INVESTIGATION OF THE DECREASE OF SOIL ORGANIC MATTER AND SOIL POLLUTION BY HEAVY METALS IN THE AREAS INTENSIVELY USED FOR MILITARY ACTIVITIES

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Abstract

Soil is an important component of biosphere. Soil Organic Matter (SOM) carries out one of the main functions in soil. Physical, chemical and biological features of soil are determined by the SOM, and cause the ability of plant growing. Each of given features can be different according to the conditions like climate, land using, etc (1).

Structure and features of soil can be caused by different factors, both natural and not. The quantity of SOM decreases because of the both agricultural and military activities (explosions in particular). Entire areas are disturbed when proceeding explosions' training and it leads even to the fertile lands turning into desert. Such destroyed and not natural landscape can be seen in the Lithuanian firing grounds, where wide scale of activities are taking place whole year long (2). Usually explosions' training takes place in the same areas so called tactical fields. Because of the regular disturbance, the plant cover in such fields is poor, sometimes is missing, waste grounds are predominating (3). In addition, the soil in such areas is polluted by heavy metals, because the explosive charges composition is based not only on the explosive materials, but also lead, zinc, copper and etc.

The research completed in Lithuania's Gaiziunai firing ground, which is second by it's size and importance in the country, aimed on the evaluation of the negative impacts made to the topsoil in the means of SOM decrease and pollution by heavy metals, caused by explosions. In some areas concentrations of heavy metals were twice and more times higher than background concentrations and the quantity of SOM in the samples analysed was approximately 50% less than in the undisturbed areas. The results leaded to the conclusions concerning negative military impacts.

Introduction

Physical, chemical and biological features of soil depend on the Soil Organic Matter (SOM), and cause the ability for plant growth. Each of the given features can differ accordingly to the conditions like climate, land using, etc. Structure and features of soil can be more or less changed by different kinds of activities. Intensive land using for military purposes makes direct influence on physical and chemical soil features, irreversibly damaging it in most cases.

There are few firing grounds in Lithuania that are used for more than 100 years by now. During such a long period the level of damage in some spots has reached the maximum value. Not speaking about the other components of the biosphere, the topsoil was damaged physically and polluted by the heavy metals and other chemical pollutants. One of the specific activities performed in the firing grounds that affects soil features is explosion training. Process of explosion can be described like an instantaneous isolation of potential energy of the explosive material because of the fast exothermic reaction with the isolation of the gaseous products. The negative impact of explosions, made to the topsoil, can be characterised by their physical (destruction of soil structure, loss of fertile soil mass), thermal (the heat of explosions burns out the top layer of soil, which is rich by organic debris) and chemical (soil pollution by remnants of explosive materials (like TNT, RDX, etc.) and heavy metals, that are present in the composition of the explosive charges) influence. Continuous land use for the explosions training leads to the pollutants accumulation in the soil (with the danger to contaminate the ground waters) and to the destruction of the fertile layer of soil.

Methods

Quantity of soil organic matter and pollution by heavy metals was investigated in the soils of the Gaiziunai firing ground, which is second by its size and importance in Lithuania. Sites for soil sampling were chosen in the areas with the different levels of disturbance, but still in the fields which are intensively used for the explosions' training (so-called the fields of tactical training).

First field for soil sampling was chosen in the area located next to the aerodrome, which is not used at the present moment. This field (which is called second tactical field – II TF) was used for different kinds of military activities (like armoured cars riding, mining, explosions of different charges and etc.) from the very start of the Gaiziunai firing grounds' foundation (it happened about 100 years ago). The crew of Gaiziunai firing ground calls this land "Sahara desert". This is because of the damaged landscape: surrounded by luxuriant forest, there's the spot, where the topsoil is heavily damaged, the vegetation is poor or absolutely missing – the sandy soil is predominating. Obviously the soil in here is poor of SOM and the wastes from bombing, mining and shooting scattered all around makes the presumption about the heavy metals pollution very likely.

