

Conference Paper

Study of the leaching alterability in Soxhlet Extractor of ceramic materials with incorporation of ashes resulting from the incineration of urban solid waste

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Abstract

Population expansion, especially in metropolitan areas, has led to an increase in the production of urban solid waste (USW) by domestic and commercial activity in urban centres. Reducing the production of these wastes is an extremely difficult task. However, the reduction processes, themselves, have the potential to produce a number of useful residues. This study focuses on the residues of incinerated USW, which produces ashes of varying compositions. This study investigates a mixture of two ashes, one resulting from the incineration of USW from LIPOR II (Intermunicipal Waste Management Service of Porto Region) and another from ValorSul (Valorisation and Treatment of Solid Waste of Lisbon and West Regions), both processed by EcolnCer (Ecological Innovations Ceramics company). Ashes from several samples of USW incorporating clays were tested to identify physical and mechanical characterisations, with a view to identifying useful ecological ceramic materials which could be used by the ceramics industry. Ceramic samples with 0%, 10% and 20% of ashes were incorporated in a clay matrix composed of 5% kaolin and 95% red clay, and submitted to leaching alterability in Soxhlet Extractor. The obtained results demonstrate the ways in which the ash percentage and the firing temperature can be important in the alterability of a ceramic material.

Keywords: Ceramic materials, Leaching, Urban solid waste

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1. Introduction

In order to try to solve the excess of residues, which Man produces on a day basis, a need to take advantage and make them useful for society arises. Thus, the incorporation of ashes resulting from the incineration of urban solid wastes (USW) is intended to reduce their amounts that will have to be landfilled and to provide a substitute for natural raw materials, contributing to the environmental sustainability and making possible the reduction of the manufacturing cost of ceramic material. Energy efficiency in construction materials is one of the major research concerns in the building sector nowadays, aiming to reduce energy consumptions and promote sustainability.

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In order to mitigate this problem, and create an ecological ceramic material, possible to insert in the ceramic industry, it were produced ceramic test samples, with 0, 10 and 20% of ashes incorporated in a clay matrix composed by 5% kaolin and 95% red clay, fired at 900° and 1000°C, and submitted to leaching alterability essays in a Soxhlet Extractor. This test allowed to simulate, in an accelerated way, the effect of the atmospheric precipitation on the ceramic samples, promoting their degradation and the leaching of some of their constituents. The samples were subjected to 6 cycles of leaching, during 1500 hours and, at the end of each cycle, they were weighed and, the solutions filtered and chemically analysed. The results showed that the ash percentage and the firing temperature can be important in the alterability of a ceramic material. Thus, it was found that ceramic material, with the higher percentage of ashes, fired at 1000°C, was the one that obtained a better improvement of its resistance to leaching alterability. In addition, it was also proved that there was no significant change in the concentration of leaching constituents.

Urban solid waste incineration (USWI) reduces the volume of waste by about 90% [1, 2] and its mass by about 70% [3]. Thus, the incorporation of ashes resulting from the incineration of urban solid wastes (USW) is intended to reduce their amounts that will have to be landfilled and to provide a substitute for natural raw materials, contributing to the environmental sustainability and making possible the reduction of the manufacturing cost of ceramic material.

Currently, an average of 2.01 billion tonnes/year of USW is produced and it is estimated that by 2025 these figures will increase to 2.2 billion tonnes/year and by 2050 the world is expected to generate 3.40 billion tons of waste annually, increasing drastically from today's number [4]. According to these data it is possible to predict the negative impacts resulting from the worldwide production of USW. Because there is no solution to mitigate this problem, the authors studied slag-embedded ceramic materials resulting from USW incineration, with the aim of reducing both the volume of waste to be landfilled and the use of natural raw materials used for its manufacture.

2. Materials and Methodology

The clays used in the production of the ceramic specimens belong to the geological formations named "Grés superiores" [5], while the USW are from the LIPOR and Valorsul Portuguese companies.

For the preparation of the specimens, firstly, the grinding and sieving of the red clay and the wrecking of the kaolin were obtained, resulting fractions of less than 250 µm.

