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Soil Surface Pollution with Heavy Metals Caused by Coal-Fired Boilers

Jolita Braduliene[1], Ieva Sveikauskaite[2]

[1, 2]Environmental protection departmnemt, Vilnius Gediminas Technical University, Vilnius, Lithuania
E-mails: [1]jolita.braduliene@vgtu.lt (corresponding author); [2]ieva.sveikauskaite@stud.vgtu.lt

Abstract. One of the goals for environmental experts is to help avoid, prevent or reduce harmful effects on human health and the environment as a whole. The idea is that the public and the polluting companies would be informed of the effects of pollutants on humans, flora and fauna. To realize this goal are carrying out environmental monitoring, investigations and analysed the results.

The aim of this work is to evaluate JSC „Nemencines komunalininkas“ boiler-No. 9 resulting air pollution. Company is located in Vilnius region. The focus is on long-term emissions, e.g. heavy metals (HM), the accumulation on the soil surface to examine boiler-No. 9 impact on the area and assessing the long-term impact on ambient air quality. Soil samples was taken by the principle of the envelope in 11 selected locations 50–300 meters around the boiler area, using non-colour, non-grease, stainless steel tools. Examination of heavy metals in the soil solution, to get the actual data on the amount of HM and their distribution in the soil around the coal-fired boiler territory. Pollutants into the environment, exposure depends on many physical and geochemical processes. Environmental pollutants distribution describes not only the various environmental processes, physical and chemical properties of materials but also the weather conditions. Carryover assessed the prevailing wind direction, as well as simulated through forecast of the largest concentrations of locations. To assess of the boiler No. 9 environmental impact of selected air pollutants was choose in long-term storage medium (soil).

Keywords: heavy metals, soil, boiler, coal.

Conference topic: Environmental protection.

Introduction

With regard to environmental pollution so far mostly meant for air and water pollution, unfairly forgetting soil. The soil is a major industry, transport, agriculture and utility emissions of toxic pollutants on human health and waste accumulator, which has its most important environmental “filter” function. Accumulation of heavy metals in the soil is a global problem that affects most of the ecosystem.

In recent years, interest in the pollution with heavy metals is increasing, because the increase in their concentration in the soil, proved population of poisoning and even death facts. Polluted air can be carried away many kilometres away from the original source of pollution due to air fluxes and affect neighbouring countries the atmosphere and soil, when deposited and absorbed into the ground (Goodarzi *et al.* 2008).

Industrial and energy companies as well as the use of fertilizers in agriculture are the biggest polluters of soil. Contaminants in the soil fall with precipitation, industry dust, motor exhaust gases and the like (Baltrėnas, Klaiugienė 2003; Baltrėnas *et al*. 2003). Migration of pollutants in the atmosphere depends on the characteristics of the transfer process in the field and a number of meteorological factors: wind, the global atmospheric circulation, pressure, local weather conditions, etc. (Rutkovienė, Sabiene 2008). Air flows, and thus the emission distribution, significantly influenced by the peculiarities of the terrain (mountains and valleys), as well as buildings and forests. In this way, a wider barrier formed vortices, so-called aerodynamic shadow with a short-term high concentrations (Mecklenburg County ... 2014).

Heavy metals (cadmium, lead, chromium, copper, zinc) are emitted with atmospheric pollution, particularly from thermal power plants. Heavy metals are very durable and partaking in the environment do not break down and accumulate in the soil organisms, plants, which we then eat, the water bodies. Moreover, plant protection products not only protects the crops, vegetables, but also adversely affects other crops, killed many beneficial organisms (Dellinger *et al.* 2000). Heavy metal accumulation in similar soils is caused by many factors: the distance from the road, distance from the industrial facility, the prevailing wind direction, terrain, vegetation, and so on (Brigden, Santillo 2002a, 2002b). It was found that HM mobility hierarchy is as follows: Pb> Co> Ni> Cu> Zn> Cr, and found that 10% and 50–70% Cr and Pb levels are potentially lively form (Sipos 2004). It is observed that most affect the migration of SM soil acidity - alkalinity, pH is defined size, soil texture, clay and organic matter content of manganese and iron oxides (Rieuwerts *et al.* 1998; Wilcke 2000).