The second field for soil sampling was chosen in the area located in the opposite side of the aerodrome, in a distance of about 1km. In the present moment this field is used for the same activities like the first one, but the difference is in the time of exploitation period. This field is called the first tactical field (I TF) and it was used less in the past, because when the Soviet armies' units ruled the Gaiziunai firing ground, in the mentioned territory there were buildings of different destination. After the Soviet army units have gone, they left a lot of not needed equipment and buildings, which turned into ruins after few years passed. So when the government of Gaiziunai firing ground was taken by the army of Lithuanian Republic, most of the buildings were exploded, and that served as a good training. It happened not more than 15 years ago and it was the start for the exploitation of the first tactical field in the means of military activities. In this area topsoil is already damaged, but the level of damage is not so heavy like in the second tactical field. Still in some spots the vegetation is almost missing, only moss and poor grass is predominating, with the few trees and bushes.

In the first field of sampling (the second tactical field IITF) 25 soil samples were taken, and in the second one – 8. Only the top layer of soil was analysed, taking samples not deeper than 0-5 cm (2). For it could be possible to value the damage made to the topsoil, 6 soil samples were taken in the mixed forest and 6 – in the pinewoods, where military activities are not proceeded.

The quantities of soil organic matter in the taken soil samples were determined using the method of weight loss on removal of the organic matter from the mineral fraction by ignition (4).

For this procedure the oven capable of being heated to approximately 650 ºC is needed. At first about 200 g of dried ground soil was scooped into tarred crucibles. They were dried for two hours at 105ºC, and the weight was recorded to +0.001 g. The procedure was repeated once again. Then 200g of dried soil were heated at 550°C for 5 hours, cooled to 150°C and weighted in a draft-free environment to 0.001 g.

Difference in mass of soil sample before and after the ignition shows the total mass of soil organic matter.

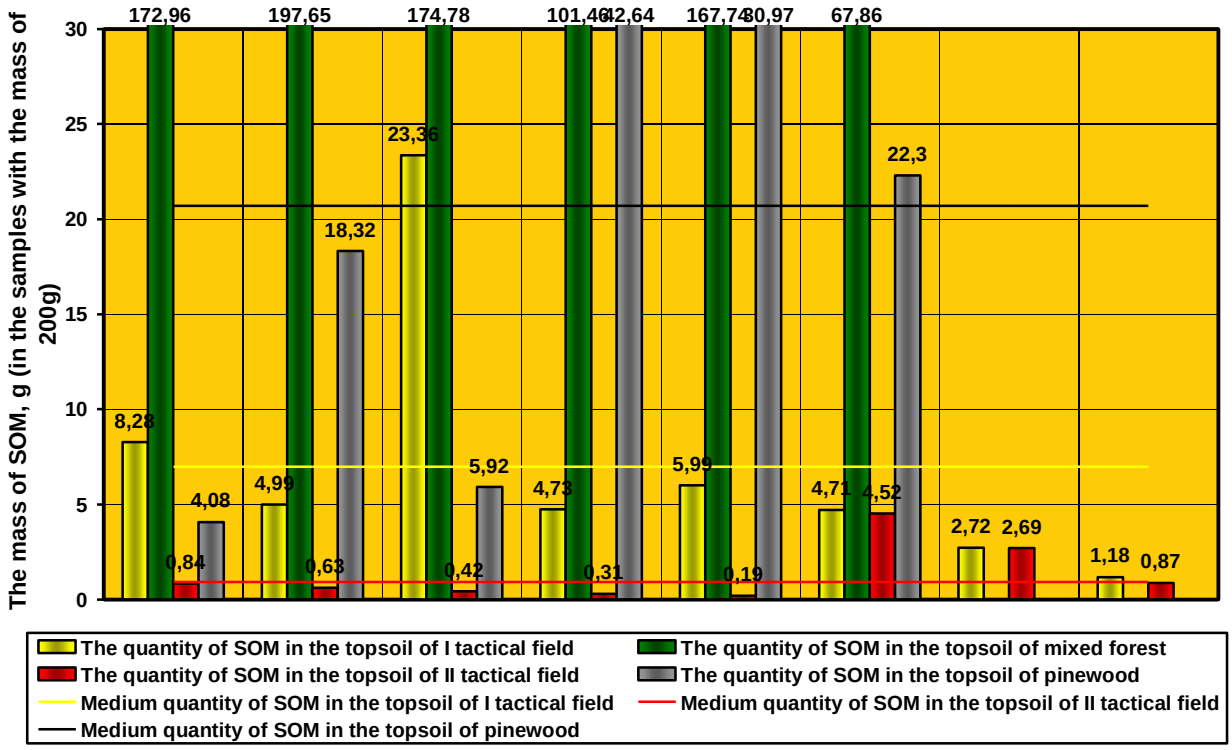
As it was mentioned before, typical heavy metals used when producing explosive charges are lead, copper and zinc. In the soils of the territories where explosions training takes place, it is very likely to find anomalies of the mentioned above heavy metals concentrations. During long years of the firing grounds exploitation concentrations of the heavy metals accumulates in the soil and becomes higher than background concentrations. With the aim to determine whether the soils of Gaiziunai firing ground are polluted by heavy metals, two fields for soil sampling were chosen. The main criterion for sampling sites choice was the intensity of land use for military concerns. The total number of soil samples taken was 52, 28 of them – in the territory of the landing forces aerodrome and 24 – in the territory of shooting ranges. In the territory surrounding the aerodrome there are two fields of tactical training. Different kinds of activities are taking place there, starting with the armoured cars riding, shooting, and finishing with the mine explosion. Shooting ranges are the territories with the specific way of use. Only shooting practises are taking place there, but with a very high intensity – sometimes shooting practises lasts for more than 8 hours a day. At the present moment cartridge-cases after the shooting are picked up, but long years before that they were left in the ground, and still in the topsoil you can find reduced rest from the cartridge cases that were used. This fact makes the thought about the soil pollution by lead, copper and zinc very likely. With the aim to determine the intensity of pollution with the less possibility of mistakes, the soil samples were taken from the topsoil, i.e. not deeper than 20cm. The samples were taken using the

