MONITORING AND RISK ASSESSMENT OF CONTAMINATED SOILS

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Summary. The present investigation was related to application and adopting of monitoring set in areas with expressed local contamination and high impact of diffuse contamination (one of so called "hot spots" in Bulgaria). The area is located around the actively functioned gold extracting factory "Chelopech Mining" EAD. The main goal of the work was to receive actual information about the present soil status- physicochemical properties, genesis of soil, and soil pollution with heavy metals and metalloids. Recommended monitoring is considered as an operational model, supporting the planning of investigations and suggesting planning of adequate land use activities. The results from this monitoring should be easily transposed on the geographical network of the basic (level I) European monitoring (16x16 km). Having in mind the needs for relevant information of the soil status of agricultural lands of both closely located villages - Chelopech and Chavdar, as well as the distribution of enterprise's buildings and tailing pond we suggested implementation of a network grid of 0.5 x 0.5 km. The soil sampling, pre-treatments of samples and detection of heavy metals and metalloids were made according to relevant ISO methods. The results showed that the content of heavy metals exceeded the accepted maximal permissible concentrations in respect to As, Cd, Cu, Zn, and Pb in randomly spread samples. The soil acidification process was established. GIS positioned

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data and interpolated maps were the visual results of monitoring investigations. Similar type of results should be used in planning of environmental management of the area.

Key words: contamination, heavy metal, monitoring, sustainable land use.

INTRODUCTION

Soil contamination is a problem discussed as a degraded process which importance exceeds agricultural area. It is a part of the global disturbance in the ecosystem in transport of energy and substances, and is a main effect of the soil degradation. Heavy metal contamination of soils (and especially soils with low pH) leads up to serious problems in the trophyc food chain. It is well known that the availability of a number of trace elements becomes greatest at low pH and the reasonable result is that plants absorb more quantities of toxic elements (Arsova, 1998; Alvarez et al., 1998; Dinev and Bojinova, 2006; Weber, 1993; Benkova, 2005).

Absorption and accumulation of metals in plants are complicated processes, defined by the behavior of the element, depending on soil characteristics and the properties of the biological reagents. That is why the regular investigations of these processes have to be a part of the environmental monitoring (Dinev and Vassilev, 2006; Japenga et al., 2005). This requires a permanent observation of the main soils functions in connection with the rules for food safety and ecology issued by the European Community (Bacon and Dinev, 2005; Dinev et al., 2005;. Yancheva and Stanislavova, 2006).

As a logic result in the way of harmonization of Bulgaria legislation to European Community's rules, our recent researches are related to the development of a modern monitoring network for area with local and diffuse contamination, relevant to specific Bulgarian conditions and soil differences. The aim of the present work was to characterize the present and past contaminations in a conflict area by receiving detailed information. The final expected result had to be initial structuring of the data for heavy

metal and metalloid concentrations in soil samples in Chelopech Mining area for the need of environmental management.

MATERIALS AND METHODS

The floatation factory is located at the foot of the South slopes in the Eastern part of Etropolska Stara Mountain and the northern part of the north part of Zlatishko plane part of the Zaltishko-Pirdopska valley.

Before developing the network a detailed review for the area investigations was done. All possible influences (erosion, wind direction etc.) and past ameliorative programs carried out were taken into account.

The soil sampling was made by a combination of 5 sub soil samples by hand. Pre-treatments of samples and detection of total concentrations of heavy metals (Cd, Co, Cu, Cr, Ni, Pb, Zn) and metalloids (As) were done according to relevant ISO methods (ISO 11466).

RESULTS AND DISCUSSION

One of the most important tasks of environmental monitoring is to receive data information, easily adopted to European network and relevant to needed monitoring level. The results from this monitoring can be easily transposed on the geographical network of the fundamental (level I) monitoring (16x16 km). Having in mind preliminary historical information, our former investigations, the needs for adequate information of soil status of agricultural lands of both close located villages- Chelopech and Chavdar, as well as the distribution of enterprise's buildings and tailing pond of Chelopech Mining EAD we suggested a network grid of 0.5 x 0.5 km.

