Journal of Applied Economic Sciences
Issue 4 (6)/Volume III /Winter 2008

THE EFFECTS OF THE MINING ACTIVITY OVER THE WATERS FROM JIU VALLEY

Cristina **BARBU**
Spiru Haret University, **Romania**

Faculty of Management Financial Accounting Craiova
cristina_barbu2000@yahoo.co.uk

Abstract:

The upper Jiu Valley, around Petrosani and Lupeni, is Romania's principal coal mining region. Many miners feel that coal mining in Romania is a moribund industry that will never regain its position of significance. Environmental contaminants associated with mining activities may affect wildlife species in many ways and at many levels within the ecosystem. Some contaminants associated with mines (e.g., lead, arsenic, cyanide, etc.) may cause acute or chronic effects on resident wildlife.

In 1950–1989, the quality of the waters of the Jiu River has constantly worsened. Because of the restriction of the social–economic activities, after 1990, the situation of the waters of the Jiu River and of the waters in Romania has continually improved. In the same time, in 1990 there is a transfer to a more rigorous management of the environment which also includes legislation according to the international norms.

Keywords: mining activity, environment, waters pollution, heavy metals.

JEL Classification: O13, P28, Q25, Q53, Q56

1. Introduction

Jiu Valley had been reputing, along time, as well as a mining zone.

But the treasure, the coal, has begun to dry out and loose its local economical value. The extraction activity and process that represented "the engine" of economical and social development in the decades at the end of XX century, has known a drastic reduction of Jiu Valley activities, and has left without jobs lots of people who represented the only income source for their families. Over and above social twitch and social and economical tenseness, this activity has left as an entailment a bad fame of a very polluted zone.

That succession, the Jiu Valley area and has been declared by the Romanian Government as underprivileged zone, and has benefit of a special attention in the economical and durable development activity.

2. Theoretical background

As the German scholar Georgius Agricola (1550), put it in his treatise on mining: "The fields are devastated by mining operations... the woods and groves are cut down, for there is need of an endless amount of wood and timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds...Further when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away."

Today mining's environmental effects remain much the same, but on a vastly greater scale. Technological advances allowed world mineral production to grow very rapidly and proportionally increased the harm to the environment. The effects of mining activity have impacted on all sections of the environment [Young, (1992)]. Today there are a number of potential impacts mining activities can have on the environment. Metals such as arsenic, lead, zinc, and cadmium, which can also spread to nearby drinking water aquifers, can contaminate water and sediments in rivers and downstream reservoirs. Soils can be contaminated with smelter emissions. Underground mining operations contain billions of litres of acid water that rise a little higher each year, threatening local aquifers and already tainted streams with contamination.

Waste material can clog streams and cloud the air over large areas. If removed overburden contains sulphur compounds, common in rock containing metal ores, it can react with rainwater to form sulphuric acid, which then may contaminate local soils and watercourses.

Tailings also usually contain residues of organic chemicals – such as toluene, a solvent damaging to human skin and to the respiratory, circulatory, and nervous systems – that are used in ore concentrations as part of the extraction process [Young, (1992)].

Another often forgotten side of the mining industry is its effects on local people and their environment. Mining operations have had devastating consequences for those whose homelands lie over mineral deposits. Developers and founders of large mining projects have rarely considered the future of local people during project planning. High levels of noise pollution, destruction of life supporting elements of their environment, such as clean water, vegetation, fertile soil, animal life and the aesthetic value of the environment, have all been consequences of mining activities all over the world. Physical threats, such as diseases, holes in the ground, explosions, mudslides, etc. can have an impact on the well–being of local residents if they are not taken into account [Craig, Rimstidt, (1998)].

Romania's most important pit coal reserves are located in the Jiu Valley basin. Before 1989, the mining industry development strategy provided for the full supply with mineral resources of the Romanian economy in order to reduce import.

The result of this policy was an overdeveloped mining sector compared to the solid mineral resources potential of Romania, absorbing over 350,000 people as direct labor and another 700,000 as indirect labor.

The economic conditions after 1989 have required the state support of the mining sector through a huge budgetary effort. Between 1990 and 2002, the state expenditure to sustain the mining sector was of USD 5,249.5 million.

The negative impact of the mining activities on the environment is a direct one and it is strictly connected with the extracting activity of the useful mineral ores, on the one hand, and it is indirectly connected with the processing activity of the mining products.