principle of the “envelope” (2). The heavy metals concentration in soil samples were determined using the method of atomic absorption spektrometry (2).

Results and discussion

As it was mentioned before, the topsoil of the II tactical field is much more damaged than the topsoil of the first one. The results of the SOM investigation confirmed such proposition (They are described in Figure 1). The medium mass of SOM in the samples (with the weight of 200g) taken in the II Tactical field (“Sahara desert”) was 0,92g (that makes only 0,46%), and in the samples, taken in the I Tactical field – 6,99g (that makes 3,49%). The minimum value of the SOM quantity was 0,19g (it makes only 0,095%) and it was determined in the soil of II Tactical field. The maximum value of SOM in soil found in the samples from the II Tactical field was 4,52g, but still it was even 64% less than medium mass of SOM in the soil of the I Tactical field. There were only two spots, where determined mass of the SOM in soil were bigger than 1,88g. Other concentrations determined were very similar, in most samples reaching not more than 0,65g. The minimum value of SOM determined in the 1st Tactical field was 1,18g, and the maximum – 23,36g (in the samples with the weight of 200g). Even though the medium SOM mass in the soil samples taken from the I Tactical field was bigger than taken in II Tactical field ones, it was still 66% less than in the soil of pinewood, and even 95% less than in the soil of the mixed forest – it is seen in Figure 1. The mass of SOM in the soil samples taken from the II Tactical field differs from the medium mass of SOM in the pinewood soil by 95%, and from the SOM mass in samples from the mixed forest – even 99%. It shows that the fertile soil in this field is absolutely damaged.

Figure 1: Quantities of SOM in the diferent types of soils - damaged and not by the military activities



The investigation was performed taking into consideration lead, copper and zinc concentrations in soil. The results showed that concentrations of both zinc and copper in the soils of investigated fields do not exceed the background concentrations. As it is shown in the Figure 3, background concentration of zinc, typical for the soils of area in which Gaiziunai firing ground takes place, is equal 35mg/kg, while the medium concentration determined was equal 4,6mg/kg in the soil of aerodrome and 3,55 mg/kg in the soil of shooting ranges. The specific features of soil can explain such a big difference, because usually it is noticed, that sandy soils can be described with less concentration of heavy metals.

