REMEDIATION STRATEGIES FOR ACID AND CONTAMINATED SOILS

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Summary. Soil pH is among the most important limiting factors for plant growth. The goal of the present work was to investigate the applicability of alternative soil amendment for acid soil to improve soil characteristics in an acid and contaminated with heavy metals area of Bulgaria. The investigations were made with saturate lime - waste material from the sugar industry (Zaharni zavodi - Gorma Oryahovitza). A number of incubation and pot experiments were carried out for characterization of this material as non-dangerous and applicable for soil improving. By a precise version of the monitoring grid applied for heavy metal distribution we took care of improving soil fertility. Environmental monitoring network of soils from Chelopech and Chavdar was chosen. Agrochemical characteristics of sample soils showed deteriorated soil fertility in respect to the soil acidity and the available forms of macro elements - nitrogen and phosphorus. In contrast, there was a very good fertility for potassium. The obtained results required for future sustainable land use, to include plan specific amelioration and agro-technical activities, such as liming and fertilizing with nitrogen and phosphorus products. Amelioration by limiting for diminution of the negative effects caused by irrational agricultural activities could be achieved an adequate change in the soil acidity. Physicochemical analyses gave us reason to resume that soils with low pH in water (bellow pH 6.0) are 75 %

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of the total number and all need adequate liming. The correction of pH by saturate lime will be economically reasonable. Having in mind the heterogeneity of the region, both as soil difference and soil acidity, determining an adequate optimal liming norm for each larger zone is needed. Distribution of lime material is shown on GIS maps and is available for farmers with calculation of the quantity of saturate lime for each point.

***Key words*:** acidification, lime, monitoring, saturated lime.

INTRODUCTION

Contemporary Bulgarian agriculture is facing a great number of problems connected with natural irregularities during the last years. The consequent economical difficulties as well as the anthropogenic influence mainly consist of soil contamination and bad farmer practices. Contamination with heavy metals is a worldwide problem. The main pollutant trace elements of soils, plants and water in investigated area are Cd, Zd, Pb, As and other elements. As a result of the activity of different non-ferrous factories approximately 200 000 ha soils in Bulgaria contain Cd, Zd, Pb, As in concentration above the permitted level (Atanasov et al., 1993; Dinev, 1998). The main direct and indirect problem is their accumulation in plants and animals organisms. This becomes risky for the landscape violation and consequently for human health (Adriano et al, 2004). Soil factors with great influence in solubility and transportation through the food chain soil – plant – animal – human are basically as follows: acidity (pH), general forms of metals in soils, soil type and organic matter (Dowdy and Volk, 1983; Welch and Lund, 1987).

Soil acidity influences the adsorption and mobility of the heavy metals and leads to increased biological accessibility. The acidification of soil is a naturally occurring process on some lands, whose intensity depends apart from genetic conditions in anthropogenetic components as well. It is qualified with lowering pH of lands, appearance to exchangeable acidity and development on aluminium and manganese toxicity, poverty of the land with the bases, the molybdenum deficit, the suppressed microbiological

activity and the acidic destructions of the clay materials (Atanasov, 2006). Many agrochemical attempts showed that a full neutralization has to be achieved to eliminate soil pH that is toxic for the plants. It means that on the soil colloids of the very acidic system with high references a neutralization by implementation of lime materials to reach on favorable (optimum) for the growth of the plant the conditions of the middle (Ganev, 1990; Palaveev and Totev, 1979; Borisov and Dinev. 2000).

The goal of our experiment was to use a network for environmental and heavy metal monitoring in recommendation variants for amelioration of agricultural lands by liming with alternative amendments in development of programs for sustainable land use.

MATERIALS AND METHODS

The investigated area was located in the foot to the Southern slopes of Pirdop-Zlatitza valley. In the beginning of the study all former ameliorative programmes were analyzed. The performance was associated in detail investigation of the distribution on the pollutant elements by monitoring network with a grid of 500 m.

The saturated lime was collected from the waste of Zaharni Zavodi-Gorna Oryahovotza. All required analyses related to the waste material (contaminants, macro- and microelements, toxic microorganisms according to Order 3 for dangerous waste and their story) were made. To characterize material as an amendment for acid soil a series of the incubation vegetative attempts on the genetically sour lands of the villages Dushevo and Sekirovo from the experimental fields of ISSNP was carried out. The lime norms applied in soil were calculated according to Ganev (1990).

RESULTS AND DISCUSSION

Investigated material was compared in preliminary investigations with classic lime. The material expressed a neutralizing capacity of 2820 mequ. The main characteristics of saturate lime was its reaction as a strong base and capacity to be involved in neutralizing processes with acidic systems of soil adsorbent, and the process of neutralization is in some steps (Ganev,

1977).

The experiments carried out with waste material from sugar factory showed that the saturate lime was non-toxic, the applicability for agricultural lands was potentially high and the material could be use for improving acid soils (Table 1).