Up to 1997, when in the Jiu Valley took place an ample restructuring process of the mining sector, there functioned 13 mines that used to spill significant amounts of residual water in the emissary. They were: Lonea Mine, Lonea Pilier Mine, Petrila Mine, Petrila South Mine, Dalja Mine, Livezeni Mine, Aninoasa Mine, Vulcan Mine, Paroseni Mine, Lupeni Mine, Barbateni Mine, Uricani Mine, and Valea de Brazi Mine. Currently, 7 of these mines still function, namely: Lonea Mine, Petrila Mine, Livezeni Mine, Vulcan Mine, Paroseni Mine, Lupeni Mine and Uricani Mine, the rest of them being shut down.

In the Jiu Valley there used to function four coal processing plants (CPP). They were: Petrila CPP, Livezeni CPP, Coroiesti CPP and Lupeni CPP. Currently, Petrila CPP, Livezeni CPP and Lupeni CPP are shut down; only the Coroiesti CPP still exists.

In order to analyze the evolution in time of the Jiu River's level of pollution due to economic and social activities in the Jiu Valley towns, the variation of the quality and quantity parameters of the upstream and downstream emissary's waters was observed, variations due to the main polluting agents, between 2005–2008.

The mines that currently pollute the Eastern Jiu River are: Lonea Mine, Petrila Mine and Livezeni Mine, and the ones polluting the Western Jiu River are: Vulcan Mine, Paroseni Mine, Lupeni Mine and Uricani Mine.

As a result of the carried out analysis it was observed that both household waters and mine waters represent major pollution sources of the Jiu River.

Generally speaking, the mines and the CPP Coroiesti are great industrial and tap water consumers, while the eviction of the used waters in carried out both with and without purging them.

The main polluters within the Jiu hydrographical basin are: the city of Craiova, DOLJCHIM Craiova, Lupeni and Petrila mine dressings.

The main polluting agent present in the surface waters was represented by solid suspensions [Suess, (1982)]. They are to be found in small concentrations in the surface waters upstream of industrial units, and their value increases significantly after spilling the used waters from the respective mines.

Also, there were noted concentrations of ammonium, phosphorous, organic substances, hydrogen sulphide, detergents and mining substances exceeding the maximum allowed concentrations. The solid suspensions contain heavy metals. The concentration of heavy metals was determined by Inductively Coupled Plasma Mass Spectrometry (ICP–MS).

Inductively Coupled Plasma Mass Spectrometry (ICP–MS) is a very powerful tool for trace (ppb–ppm) and ultra–trace (ppq–ppb) elemental analysis. In ICP–MS, a plasma or gas consisting of ions, electrons and neutral particles is formed from Argon gas. The plasma is used to atomize and ionize the elements in a sample [Yau, Chan, (2005)]. The resulting ions are then passed through a series of apertures (cones) into the high vacuum mass analyzer. The isotopes of the elements are identified by their mass–to–charge ratio (m/e) and the intensity of a specific peak in the mass spectrum is proportional to the amount of that isotope (element) in the original sample.

This method has been widely applied to biological, agricultural, metallurgical, geological and environmental samples [Waddell, Lewis, Hang, Hassell, Majidi, (2005)].

3. Experimental

The acute problem of water pollution has been caused by a continuous growth in the anthropogenic impact on the natural environment. Heavy metals occupy one of the first places in the list of the most frequently occurring and toxic contamination.

The determinations of heavy metals have been made with an AGILENT 7500 ICP–MS instrument, G3155A pattern. It can measure elements traces at ppt level.

Water samples were collected manually into polyethylene bottles. Prior to use, all bottles were cleaned with 10% HNO_3, rinsed with distilled water and water to be analyzed [Stoica, Stanescu, Baiulescu, (2003)]. Before the analysis the samples were filtered. The relative non–condensing humidity was maintained within the range of 25% to 80%. The operational temperature range was 15 – 27^{0}C. The instrument was stored within a temperature of 5 ^{0}C to 45 ^{0}C [Stoica, Babaua, Iorgulescu, Marinescu, Baiulescu, (2002)]. The measurements of heavy metals concentration were made on the Jiu river course, in January and June 2005 that represent two seasons: winter and summer, and in January and June 2008. The most dangerous heavy metals from Jiu River, in seven points from Jiu: (1) Campu' lui Neag; (2) Lupeni (The West Jiu); (3) Iscroni (The West Jiu); (4) Livezeni (The East Jiu); (5) upstream the confluence with Sadu; (6) Balteni; (7) Podari have been determined. The first five harvesting points are situated in mining zone and the last two harvesting points are situated downstream of mining zone. These seven points were selected, because all of them are considered a critical zone by point of view of the waters pollution with heavy metals provided from mining activity.