Figure 2: Distribution of lead (Pb) concentrations in the territory of the Gaiziunai firing grounds shooting ranges

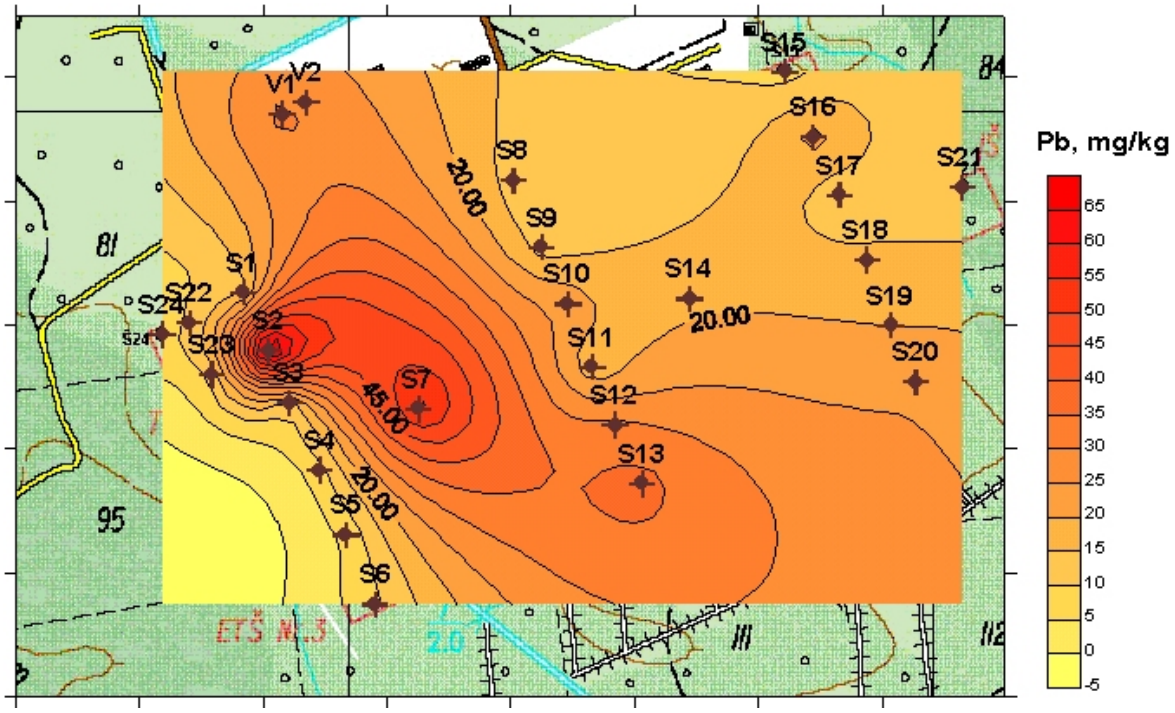
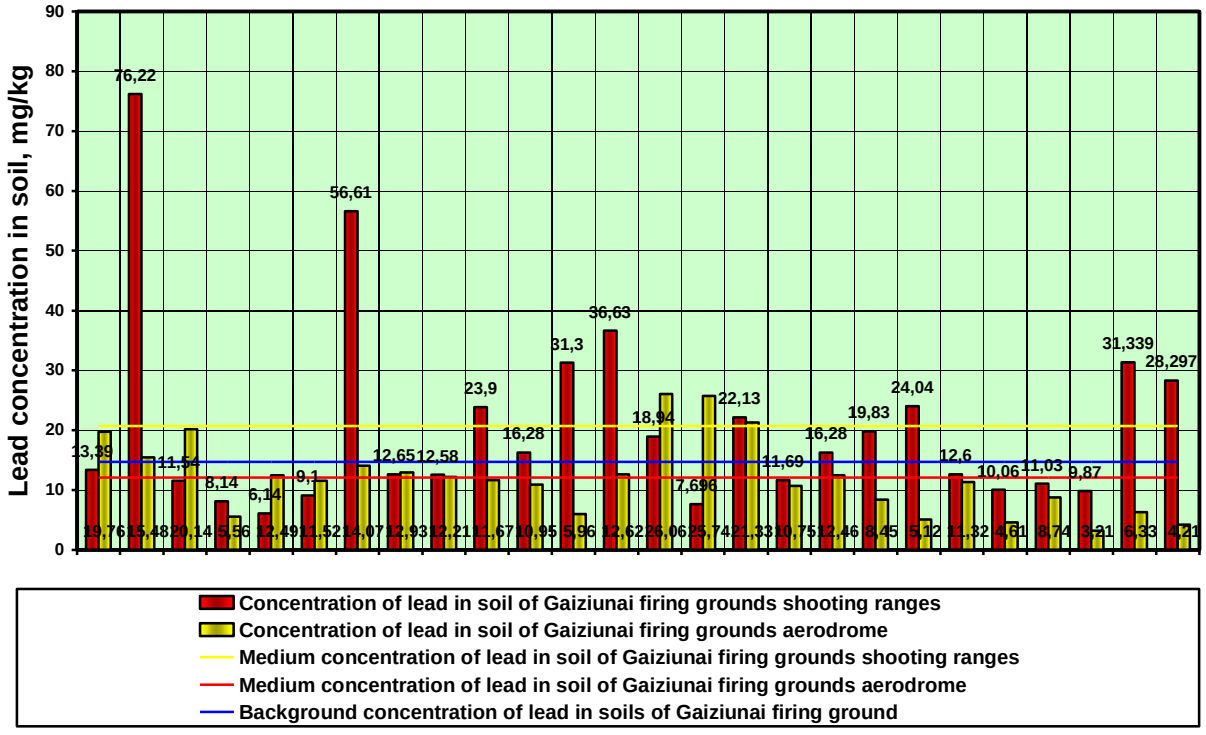


