Assessment of potential contamination of trace elements in Chadak mining area, Uzbekistan

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INTRODUCTION

Solution of environmental problems is becoming a priority for the sustainable development of industrial areas. This is especially true in mining regions, where the mining activities for extraction and processing of metal products may result in a large amount of pollutants that can spread through the environment and contaminate nearby soils, waters, and the atmosphere (Parth et al., 2011).

In sulphide mineralized areas, acid mine drainage (AMD) is one of the most serious environmental hazards, causing the solubilization of heavy metals and related elements (Astrom, 1998). Moreover, in semi-arid climate AMD generation is not a short-term problem, although the pollution can persist for thousands of years due to the low rate of evolution of this process under this type of climate (Kempton and Atkins, 2000).

The main purpose of this work was to assess the potential environmental risk by trace elements contamination resulting from tailing dumps of Chadak mine, by the study of total concentration of these elements in tailings and soils nearby the mining area.

MATERIALS AND METHODS

Samples were collected from the vicinity of Chadak ore field, which is located in the Pap district of Namangan region (eastern, Uzbekistan) in the north-eastern part of the Kurama ridge in Chadak basin (fig.1).

The area is characterized by a relatively developed mining industry operating since 1970 as gold-extracting factory. Mining is conducted by both underground and open pit methods, and generates large amount of wastes that are accumulated in two dumps, one active and other abandoned (fig. 2).

A total of 40 samples were collected from the surface layer (0-10 cm) of soils and tailing dumps, selected on a grid of 100x100m covering the active and abandoned tailing dumps. Also 6 samples of the abandoned tailings dump were collected at different depth from three layers (A-30, B-30-80, C-80-150 cm).

Collected samples were air-dried at room temperature and sieved through 2 mm for subsequent analysis. Total concentration of trace elements (Ni, Cu, As, Pb, Zn, Sb) was analyzed using X-ray fluorescence spectrometer (WDXRF) after preparation of pellets with finely-ground samples.

Statistical analyses of the data were performed with SPSS v.15.0 software, for one-way analysis of variance (ANOVA) and Tukey's test. The significant differences were considered when $p < 0.05$.

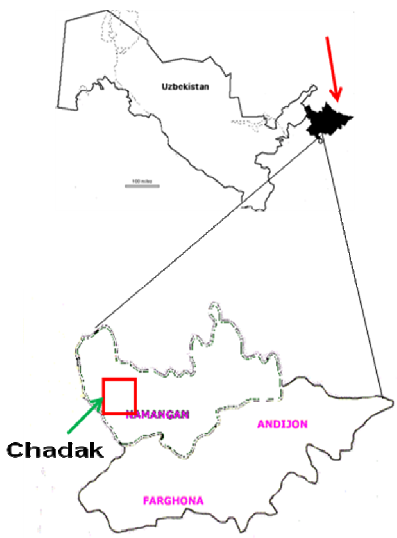

fig 1. Location map of the studied area.

RESULTS AND DISCUSSION

Background concentration (BC) of trace elements was estimated according to Díez et al. (2007) from soils located outside the tailing ponds, and revealed that the values (mg/kg) for Ni, Cu, Zn, As, Pb and Sb were 31, 37, 135, 15, 48 and 4, respectively. These concentrations are in the range of those BC values reported in the area with the exception of Pb, which showed higher values in our study.

According to the surface sampling (Table 1), the mean values of Ni were lower than the BC in all samples and only showed significantly higher values in soils of the active tailing dump. Pb and Cu were in the range of the BC with no statistically significant differences in any case. On the other hand, As revealed very high concentrations in the surface sampling, with the exception of the soils of the active tailing dump, which showed similar values to the BC. Zn and Sb were below the BC in the surface sampling (soils and tailings) at the abandoned dump. However, significantly higher values were found in the surface tailing samples at the active dump.

Samples in the vertical profile in the abandoned tailing dump (Table 2) showed differences according to the surface sampling. Ni and Cu presented no significant difference along the profile, being these values in the range of the BC. Zn and Pb showed no significant difference between the profile layers, although the concentrations were higher than the BC of the area. As and Sb presented significant difference in the profile samples, with the highest values in the first layer (0.3m); otherwise, these concentrations are sharply higher than the background values, with mean values exceeding almost 200- and 50-fold, respectively the BC in the area.

palabras clave: suelos contaminados, elementos traza, balsa de lodos.

key words: polluted soils, trace elements, tailing dump.

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fig 2. Location of collected samples from tailing dumps and surrounding soils.

Sampling area		Ni	Cu	Zn	As	Pb	Sb
Background value		31	37	135	15	48	4
Active tailing dump	Soil Mean *SD*	154.3 (a) *80.1*	16.5 (a) *7.4*	104.9 (a) *21.5*	11.3 (a) *3.7*	35.6 (a) *1.3*	2.4 (a) *1.1*
	Tailing Mean *SD*	5.6 (b) *1.5*	35.5 (b) *12.8*	236.6 (b) *86.3*	31.6 (b) *10.9*	137.3 (b) *68.6*	6.1 (b) *2.5*
Old tailing dump	Soil Mean *SD*	23.6 (b) *2.3*	31.2 (b) *4.1*	79.8 (a) *13.9*	27.2 (b) *12.2*	27.2 (a) *5.44*	3.0 (a) *1.0*
	Tailing Mean *SD*	17.2 (b) *6.5*	24.2 (b) *11.3*	81.0 (a) *6.3*	27.7 (b) *14.1*	33.2 (a) *4.6*	3.0 (a) *1.4*

***Table 1.** Concentration of trace elements (mg/kg) in soils and tailing dumps of the surface sampling (0-10 cm). SD: standard deviation. Letters indicate significant differences (p<0.05).*

Sampling area		Ni	Cu	Zn	As	Pb	Sb
Ecotoxicological level*		210	190	720	40	290	nd
Vertical profile in old tailing dump	Layer A Mean *SD*	37.0 (a) *4.2*	24.0 (a) *1.4*	330.5 (a) *17.6*	2947.5 (a) *598.9*	303.0 (a) *22.6*	197.0 (a) *28.2*
	Layer B Mean *SD*	8.0 (a) *2.8*	50.0 (a) *28.2*	285.5 (a) *118.0*	331.0 (b) *264.4*	264.5 (a) *43.1*	35.5 (b) *10.6*
	Layer C Mean *SD*	11.0 (a) *1.4*	46.5 (a) *4.9*	265.5 (a) *62.9*	559.5 (b) *21.9*	328.0 (a) *114.5*	9.0 (b) *7.0*

***Table 2.** Concentration of trace elements (mg/kg) in vertical profile from abandoned tailing dump. SD: standard deviation. nd: no data. Letters indicate significant differences (p<0.05). *Van den Berg et al (1993)*

This study reported that the As, Zn, Pb and Sb concentrations were much higher in abandoned tailings than in active tailings dump. These values exceeded the BC of the area. The comparison of these concentrations with the ecotoxicological levels proposed by Van den Berg (1993) indicates that As is the element with the highest potential of pollution. In fact, the mean value of 2947.5 mg/kg in the uppermost part of the profile of the old tailing dump represents a potential risk of pollution at the Chadak area.

CONCLUSIONS

The proximity of the Chadaksay river and the village of Chadak close to the mining area is an important concern to be considered after the results of potential contamination by trace elements obtained in our study. However, further investigations including general soil characterization (pH, cation exchange capacity, organic carbon etc.), mineralogical studies, and metal speciation are required to assess the potential toxicity and bioavailability of the pollutant elements.

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