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Z.M. Biyasheva*, A.B. Kerimkulova, A.A. Nurmuchambetova, A. Erzhanova

Department of Molecular Biology and Genetics, al-Farabi KazNU, Almaty, Kazakhstan

*E-mail: zarbiya@mail.ru

Prolonged accumulation of wastewater and its treatment at the Tekeli lead and zinc mining complex

Abstract

The aim of the present research is determination of the some heavy metals content in a grain of barley, grown in the tailing impact area; the radio nucleus content in the specimen of species indicator and its organ can be judged by a total radioactivity level and relation to the maximum acceptable concentration (MAC) level. Water and biosamples test preparation have been conducted according to standard methods. Barley bioindication has shown the MAC exceeding of all the studied heavy metals. A higher level of the lead accumulation in seeds compared with the barley biomass has been observed. The present data show quite satisfactory condition of the area of investigation in accordance with radioactivity.

Key words: tailings, heavy metals, radioactivity, bioindication.

Introduction

Tekeli is located at the foothills of the north-western range of Dzhungar-Alatau mountains. Its area is 0.1 thousand km^2.

The town is situated 46 km to the south-east from its regional centre and 285 km to the north-east from Almaty [1]. Being the industrial leader of country the ground makes an essential contribution to the contamination of the region environment. The waste of the production has been slag heap put up in the tailings for a long time. That is why the aim of the present research is the ecological assessment of soil pollution sequences as well as the water with heavy metal and their bioaccumulation in the area adjoined to the tailings of lead and zinc production [2]. The tailing existed since 1960s. We started investigating the state of the reservoir in 2009 when volume of water in it decreased sharply (Fig. 1a) because of breaking off metal extraction. In 2011 the tailing was filled with water due to the work on building material production in the Tekeli mining industry enterprise (Fig. 1b). First, the wastewater treatment system consisted of plant tailing and six bio-ponds. The water purification was made, through the bio-ponds system which descended into the Karatal river, one of the important water resources of the Ili-Balkhash basin.

(a) (b)
Figure 1 – Tailings: a) dried up part till 2011 year;
b) hydrous part beginning with 2011 year

First of all we investigated the water quality in the tailing, pond and heavy metals content in biological objects exposed to the waste water impact of the mining complex (Fig. 2 a, b).

The present paper analyzes the heavy metals accumulation in sediments of the tailing and bio-ponds in connection with testing proposals for their irrigation and transfer to an agricultural land.

(a) (b)
Figure 2 – Bio-pond (a) and tailing (b) dried up part till 2013 year

Materials and methods

The soil and plants test selection has been carried out according to the following scheme: a mixed sample consisting of 5 test based on the method of an envelope has been picked up. The samples have been selected by a shade as deep as a tilling layer (up to 20-25 cm) [3].

Mineralization test has been conducted gradually raising the temperature in electrical furnace up to 50°C every 30 minutes and fraught it up to 460°C. Water and bio-samples test preparation have been conducted according to standard methods [4]. The determination has been conducted using the atom-absorption method [5].

For getting the average values of parameters statistical quantities were treated by conventional methods of variation statistics [6]. In all the cases the average values and its error were determined. T-test was used to prove the reliability of average differences.

Differences were considered significant at P≥0.95. For tabular and graphic results obtained the program Microsoft EXCEL Windows has been used.

Results and their discussion

The aim of the present research is determination of the some heavy metals content in a grain and barley *Hordeum spontaneum* C., grown in the tailing impact area.

For getting biomass stems and leaves of plants have been used. Tests have been taken quite accidentally (Fig. 3, 4). The determination has been conducted using the atom-absorption method [7].

Accumulation was studied in parallel the same heavy metals in barley grown near the tailings, which is used as feed for livestock. Samples of soil and plants were taken in autumn 2013 and 2009.

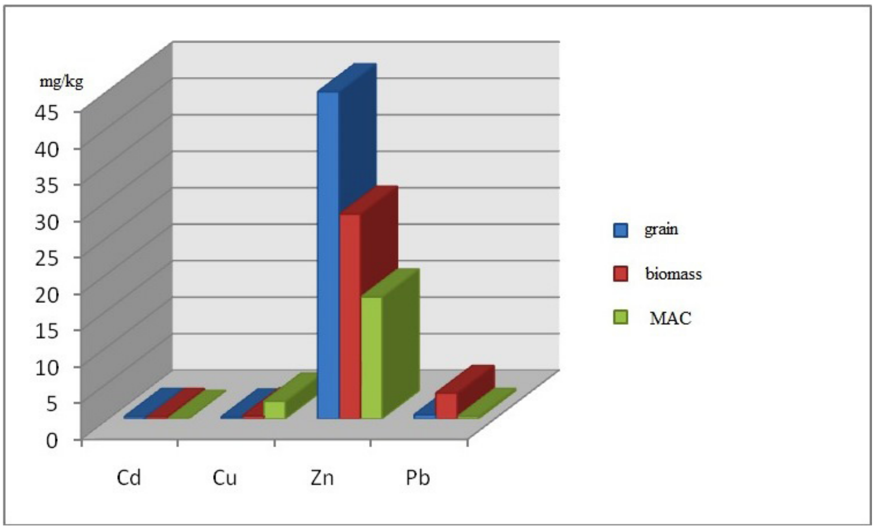

Figure 3 – Comparing the heavy metals content in a grain and biomass *Hordeum spontaneum* C. (barley) with MAC ones in the samples of 2009 from the shore area of the tailing in Tekeli