Then each raw material was dried at 110 ° C for 24 hours. After cooling the residue, the red clay and the kaolin were weighed in their respective proportions, the mixtures consisting of 0%, 10% and 20% of USW, and the remainder by the clays. From the clay fraction of the mixtures were introduced 5% kaolin and 95% red clay. Then water was added to the mixtures (according to their plasticity) and with the pulp several specimens were produced for each percentage of USW. Trapezoidal samples were made by pressing it in plaster molds, having approximately the following dimensions: larger base 2 cm, smaller base 1.5 cm, height 1 cm and length 12 cm. After unmolding, they were dried at 110 ° C for 24 hours to constant weight and then fired at 900°C and 1000 ° C with a 1 hour plateau. At the end of this step, the specimens were sectioned, weighed and placed in the Soxhlet extractor (Fig.1) and leached with distilled water over 6 cycles for a total of 1500 hours of testing.

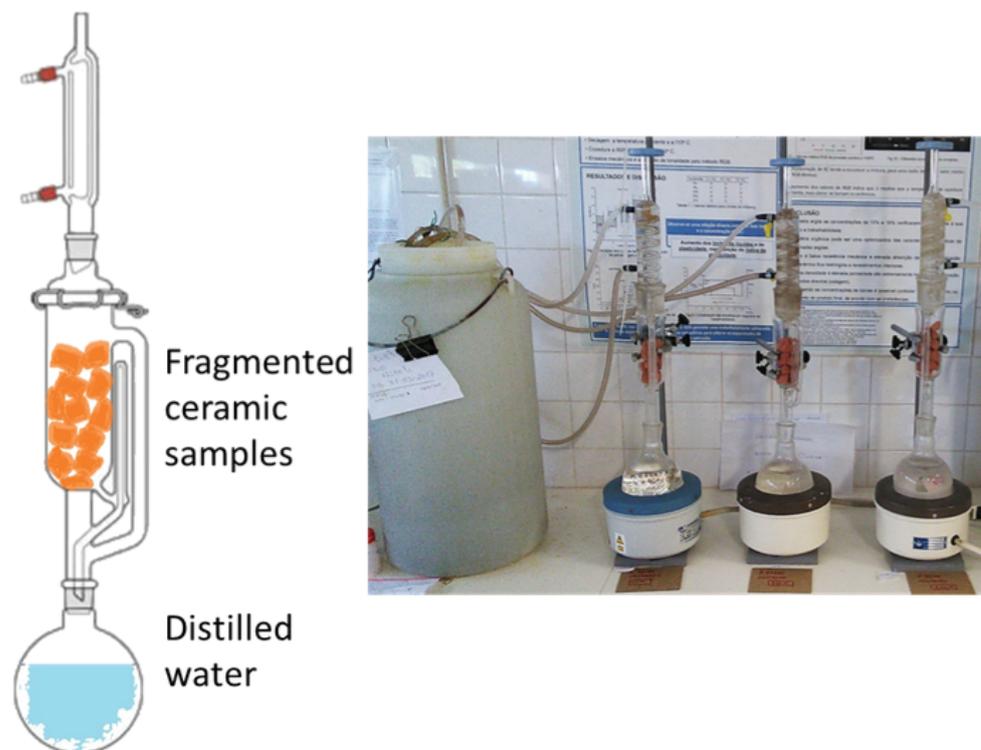


Figure 1: Leaching samples with Soxhlet extractor

At the end of each cycle, the fragments were weighed and the leachate collected, filtered and the solutions analyzed by atomic absorption spectrophotometry (Perkin Elmer AAnalyst 200).

3. Results & Discussion

Based on the results obtained for the weight loss, it was possible to verify that the addition of slag resulted in an increase of the alterability, particularly of the ceramic material fired at 900 °C, with a higher percentage of fine particles that disintegrated and released into the solution, thus decreasing the mass of the test samples (Fig. 2a). Increasing the firing temperature to 1000 °C reduced the alterability of the ceramic material, and lower mass percentages of disintegrated material were recorded after the leaching cycles (Fig. 2b). In the most porous material with 20% slag, there was a total mass loss of 5% and 1.8% for the samples fired at 900 °C and 1000 °C, respectively (Fig. 2a and b).

