Science of the Total Environment 430 (2012) 28–33

Contents lists available at SciVerse ScienceDirect

Science of the Total Environment

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

Short Communication

Comparison of elemental contents in earthworm cast and soil from a mercury-contaminated site (Idrija area, Slovenia)

Tamara Teršič *, Mateja Gosar

Geological Survey of Slovenia, Dimičeva ulica 14, SI-1000 Ljubljana, Slovenia

ARTICLE INFO

Article history:
Received 12 December 2011
Received in revised form 24 April 2012
Accepted 24 April 2012
Available online 19 May 2012

Keywords:
Earthworm casts
Environmental geochemistry
Mercury
Idrija area
Soil contamination

ABSTRACT

The aim of this paper was to test the new sampling media—earthworm casts in a highly contaminated area. The investigation was carried out at the ancient Hg ore roasting site Pšenk in the surroundings of Idrija, where extremely high Hg contents in soils and SOM were determined in previous investigations. 32 earthworm cast samples were collected in the research grid 30×30 m in order to compare the Hg contents and spatial distribution in earthworm casts to the values and distributions in SOM and soil (0–15 cm). Extremely elevated Hg concentrations were determined in earthworm casts from the studied area ranging from 5.4 to 4330 mg/kg with the median of 31 mg/kg. The Hg values in casts are somewhat lower than in soil (6.3–8600 mg/kg) and slightly higher compared to soil organic matter (SOM) (1.5–4200 mg/kg). Strong correlation ($r^2 = 0.75$) between Hg contents in casts and soil was found, while correlation between casts and SOM was positive but weaker ($r^2 = 0.35$). Spatial distribution of Hg in earthworm casts show the highest concentrations in the central part of investigated area, similar to the distribution in soil. Hg contents rapidly decrease from the center toward the margins of the studied area, where they reach values of less than 50 mg/kg. It was shown that Hg contents and dispersion in casts are comparable to those in soil, which indicates that at investigated area soil contamination is strongly reflected in contamination of earthworm casts.

1. Introduction

Pšenk is one out of 21 localities of ancient ore roasting sites established in the hills surrounding Idrija, where mercury ore was roasted in the first 150 years (16th and first half of 17th century) of mercury production in Idrija (Čar and Terpin, 2005; Kavčič, 2008). It is located about 2 km south-west from Idrija, on a flattened surface at Lačna voda stream. The unique way of roasting very rich mercury ore at this site has resulted in soil contamination and considerable amounts of waste material that potentially leach Hg into the surrounding environment (Teršič et al., 2011).

Previous studies have shown that the Pšenk ancient roasting site and its surroundings are highly contaminated with Hg (Gosar and Čar, 2006; Teršič, 2010a; Teršič et al., 2011; Teršič and Gosar, 2009). Extremely high total mercury concentrations in soils and soil organic matter (SOM) were determined at Pšenk, with some zones displaying values well above 5000 mg/kg of mercury. The highest Hg values were found in soil (0–15 cm) in the central part of investigated area (approximately 40×50 m), where the determined median was 695 mg/kg (60–8600 mg/kg). On approximately 14 ha (37% of studied area) the area is highly polluted (>100 mg/kg Hg in soil). The contents decrease rapidly with the distance from this area. Extremely elevated Hg concentrations in investigated soils were assigned to considerable losses of Hg during ore processing (Teršič, 2010a, 2010b).

Because of the numerousness of roots and rock fragments at the mentioned roasting site area, soil sampling was difficult. The abundance of earthworm casts on the soil surface brought up an idea to implement the research with cast sampling to assess whether in certain conditions (problems with soil sampling, enough casts) this sampling media could be a suitable sampling material instead of soils.

The objectives of our research were to determine the Hg contents and dispersion in earthworm casts from the Pšenk ancient Hg roasting site and to compare them to the values in SOM and soil (0–15 cm). The main purpose was to assess the reflection of soil contamination in casts with the intention to estimate whether the data about cast contamination can tell us something about the dispersion and distribution of contaminant in soil. The contents of 36 other elements were also determined in earthworm casts in order to establish increased values of any of these elements and to compare the values in casts to the contents in SOM and soil (0–15 cm) from investigated area.

1.1. Earthworm casts

Casting occurs when earthworms ingest soil and leaf tissue to extract nutrients, and then emerge from their burrows to deposit the

* Corresponding author. Tel.: +386 1 2869 765; fax: +386 1 2869 753.
E-mail addresses: tamara.tersic@geo-zs.si (T. Teršič), mateja.gosar@geo-zs.si (M. Gosar).

0048-9697/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.scitotenv.2012.04.062

fecal matter (casts), as mounds of soil on the surface. Earthworm cast consists of mixed inorganic and organic materials from the soils that are voided after passing through the earthworm intestine. Total cast production is an indicator of burrowing and soil turnover, because 99.9% of ingested material is egested as casts (Chaudhuri et al., 2009).

