ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 4 2009

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CADMIUM IN ECOSYSTEMS

KADM W EKOSYSTEMACH

Abstract: Cadmium and its derivatives are considered the most toxic compounds between heavy metals. Beside cadmium have very few independent minerals it is associated in many cases with zinc. Cadmium interacts with zinc in organisms and is a big dependence on the rate of these elements in various humans, animals and plants. It was demonstrated that cadmium compounds can influences to fall ill with cancer. A lot of scientists studied the damage of DNA due to exposure at cadmium compounds in various conditions. It is very interesting to mention the role of trace elements including cadmium in agrosystems. A real source of cadmium is the use of fertilizers. One important studied on cadmium toxicity is the induced oxidative stress.

The paper presents some data obtained by the authors concerning the presence of cadmium in waters, foods as well as in various types of clinical and pharmaceutical compounds.

Keywords: cadmium, toxicity, ecosystem

Cadmium was discovered by Friedrich Stromeyer in 1917. It can be considered one of the most dangerous inorganic pollutants, due to the fact that it has effects on kidney, liver and in general on metabolic system. There are only few cadmium ores such as: Grenokite – CdS with 77 % cadmium, Otawite – cadmium basic carbonate and Monteponite CdO. In general, in ores cadmium is associated with zinc, copper and lead. It is ejected in the atmosphere by volcanic activity and cadmium is used as anticorrosive agent, stabilizer in PVC products, color pigment, neutron-absorber in nuclear power plants, nickel-cadmium batteries. It is very interesting that cadmium can be found also in phosphate fertilizers.

Total global emission of cadmium amounts is around 7000 Mg/year and in lithosphere, the quantity of cadmium is $5 \cdot 10^{-5}$ %. In general, the maximum permissible value of cadmium for workers is 15 $\mu g/dm^3$. Cadmium resorption is possible by gastrointestinal, pulmonary and dermal ways.

Cadmium is listed by the US Environmental Protection Agency as one of 126 priority pollutants, the half-life in humans is estimated to be between 15 and 20 years

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[1] and it can produce osteoporosis, non-hypertrophic emphysema, irreversible renal tubular injury, anaemia, eosinophilia, anosmia and chronic rhinitis.

Cadmium it is very similar with zinc, and these two metals frequently are present in some ores together. The effects of acute cadmium poisoning in humans are very serious – high blood pressure, kidney damage, damage of red blood cells. Some physiological action of cadmium are due to its chemical similarity to zinc and may replace zinc in some enzymes, producing a disturbance of enzyme stereostructure and impairing its catalytic activity.The zinc status of the body is important in relation to cadmium toxicity development. The increased zinc supply may reduce cadmium absorption and accumulation and prevent or reduce the adverse action of cadmium, whereas zinc deficiency can intensify cadmium accumulation and toxicity. In biological systems cadmium and zinc are linked to macromolecules, primarily through sulphur, oxygen and nitrogen. They bind preferentially to some proteins-albumin in the blood stream and metallothionein (MT) and other proteins in tissues. In this way, one of the metals can influence the uptake and action of the other, depending of the level. The role of the cell wall, the plasma membrane in the mycorrhizas, as the main barrier's against cadmium entrance to the cell, as well as some aspects related to phytochelatin-based sequestration and compartmentalization process are studied. The most studied topics of cadmium toxicity are considered cadmium-induced oxidative stress.

In general, plant accumulation of a given metal is a function of uptake capacity and intracellular binding cites. At every level, concentration and affinities of chelating molecules, as well as the presence and selectivity of transport activities affect total accumulation rates. Trace elements mean elements present at low concentration ($mg \cdot kg^{-1}$ or less) in agrosystems. Trace elements such as Cd, Pb, Cr, Ni, Hg and As have toxic effects on living organism and are often considered as contaminants. In Fig. 1 handling of cadmium in human body are presented [2].

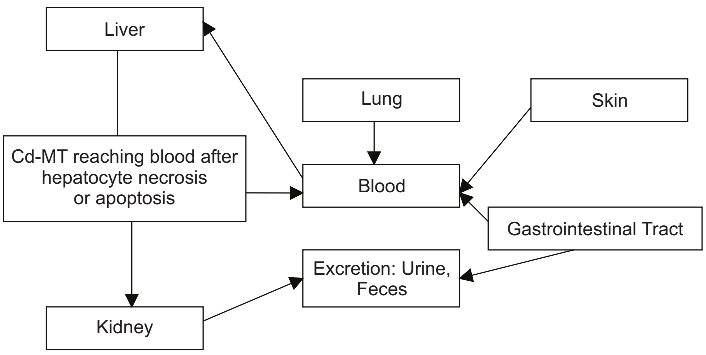

Fig. 1. Handling of cadmium in human body [2]

And in Fig. 2 the effects of cadmium on several organ systems are presented [3].

