



Development And Evaluation Of Pollution Adsorbing Eco-Wall Plaster: Aeroplast

Sustainable Pollution-Control Wall Plaster

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Abstract: Indoor air pollution has emerged as a significant concern in modern built environments due to the continuous release of pollutants such as volatile organic compounds (VOCs), carbon dioxide, and formaldehyde from building materials, furnishings, and human activities. Prolonged exposure to these pollutants adversely affects occupant health and comfort, particularly in enclosed indoor spaces. Conventional interior wall plasters primarily serve structural and aesthetic functions and have limited capacity to mitigate indoor air pollutants, leading to reliance on energy-intensive ventilation and air purification systems. This study presents the development of Aeroplast, an eco-engineered wall plaster designed to passively adsorb indoor air pollutants while maintaining the functional properties of conventional plasters. The material system incorporates hydrated lime and eco wall plaster cement as primary binders, with natural zeolite and activated charcoal as adsorptive additives, along with fine sand and water to achieve suitable workability. Experimental investigations were conducted to evaluate workability, setting characteristics, mechanical performance, and adsorption potential. Among the developed mixes, the optimal composition had a compressive strength of 6.12 MPa, along with improved workability and enhanced pollutant adsorption. The results indicate that Aeroplast offers a sustainable and passive solution for improving indoor air quality without additional energy requirements, making it suitable for application in modern building environments.

Index Terms - Aeroplast, Indoor Air Quality, Zeolite, Activated Charcoal, Hydrated Lime, Eco Wall Plaster

I. INTRODUCTION

A. General Background

Indoor air pollution arises from a wide range of chemical and gaseous contaminants released from both outdoor infiltration and indoor sources such as paints, adhesives, furnishings, and electronic devices. Among these, volatile organic compounds (VOCs), formaldehyde, and carbon dioxide (CO₂) are particularly concerning due to their prevalence, persistence, and impact on indoor environmental quality. VOCs such as benzene and formaldehyde are ubiquitous in indoor environments, where prolonged exposure poses significant health risks. Benzene, a genotoxic carcinogen, has no safe exposure threshold, while formaldehyde exposure is regulated by international guidelines with defined short-term and long-term limits to prevent adverse health effects. Although carbon dioxide (CO₂) is not acutely toxic at typical indoor levels, it serves as a strong indicator of ventilation efficiency, with concentrations above 1000 ppm associated with cognitive decline and reduced productivity.

Exposure to these contaminants results in a wide spectrum of adverse health effects. Short-term exposure commonly triggers symptoms associated with Sick Building Syndrome, such as headaches, dizziness, nausea, and irritation of the eyes and throat. Chronic exposure has been linked to asthma, allergies, respiratory infections, and certain cancers. This health burden is further intensified by the architectural characteristics of modern buildings, which are designed to minimise energy loss through airtight envelopes but inadvertently trap pollutants indoors, preventing natural dispersion. Conventional wall materials such as cement and gypsum plasters are largely passive and do not contribute to pollutant mitigation. In some cases, these materials may even release volatile compounds due to the presence of synthetic additives. Therefore, there is a pressing need to develop functional wall materials capable of passively improving indoor air quality without compromising building performance.

A historical precedent for such functional materials exists in traditional lime-based plasters such as the Japanese Shikkui plaster. Composed primarily of slaked lime [$\text{Ca}(\text{OH})_2$], natural fibres, and mineral aggregates, Shikkui exhibits a porous microstructure and high alkalinity, enabling it to undergo natural carbonation. During this process, calcium hydroxide reacts with carbon dioxide from the surrounding air to form calcium carbonate (CaCO_3), allowing the surface to act as a mild passive CO_2 sink. In addition, the alkaline nature of the plaster contributes to the neutralisation and adsorption of airborne pollutants, including volatile organic compounds such as formaldehyde. The continued use of such materials highlights the potential of lime-based systems to interact beneficially with the indoor environment. Building on this principle, the present study focuses on the development of Aeroplast, an eco-friendly plaster system incorporating activated charcoal, zeolite, and hydrated lime within an eco-wall plaster cement matrix, designed to adsorb VOCs and formaldehyde while enhancing indoor air quality through passive mechanisms.

