U.P.B. Sci. Bull., Series B, Vol. 77, Iss. 2, 2015 ISSN 1454 – 2331

SOIL QUALITY VARIATION IN A CEMENT PLANT IN ROMANIA

Elena HOLBAN[1], Elena DIACU [2], Vasilica DĂESCU[3]

The yearly variation of the soil quality for the samples collected from four important points of a cement plant and from Hamzoia village situated near the plant, during 2006 – 2013 period is assessed. The samples were collected during eight years from the four following sampling points: fuel deposit, landfill, general evacuation and village. The analyzed parameters for soil were: pH, conductivity, cadmium, copper, chromium, nickel, lead, zinc, manganese and petroleum products content. The concentration level of heavy metals in soil has indicated that the cement industry together with the traffic emissions were mainly responsible for metal pollution in that respective area.

Keywords: physical and chemical parameters, soil quality, cement factory, heavy metals, petroleum products

1. Introduction

Sustainable development involves the ensuring of equilibrium between growth, preservation and reconstruction of the natural landscape, meant to ensure a harmonious development, able to meet both actual and prospective requirements.

The soil, as well as air and water, are environmental factors with great influence on health. The formation and protection of surface water sources and especially those underground waters depends on soil quality. Soil is the meeting place of pollutants.

One of the challenges we have to face is particulate matter deposition on soil, which represents an important source of soil pollution with heavy metals [1].

The pollutant particles from air and toxic gases, dissolved by rain in the atmosphere return into the soil.

Infiltration waters impregnate the soil with pollutants that will be carried to the depths, and the polluted rivers will infect flooded or irrigated areas. The

[1] PhD Student, Faculty of Applied Chemistry and Materials Science, University POLITEHNICA of Bucharest, National Research and Development Institute for Environmental Protection, Bucharest, Romania, e-mail: holban.elena@yahoo.com

[2] Professor, Faculty of Applied Chemistry and Materials Science, University POLITEHNICA of Bucharest, Romania, e-mail: elena_diacu@yahoo.co.uk

[3] Scientific Counselor, National Research and Development Institute for Environmental Protection, Bucharest, Romania, e-mail: vasilica_daescu@yahoo.com

natural environment pollution with heavy metals is a worldwide problem, because these metals are indestructible and most of them have toxic effects on living organisms [2, 3].

All heavy metals are largely immobile in the soil systems, thus they tend to accumulate and persist in soil for a long time [2]. The most frequently reported heavy metals in soil are cadmium, chromium, lead, zinc and copper [2, 4]. There is an increased awareness that the heavy metals which are present in the soil can have negative consequences on human health and on the environment [2,5]. Different industrial activities have a negative impact on the various environmental components like water, air, soil and vegetation [6-11].

In the environment numerous chemical compounds arose from both natural and anthropogenic sources and they exert toxic effect to living beings, to biological systems [12].

Due to its technology, the construction materials industry releases a large amount of pollutants which influence the quality and soil functions.

The cement industry is one of the 17 more polluted industries, listed by the central pollution control board. It is the major source of particulate matter, SOx, NOx and CO emissions [6]. In this advanced and modern world, the cement industry is involved in structures development. The cement is the basic concrete ingredient used in constructing of modern buildings and structures [6].

Cement industry has been involved for the last decades in the co-processing of wastes resulting from other industries, as a priority in its effort toward a responsible management of non-renewable resources [13].

In cement industry, the emissions and imissions of the soil can result from:

- household waste storage and those resulting from the production process;
- transportation and storage of fuels (gasoline, diesel, fuel oil) and oils;
- deposition of particulate matter on the soil, as a result of the production process, without taking measures to prevent this (installation of filters, etc.);
- the transport and handling of raw materials and the road transport.

Cement dust contains heavy metals like chromium, nickel, cobalt, lead and mercury, pollutants hazardous to the biotic environment with impact for vegetation, human health, animal health and ecosystem [6, 14]. The physical and chemical characteristics of a soil site are strongly governed by the pH. The conductivity is also a good indicator of soil quality [15]. These soil properties and the heavy metals content are important for monitoring the environmental pollution related to cement industry [15].

2. Experimental

In order to quantify the generated impact of the analyzed cement factory activities on the soil quality in the period 2006-2013, soil samples from four important points of the factory perimeter and from the village situated near the factory were collected. The soils specimens were collected from different locations (general evacuation, fuel deposit, village and landfill), presented in Fig. 1.

Fig. 1. Sampling locations of the soil specimens

2.1. Materials and methods

In the period ranging between years 2006-2013, a total number of 32 soil samples were collected. The specimens were sampled from 5 cm depth, using a sampler. The sampler was cleaned after each sample specimen to prevent accidental contamination due to the previous chemical species that can interfere in the determination. The sampling operations were performed according to standard methods for soil evaluation [16], and the results were interpreted in accordance with the legislation in force for soil quality [17]. After sampling, the soil samples were transferred in new plastic labeled bags. All samples were collected in the absence of groundwater.