The created scheme included agricultural lands and a forest area with characteristic land use - pastures, cultivated area (mainly for cereal growing), private yards etc. The model of the network suggested that received detail information could be characteristic for the soil status around the soil sample in a radius of 500 m. In the whole monitoring scheme were included about 2500 ha. The points situated in the forest lands were excluded for interpretation in the present work.

Analyses of soil results supported particularly the former investigations.

The concentration of heavy metals is characterized as toxic, surpassing the Permissible Level Content (according to National Rules- Order 3/ 2002, Ministry of Environmental and Waters, Bulgaria) compared with fixed concentration at respective soil acidity (pH, measured in water). The application of the monitoring network permitted a serious investigation of the research area in details. The soil, contaminated with heavy metals and metalloids was randomly spread and located in some sampling points of both villages Chelopech and Chavdar. Two specific zones could be separated according to soil physico-chemical characteristics and mainly by the highest contamination by Cu and As especially: the first one - south of the tailing pond and the second one - close to the factory. Different explanations regarding the results were discussed. One reason is the pedogenic origin - in

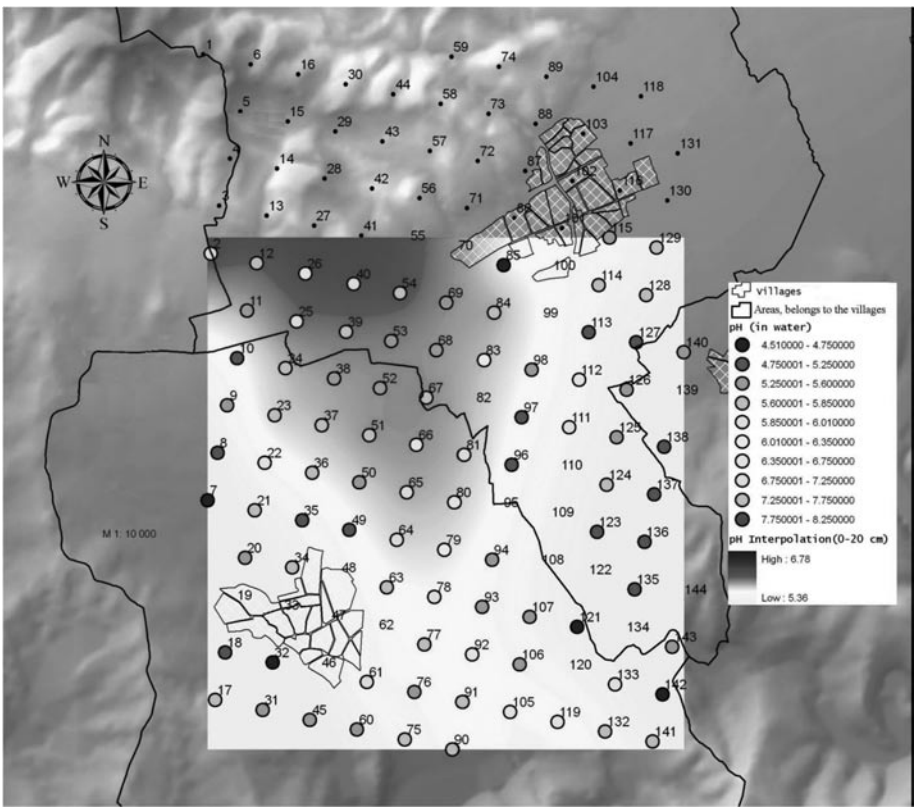

Fig. 1. GIS-map of soil acidity measured in samples of the monitoring network

the area rocks are enriched with metals (Cu, Au, Fe etc) and a number of years several mines used to operate. Another confirmed process is the anthropogenic contamination in the last decades from of copper and gold factories working there. Two different ways of impact can be described. One way is by dust (air) pollution of soil, plant and water. The acidification of the soil is another reason for detection of high concentration of some heavy metals and increased (relatively) mobility of heavy metals. The