The aspect of Jiu River was different during the three seasons, being under the influence of the meteorological conditions. The results of the analysis can be influenced by defective harvesting or by the improper preparation of the material. The distance from the river side is about 2.00 – 2.50 meters and the depth was about 0.20 – 0.50 meters [Stoica, Babaua, Iorgulescu, Marinescu, Baiulescu, (2002)].

Heavy metals represent one the most important categories of pollutants or natural water. Increased urbanization, industrialization and mining activity are to blame for an increased level of trace metals, especially heavy metals, in our waterways. Toxicity levels depend on the type of metal, its biological role, and the type of organisms that are exposed to it [*Current Medicinal Chemistry*, *Metals, Toxicity and Oxidative Stress*, (2005)].

Living organisms require varying amounts of "heavy metals." Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans. Excessive levels can be detrimental to the organism. Other heavy metals such as mercury and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness. Certain elements that are normally toxic are, for certain organisms or under certain conditions, beneficial. Examples include vanadium and even cadmium.

The concentrations of four heavy metals: arsenic, mercury, lead and cadmium have been determined. The results obtained in this study, have been compared with the concentration from the Romanian Standard [MAPM, (2002)].

In the **table 1** the level of heavy metals from the Romanian Standard are presented [MAPM, (2002)].

Table 1. Concentrations of heavy metals from the Romanian Standard

Heavy Metals	M.U.	Concentrations values – Romanian standard				
		I	II	III	IV	V
As	μg/L	natural	5	10	25	>25
Hg	μg/L	natural	0,1	0,2	0,5	>0,5
Pb	μg/L	natural	5	10	25	>25
Cu	μg/L	10	20	40	100	>100
Cd	μg/L	natural	0,1	0,2	0,5	> 0,5

4. Results and Discussions

Arsenic contamination of groundwater is a natural occurring high concentration of arsenic in deeper levels of groundwater, which became a high–profile problem in recent years due to the use of deep tubewells for water supply causing serious arsenic poisoning to large numbers of people [Ford, (1996)]. A 2007 study found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning of drinking water [Velitchcova, Pentcheva, Daskalova, (2007)]. Arsenic is a carcinogen which causes many cancers including skin, lung, and bladder as well as cardiovascular disease. The Elemental arsenic and arsenic compounds are classified as "toxic" and "dangerous for the environment" in the European Union under directive 67/548/EEC.

The IARC recognizes arsenic and arsenic compounds as group 1 carcinogens, and the EU lists arsenic trioxide, arsenic pentoxide and arsenate salts as category 1 carcinogens. Adults may be exposed through work in a metal foundry, mining, glass production, or the semiconductor industry. Also, arsenic can proceeds from acid mine drainage.

Sources of Mercury. Mining and incineration of coal, medical and other waste, contribute greatly to mercury concentrations in some areas. In the aquatic environment, mercury can be: dissolved or suspended in the water, trapped in the sediments, ingested by living things (biota) [Clifton, (2007)]. Methylmercury is the form of mercury most available and most toxic to biota (including zooplankton, insects, fish, and humans). This form of mercury is easily taken up by biota and bioaccumulate in their tissues. Unlike many other fish contaminants, such as PCBs and

DDT, mercury does not concentrate in the fat, but in the muscle tissue. Thus, there is no simple way to remove mercury–contaminated portions from fish that is to be eaten. Methyl mercury is formed when metallic mercury enters the air or water from mining ore deposits and waste, and from manufacturing plants.

Sources of Lead. The most important ways lead can enter the environment are through mining practices and steel industry. The Lead is the most known metallic pollutant. Being strongly absorbed by the waters sediments, the lead gets to plants and animals. In the aquatic systems, influenced by the temperature, salinity and pH, its solubility can grow. High levels of this metal could be a result of environmental pollution as well as of high levels of mineral contents in soils of production areas [Pichard *et al*., (2002)]. It is extremely toxic, it diminishes immunity of the human body, diminishes the capacity of oxygenating the blood and alters the function of the nervous system. The Lead is also responsible for the illness known as saturnism. The effects of these illnesses are also obvious at the succeeding generations [Prased, (1988)].