Before analyses, soil samples were subjected to preliminary operations such as: drying, removing of gravel and residual plant, shredding and sieving through sieves with mesh of 2 mm, and stored in closed plastic containers.

For chemical and physical analysis, the conductivity and soil pH was determined according to SR ISO 10390/2005 [18] standard method, using a SenTix41 pH-meter and the TetraCon325 conductometer, of the Multi 340i Set electrochemical analyzer.

The soil specimens were digested with aqua regia (HNO_3: HCl =1:3) and the total concentration of the heavy metals were analyzed by the atomic emission spectroscopy method, using the AAS SPECTRA A250+ VARIAN device. The petroleum products were determined by IR spectrometry method, using the Spekord M80 device. In the Table 1 are presented the physicochemical parameters determined through the performed analyses.

Table 1.

List of determined physico-chemical parameters and their test methods

No. crt.	Parameters	Unit	Test methods
1.	pH	pH unit.	ISO 10390/2005
2.	Conductivity	µS/cm	SR ISO 11265/1998
3.	Cadmium	mg/kg d.s.	
4.	Copper	mg/kg d.s.	
5.	Chromium	mg/kg d.s.	
6.	Nickel	mg/kg d.s.	SR ISO 11048/1999
7.	Lead	mg/kg d.s.	
8.	Zinc	mg/kg d.s.	
9.	Manganese	mg/kg d.s.	
10.	Petroleum products	mg/kg d.s.	SR 13511/2007

3. Results and Discussion

The pH and electrical conductivity values assessed during the period 2006 -2013 on the soils sampled from cement plant area and from the village situated near the factory were represented in Figures 2 and 3. During the entire monitoring period, the soils pH level ranged in a narrow interval (6.4 to 7.1), which suggest low acid to neutral conditions for all soil samples. However, low acid pH levels recorded in cement plant area which includes the three sampling points (fuel deposit, the landfill and near general evacuation) would not affect the plants growth conditions [15-20]. In the same time, the electrical conductivity evolution of the soils collected from the fuel deposit and landfill points show an increasing trend (from 350-450 µS/cm in 2006 to approx. 500 µS/cm in 2013), and for those collected from the village and near general evacuation points, a decreasing trend (from 700-850 µS/cm in 2006 to approx. 550-600 µS/cm in 2013).

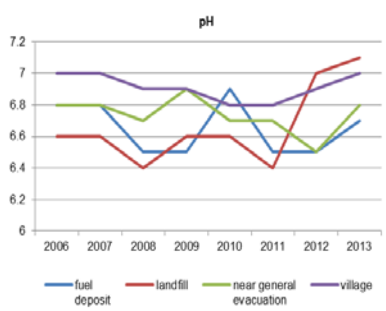


Fig. 2. Annual evolution of soil pH for cement plant area

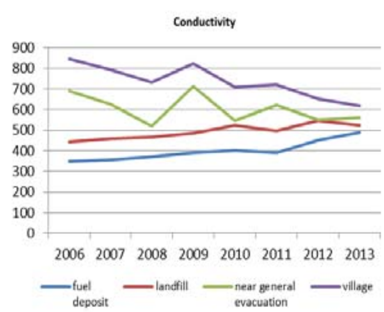
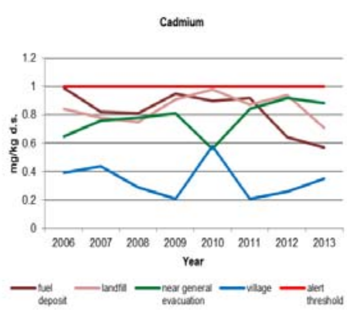


Fig. 3. Annual evolution of electrical conductivity for cement plant area

The heavy metals concentration in the soil samples and the corresponding warning threshold (according to 756/1997 Order) are presented in Fig. 4. For the studied area, cadmium, chromium and manganese concentration in the samples are under warning threshold (Fig. 4a, 4b and 4c), the lowest values corresponding to the village area (0.21 mg cadmium/kg d.s. in the years 2009 and 2011). The lead and nickel concentration registered during the monitoring period are generally over the warning threshold, with a maximum value of 41.9 mg lead/kg d.s. in 2010, and 33.8 mg nickel/kg d.s. in 2013 (Fig. 4c and 4d). Lead is a metal with high volatility. Its presence into environment can be explained by using the traditional or alternative fuel and secondary materials (fly ash or granulated furnace slag) with lead content, at the cement processing.

Copper concentration of the soil specimen, sampled from the landfill, exceed the warning threshold (25.8 mg/kg) in years 2010 and 2012 (Fig. 4e). The zinc concentration of the soil samples, collected from the fuel deposit, exceed the warning threshold (152 mg/kg d.s.) for all studied period (Fig. 4f), but it has a tendency of mitigation in soil; thus, between years 2012 and 2013, its measured concentrations do not exceed the warning threshold. Other researches have noticed that the area near the cement plant has the highest lead, zinc and cadmium levels [19].