The industrial giant, to produce energy by burning fossil material such as lignite, has left as waste ashes in landfills around the plants, has released tons of all as polluting particles in the air, the residual in the soil, so these are indicators that the impact of heavy metals in the environment; air, surface water and soil, is more than evident (Korca *et al.* 2016; Krasniqi *et al.* 2016).

The aim of this work is to evaluate JSC "Nemencines komunalininkas" boiler-No. 9 resulting soil pollution by the air pollution.

Sampling points

JSC "Nemencines komunalininkas" boiler No. 9 is located in the district of Vilnius. Bezdoniai village community garden is located in 100–150 meters from territory of company. Company's territory is located in not less than 500 meters from the local roads, in wooded plains area. Thus, the additional influence of road transport emissions and dust has been not raised.

Sampling sites were established in 3 different ways:

- modelled particulate matter concentration location by program AERMOD view. Accordance with the simulated data were selected 3 sampling zone, where particulate matter concentrations were as follows: Zone 1 – the biggest (~1.13 g/m^3); Zone 2 – the average (~0.68 g/m^3); Zone 3 – the lowest (~0.64 g/m^3) (Fig. 1);
- under Wind rose (Fig. 2);
- under the direction of the world (N, E, S, W) (Fig. 3).

Fig. 1. Sample points under simulated air pollutants in ambient air

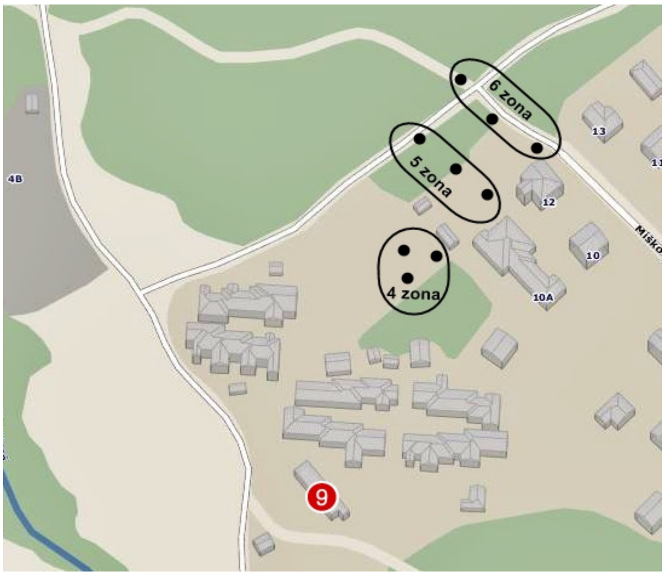

Fig. 2. Sample points in accordance with prevailing winds (wind rose)

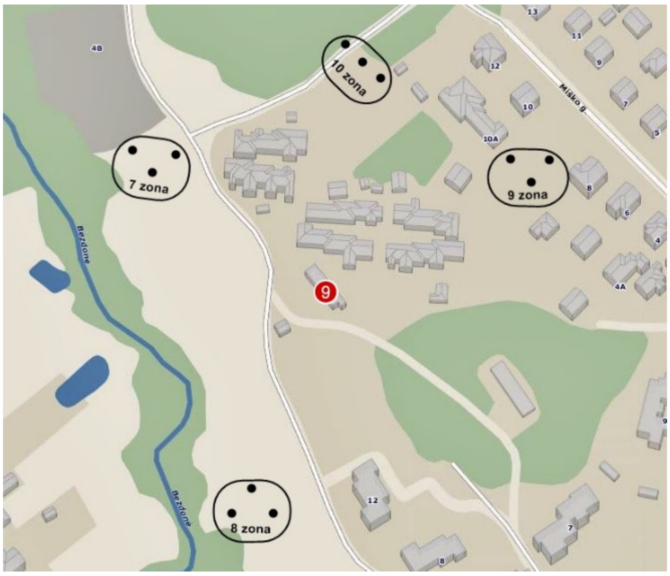

Fig. 3. Sample points under the direction of the world (N, E, S, W)