Table 1. Agrochemical characteristics of saturate lime from Zaharni Zavodi AD, Gorna Oryahovitza.

Saturate lime	pH (KCl)	NH_4-N	NO_3-N	P_2O_5	K_2O	C
		mg.kg^{-1}		mg.100 g-1		%
Fresh lime	12.4	7.15	2.0	6.8	4.2	1.82
Stored lime	7.98	6.56	12.5	11.4	4.48	1.97

The physicochemical parameters of the samples from the monitoring net in Chelopech gave us reason to conclude that soils were very acid. One of the reasons was the soil genesis. More important was the other impact: the anthropogenic acidification by industrial activities and unsustainable agricultural practices.

Table 2. Distribution of soils in pH and calculated doses for liming with saturated lime.

pH	Samples, number	% from total number of samples	Lime material to pH 6.0 kg.da^{-1}	Lime material according to $H_{8.2}$-kg.da^{-1}
till 4,5	10	23	544	991,8
5,0	21	47	311,8	815,2
5,5	6	13	310,3	489
6,0	1	2	53	156,6
6,5	6	13	not	not
Above 7	1	2	not	not

Soil acidity showed a prevalence to the areas with a very low (pH 4.1 - 4.5) to extremely low acidity (pH 4, 0) that constituted about 66. 3 % from the number of the points. They were 18, 6 % of the samples with a low and

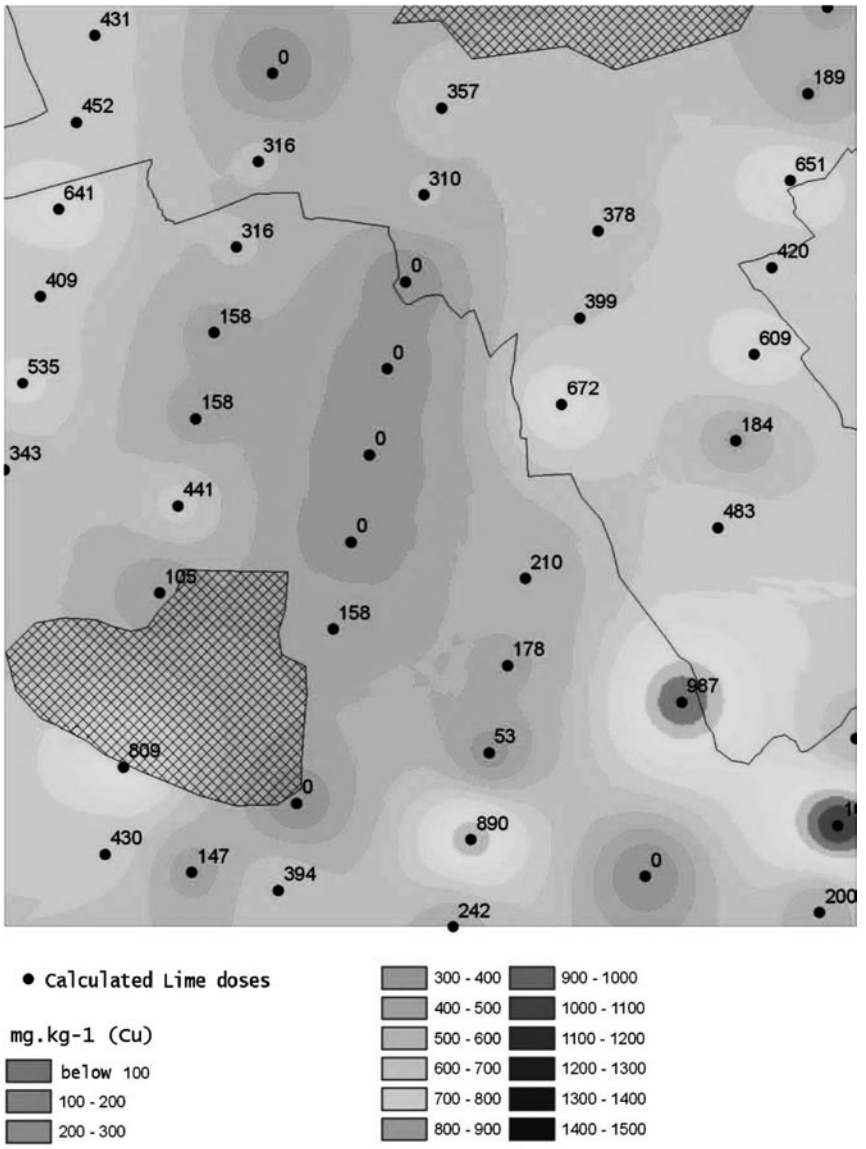

Fig. 1. Doses of saturate lime for neutralization of soil acidity to pH 6.0 according to Ganev (1990).

neutral reaction, and only 7 % of the samples expressed an alkaline reaction. The distribution of the soil reaction values of the land of Chelopech and Chavdar is shown in Table 2.