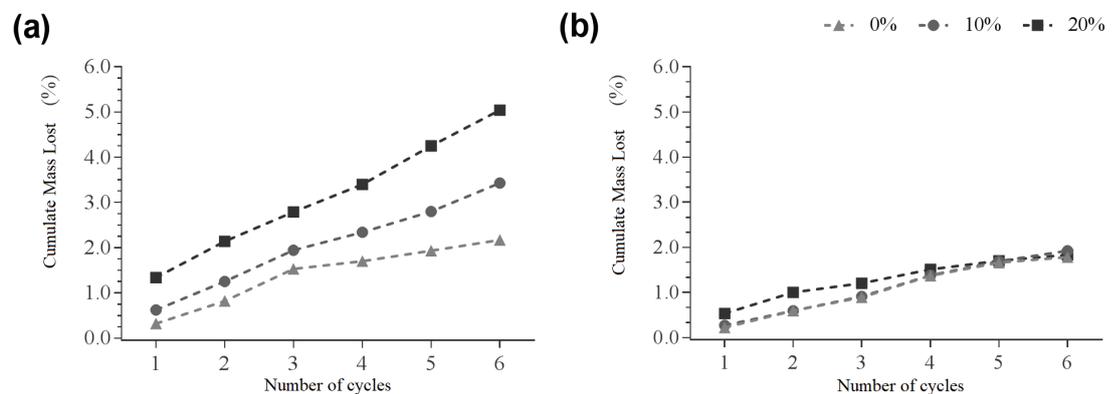


Figure 2: Cumulate mass loss of ceramic fragments produced at (a) 900 °C and (b) 1000 °C, as a function of the percentage of USW per leaching cycle.

There was an improvement of leaching strength of approximately 3,2%. The specimens with 10% slag had a mass loss of 3,4% and 1,9%, corresponding to a gain in strength of 1,5%.

For natural samples with 0% slag, 2,2% and 1,8% of lost material were obtained respectively, representing an improvement of 0,4% (Fig.3).

According to the results of chemical analysis of the water resulting from the leaching cycles (Fig. 4), it was possible to verify that of the studied elements (Si, Al, Mg, Ca, Na, K and Fe) the ones that presented greater mobilization for the leaching solution were Si and K. The increase in fired temperature of the ceramic samples promoted an increase of Al and Si concentrations for 0% and 10% of slag and also of Al for 20% of slag, and a decrease of K for all scenarios and Ca for 0% with 10% slag. Generally, increasing the concentration of elements in the leachate can be considered a negative aspect, however, as the order of magnitude of the concentrations is not significant, acceptable values are considered.

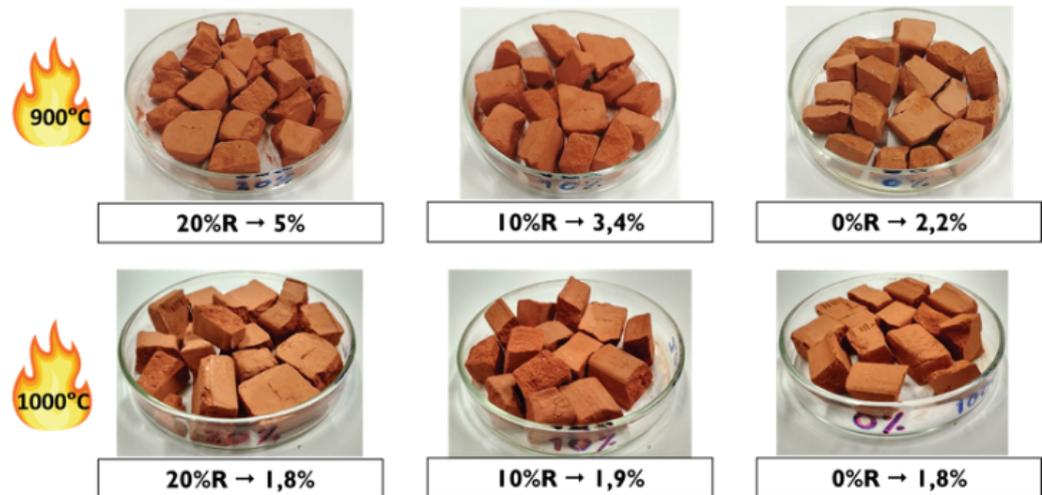


Figure 3: Mass loss after Leaching

4. Conclusions

It was concluded that the increase of the fired temperature made the ceramic samples more resistant to physical/chemical alteration, especially the specimens with 20% slag. Given the results of the chemical analysis of leachate, it was possible to verify that the increase in temperature promoted a slight increase in the concentrations of some of the Major elements analyzed. Nevertheless, the order of magnitude of concentration variation was acceptable, and therefore this increasing in chemical alterability was not considered significant.