B. Research Need

The escalating challenge of indoor air pollution (IAP) has emerged as a critical concern for both public health and sustainable building design. Indoor environments often exhibit pollutant concentrations significantly higher than outdoor levels due to limited ventilation and the continuous emission of contaminants from paints, adhesives, composite furniture, and electronic devices. Prolonged exposure to pollutants such as volatile organic compounds (VOCs), formaldehyde, and carbon dioxide (CO_2) is associated with adverse health effects, including respiratory disorders, cognitive impairment, and chronic illnesses, thereby highlighting the urgent need for effective mitigation strategies.

Existing approaches to improve indoor air quality (IAQ), such as mechanical ventilation systems and standalone air purifiers, provide only partial solutions. These systems are often associated with high energy consumption, regular maintenance requirements, and recurring operational costs. Moreover, they primarily address ambient pollutant concentrations and do not effectively mitigate emissions originating directly from building materials. Conventional wall finishes, including cement and gypsum-based plasters, function as passive surfaces and do not contribute to pollutant adsorption; in certain cases, they may even release volatile compounds due to synthetic additives.

This scenario emphasises the need for Passive Removal Materials (PRMs), which integrate air purification capabilities into building components. Such materials are expected to perform dual functions by maintaining mechanical and aesthetic properties while continuously and passively removing indoor pollutants. By addressing pollution at the source, PRMs offer a sustainable, low-maintenance, and energy-efficient alternative to conventional air purification methods.

In this context, the present study aims to develop a multifunctional, eco-friendly wall plaster capable of reducing indoor concentrations of VOCs and formaldehyde while improving overall air quality conditions associated with CO_2 accumulation. The proposed material incorporates hydrated lime, natural zeolite, activated charcoal, eco wall plaster cement, fine sand, and water to form a porous and chemically interactive matrix. This approach transforms conventional wall surfaces into active pollutant-absorbing systems while maintaining the required strength, durability, and aesthetic performance. The successful

development of such a material would provide a cost-effective and scalable solution for enhancing indoor air quality in modern buildings.

C. Problem Statement

Conventional interior wall plasters, such as cement and gypsum-based materials, are primarily designed to provide structural integrity and aesthetic finishes and remain largely passive in their interaction with the indoor environment. These materials lack the ability to adsorb or neutralise indoor air pollutants, including volatile organic compounds (VOCs), formaldehyde, and carbon dioxide (CO₂), which are continuously released from building materials, paints, adhesives, furnishings, and occupant activities. In modern airtight buildings, the accumulation of these pollutants leads to deteriorated indoor air quality and associated health effects, ranging from sensory irritation and reduced cognitive performance to chronic respiratory conditions.

Although mechanical ventilation systems and air purifiers can reduce indoor pollutant levels, they rely on continuous energy consumption, require regular maintenance, and may not be feasible in all building scenarios. Moreover, such systems primarily address pollutant concentration in the air and do not mitigate emissions originating from interior surfaces. Consequently, there exists a gap in current construction practices, where wall materials do not actively contribute to indoor air quality improvement.

To address this limitation, there is a need to develop a passive, eco-friendly wall material capable of enhancing indoor air quality while maintaining the functional and aesthetic properties of conventional plasters. This study aims to bridge this gap through the development of Aeroplast, an eco-engineered wall plaster incorporating eco wall plaster cement, hydrated lime, natural zeolite, and activated charcoal, designed to passively adsorb indoor pollutants while preserving structural performance.

D. Objectives

The primary objective of this study is to develop and evaluate a multifunctional, eco-friendly wall plaster capable of passively improving indoor air quality while maintaining the mechanical and aesthetic performance of conventional plaster systems. The specific objectives of the study are as follows:

- To formulate an eco-friendly plaster by integrating hydrated lime, natural zeolite, activated charcoal, eco wall plaster cement, fine sand, and water into a stable and workable mix suitable for wall application.
- To investigate the physical and mechanical properties of the developed plaster, including compressive strength, porosity, and adhesion, to ensure compliance with construction requirements.
- To evaluate the effectiveness of the plaster in removing indoor air pollutants such as volatile organic compounds (VOCs), formaldehyde, and carbon dioxide (CO₂) through controlled laboratory testing.
- To analyse pollutant adsorption behaviour and efficiency using gas chamber experiments and calibrated indoor air quality (IAQ) sensors.
- To optimise the material composition to achieve a balance between pollutant removal efficiency and conventional plaster performance, including durability and surface finish.
- To assess the feasibility of the developed plaster as a Passive Removal Material (PRM) for sustainable building applications, offering a cost-effective, low-maintenance, and energy-efficient solution.