latter process was discussed and confirmed for the operation of copper - enriched factory (now- a part of Comerio- Pirdop). It is located about 5 km in East direction. The data of our investigation using a GIS oriented map for environmental monitoring showed that probably the increased acidification in the same direction was due to activities of Cumerio's factory. Thus, the data of our study showed that most of soil samples (about 83 %) had strongly acidic pH. Respectively, they had a very low buffer capacity (low content of basic ions), middle or high hydrolytic acidification, a middle or low sorption capacity (Figure 1). It was well expressed around the factory (in the Southern slopes of the East part of the Balkan mountain) also.

However, the monitoring we carried out gave us reason to assume that

Table 1. Concentration of heavy metals and As in soil samples from agricultural lands around Chelopech Mining, mg.kg^{-1}

	As	Cd	Co	Cu	Cr	Ni	Pb	Zn	Hg	Fe	pH*
average	31,7	0,6	13,2	118,5	35,3	26,0	39,5	98,1	0,04	24535,9	6,0
median	21,4	0,562	13,7	80,8	32,1	26,3	27,9	77,9	0,0325	23930	5,72
max	128	1,33	22,63	1361	135	57,1	159	332	0,148	46544	8,1
min	10,3	0,413	5,48	28,8	5,17	4,96	7,65	48,6	0,011	8695	4,5

*- pH in water (w/v=1:5)

the values for most of the elements did not exceed more than three-fold for permissible Level Content (PLC) for the relevant pH and element (Table 1).

The soil contamination with heavy metals, mainly Cu (Figure 2), Pb, Zn and As was heterogeneous (horizontal and vertical) related to soil profile, disturbed structure of community pedogenes (micro and macro flora). Having in mind the results we could make some recommendations for soils ecosystems to specify state of today and specific actions for get better of pointed zonal problems.

All these remarks led us to conclude that the soil acidity is the basic value for evaluation of soil contamination by several elements.

During the investigation we resumed that the actual rules for characterization of contaminated soils was not well adopted to the current

