



A FRAMEWORK FOR CLASSIFYING SEWER GAS-PHASE CORROSIVITY BASED ON MATERIAL RESPONSE

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ABSTRACT

Concrete and protective materials deteriorate under biologically induced corrosive conditions commonly found in sewer systems. Understanding corrosivity—the severity of corrosion in a given environment—is essential for selecting materials, designing mitigation strategies, and estimating service life and lifecycle costs. This study examines corrosion of concrete sewer infrastructure, including large-diameter pipes, access chambers, and wet wells, where degradation is driven by microbial generation of sulphuric acid under specific environmental conditions. A quantitative classification of sewer gas-phase corrosivity was developed using field data from ordinary Portland cement (OPC) assets in service for 17–81 years across Australian utilities. Corrosivity was correlated with environmental parameters including H₂S, CO₂, temperature, and relative humidity, which served as surrogate indicators. To validate the framework, commercially available materials, including calcium aluminate and geopolymer cement-based systems, were deployed in sewers representing different corrosivity classes. Comparative observations demonstrated clear differences in material performance across exposure severities, confirming the framework’s practical relevance. The proposed classification enables improved alignment between environmental exposure and material selection, supporting enhanced durability, optimised lifecycle costs, and more resilient wastewater infrastructure.

INTRODUCTION | BACKGROUND

Concrete and protective materials in sewer environments are vulnerable to biologically induced corrosion driven by microbial sulphuric acid formation under aggressive gas-phase conditions.^{1–3} Corrosion severity varies widely depending on environmental exposure and directly influences durability, service life, and lifecycle cost. Despite this variability, sewer environments are often classified generically as “severe,” limiting differentiation of

exposure conditions and optimisation of mitigation strategies.^{4,5} Corrosivity, defined as the severity of corrosion under a given environment, is a key parameter for material selection and asset management. However, quantitative frameworks linking environmental parameters to field corrosion outcomes remain limited. This study presents a field-based classification of sewer gas-phase corrosivity developed under the CRC-P Smart Lining program. The framework links measurable environmental parameters to long-term corrosion observations and provides a practical basis for durability-informed decision-making in wastewater infrastructure.

METHODS

Field Assets and Environmental Monitoring

The classification was developed from field investigations of ordinary Portland cement (OPC) sewer assets in service for 22–81 years across Australian utilities. Assets representing a wide range of deterioration levels were selected to capture diverse corrosive environments. Environmental monitoring followed WSAA protocols⁶ and included hydrogen sulphide (H₂S), carbon dioxide (CO₂), gas temperature, and relative humidity—key drivers of biogenic corrosion.^{3,7}

Corrosion Assessment and Normalisation

Cores extracted from representative locations were analysed for depth of corrosion. A semi-empirical dose–response approach was used to normalise corrosion rates and enable comparison across assets with different exposure histories.

Validation Using Protective Materials

To validate the framework, commercially available protective mortars—including calcium aluminate cement (CAC) and geopolymer systems—were installed in live sewer environments spanning a range of corrosivity levels. Periodic inspection and coring over up to three years were used to evaluate relative material degradation.

CLASSIFICATION OF SEWER GAS-PHASE CORROSIVITY

Biogenic corrosion results from interactions between microbial communities, environmental conditions, and cement chemistry.³ Field observations identified H₂S concentration, moisture availability, temperature, and gas-phase chemistry as dominant drivers of corrosion progression.⁷ Using normalised corrosion data and environmental measurements, sewer gas-phase conditions were categorised into five corrosivity classes (C1–C5), representing increasing severity from very low to very high corrosion potential (Table 1). The classification was anchored to observed corrosion depths in OPC assets and corresponding environmental ranges, enabling differentiation of sewer environments using measurable exposure parameters rather than generic severity assumptions. Field observations also suggest that extremely high H₂S conditions may not always correspond to proportionally higher corrosion rates, highlighting the

importance of multi-parameter classification. The framework is therefore adaptive and can be refined as additional field data become available.