Control samples (11 Zone) were taken at 1500 meters from the source of contamination in a westerly direction.

Identified sample place divided into 11 separate zones.

Soil samples were taken at 0-10 cm depth according LST ISO 10381-1:2005 Soil quality. Sampling. Part 1: Guidance on the design of sampling programmes (idt ISO 10381:2002) and LST ISO 10381-2:2005-12 Soil quality. Sampling. Part 2: Guidance on sampling techniques (idt ISO 10381-2:2002).

HM in soil samples were determine according LST ISO 11047:2004 Soil quality. Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc in aqua regia extracts of soil. Flame and electrothermal atomic absorption spectrometric methods (idt ISO 11047:1998).

Results

Soil pH was determined in Samples. pH was equal to 4. The sampling of soil consists of two components: a sandy loam and sand.

HM concentration caused by boiler distribution activity in the soil, mg/kg

It was taken control sample of the soil in order to evaluate soil background contamination with heavy metals. The investigations point was behind 1.5 km from analysed boiler. Soil type was as what surrounds company's territory soil (sandy loam and sand).

From the common soil contamination with heavy metals concentrations results in that territory were taken away the control sample concentrations of heavy metals results, assuming that the results indicate the precise quantities of heavy metals affect the boiler room areas, e.g. the concentration will treat the concentration resulting solely on boiler room influences.

In the soil samples were determined these heavy metals: zinc and copper.

Limit contamination of soil with zinc and copper values according to Lithuanian legislation are shown in Table 1.

Table 1. Limit contamination of soil with zinc and copper values according to Lithuanian legislation

Heavy metal	The maximum allowable concentration (MAC), mg/kg	Background chemical substance, mg/kg	
		sand and sandy loam soil	loam and clay soils
zinc (Zn)	300	26	36
copper (Cu)	100	8.1	11

Boiler emissions of copper and zinc in the soil presented in Figures 4 and 5.

