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Comparative leaching tests of different types of wastes

Anda-Gabriela Tenea, Alexandru-Paul Rus, Gabriela-Geanina Vasile, Cristina Dinu, Ana-Ioana Paris*

National Research and Development Institute for Industrial Ecology-ECOIND, Pollution Control Departament, Drumul Podu Dambovitei Street 57-73, 060652, Bucharest, Romania

* E-mail: rus.alexpaul@yahoo.com

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Abstract:
The experimental study aimed at an extensive study of different waste matrices (soil mixed with coal, coke, petroleum coke, ash, polluted industrial soil) and sludge from the perspective of the leaching of certain toxic metals, in order to allow a comparison between the obtained values and the requirements of the legislation. Additionally, the in-house topic aimed to create a documented study regarding the differences in metal leaching at different liquid-to-solid volume-to-mass ratios.

Keywords: leaching tests (L1:10; L1:2), solid matrices, soil, waste, sewage sludge, ash, coke

1. INTRODUCTION

The pollution generated by the leaching of pollutants from polluted industrial soils is one of the most important problems facing the world today. This problem affects negatively the economic society and people's everyday life [1]. Waste represents material resulting from a technological (or domestic) process of making a certain product, which can no longer be used directly in the production of that product. The wastes can be substances, materials, objects, raw materials from economic, household and consumer activities [2, 3].

The increase in the generation and disposal of solid municipal waste has become a great challenge for society, which leads to serious concerns about the environment and the economy [4, 5].

The lack of industrial waste management, especially in developing countries such as India, has led to serious environmental problems also due to the limited land for waste disposal. The current practice of uncontrolled waste disposal near the industrial areas of the cities creates serious environmental problems, as result of leaching of diverse ions and toxic metals from polluted wastes [6].

The eluate represent the liquid produced when water passes through any type of permeable material. Usually, this eluate can contain dissolved or suspended materials, or both [7, 8].

The leaching tests consist in chemical extraction methods used to determine the concentration of metals in solid wastes, in order to identify and quantify of potentially toxic metals that can be released into the environment in the case of improper wastes storage. The analysis of the leachate indicated if the concentrations of metals in the waste exceed the limits imposed by the in force regulations, in which case additional waste management measures are necessary [9]. Thus, the leachate proves to be an essential method in waste analysis, allowing the evaluation of the potential risk associated with metals / metalloids and contributing to environmental protection measures against the harmful effects of toxic wastes.

2. MATERIALS AND METHODS

2.1. Materials

To achieve the objectives of the study, six types of waste were used: soil mixed with coal, coke, ash, a petroleum coke, industrial soil and a sewage sludge.

Plants subjected to stress with toxic metals were sampled after each month of the experiment, they were subjected to a digestion process in a microwave system (Milestone Ethos Up) in an acidic environment (mixture of HNO_3 and H_2O_2, ultrapure quality reagents).

2.2. Testing methods

Thus, two types of leaching ratios were performed for each type of waste: L 1:2 (g/L) (mass: volume) and L 1:10 (g/L) (mass: volume). The selected wastes for the leaching tests were sieved using a 4 mm sieve, after removing the larger parts. Finally, was resulted a homogeneous solid mass with the same particle size for all analyzed wastes. After sieving, a quantity of solid mass was weighed for each type of waste and was mixed with a specific ultrapure water, in order to respect the leaching ratios of 1:2 (m/V), respectively 1:10 (m/V). The solutions were mixed on a shaker for 24 h at 100 rpm. Finally, the solution was filtered and was analyzed for metal concentrations.

2.3. Analytical methods

An optical emission spectrometer with inductively coupled plasma (ICP-EOS) type AVIO 500, manufactured by Perkin Elmer, was used for the detection and quantification of the metals (As, Ba, Cd, Co, Cr, Cu, Mo, Ni, Pb, Se, Sb and Zn) imposed by the Romanian Legislation [9].

The calibration curves were performed in the range 10÷50 μg/L, respectively 100÷500 μg/L using a multi-element certified reference material (MRC) that contained all the studied metals (MRC ME21, 100 mg/L, Supelco, Germany).

3. RESULTS AND DISCUSSION

3.1. Results

In figure 1 are presented comparative results for all six wastes in both leachates, only for the metals with concentration higher than quantification limits of the applied method.

