



UNIVERSIDAD NACIONAL DE COLOMBIA

# **Evaluación ambiental del uso de geopolímeros basados en dos puzolanas volcánicas como alternativa potencial al cemento portland**

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## Resumen

La insustentabilidad actual de la industria del cemento portland, ha conllevado a la búsqueda de nuevos materiales alternativos menos contaminantes, dando lugar a los denominados geopolímeros. La presente tesis consiste en la evaluación ambiental del uso de geopolímeros basados en dos puzolanas volcánicas, para determinar su viabilidad como alternativa del cemento portland; se presenta además un análisis teórico ambiental comparativo entre los geopolímeros y el cemento portland. Para tal propósito, se llevó a cabo la caracterización de las puzolanas empleando técnicas como fluorescencia de rayos X (FRX), difracción de rayos X (DRX) y granulometría laser. Para la determinación de la potencial toxicidad de los insumos involucrados en los geopolímeros se aplicaron las normas de TCLP (del inglés *Toxicity Characteristic Leaching Procedure*) y UNE EN 12457-2. Los resultados muestran que los mejores porcentajes de retención fueron de 99,95% para Ba, 99,99% para Sr, 99,93% para Zn, 92,5% para S, 98,95% para V, y 98,71% para Cr, cumpliendo con los límites máximos reportados por la legislación, evidenciando además una alta eficiencia en la encapsulación de contaminantes como Pb y Ni, cuyos valores siempre fueron superiores al 99%. Por lo tanto, en las proporciones estudiadas es viable el uso de geopolímeros, y representan una buena oportunidad para el sector de la construcción.

**Palabras clave:** Geopolímeros, puzolana volcánica, metales pesados, encapsulación, materiales alternativos al cemento portland, TCLP, UNE EN 12457-2.

## Abstract

Current unsustainability of portland cement industry, has led to the search for new cleaner alternative materials, leading to the geopolymer denominated. This thesis consists of the environmental assessment of the use of geopolymer based on two volcanic pozzolan to determine its viability as an alternative portland cement; a comprehensive comparative study between geopolymer environmental and portland cement is also presented. For this purpose is carried out using pozzolan characterization techniques such as XRF, XRD and laser granulometry. To determine the potential toxicity of inputs involved in the geopolymer standards TCLP (Toxicity Characteristic Leaching English Procedure) and UNE EN 12457-2 were applied. The results show that the best retention percentages were 99.95% for Ba, Sr 99.99%, 99.93% for Zn, 92.5% for S, 98.95% for V, and 98.71 % for Cr, complying with the maximum reported by the legislation, also showing a high encapsulation efficiency of pollutants such as Pb and Ni, whose values were always higher than 99%.. Therefore, in the studied proportions is viable its use, and represents a good opportunity for the construction sector.

**Keywords:** Geopolymers, volcanic pozzolan, heavy metals, encapsulation, alternative materials Portland cement, TCLP, UNE EN 12457-2.

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