Table 1. Proposed classification of sewer gas-phase corrosivity (C1–C5) based on field-normalised OPC corrosion data

Environmental Conditions				Predicted Depth of Corrosion (mm)		Corrosion Impact	Corrosion Classification
H ₂ S (ppm)	CO ₂ (ppm)	T _g (°C)	RH (%)	10 years of service	100 years of service		
>155	<2500	15-30	95-99	>30	>180	Very High	C5
135-155	2500-4400	15-30	95-99	21-30	166-180	High	C4
70-135	4400-7600	15-30	95-99	14-21	120-166	Medium	C3
15-70	7600-9400	15-30	95-99	6.7-14	55-120	Low	C2
0-15	>9400	15-30	95-99	<6.7	<55	Very Low	C1

VALIDATION AND IMPLICATIONS

Exposure trials using CAC and geopolymer mortars demonstrated degradation trends consistent with the proposed classification (Figures 1 and 2). Materials installed in higher corrosivity classes exhibited greater corrosion depths compared with those in lower classes, confirming that the framework captures meaningful differences in environmental severity.

While CAC systems generally showed lower degradation than geopolymer mortars, the objective was not comparative material ranking but validation of classification sensitivity. The results demonstrate that environmental classification can be used to predict relative material performance and guide targeted deployment of protective systems.

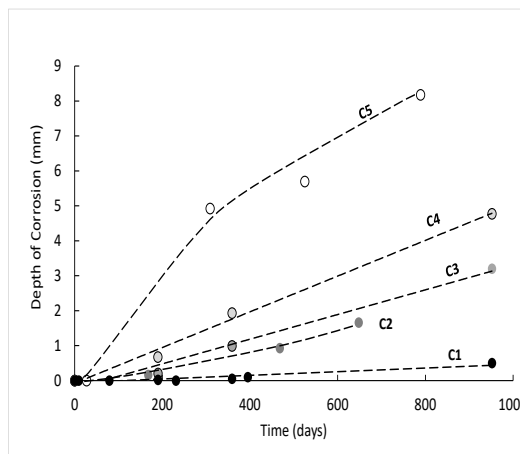


Figure 1. Corrosion depth of calcium aluminate mortars across sewer environments classified as C1–C5

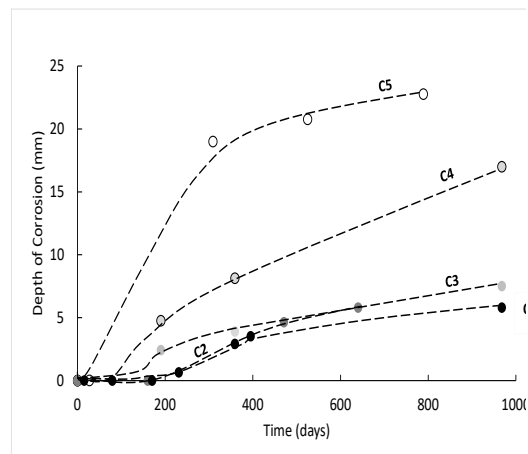


Figure 2. Corrosion depth of geopolymer mortars across sewer environments classified as C1–C5

IMPLICATIONS FOR ASSET MANAGEMENT

The proposed classification provides a practical tool for aligning material selection and rehabilitation strategies with environmental exposure conditions. By linking measurable environmental parameters to corrosion outcomes, the framework supports improved asset prioritisation, risk-based maintenance planning, and optimisation of lifecycle costs. The classification also enables more informed selection of corrosion-resistant materials and protective linings, contributing to improved durability and resilience of wastewater infrastructure. Given its field-based foundation, the framework is readily transferable across sewer networks and can be refined through continued monitoring and integration of long-term corrosion datasets.

CONCLUSIONS

A quantitative classification framework for sewer gas-phase corrosivity was developed based on long-term field observations of OPC sewer assets. Corrosivity was shown to correlate with measurable environmental parameters including H₂S, CO₂, temperature, and relative humidity, enabling classification into five exposure categories (C1–C5). Validation using CAC and geopolymer mortars demonstrated degradation trends consistent with the proposed framework, confirming its practical relevance. The classification provides a robust basis for linking environmental exposure to material performance and supports improved durability planning for wastewater infrastructure. Future refinement is expected through integration of additional long-term monitoring data and broader material validation.

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