Cadmium affects both gene transcription and translation. The major mechanism of gene induction by cadmium knows so far are modulation of cellular signal transduction pathways by enhancement of protein phosphorylation and activation of transcription

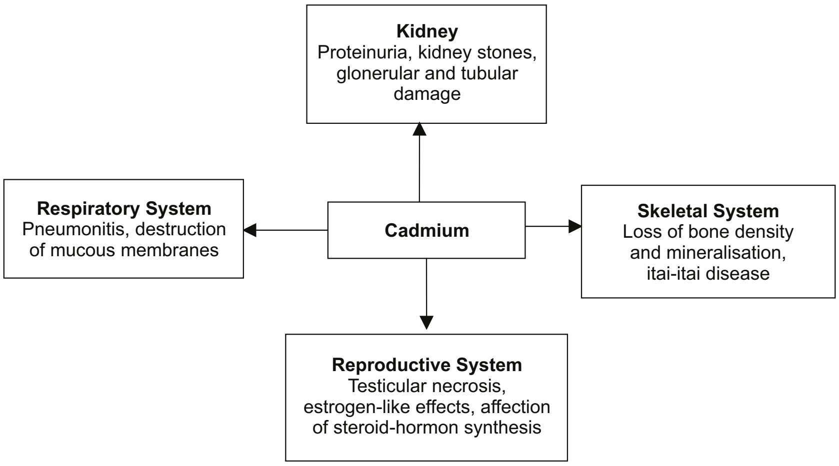

Fig. 2. Cadmium effects on several organ systems [3]

and translation factors. Cadmium interferes with antioxidant defence mechanisms and stimulates the production of reactive oxygen species, which may act as signalling molecules in the induction of gene expression and apoptosis. The inhibition of DNA repair process by cadmium represents a mechanism by which cadmium enhances the genotoxicity of other agents and may contribute to the tumour initiation by this metal.

Cadmium is a potent human carcinogen and occupational exposure to it has been associated with cancers of the lung, the prostate, the pancreas, and the kidney. Because of its characteristics as a lung carcinogen, cadmium has been classified as a category 1 carcinogen (human carcinogen) by the International Agency for Research on Cancer and the National Toxicology Program of the USA [4]. Another source of cadmium is the cigarettes that contain about 20 μg of cadmium per pack, or about 1 μg per cigarette. About 30 % of that goes into the lungs and is absorbed, and the remaining 70 % goes into the atmosphere to be inhaled by others or to contaminate the environment, thus cadmium is dangerous for active, but also for passive smokers [5].

In our previous studies [6, 7], cadmium was determined from different samples, such as waters, foods as well as in various types of clinical and pharmaceutical compounds.

In Table 1 the comparative studies on cadmium and zinc concentration by ICP-AES and ASV methods are presented [6]. Twelve water samples were collected from Arges River and filtered before heavy metals analysis. Heavy metals from water samples were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES). The instrument used, a SPECTROFLAME-P (SPECTROanalytical Instruments, Germany), has the following characteristics: argon was of spectral purity (99.998 %), cooling flow rate 12 $dm^3 \cdot min^{-1}$, auxiliary flow rate 0.8 $dm^3 \cdot min^{-1}$, nebulizer flow rate 1 $dm^3 \cdot min^{-1}$, and consumption rate of the liquid sample was about 2 $cm^3 \cdot min^{-1}$. The instrument has 30 fixed spectral channels that can simultaneously be monitored by the three polychromators and allows for background correction, application of internal standard method and other facilities. For ASV determinations, an electrochemical system polarographic and voltammetric ensemble, Trace Master 5, and POL 150 Polarographic Analyzer (Radiometer, Copenhagen), were used. The electrochemical cell contained a working electrode: hanging mercury drop electrode (HMDE), a reference electrode: Ag/AgCl and as auxiliary electrode, platinum wire.