Cadmium. Many acid mine discharges contain elevated levels of potentially toxic metals, especially nickel, cadmium and copper with lower levels of a range of trace and semi–metal ions such as lead, arsenic, and manganese.

In aquatic ecosystems cadmium can bio accumulate in mussels, oysters, lobsters and fish. The susceptibility to cadmium can vary greatly between aquatic organisms. Salt–water organisms are known to be more resistant to cadmium poisoning than freshwater organisms. Animals eating or drinking cadmium sometimes get high blood–pressures and nerve or brain damage [Nogowa, (2004)].

In the **figure 1** the concentrations of Arsenic, Mercury, Lead, Copper and Cadmium in January 2005, in seven harvesting points are presented.

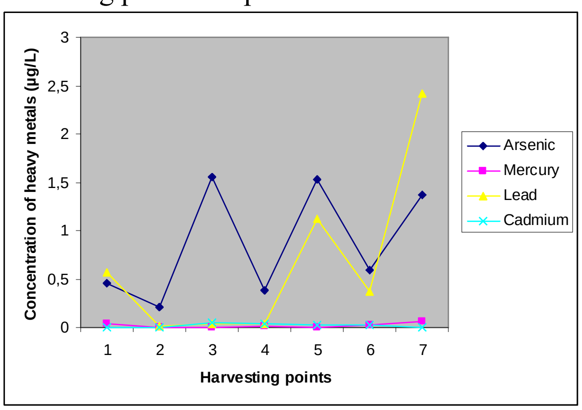

Figure 1. Concentrations of heavy metals in January 2005 (µg/L)

The provided limit for arsenic is As =7,2 µg/L, for mercury is 1 µg/L, for lead is 1,7µg/L and for cadmium is 1 µg/L [NTPA 001/2005].

The figure shows that the concentration of arsenic is between 0,23 µg/L in Lupeni point and 1,61 µg/L As in Iscroni point. Both of these harvesting points are inside the [Barbu, Popescu, Selisteanu, Preda, (2008)] mining zone. The concentration of lead is between 0 µg/L in Lupeni point and 2,57 µg/L in Podari point. That means the concentrations of Pb in Podari point, in June is more than provided limit. Podari is situated in downstream of evacuation of sewage waters from Craiova.

The concentrations of mercury in all the harvesting points do not overtake the admitted limit. The same situation is for cadmium.

In the **figure 2** the concentrations of Arsenic, Mercury, Lead, Copper and Cadmium in June 2005, in seven harvesting points are presented.

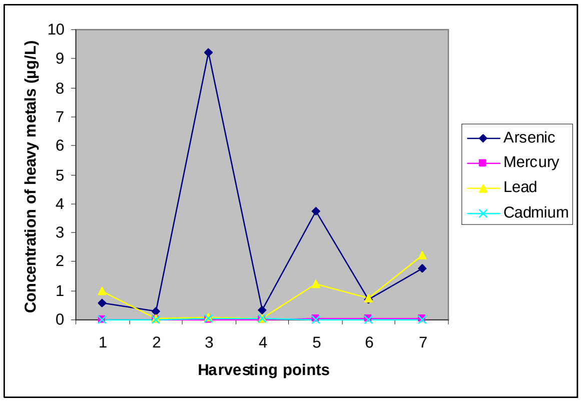

Figure 2. Concentrations of heavy metals in June 2005 (µg/L)

In June 2005, the concentration of the arsenic grows in Iscroni point until 9,1 µg/L, more than provided limit. This zone is intensively polluted by Vulcan Mine, Paroseni Mine, Lupeni Mine and Uricani Mine. The lead in (5) and (7) points overtakes the admitted limit. The (5) harvesting point is upstream the confluence with Sadu. Here Jiu River collects the waters of all mining zone and that explain the high level of pollution from that harvesting point. The concentrations of mercury and of cadmium in all the harvesting points do not overtake the admitted limit.

In the **figure 3** the concentrations of Arsenic, Mercury, Lead, Copper and Cadmium in January 2008, in seven harvesting points are presented.