The laboratory tests demonstrated that the USW ash can be used as a secondary raw material, and under fixed conditions, it can benefit the ceramic materials. Thus, it was found that its addition improved the ceramic shrinkage when subjected to firing temperatures not greater than 1000°C, it reduced the mass lost after firing, it didn't interfere with ceramic color and, due to the increase of the porosity of the material, may be beneficial for the construction of ceramics with good thermal and acoustic isolation, for that, they are better to apply indoors.

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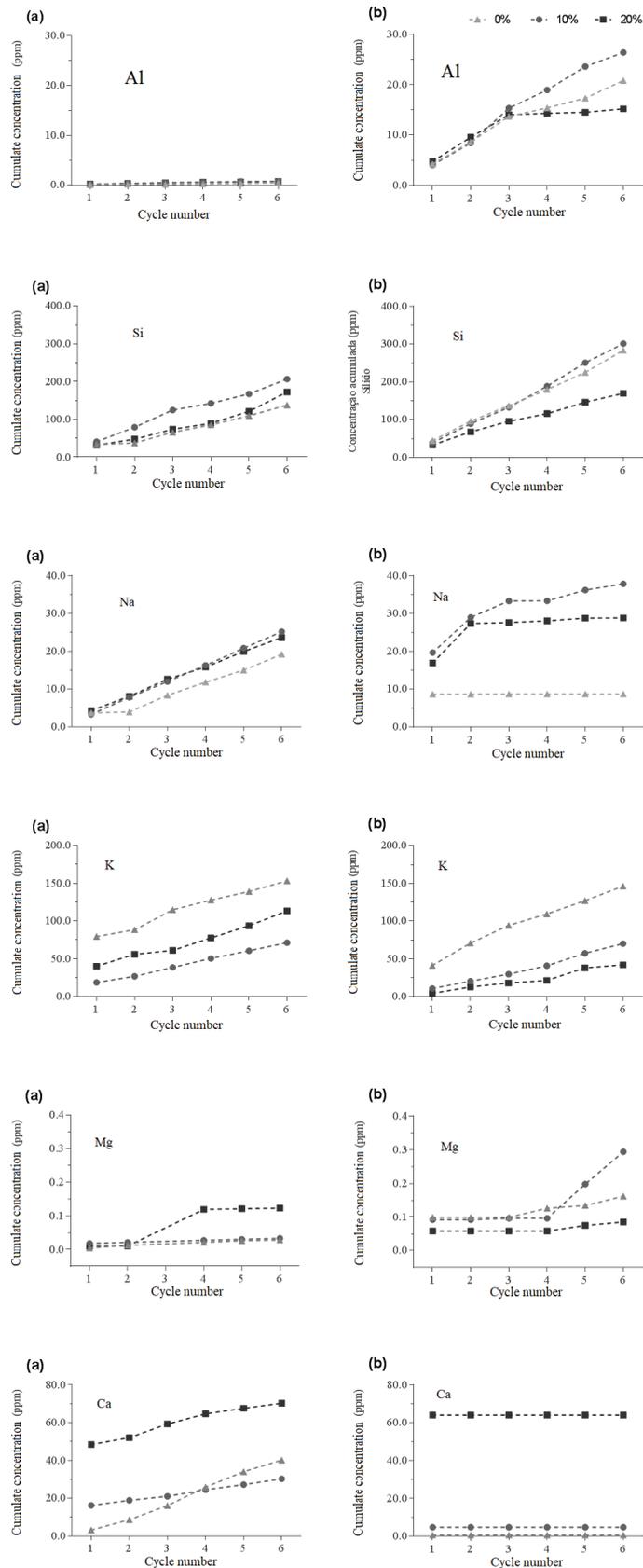


Figure 4: The accumulated concentration variation of Si, Al, Mg, Ca, Na and K of the ceramic fragments produced at (a) 900 °C and (b) 1000 °C, as a function of the percentage of USW per leaching cycle.

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