Table 1

Comparative studies on cadmium and zinc concentration by ICP-AES and ASV methods [6]

Sample	Cadmium [μg/dm^3]				Zinc [μg/dm^3]			
	April 1999		May 1999		April 1999		May 1999	
	ICP-AES	ASV	ICP-AES	ASV	ICP-AES	ASV	ICP-AES	ASV
1	0.40	0.30	3.60	4.33	0.50	0.21	0.50	0.23
2	6.70	5.50	3.60	4.40	0.50	0.15	0.50	0.41
3	—	—	7.30	7.08	0.50	0.19	0.50	0.39
4	—	—	9.40	7.60	0.50	0.18	0.50	0.35
5	—	—	1.30	0.72	0.50	0.27	15.70	14.60
6	4.90	3.01	3.00	1.93	0.50	0.22	46.00	57.23
7	—	—	1.70	1.60	6.00	4.60	66.10	58.77
8	—	—	6.00	4.82	3.70	7.92	95.20	90.50
9	1.30	0.80	6.80	5.50	0.50	0.35	126.10	120.80
10	8.90	7.22	3.40	2.80	18.70	15.00	164.80	139.00
11	7.10	5.40	4.30	3.72	43.90	40.10	207.30	201.20
12	0.40	0.50	3.80	3.45	28.70	28.40	240.70	236.00

Another study concerned with heavy metals determination from Rosia Montana District, a gold mining area in Romania. Twelve samples were collected, four from Corna River, five from Rosia Montana River (the mining processing waters flow in this river) and three samples from Abrud river. Increased concentrations of metal ions are observed especially for samples collected from Rosia Montana River, and for sample collected from Abrud town, the concentration can be explained by domestic waste-waters that are discharged into Abrud River and other waste materials deposited on the river bed. Presently, the mining activity was reduced, but the solid rock (waste) deposited by the river side remained the main pollution source. The highest concentrations were found for cadmium in September 2004: 0.17 mg/dm^3. Comparing the results obtained with the maximum concentration accepted by Romanian Standard the limit-concentration has exceeded by over 1,000 times [7]. To re-establish equilibrium in this ecosystem, mining activities must stop or pollution controls must be established. While these water courses are not used for industrial purposes or for human consumption, they do flow into the Mures River, an important water supply for industry.

Table 2

Cadmium concentration in water samples collected from Rosia Montana District

Sample	Cd [mg/dm^3]		
	April 2004	July 2004	September 2004
1	0.009	0.020	0.010
2	0.060	0.010	0.009
3	0.020	0.020	0.009
4	0.009	0.009	0.009
5	0.090	0.009	0.009
6	0.020	0.009	0.009
7	0.009	0.009	0.030
8	0.090	0.030	0.150
9	0.070	0.140	0.009
10	0.060	0.100	0.170
11	0.020	0.080	0.090
12	0.009	0.009	0.010

By observing these data it is possible to have an idea about the pollution degree at a local level. It can be observed that in some location sites the concentration of cadmium were very high (Table 2). The samples in which the concentrations are very high were collected from Roşia River, where the area was intensely affected by mining activity. Heavy metals present in the waste from mining and metallurgical activities are often dispersed in the environment by wind and water. The extent and degree of heavy metals contamination in the vicinity of mines may vary depending of geochemical characteristics, the mineralization of tailings, physical-chemical conditions and the process used to extract metals. Pollutant cadmium in water may arise from industrial discharges and mining wastes.

Conclusions

One can conclude that cadmium is present in water, soil, plants and human body in various quantities, but due to the toxicity of this element, the establishment of real concentration is very important. Water contamination by cadmium can influence the agrosystems as well as the body system, because cadmium affect especially lung, liver and kidney.

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KADM W EKOSYSTEMACH

Abstarkt: Kadm i jego związki są uważane za najbardziej toksyczne wśród metali ciężkich. Kadm występuje w bardzo niewielu minerałach, często wraz z cynkiem. Ze względu na interakcje pomiędzy kadmem a cynkiem ich zawartość w organizmach ludzkich, zwierzęcych i roślinnych jest zróżnicowana. Wykazano, że związki kadmu wpływają na zwiększenie zachorowań na raka. Badano wpływ związków kadmu na występowanie uszkodzeń w DNA w różnych warunkach. Interesująca jest rola mikropierwiastków, w tym kadmu, w agrosystemach. Dużym źródłem kadmu są stosowane nawozy. Jednym z ważnych kierunków badań jest wpływ toksyczności kadmu na wywołanie stresu oksydacyjnego. Pzedstawiono dane uzyskane przez autorów dotyczące obecności kadmu w wodach, żywności, jak i w różnego rodzaju substancjach klinicznych oraz farmaceutycznych.

Słowa kluczowe: kadm, toksyczność, ekosystem