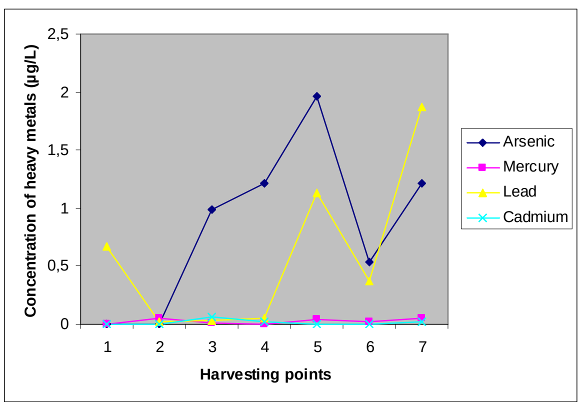

Figure 3. Concentrations of heavy metals in January 2008 (µg/L)

The concentration of arsenic grows relatively constantly, from the source towards the flowing point. In (5) harvesting point, upstream the confluence with Sadu, the concentration of As reach the value 1,99 µg/L, does not overtake the admitted limit. The level of Pb in (5) point is 1,12 µg/L and in Podari point is 1,95 µg/L, in that point more than provided limit. The concentrations of mercury and of cadmium in all the harvesting points do not overtake the admitted limit.

In the **figure 4** the concentrations of Arsenic, Mercury, Lead, Copper and Cadmium in June 2008, in seven harvesting points are presented.

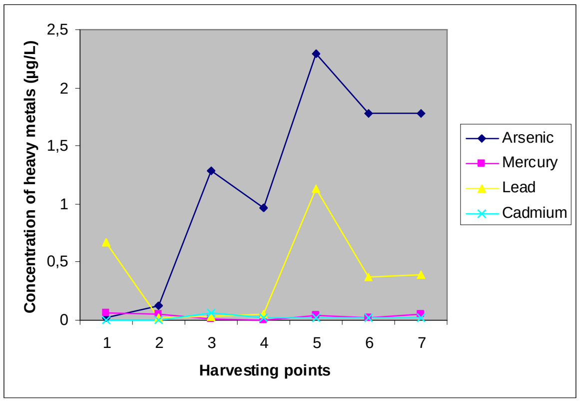

Figure 4. Concentrations of heavy metals in June 2005 (µg/L)

In June 2008 the concentration of arsenic is between 0,021µg/L in Campu' lui Neag and 2,29 µg/L upstream the confluence with Sadu. The concentrations of arsenic in all the harvesting points do not overtake the admitted limit. The measurements show that in all points of harvesting, the level of lead is below the admitted limit. It can be seen that upstream the confluence with Sadu the level of lead (1,13 µg/L) is bigger than the concentration of Pb in other points. The concentrations of mercury and of cadmium in all the harvesting points do not overtake the admitted limit.

5. Conclusions

Acid mine drainage, refers to the outflow of acidic water from (usually) abandoned metal mines or coal mines. However, other areas where the earth has been disturbed (e.g. construction sites, subdivisions, transportation corridors, etc.) may also contribute acid rock drainage to the environment [Freese, (2004)].

The mining industry of coal from Jiu Valley completely eliminates existing vegetation, destroys the genetic soil profile, displaces or destroys wildlife and habitat, extent permanently changes the general topography of the area mined. Ground water supplies may be adversely affected by surface mining. These impacts include drainage of usable water from shallow aquifers; contamination of usable aquifers below mining operations due to infiltration of poor quality mine water; and increased infiltration of precipitation on spoil piles.

The measurements show that in the Eastern Jiu only three mining units discharge (Lonea, Petrila and Livezeni), it is not so polluted due to dilution. Therefore it is confirmed that this affluent fits into the II quality category and it is in the process of natural regeneration.

The Western Jiu River's waters are more polluted than the ones in the eastern side of the basin, and they do not fulfil the quality conditions for the IV category waters. This pollution is due to large quantities of used waters discharged by the four mining units (Vulcan, Paroseni, Lupeni and Uricani) and by the CPP Coroiesti.

