxicity of the dust depends upon the proximity of environmental receptors and type of ore being mined. High levels of As or Pb in windblown dust usually pose the greatest risk (Candeias et al., 2015).

Wastes from mining activity generally contain metal-rich particles that can be easily mobilized and may reach residential areas posing an increase of the risk derived to the exposure to metals via inhalation, ingestion and absorption (Carkovic et al., 2016; Lee et al., 2016), causing the accumulation of metals in the human body and diseases (Varrica et al., 2014; Nkosi et al., 2015). The abandonment of tailing ponds and transfer of metals from mines to populated areas has been reported by different researches around the world (Martínez López et al., 2008; Park et al., 2014; Candeias et al., 2015; Lee et al., 2016; Castillo et al., 2013; Kríbek et al., 2016). Liao et al. (2005) and Song et al. (2013) reported urban soils affected by mine wastes from 7 to 24 km far away from mine ponds, while La Unión and Mazarrón mining districts are less than 1 km to La Unión and Mazarrón towns respectively. Alcolea et al. (2015) and Sanchez et al. (2017) reported high deposition rates of atmospheric particle with high concentration of metal(loids) in the agricultural and

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urban areas around mining area of Cartagena-La Union, linked this results with a potential environmental and a public health. However, the concentration of metal(loid)s in urban soil and road dust of the main towns (La Unión and Mazarrón) has not been already evaluated.

Therefore the objectives of this study were evaluate the influence of the tailing pond as source of metals and arsenic in urban soils and road dust in Mazarrón and La Union towns, and identify the physicochemical properties involved on the potential mobility of metal(loid)s in each type of sampled material (mine wastes, urban soil and urban road dust).

2. Materials and methods

2.1. Study area and sampling collection

Sampling areas were located in two different mining districts: La Unión and Mazarrón (SE, Spain). The climate is semiarid Mediterranean characterized by an annual average temperature of 18 °C and an annual precipitation of 290 mm (AEMET, 2016). Two tailing ponds from the extractive activity of Pb, Zn and Fe sulphides were selected. This selection was carried out according to their proximity to the towns (<1 km), surface area (>5000 m^2), acidic conditions and high concentration of metals. La Unión pond (37°37′05.7″N, 0°54′17.2″W) has an extension approximately of 15500 m^2 and Mazarrón pond (37°36′1″N, 1°19′52.2″W) of 6100 m^2, the extreme conditions (acidity, metal(loids), and salinity) prevent the spontaneous colonization of vegetation(Fig. 1).

Ten waste samples from the mine ponds (5 samples from each pond) were collected, each sample were composed by 5 subsamples from 0 to 15 cm depth. In addition, 10 urban soil (5 from each town) were taken in the topsoil from urban parks with a soil spade (0–15 cm depth) and 10 road dust samples (5 samples for each town) were collected by sweeping an area of 1 m^2 using a polyethylene brush (Acosta et al., 2015). The amount of dust collected in each site was 250–500 g. In order to avoid re-suspension of the finest particles during sampling, the sweeping was slow and directly into the plastic bag (Acosta et al., 2011). The sampling into each place was carried following a random procedure.

2.2. Analytical method

Soil and mine waste samples were dried at 40 °C for 48 h and passed through a 2 mm sieve. A subsample of each sample was ground using an agate mortar (RetschRM 100). The pH was measured in a 1:2.5 water/soil suspension (Soil Survey Staff, 2004) while the electrical conductivity (EC) was measured in a 1:5 soil/water suspension (Andrades, 1996). The equivalent calcium carbonate was determined using the Bernard's calcimeter and the organic carbon content by dichromate oxidation method (Soil Survey Staff, 2004).

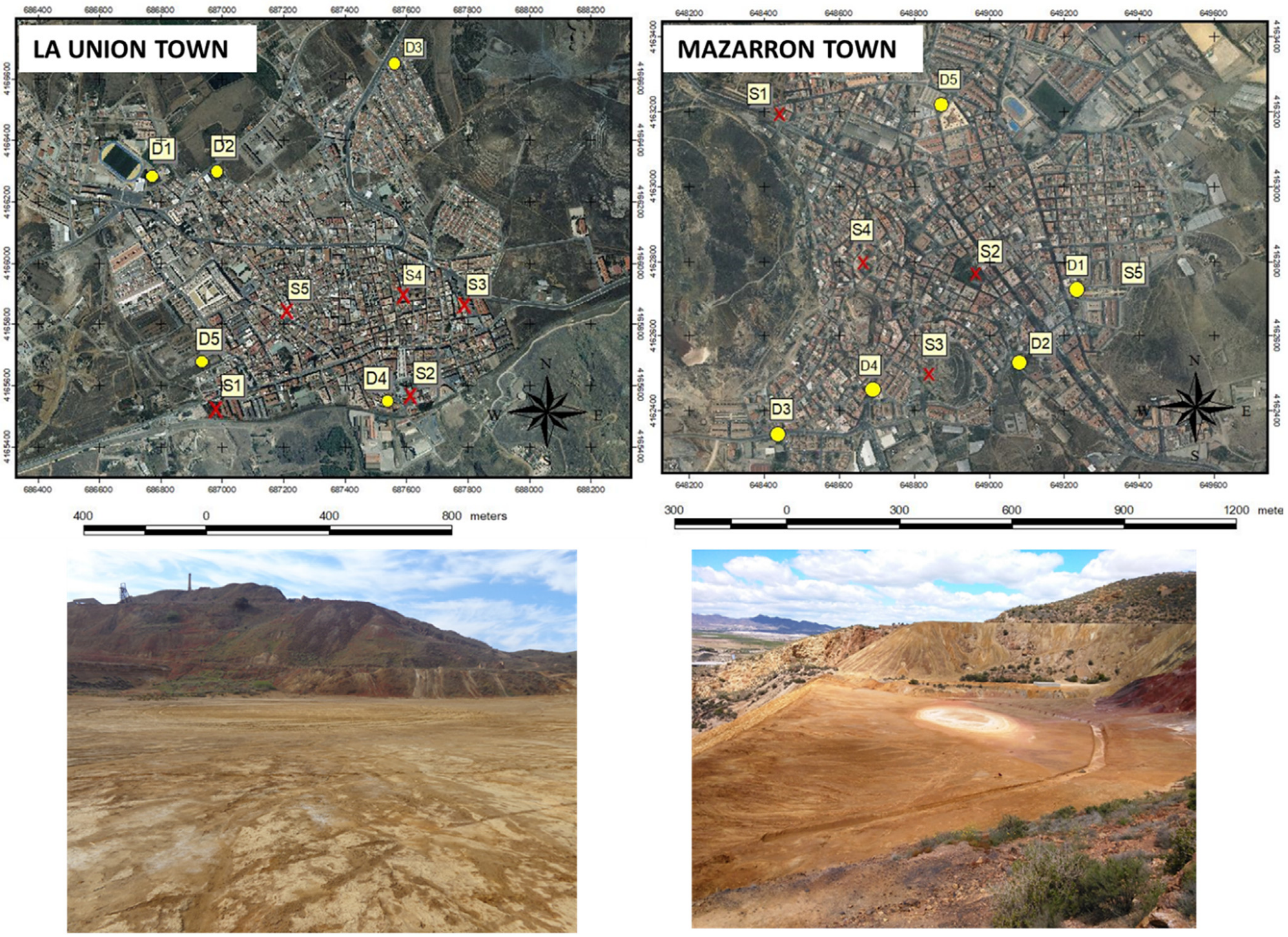

Fig. 1. Dust (D) and soil (S) samples in La Union and Mazarron cities and photos of mine ponds.