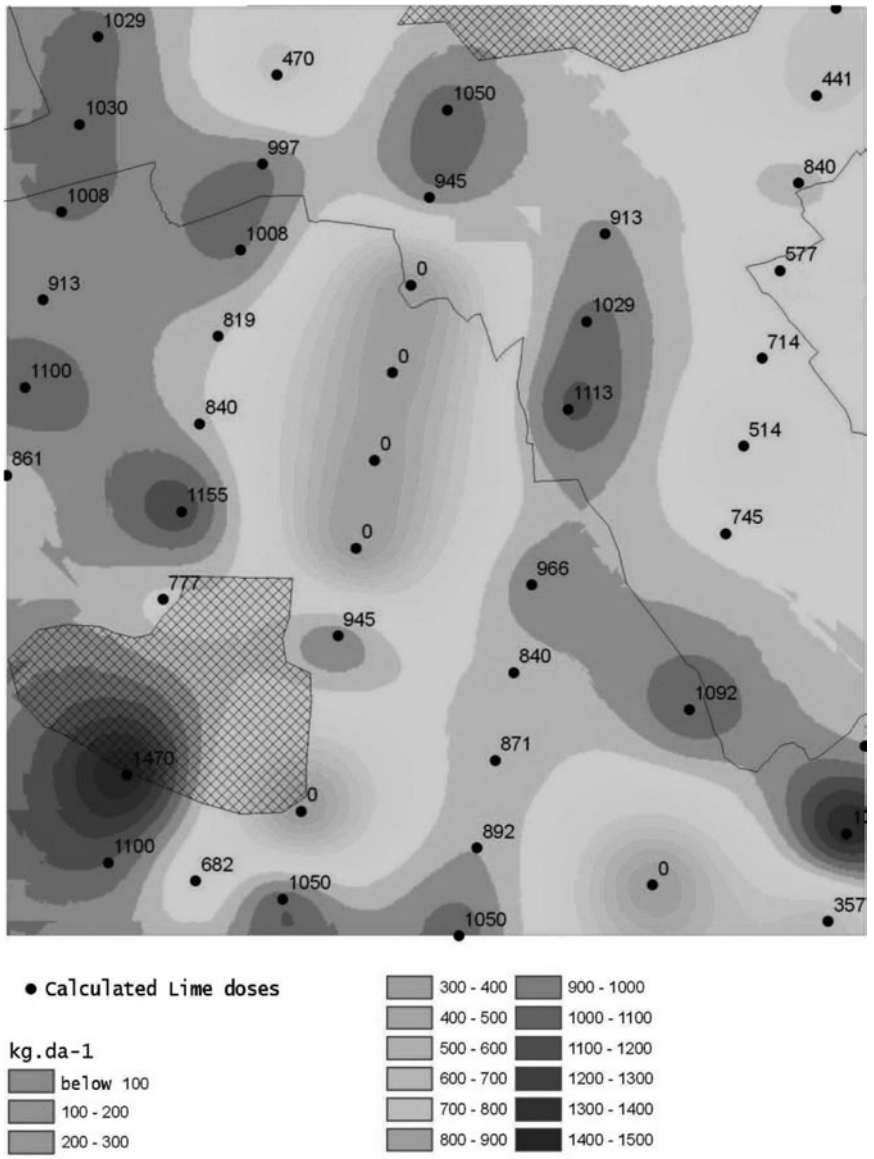

Fig. 2. Doses of saturate lime for neutralization of full soil acidity to $H_{8.2.}$ according to Ganev (1990).

The obtained results confirmed the need for fast and adequate remediation activities in the area. For these needs we developed a preliminary schedule for measuring saturated lime in practice, needed for amending the land with high acidity (Figure 1). The data showed optimization of the land reaction (of Al -pH 6. 0) according to Ganev (1990).

The complicated situation with heavy metal contamination of the soil required additionally the necessity for blockage of the heavy metals because the region was affected by diffuse contamination and was responsived to secondary acidification of the lands required to suggest the opportunity for the full neutralization of the acidic status, e.g. the neutralization according to $H_{8.2}$. (Figure 2).

Consequently, implementation of the present monitoring project in the part for a physico-chemical investigations of the lands gave us the opportunity for physico-chemical characterization of the land in aspect of forthcoming ameliorative procedures.

Conclusions

The potential of saturate lime was evaluated and material was included in the list of amendments for acid soils in Bulgaria. Moreover, it was established that the use of this waste product was related to additional positive ecological consequences related to the store on the territory of the depot. For the purposes of the farmers and sustainable land use two versions for Chelopech and Chavdar in the lands were discussed - for pH optimal for plant growth and for the full immobilization of basic ions. By precise analytical procedures and consequences the presented strategy for ecological monitoring of acid and contaminated with heavy metals soil by lime material measure up to neutralizing the transport acidity until full neutralization as well as to the sourness on the land adsorbent.

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