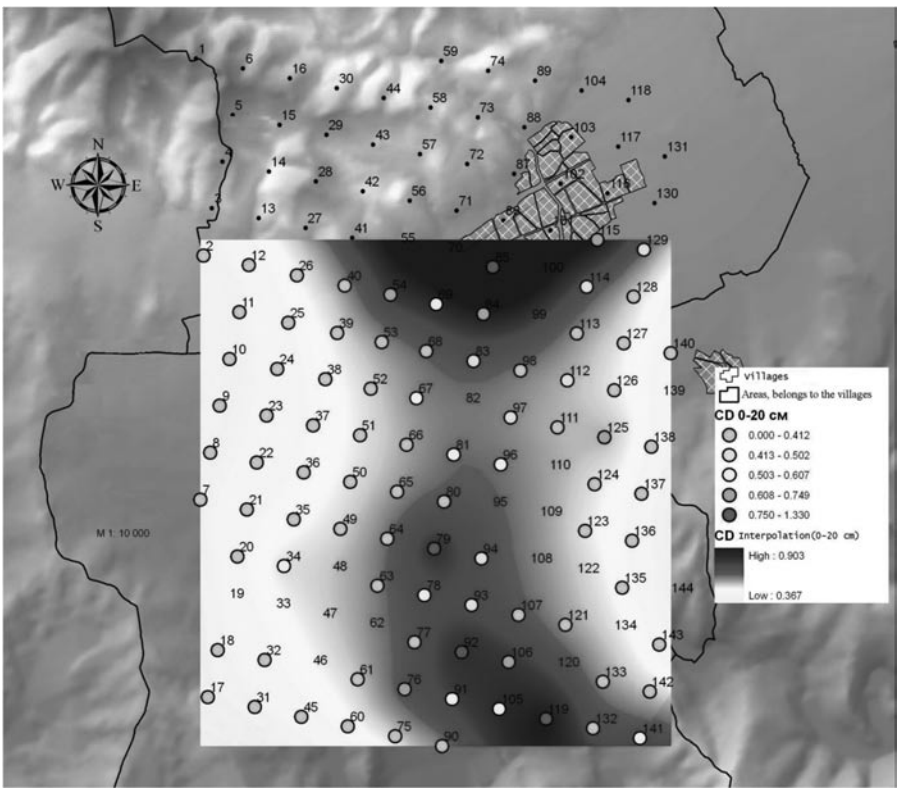

Fig. 2. Distribution of Cu in the upper soil layer (0-20 cm).

point-of-view in European standards. The need for new legislation of management of contaminated soils in Bulgaria was well expressed by represented data for content of heavy metals in soils samples collected on our monitoring research on agriculture land.

Conclusion

Our investigation on the soil status of the area of Chelopech - Mining was carried out by implementation of relatively new for Bulgaria monitoring principles. The fixed located points of GIS oriented was sampled and detected for main physico-chemical soil properties. The distribution of soil acidity (pH) and concentration of heavy metals was shown on a real map. The critical points with concentrations of the heavy metals in the soil samples exceeding the Permissible Level concentrations were located.

The type of the received results could be easily used in supporting experts in planning of durable monitoring plan and management of sustainable land use.

References

Alvarez, G., B. Jimenez, G. Carral, M.Gutierez, 1998. Aluminium distribution and soil acidity in a Mediterranean mountain area. Proc. of 16th Word Cong. Of Soil Sci., 1, 457-460.

Arsova, A., 1998. Bioecological testing of carbonate deposit designed for liming copper polluted acid soil. J. Balkan Ecology, 3, 85-89.

Bacon, J., N.Dinev, 2005. Isotopic characterization of lead in contaminated soils from the vicinity of a non-ferrous metal smelter near Plovdiv, Bulgaria. Environmental Pollution, 134, 247–255.

Benkova, M., 2005. Colloid-chemical interactions at organo-mineral amelioration of soils, contaminated with heavy metals. PhD thesis, NPISS, Supervisors Prof DSc T.Raychev and Assoc. Prof. Dr.N.Dinev.

Dinev, N., A.Vassilev, 2006. Phytoremediation and sustainable use of metal contaminated soil in Bulgaria. In: Processing of IMIDRA- Soil

remediation technologies, November, Madrid (CD- copies).

Dinev, N., P.Bojinova, 2006. Ecological investigations and agricultural status in the region of lead-zinc smelter near the town of Plovdiv. Proceedings of I-st International Symposium "Ecological approaches towards the production of safety food", 19-20 Oct. 2006, Assoc. "Regional science and Technology Unions"-Plovdiv, Bulgaria, 121-126.

Dinev, N., R.Donkova, and L.Dimova, 2005. Estimation of biological indicators of heavy metal polluted soils. Proceedings of National Conference with international participation "Management, use and protection of soil resources". May 15-19, 2005, Sofia, ISBN 954-749-058-3, 437-439.

Japenga, Jan, L. Bonten, R. Kucharski, O. Novosielska, N. Dinev, 2005. Revegetation as a tool for risk containment of heavy metal polluted sites. Third International Phytotechnologies Conference. April 20-22, 2005 Atlanta,GA.

Weber,J., 1993. Humus substances impact on the accumulation and migration of some heavy metals originated from industry emitted dust. Zesz.Probl. Post. Nauk Roln, Warsaw, 411, 284-292.

Yancheva, D., L.Stanislavova, 2006. Heavy metals content of oriental tobacco from the region of Kardjali. Ecology and Health, 3, 298-302.