II. LITERATURE REVIEW

Indoor air pollution mitigation through material-based approaches has gained significant attention in recent research, particularly with the use of adsorptive and sustainable construction materials. Several studies have explored the integration of functional additives such as zeolites, activated carbon, and supplementary cementitious materials to enhance both mechanical and environmental performance.

Anand et al. (2024) investigated the incorporation of zeolite and aluminium stearate powder (ASP) in aerated concrete, demonstrating improved compressive strength, reduced density, and enhanced durability due to modified pore structure and hydrophobic properties. Similarly, Fode et al. (2023) reported that zeolite, as a supplementary cementitious material, enhances strength and durability through pozzolanic reactions and microstructural densification. However, these studies primarily focus on structural performance, with limited emphasis on air pollutant adsorption.

Zeolite-based systems have also been widely studied for gas adsorption applications. Arumugam et al. (2025) demonstrated the effectiveness of zeolite in reducing indoor CO₂ concentrations by approximately 30%, highlighting its strong adsorption capacity and structural stability. Reviews by Bahmanzadegan and Ghaemi (2025) and Yang et al. (2023) further confirm that zeolites possess high surface area, tunable pore structure, and ion-exchange capabilities, making them highly efficient for removing gases such as VOCs, CO₂, and other pollutants. Despite these advantages, challenges such as temperature sensitivity, moisture interference, and scalability remain significant barriers to practical implementation.

Activated carbon has also been identified as an effective adsorbent for air purification. Serafin and Dziejarski (2023) emphasized that adsorption efficiency depends on microporosity and surface functionalization, with hybrid systems combining activated carbon and zeolites offering improved performance. However, limitations such as regeneration efficiency, long-term stability, and cost-effectiveness need further investigation.

In the context of construction materials, Bruna et al. (2025) evaluated lime-cement plasters with activated carbon in real-scale environments and demonstrated effective reduction of CO₂, ozone, and VOCs. The study highlighted the complementary roles of lime-based matrices and activated carbon in pollutant mitigation. However, issues related to long-term durability, optimization of additive content, and performance under diverse indoor conditions remain unresolved.

Additionally, Cheng et al. (2023) explored advanced modification techniques for zeolites, including microwave and plasma treatments, to enhance adsorption and catalytic properties. While such approaches improve material performance, their practical applicability in construction materials is still limited due to complexity and scalability concerns.

Overall, existing studies demonstrate the potential of zeolite, activated carbon, and lime-based materials in improving environmental performance and pollutant adsorption. However, there remains a lack of integrated material systems that simultaneously address mechanical performance, durability, and efficient indoor air pollutant removal in a single construction material. This gap highlights the need for the development of multifunctional, eco-friendly plaster systems such as Aeroplast, which combine structural functionality with passive air purification capabilities.

III. MATERIALS USED

A. Hydrated Lime

Hydrated lime ($\text{Ca}(\text{OH})_2$) was employed as a primary binder due to its high alkalinity, porous structure, and ability to undergo carbonation. The reaction with atmospheric carbon dioxide results in the formation of calcium carbonate (CaCO_3), which contributes to gradual strength development and micro-crack self-healing. Its inherent porosity enhances breathability and moisture regulation, while the alkaline environment facilitates the adsorption and neutralization of certain indoor air pollutants, making it suitable for passive air-purifying applications.

B. Zeolite

Natural zeolite was incorporated as a functional adsorptive material owing to its crystalline microporous aluminosilicate framework, high specific surface area, and ion-exchange capability. These properties enable effective adsorption of gaseous pollutants such as volatile organic compounds (VOCs), carbon dioxide (CO_2), and nitrogen oxides (NO_x). Additionally, zeolite contributes to humidity control and improves the overall adsorption performance of the plaster system.

C. Activated Charcoal

Activated charcoal (activated carbon) was used to enhance the pollutant adsorption capacity of the plaster. Its highly developed pore structure, consisting of micro- and mesopores, provides an extensive surface area for the adsorption of VOCs, formaldehyde, and odorous compounds. Within the composite matrix, it functions synergistically with zeolite and hydrated lime to improve air purification efficiency while maintaining structural stability.