Numerous studies on earthworms in contaminated soils (Ernst et al., 2008; Kamitani and Kaneko, 2007; Udovič and Leštan, 2007; Zhang et al., 2009) or in laboratory experiments (Burton et al., 2006; Cheng and Wong, 2002; Domínguez-Crespo et al., 2011; Kızılkaya, 2004; Nahmani et al., 2005; Zorn et al., 2005) have been performed, while investigations in non-contaminated sites are rare (Ernst et al., 2008; Rieder et al., 2011). Mostly, earthworms were proven to be a good biological indicator; they can be sampled easily, have a wide distribution range and strongly accumulate pollutants. Their limited mobility means that they are representative of a precise site, which makes them suitable for monitoring the impact of contaminants. The presence of contaminants in earthworms poses a serious risk of secondary poisoning of vertebrate predators due to biomagnifications (Reinecke and Reinecke, 2004). The process of cast production and/or earthworm bioturbation causes soil mixing and surface casting may also contribute to a redistribution of contaminants in the soil profile (Zorn et al., 2008, 2005). Deep burrowing species can bring polluted soil from deeper layers to the soil surface and may increase metal availability in soil (Zorn et al., 2005). Chemical and physical properties of casts have been investigated in many studies (Bityutskii and Kaidun, 2008; Buck et al., 1999; Chaudhuri et al., 2009; Jégou et al., 2001; Jouquet et al., 2008; Oyedele et al., 2006; Schrader and Zhang, 1997; Zorn et al., 2008). However, in the literature we can find only few studies on metal contents in earthworm casts compared to surrounding soil (Kızılkaya, 2004; Udovič and Leštan, 2007; Zhang et al., 2009; Zorn et al., 2005). The findings of these investigations are compared to the results obtained in our study later in discussion.

2. Materials and methods

2.1. Sampling

Earthworm casts, deposited on top of the soil, were collected at the ancient roasting site area Pšenk. Sampling was performed at the area of former roasting site and its surroundings, on approximately 150×150 m big area (Fig. 1). Earthworm cast samples were collected from 32 sampling points in the research grid 30×30 m. At each sampling location on average 5–10 casts were collected in the 2.5 m radius to create the composite sample.

In this paper Hg contents in casts are compared to Hg contents in soil (0–15 cm) and SOM which were determined in our previous investigation (Teršič et al., 2011), when detailed soil sampling was performed. At 73 soil sampling points surface organic matter-rich soil layer (SOM) and underlying soil layer (0–15 cm) were sampled in the 30×30 m research grid. At the central, most contaminated area of past roasting processes (approximately 200 m^2) the sampling was performed in a dense 10×10 m research grid. In this research we chose the same locations for cast sampling, although the sampling area in this study was slightly smaller and differently from before mentioned investigation, where SOM and soil sampling in the central investigated area was performed in the research grid 10×10 m, here we did not use such dense research grid (Fig. 1). The reason for this was that we already collected composite sampling material from around the sampling point and such dense sampling would have no significance. For comparison between elemental contents in SOM, soil and casts, we used only data about elemental contents in SOM and soil from the locations where earthworm casts were sampled.

The detailed descriptions of the sampling area, sampling locations and mercury distribution in SOM and soil from the investigated area are given in the preliminary geochemical study at the Pšenk roasting site (Teršič and Gosar, 2009) and in the study of environmental influences of historical small scale ore processing at Idrija area (Teršič,

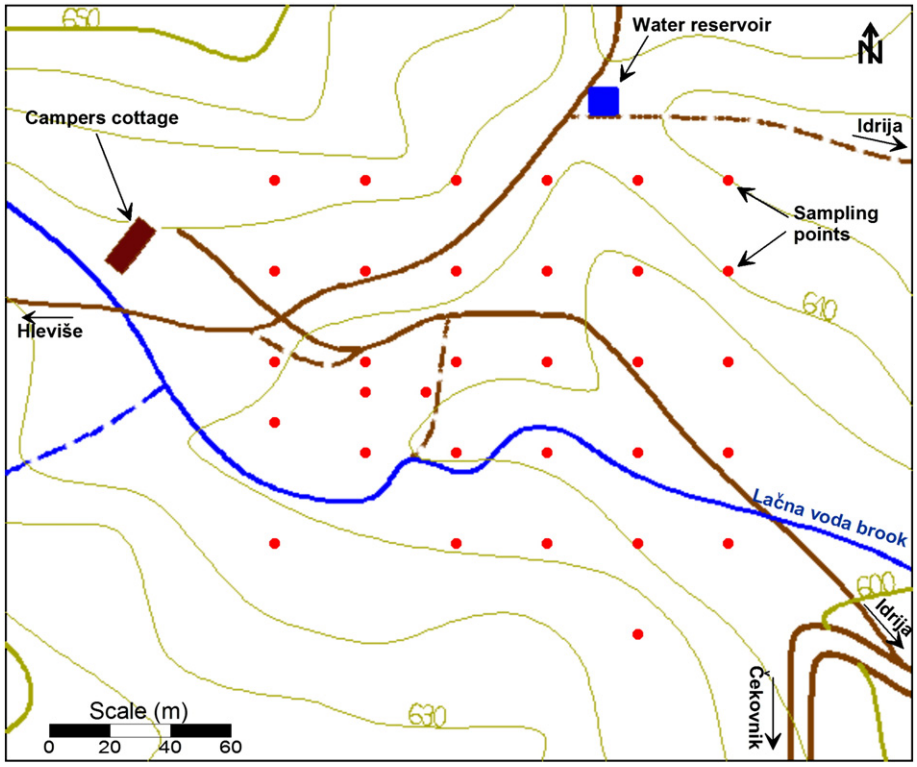

Fig. 1. Investigated roasting site at Pšenk with earthworm cast and soil sampling locations.