As the mine waters from the Jiu Valley have specific features that bear a negative influence on the cleaning processes, their simple cleaning is not enough in order to remove the evacuated solid suspensions. Due to their colloidal nature, the suspensions from the residual waters from the coal mining cannot be efficiently removed unless physical and chemical coagulation processes are engaged, using either classical chemical reagents. These water purging technologies are aimed at fitting these waters within limits admitted by regulations in force in our country, namely NTPA 001/2005 regarding the limit values for charging with polluting agents of industrial used waters and household waters discharged in natural receptors.

Coal mining is only a temporary use of land, so it is vital that rehabilitation of land takes place once mining operations have stopped.

It can be seen that in 2008 the levels of all analysed heavy metals are less than the concentrations in 2005. Also, it can be seen that both in 2005 and in 2008, in winter's months, the level of all analysed heavy metals is less than the level in summer's months.

After 1990, a part of the mines from the Jiu Valley were closed, which had led to a constant lower of the concentration of the heavy metals from the Jiu River. Until then, a part of the chemism of the waters in the area was determined by the excessively mining practiced in these areas.

6. Acknowledgments

This work was supported in part by the National University Research Council – CNCSIS, Romania, under the research projects 621/2007–2008:"Advanced procedures for modelling, identification and nonlinear control of biochemical and biotechnological processes for water quality improvement".

7. References:

[1] Barbu C., Popescu Al., Selisteanu D., Preda A., (2008),. *The determination of the concentrations of some toxic heavy metals on the Jiu River Course using ICP–MS,* in: *Asian Journal of Chemistry*, Vol. 20, No 3, pg. 2037–2046

[2] Clifton J.C. 2nd, (2007), *Mercury exposure and public health,* Pediatr Clin North Am. 54(2):237–69, viii

[3] Craig, J.R., Rimstidt, J.D., (1998), *Gold Production History of the United States,* Ore Geology Reviews, 13, pp 407–464

[4] *Current Medicinal Chemistry*, *Metals, Toxicity and Oxidative Stress,* Volume 12, Number 10, pp. 1161–1208(48), May 2005.

[5] Ford, M., (1996), *Heavy metals*, in: Tintinalli JE, ed. *Emergency Medicine: A Comprehensive Study Guide*, 4th ed. Vol, 158, McGraw–Hill, 839–4.

[6] Freese B., (2004), *Coal: A Human History*, New York: Penguin Books, 304 pp

[7] MAPM (Romanian Ministry of Environment and Water Management) order no.1146, 2002.

[8] Nogowa K., (2004), *Environmental cadmium exposure, adverse effects, and preventative measures in Japan*, in: *Biometals*, 17(5):581–7

[9] NTPA 001/2005. *The limit values for charging with polluting agents of industrial used waters*.

[10] Pichard A., Bisson M., Hulot C., Lefèvre J.P., Magaut H., Oberson–Geneste D., Morin A., Pépin G., (2002), *Fiche de donnees toxicologiques et environnementales des substances chimiques, Plomb et ses derives,* INERIS, Franța.

[11] Prased A.S., (1988), *Essential and Toxic Trace Elements in Human Health and Disease,* Ed. A.R.Liss, New York.

[12] Stoica, A.I., Babaua, G.R., Iorgulescu, E.E., Marinescu, D., Baiulescu, G.E., (2002), *Differential pulse cathodic stripping voltammetric determination of selenium in pharmaceutical products*, J. Pharm. Biomed. Anal., 30, p.1425–9

[13] Stoica, A.I., Stanescu, V., Baiulescu, G.E., (2003), *The determination of the some ions on the Arges River Course using ionic chromatography* (in Romanian), Rev. Chim., 54, Nr. 5, Bucharest, p.386–389

[14] Suess, M.J., (1982), *Examination of Water for Pollution*, Volume 1, Pergamon Press, Oxford

[15] Velitchcova N., Pentcheva E.N., Daskalova N., (2007), *Determination of arsenic, mercury, selenium, thallium, tin and bismuth in environmental materials by inductively coupled plasma emission spectrometry*, in: *Spectrochimica Acta B*, 59, 871–882

[16] Waddell, R., Lewis, C., Hang, W., Hassell, C., Majidi, V., (2005), *Inductively coupled plasma mass spectrometry for elemental speciation: Applications in the new millennium*, in: *Applied Spectroscopy Reviews*, 40, 33–69

[17] Yau, M.H.P., Chan, W.T., (2005), *A novel detection scheme of trace elements using ICP–MS,* in: *Journal of Analytical Atomic Spectrometry,* 20, 1197–1202