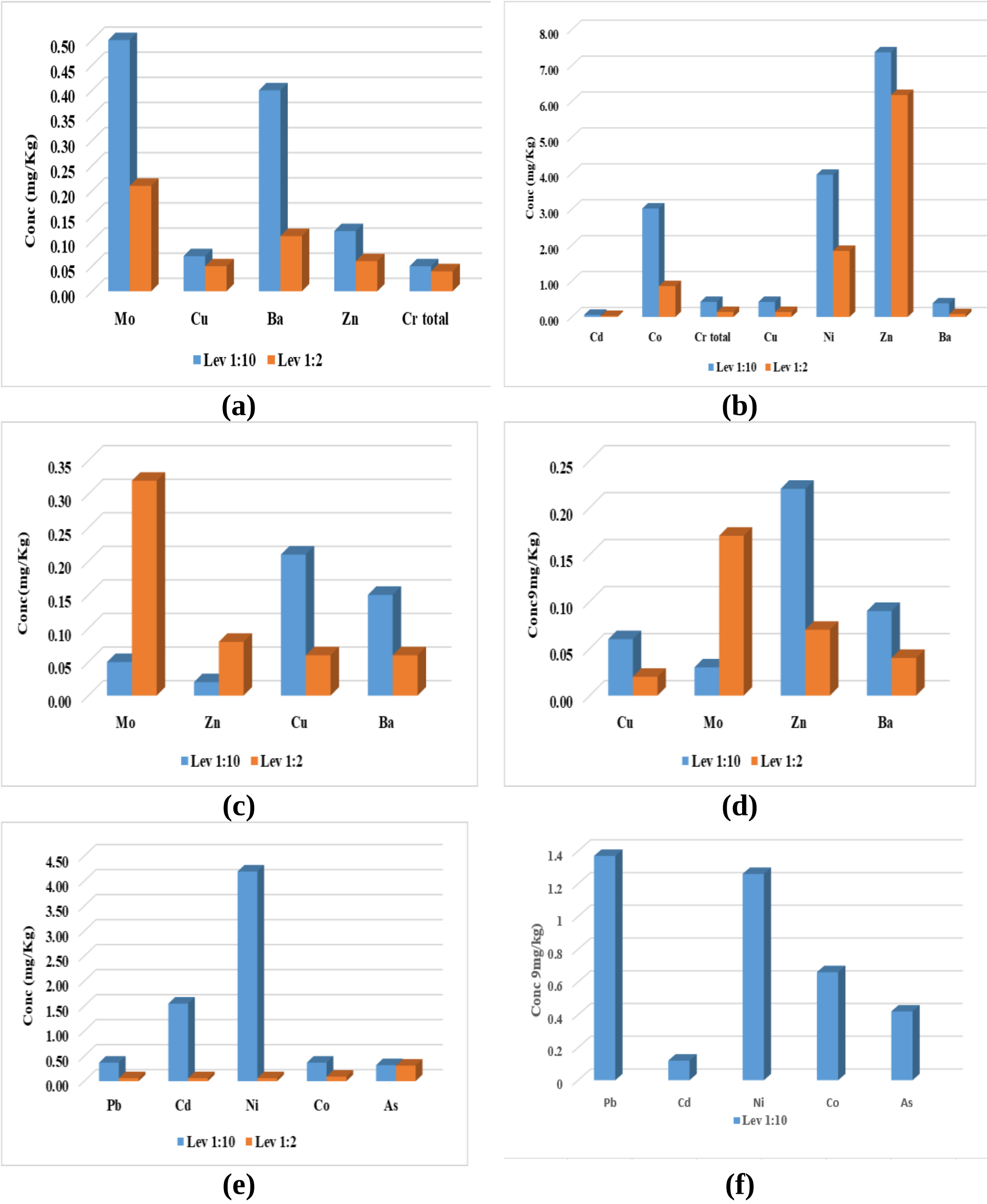

Figure 1. Comparison of the results obtained after the 1:10 (m/V) and 1:2 (m/V) leaching tests for the samples of (a) ash, (b) soil+coal, (c) coke, (d) petroleum coke, (e) polluted industrial soil, (f) sewage sludge

3.2. Discussion

In the case of ash, soil+coal and industrial soil wastes, the results obtained in the 1:10 leaching tests were higher than those obtained in the 1:2 leaching tests. In the case of coke-type wastes, for Mo and Zn the results were lower in the case of the 1:10 (m/V) leaching tests compared to those obtained in the 1:2 (m/V) leaching tests, while the results obtained in the case of Cu and Ba, the results obtained after the 1:10 (m/V) leaching tests were higher compared to those obtained after the 1:2 (m/V) leaching tests. In the case of petroleum coke type waste, the results obtained for Cu, Zn and Ba were higher in the case of the 1:10 (m/V) leaching tests compared to the results obtained in the case of the 1:2 (m/V) leaching tests, unlike the results obtained for Mo, which were higher in the case of the 1:2 (m/V) leaching tests compared to the results obtained in the case of the 1:10 (m/V) leaching tests (Figure 1).

The differences observed in the results of the 1:10 (m/V) and 1:2 (m/V) leaching tests for various types of waste may be explained by variables such as the leaching ratio used, differences in the metal sorption capacity of the waste, as well as potential chemical reactions that have place during the leaching process. In general, when a lower leaching solution ratio is used, the metal concentrations are likely to be higher in the solution because it contains less water for dilution. This can lead to higher concentrations of metals extracted from the waste in the 1:2 (m/V) test results. On the other hand, using a ratio higher than 1:10 (m/V) can dilute the metal concentrations, leading to lower results in certain cases in the leaching solution. However, due to the solid: solution ratio used, reporting results in mg/kg for both tests, may lead to lower results in the case of the leaching test of 1:2 (m/V) compared to 1:10 (m/V).

4. CONCLUSION

The results of the leaching tests allowed the classification of the analyzed waste into distinct categories - inert, non-hazardous or hazardous - depending on the concentrations of the metals analyzed. This classification is essential for the adoption of an appropriate waste management regime.

Proper waste management is essential to protect the environment and public health. The correct identification of waste categories, based on the results of leaching tests, can guide the decisions of authorities and operators in order to adopt appropriate measures for environmental protection.

The comparative analysis of leaching test results for different types of waste underlines the importance of responsible and correct waste management, according to established norms and standards. Knowing and understanding the behavior of metals in the waste matrix is important for protecting the environment and ensuring a healthy environment for the community.

5. ACKNOWLEDGMENTS

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