Figure 3: Lead concentrations in soils of Gaiziunai firing ground



Background concentration of copper in soils of Gaiziunai firing ground is equal 11,5 mg/kg, while the medium determined concentration in soil of aerodrome reached only 2,28 mg/kg, and 3,19 mg/kg in soil of shooting ranges. Such a small concentrations of zinc and copper in soil is a proof, that soils of Gaiziunai firing ground are not polluted by mentioned metals. It might be because of specific military equipment used for training, where main component for exploding charges or bullets is lead. And it is seems very likely because of results achieved. The background concentration of lead, typical for the area, is 14,7 mg/kg, The medium concentration of lead, determined in the soil of aerodrome, was 18% less than background concentration. In some spots of both aerodrome and shooting ranges lead concentrations were much higher than background. Maximum concentration determined was equal 26,06 mg/kg, and it is 43% more than background. As it is shown in the Figure 2, worse situation appears to be in the soil of shooting ranges. In this field even medium determined lead concentration exceeds background 27%, and the maximum value (which is equal 76,22 mg/kg) is 80% higher than background. It can be explained by the fact, that shooting ranges in Gaiziunai firing ground are the most frequently used territories.

Conclusions

Intensive land using for military purposes makes direct influence on physical and chemical soil features, irreversibly damaging it in most cases. During a long period of land using for military purposes, the level of damage in some spots has reached the maximum value - the topsoil was damaged physically and polluted by the heavy metals and other chemical pollutants.

The negative impact of explosions, made to the topsoil, can be characterised by their physical (destruction of soil structure, loss of fertile soil mass), thermal (the heat of explosions burns out the top layer of soil, which is rich by organic debris) and chemical (soil pollution by remnants of explosive materials (like TNT,RDX, etc.) and heavy metals, that are present in the composition of the explosive charges) influence.

The results of the investigation, which was performed in the shooting range of Gaiziunai in Lithuania, showed the biggest mass of SOM in the soils of mixed forest (147,08 g in the samples with the mass of 200g), less quantity of SOM was found in the soil of pinewood (20,71g). In the soil of II tactical field medium mass of SOM was only 0,92g, and it shows the biggest damage made to this territory. In the soil of I tactical field SOM mass was bigger (6,99g) showing the less damage. Comparing the results achieved, it can be concluded, that the topsoil of both tactical fields in Gaiziunai firing ground are severely damaged: the quantity of SOM in the soil samples taken from the 1st tactical field were 66% less than in the soil of pinewood, and even 95% less than in the soil of the mixed forest. The mass of SOM in the soil samples taken from the II Tactical field differs from the medium mass of SOM in the pinewood soil by 95%, and from the SOM mass in samples from the mixed forest – even 99%. It shows that the fertile soil in this field is absolutely damaged.

Results of the investigation performed in the territory of aerodrome and shooting ranges showed that concentrations of zinc and copper are not higher than background. Medium concentrations of lead in soil of the shooting ranges of Gaiziunai firing ground exceeds background, in some spots even twice and more. It shows a danger of further pollution and in a case of cumulating lead in soil, the groundwater can be polluted. So it is necessary to monitor the level of pollution and to clean the soil of shooting ranges.

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