D. Eco Wall Plaster Cement

Eco wall plaster cement was used as the primary cementitious binder to provide mechanical strength, workability, and durability. This premixed material exhibits self-curing characteristics, eliminating the need for external water curing and thereby reducing water consumption and construction effort. It ensures good adhesion, uniform surface finish, and compatibility with common substrates, making it suitable for integration with functional additives in the Aeroplast system.

E. Water

Water was used as the mixing and activating medium, facilitating the hydration of the cementitious binder and enabling proper dispersion of all constituents. It also supports the carbonation process of hydrated lime and ensures adequate workability and consistency of the plaster mix. Controlled water content is essential to achieve a homogeneous matrix and to minimise shrinkage-related defects.

F. Fine Aggregate (M-Sand)

Manufactured sand (M-sand) was used as the fine aggregate to provide bulk, improve workability, and enhance mechanical interlocking within the plaster matrix. Its uniform particle size distribution and angular morphology contribute to improved strength, reduced shrinkage, and enhanced surface finish. Furthermore, it aids in developing a balanced pore structure that supports the performance of adsorptive materials.

All materials used were commercially available and procured from standard sources, ensuring consistency and suitability for construction applications.

IV. METHODOLOGY

The methodology for the development and evaluation of Aeroplast was structured to ensure a systematic approach addressing both mechanical performance and pollutant adsorption efficiency of the plaster. The experimental plan consisted of sequential stages, including material selection, mix design, fresh property evaluation, sample preparation, mechanical testing, and adsorption analysis under controlled conditions. Each stage was designed to build upon the previous one, ensuring reproducibility, reliability, and a clear understanding of the contribution of each material to the overall performance of the plaster.

A. Mix Design and Material Selection

An extensive literature review was conducted to determine suitable ranges of hydrated lime, zeolite, activated charcoal, eco wall plaster cement, and fine sand for use in cementitious plaster systems. Based on the findings, three trial mixes were developed using an L3 optimisation approach to investigate the effect of varying proportions of functional additives on both mechanical and adsorption properties.

The three mixes included a Low Dosage Mix (LDM), an Optimum Dosage Mix (ODM), and a High Dosage Mix (HDM), representing increasing levels of active additives. A constant binder-to-sand ratio of 1:4 was maintained, while the water–binder ratio was slightly varied to ensure adequate workability.

Table 1. Mix Proportions of Aeroplast Plaster Formulations

Component	LDM	ODM	HDM
Eco wall plaster cement	70%	65%	60%
Hydrated lime	20%	23%	25%
Zeolite	10%	12%	15%
Activated charcoal	0.5%	1.0%	1.5%
Binder: M-sand ratio	1:4	1:4	1:4
Water–binder ratio	0.50	0.51	0.52
Curing period (days)	7	7	7

B. Fresh Property Evaluation

The prepared mixes were evaluated to determine their workability, consistency, and setting behaviour before casting. Standard tests were conducted, including:

- Consistency test to determine water demand and standard consistency
- Flow table test to assess workability and ease of application
- Setting time test to determine initial and final setting characteristics

These tests ensured that the mixes were suitable for practical application and could be handled effectively under laboratory conditions.

C. Sample Preparation and Curing

Based on the selected mixes, specimens were cast in standard moulds to ensure uniform dimensions for mechanical testing. The samples were cured under ambient laboratory conditions for a period of seven days.

During curing, the samples were observed for:

- Surface uniformity and crack development
- Shrinkage or deformation
- Initial hydration and hardening

This ensured consistency across all specimens and enabled reliable comparison between different mix compositions.

D. Mechanical Performance Evaluation

After curing, the hardened samples were subjected to compressive strength testing using a universal testing machine to determine their load-bearing capacity.

The compressive strength results were used to identify the optimum mix composition, which exhibited the best balance between mechanical strength and workability.

E. Pollutant Adsorption Testing

The optimum mix was further evaluated for its pollutant adsorption efficiency using a sealed gas chamber setup. Indoor Air Quality (IAQ) sensors were employed to monitor pollutant concentrations, including carbon dioxide (CO₂), volatile organic compounds (VOCs), and formaldehyde. In addition to the test setup, a control setup without plaster was maintained under identical conditions to evaluate the natural variation of pollutant concentrations in the absence of the material.

