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# Methodology for Assessing the Acid Rain Resistance of Volcanic Ash-Based Alkali-Activated Concrete for Infrastructure in Goma, DRC

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Amadou Traoré<sup>1</sup>

<sup>1</sup> Official University of Bobo-Dioulasso

Correspondence: [atraor@aol.com](mailto:atraor@aol.com)

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## ABSTRACT

{ "background": "The durability of conventional concrete in acidic environments is a significant concern for infrastructure in regions affected by industrial or volcanic pollution. Alkali-activated materials, particularly those derived from volcanic ash, offer a promising sustainable alternative, but their long-term performance under acid rain exposure requires rigorous assessment.", "purpose and objectives": "This article presents a novel, standardised methodology for evaluating the acid rain resistance of alkali-activated concrete formulated with volcanic ash from Mount Nyiragongo. The objective is to establish a predictive framework for material degradation to inform durable infrastructure design in Goma and similar volcanic regions.", "methodology": "The proposed method involves accelerated laboratory testing using a cyclic immersion regime in a synthetic acid rain solution (pH 3.5, simulating sulphate and nitrate deposition). Specimens are characterised pre- and post-exposure via mass change, compressive strength, ultrasonic pulse velocity, and microstructural analysis (XRD, SEM-EDS). Degradation kinetics are modelled using a non-linear regression:  $\delta Mt = \beta_0 + \beta_1 \ln(t) + \epsilon$ , where  $\delta Mt$  is mass loss,  $t$  is exposure time, and  $\epsilon$  represents heteroskedastic errors corrected with robust standard errors.", "findings": "As this is a methodology article, no empirical results from applying the protocol are presented. However, the proposed analytical framework is designed to quantify degradation rates, with an expected outcome being the determination of a threshold mass loss (e.g., >5%) correlating with a significant reduction in mechanical performance, estimated with 95% confidence intervals.", "conclusion": "The developed methodology provides a comprehensive and replicable protocol for assessing the acid durability of volcanic ash-based alkali-activated concretes, filling a critical gap in material standardisation for aggressive environmental conditions.", "recommendations": "It is recommended that this methodology be adopted for qualifying local volcanic ashes for construction use in Central and East Africa. Further validation through long-term field exposure studies at

**Keywords:** Alkali-activated materials, Acid rain resistance, Accelerated durability testing, Volcanic ash pozzolan, Central African Rift, Geopolymer concrete, Infrastructure durability

**Article Highlights**

- Proposes a cyclic immersion test using synthetic acid rain (pH 3.5) to simulate aggressive environmental conditions.
- Integrates mass change, compressive strength, ultrasonic pulse velocity, and microstructural analysis for comprehensive assessment.
- Employs a non-linear regression model to quantify degradation kinetics and predict material performance thresholds.
- Aims to establish a replicable protocol for material qualification in volcanic regions like Goma, DRC.

**Methodological Focus**

This article presents a testing and analytical framework. It does not report empirical results from applying the protocol, but details the procedure for future validation studies.

*This protocol addresses a critical standardisation gap for sustainable construction in aggressive environments.*



## ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.



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