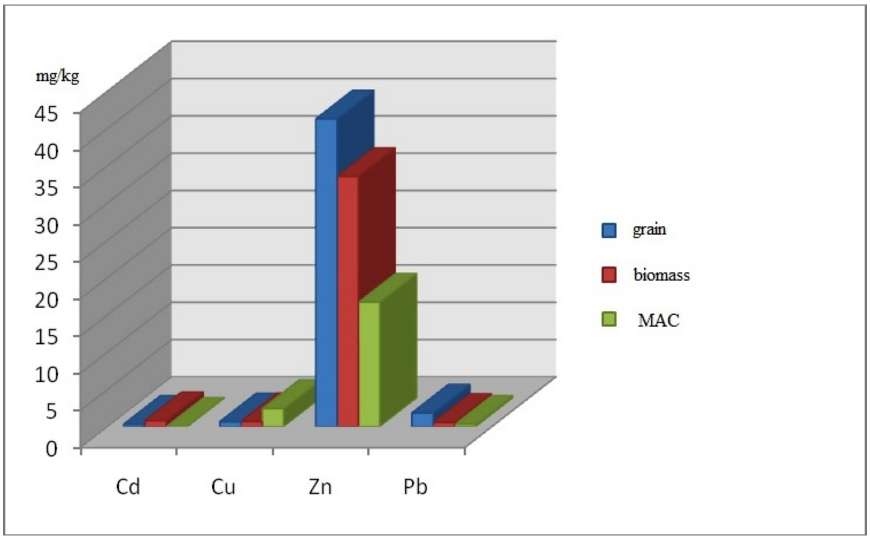

Figure 4 – Comparing the heavy metals content in a grain and biomass *Hordeum spontaneum* C. (barley) with MAC ones in the samples of 2013 from the shore area of the tailing in Tekeli.

Heavy metals come to the bio-objects mainly from the environment: from the lead and zinc complex tailing water through the shore soil where cultivated plants have been grown (Table 1).

A high lead content in the soil near the tailings has been recorded.

Probably, some part of its heavy metals comes to the soils of fields located 100-200 m (Table 2).

Table 1 – Heavy metals content in the soil from the tailing the lead and zinc mining complex tailing (2013 year)

Place collection of samples	Heavy metals content in the soil mg/kg The average value and average arithmetic mistake (M±m)							
Bio-pond N4	Cd	Cu	Pb	Ni	Mn	Zn	Co	Cr
	11.4±0.9	5250±577	4240±382	50±3.5	28000±3080	318750±37050	50±3.3	86±6.9
Multiple exceeding of MAC bio-pond N4	11.4	1750	132.5	12.5	18.6	13858.7	10	14.3
Tailing sediments	12.75±1.15	55±4.1	480±52.8	99±59.4	34200±2223	206250±24750	53±4.24	13.33±0.8
Multiple exceeding of MAC of the tailing sediments	12.75	18,3	15	24.75	22.8	8967.4	10.6	2.22
MAC mg/kg	1	3	32	4	1500	23	5	6

Table 2 – Heavy metals content in the soil from the lead and zinc mining complex tailings area influence

	Heavy metals content in the soil mg/kg			
	Cd	Cu	Zn	Pb
Control M±m (average arithmetic mistake)	0.93±0.15	7.36±0.29	79.34±2.50	79.57±4.29
MAC gross content	0.5	3.0	23.0	32.0
Multiple exceeding of MAC	1.86	2.45	3.44	2.49

The present data testify to the lead accumulation in a soil exceeding this metal MAC according to the gross content more than twice. Barley bioindication has shown the back-dropped content exceeding of all the studied heavy metals. A higher level of the lead accumulation in seeds compared with the barley biomass has been observed.

The radio nucleus content in the specimen of species indicator and its organ can be judged by a total radioactivity level and relation to the back-dropped level (Table 3).

Table 3 – The total level at alpha and beta radiation concerning specimen and organs of species indicators (Hordeum spontaneum C.- barley)

Name of sample	Total activity (1/min*cm2)	
	Alpha activity	Beta activity
Grain	0.07±0.005	0.1±0.002
Grain	0.08 ±0.005	0.1±0.002
Stems and leaves	0.08±0.003	0.1±0.002
Admissible content	2	5

The exceeding of alpha and beta radiation back-dropped level in the organs and specimen of species indicators has not been found. Similar samples of 2012 have been studied at the gamma spectr cmplex progress in the board of radiation sanitary and radiology at the Ministry of Health in the Republic of Kazakhstan (Table 4) [8, 9].

Table 4 – Content of cesium and strontium in species indicator Hordeum spontaneum C. – barley

Index indicator of ingredients	Concentration found	Unit of dimension	Admissible content in food-stuffs and drinking water	
Barley grains			Ci/kg	Bg/kg
Cesium-137	less than 3.0	Bg/kg	$1.0*10^{-8}$	370
Strontium-90	less than 0.7	Bg/kg	$1.0*10^{-9}$	37
Stems, barley leaves				
Cesium-137	less than 3.0	Bg/kg	$1.0*10^{-8}$	370
Strontium-90	9.0±0.6	Bg/kg	$1.0*10^{-9}$	37

Conclusion

Present data show quite satisfactory condition of the area of investigation in accordance with radioactivity.

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