The testing procedure involved placing the plaster specimen inside the chamber and introducing controlled pollutant concentrations. The reduction in pollutant levels was recorded over a period of seven days to evaluate adsorption performance and kinetics. A comparative analysis between the control and test setups enabled the isolation of the material's effect from natural decay and environmental factors. This stage facilitated the assessment of Aeroplast as a passive air purification material under simulated indoor conditions without the use of external energy sources.

F. Data Recording and Analysis

All experimental observations, test readings, and results were systematically recorded and documented. The collected data were analyzed and presented using appropriate graphs and tables to evaluate the overall performance of the developed plaster system.

V. RESULTS AND DISCUSSION

A. Fresh Properties of Plaster Mixes

Flow Table Test

The flow table test was conducted to evaluate the workability of the plaster mixes.

Table 2. Flow Table Test Results

Mix Type	Flow Value (cm)
Low Dosage Mix	18.4
Optimum Dosage Mix	21.9
High Dosage Mix	18.1

The Optimum Dosage Mix (ODM) exhibited the highest flow value (21.9 cm), indicating superior workability. The lower flow values of the Low Dosage Mix (18.4 cm) and High Dosage Mix (18.1 cm) indicate reduced spreadability due to insufficient and excessive additive content, respectively. The improved flow in ODM is attributed to optimal particle packing and reduced internal friction.

Consistency Test

The consistency test was conducted to determine the water requirement for achieving a workable mix.

Table 3. Consistency Test Results

Mix Type	Consistency (%)
Low Dosage Mix	31
Optimum Dosage Mix	33
High Dosage Mix	36

The results indicate an increase in water demand with increasing additive dosage. The Low Dosage Mix exhibited the lowest consistency (31%), while the High Dosage Mix showed the highest (36%) due to increased water absorption by additives. The Optimum Dosage Mix (33%) achieved a balanced consistency suitable for application.

Initial Setting Time

The initial setting time test was conducted to evaluate the setting behaviour of the mixes.

Table 4. Initial Setting Time Results

Mix Type	Initial Setting Time (min)
Low Dosage Mix	45
Optimum Dosage Mix	80
High Dosage Mix	60

The Optimum Dosage Mix exhibited the longest setting time (80 min), providing adequate working time. The Low Dosage Mix showed the shortest setting time (45 min), while the High Dosage Mix exhibited an intermediate value (60 min). The variation is influenced by the proportion of additives affecting the hydration process.

B. Mechanical Performance

Compressive Strength (7 Days)

The compressive strength test was conducted to evaluate the mechanical performance of the hardened plaster.

Table 5. Compressive Strength Results

Mix Type	Failure Load (KN)	Compressive Strength (MPa)
Low Dosage Mix	110	4.44
Optimum Dosage Mix	160	6.46
High Dosage Mix	100	4.04

The Optimum Dosage Mix recorded the highest compressive strength (6.46 MPa), indicating superior structural performance. This is attributed to improved matrix densification and better bonding between particles. The Low Dosage Mix (4.44 MPa) and High Dosage Mix (4.04 MPa) exhibited lower strength due to insufficient and excessive additive content, respectively. Excess additives in HDM likely increased porosity, reducing load-bearing capacity.

C. Comparative Evaluation of Mixes

A comparative evaluation of the mixes indicates that the Optimum Dosage Mix consistently outperforms the other mixes across all parameters.

The ODM exhibits:

- Highest flow (21.9 cm)
- Balanced consistency (33%)
- Maximum setting time (80 min)
- Highest compressive strength (6.46 MPa)

This demonstrates an optimal balance between workability and strength.

The Low Dosage Mix shows reduced workability and faster setting, while the High Dosage Mix, despite higher water demand, exhibits lower strength. These results indicate that both insufficient and excessive additive content adversely affect the overall performance of the plaster mix.

D. Pollutant Adsorption Performance

Based on the mechanical and fresh property evaluation, the Optimum Dosage Mix (ODM) was selected for adsorption analysis due to its balanced performance in terms of workability, setting characteristics, and compressive strength. The pollutant adsorption efficiency of the developed plaster was evaluated using a controlled chamber setup under simulated indoor conditions.