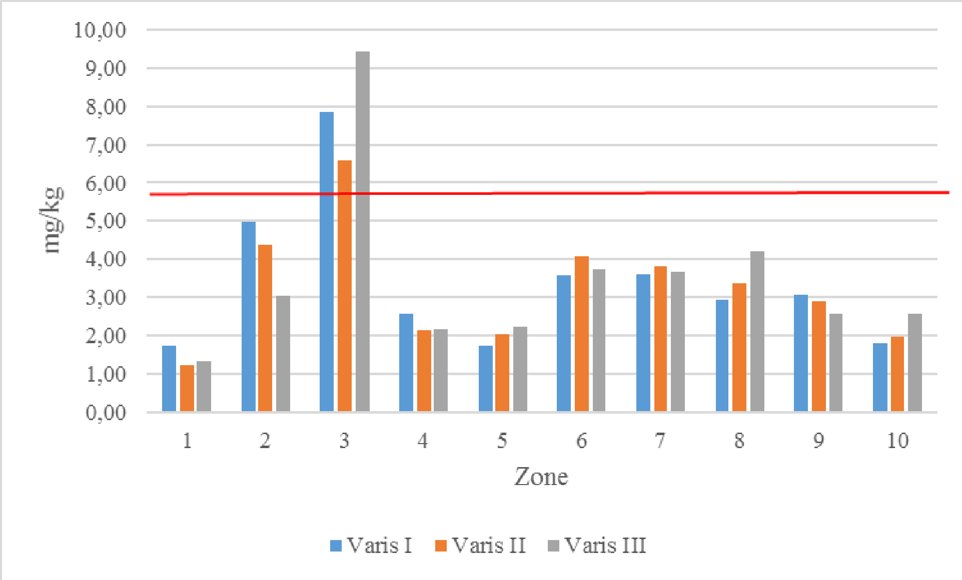

Fig. 4. Boiler pollution concentration of copper in the soil

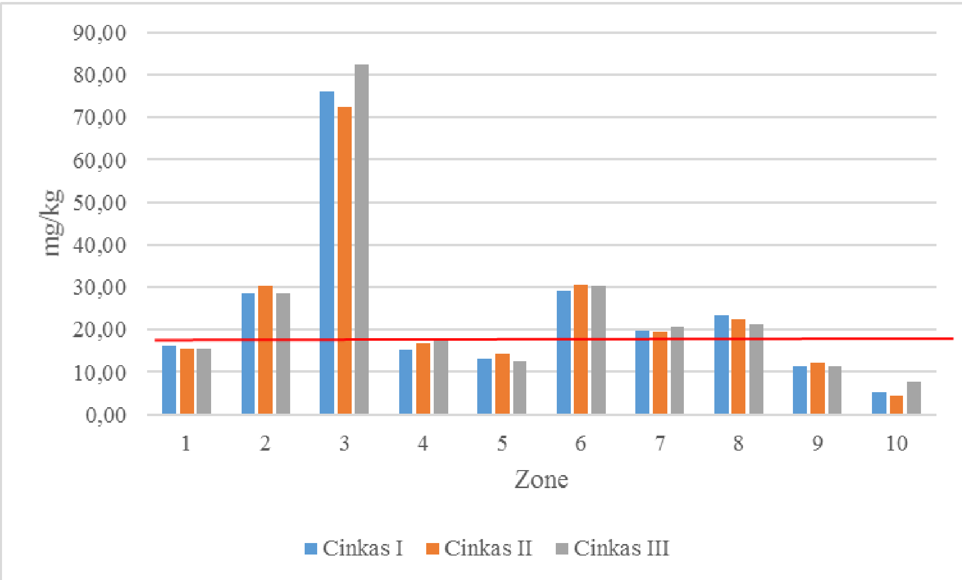

Fig. 5. Boiler pollution concentration of zinc in the soil

The highest concentrations of both zinc (82.37 mg/kg) and copper (9.41 mg/kg) was determined in zone 3. This area was chosen having relied obtained ground-level concentrations of particulate matter modelling results, particularly in the area of PM concentration is relatively high, in addition to this limited area remote from zone 1, which simulation has been set to the most polluted particulates.

The lowest concentrations of zinc (11.24 mg/kg) was determined in the zone 10. This zone was choose by the direction of the prevailing winds, but greatly removed from the boiler territory (~300 meters).

The lowest concentration of copper (1.23 mg/kg) was determined in zone 1, which was found in modelling support, where ground-level particulate matter concentrations were highest. We conclude that the boiler does not seriously affect the overall heavy metal pollution in the soil.

HM concentration in snow mineral dust and soil solution, mg/l

Results of HN concentration in snow mineral dust was published in article of Sveikauskaitė and Braduliene (2016). In this paper is compared previously results of HM in snow mineral dust and new result of HM in soil solution (Fig. 6).