Arpita and Mitko [20] reported that the top soils near the cement plant are enriched in lead, zinc, chromium, cadmium, mercury and vanadium issued from the cement kilns. This phenomenon happened due to rainfall which carried in soil the heavy metal emissions.



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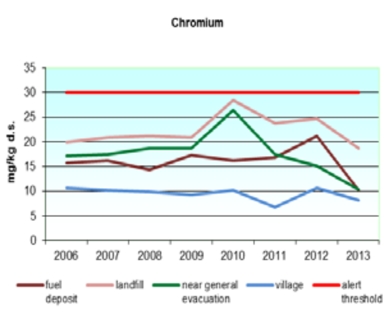

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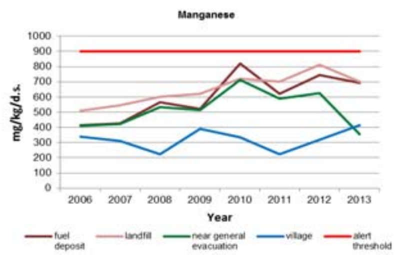

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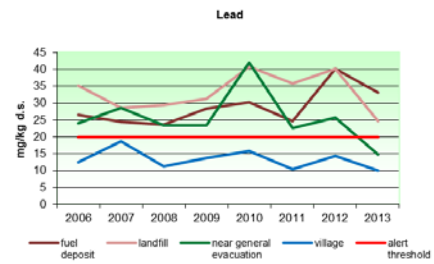

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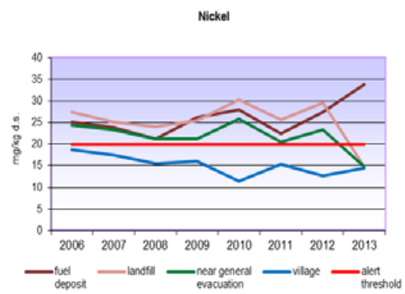

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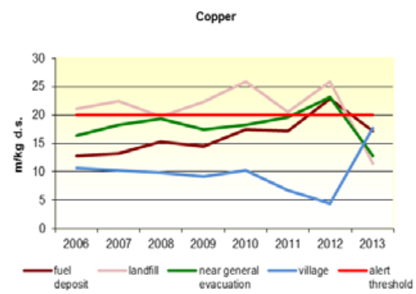

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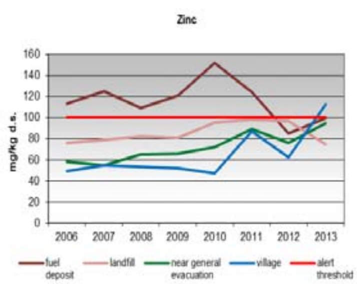

g

Fig. 4. Annual evolution of heavy metals concentrations in the soils for cement plant area a) cadmim; b) cromium; c) manganese; d) copper; e) nickel; f) lead; g) zinc

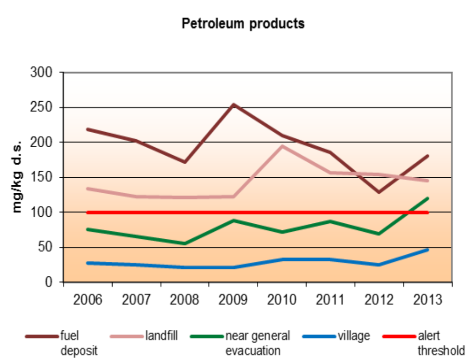

Fig. 5. Annual evolution of petroleum products concentration in soil for cement plant area

The concentration of the petroleum products overpasses the warning threshold during the monitoring period in case of fuel deposit and landfill sampling points (Fig. 5). This behavior was expected, because these pollutants are components of the combustion fuel.

For the specimens sampled in the village area, the heavy metals and petroleum products concentration do not exceed the warning threshold (Figs. 4 and 5).

6. Conclusions

This paper presents the results of soil monitoring during 2006 – 2013 period for the following quality parameters: pH, electrical conductivity and major pollutant content in soil samples from four major points of a cement plant area, and from a village situated near the respective plant. The pH was slightly acidic to neutral, being suitable for growing plants. The obtained results indicate that the cement plant area has been affected by the anthropogenic activity developed in this industrial zone. This lead to a high heavy metals accumulation in soils near the factory, in comparison with soils from the village area.

In the village area, the concentration of all heavy metals and petroleum products do not exceed the warning threshold and, consequently, the soil quality is not affected by the industrial activities. Therefore, the cement plant together with the traffic emissions is mainly responsible for the soil pollution with heavy metals in the factory area.

The novelty of this work consists in monitoring soil quality inside a cement factory over a period of seven years. This monitoring will continue over the next few years.

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