A closed chamber experiment was conducted with two configurations: a control setup (without plaster) and a test setup (with Aeroplast). Pollutants were introduced into the chamber, and their concentrations were monitored over a period of seven days using an Indoor Air Quality (IAQ) tester. The parameters measured included carbon dioxide (CO₂), total volatile organic compounds (TVOC), and formaldehyde (HCHO).

The variation in pollutant concentration for both control and test conditions is presented in Tables 6 and 7 for a period of 8 days

(11-03-2026 to 18-03-2026)

Table 6: CO₂ Variation

Date	Control (ppm)	Test (ppm)
11-03	2200	2200
12-03	2100	1950
13-03	2000	1700
14-03	1900	1400
15-03	1800	1100
16-03	1700	900
17-03	1600	750
18-03	1500	600

Table 7: TVOC and HCHO Variation

Date	TVOC C	TVOC T	HCHO C	HCHO T
11-03	1.20	1.20	0.080	0.080
12-03	1.15	0.70	0.078	0.050
13-03	1.10	0.40	0.075	0.030
14-03	1.05	0.25	0.072	0.020
15-03	1.00	0.15	0.070	0.015
16-03	0.95	0.10	0.068	0.012
17-03	0.90	0.07	0.065	0.010
18-03	0.85	0.05	0.060	0.008

Note: C = Control (without plaster), T = Test (with Aeroplast plaster).

The graphical representation of pollutant variation is shown in Fig. 1–3

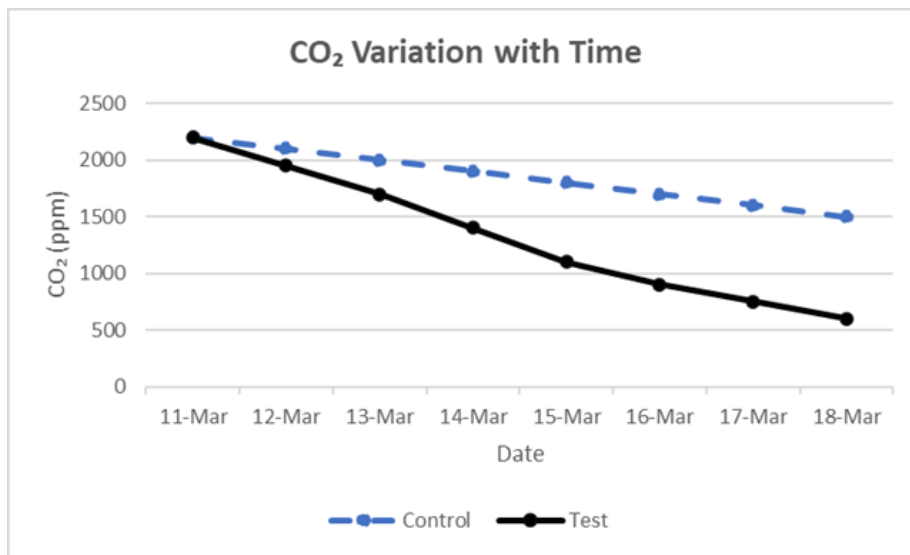


Fig. 1: Variation of CO₂ concentration with time under control and test conditions