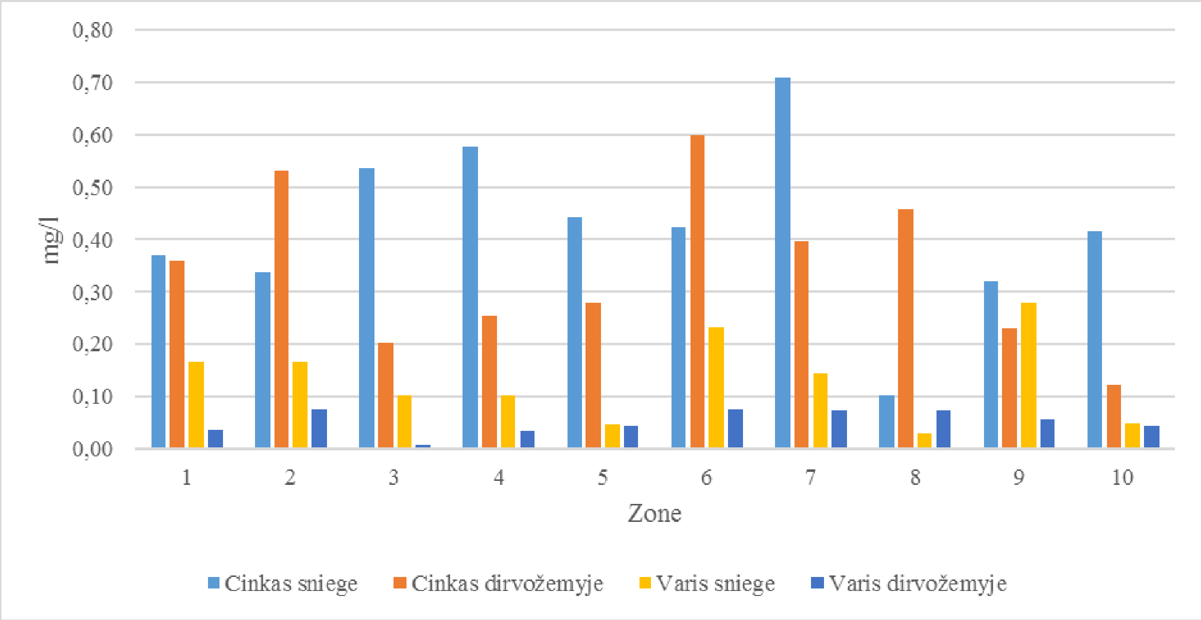

Fig. 6. Zinc and copper concentration distribution of soil and snow solutions in different areas

As can be seen from the graph (Fig. 6), almost in all cases higher concentrations of heavy metals were found in snow mineral dust than later in the same places in soil solution. Zinc concentration was 1.75 times higher in snow mineral dust than the concentration in soil solution from sampler taken in zone 7.

However, 2, 6 and 8 zones zinc in soil considerably higher, respectively 1.6, 1.4 and 4.8 times. As expected, the HM (zinc) concentration in the soil solution is higher according to the prevailing wind direction (NE), but the unexpected results (the highest concentration) found in samples, taken the windward zone (Zone 8). It is likely that the pollution could start to accumulate much earlier or pollutants were to carry long-range.

Copper case in all samples the concentration of copper found higher in snow dust than in soil solution. Only samplers from zone 8 give the opposite: copper concentration in the soil solution was 4 times higher than the concentration in snow dust in this place.

It happens due to the migration of heavy metals in soil layers which are poor draining, heavy metals could penetrate deeper or have been washed away during the storm. In addition, there was found clay impurities in soil samples, and can be explained by the heavy metals retention in the soil layer.

Conclusions

1. Wind rose and computer modelling determined the boiler in the Bezdonys village (Vilnius area) area of influence confirmed. It can be argued that it is the prevailing winds carry the particulates to specific locations. On the other meteorological factors accumulate heavy metals and other north-western area of influence locations.
2. The lowest concentration of copper (1.23 mg/kg) was determined in zone 1, which was found in modelling support, where ground-level particulate matter concentrations were highest. We conclude that the boiler does not seriously affect the pollution in the soil by cooper.
3. The lowest concentration of zinc (5.1 mg/kg) was determined in zone 10, which was found under the direction of the world (N). North wind direction is one of the most frequent winds. We conclude that the boiler affect the pollution in the soil by zinc.

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