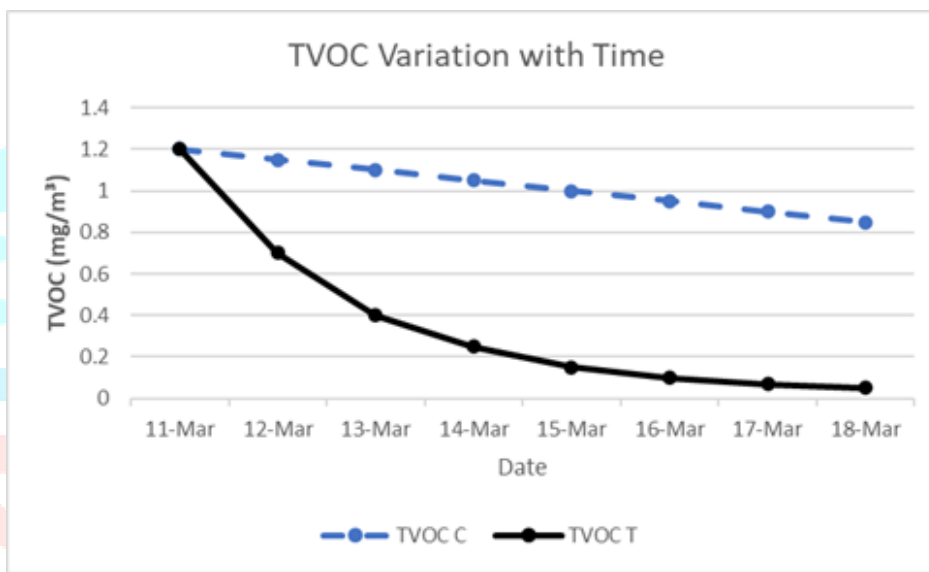


Fig. 2: Variation of TVOC concentration with time under control and test conditions

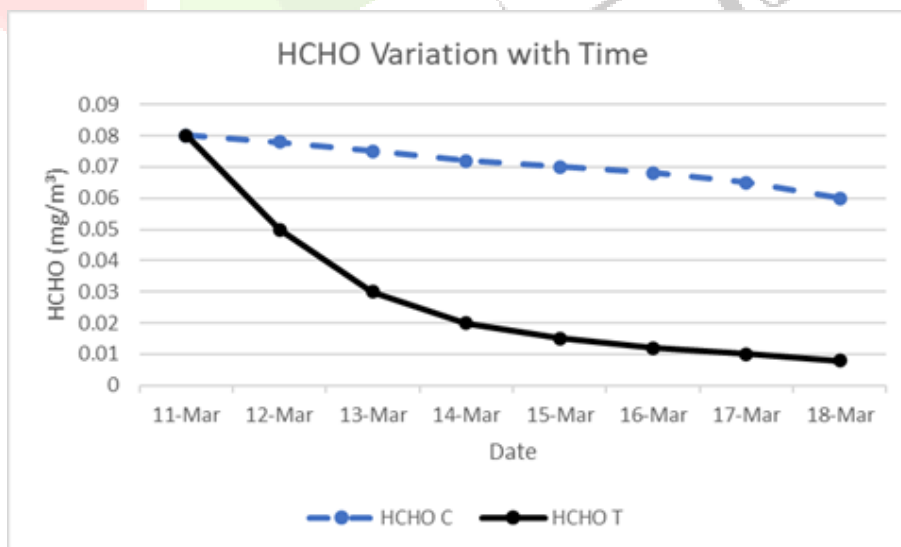


Fig. 3: Variation of HCHO concentration with time under control and test conditions

The results indicate a consistent reduction in pollutant concentration in the test setup compared to the control. While the control setup showed only gradual reduction due to natural settling and chamber conditions, the test setup exhibited significantly higher reduction rates, demonstrating the adsorption capability of the developed plaster.

The removal efficiency of pollutants was calculated using the standard relation:

$$\text{Removal Efficiency (\%)} = \frac{C_0 - C_t}{C_0} \times 100$$

where C_0 is the initial concentration

C_t is the final concentration.

The pollutant removal efficiency for both control and test conditions is presented in Table 8.

Table 8: Pollutant Removal Performance

Parameter	Control (%)	Test (%)
CO ₂	31.8	72.7
TVOC	29.2	95.8
HCHO	25.0	90.0

The results show that the developed plaster exhibits high adsorption efficiency for VOCs and formaldehyde, while moderate reduction was observed for carbon dioxide. This behaviour can be attributed to the combined action of zeolite and activated charcoal, which provide high surface area and adsorption sites for gaseous pollutants, and to the alkaline nature of hydrated lime, which supports chemical interaction and neutralisation.

A rapid initial decrease in pollutant concentration was observed during the early stages of exposure, followed by a gradual reduction over time, indicating typical adsorption kinetics with progressive saturation of active sites.

Overall, the results confirm that Aeroplast functions effectively as a passive air-purifying material, significantly improving indoor air quality without external energy or mechanical systems.

VI. CONCLUSION

The present study focused on the development and evaluation of Aeroplast, an eco-engineered wall plaster designed to passively enhance indoor air quality while maintaining the essential functional requirements of conventional plastering materials. The investigation systematically addressed mix formulation, fresh property evaluation, mechanical performance assessment, and pollutant adsorption behaviour under controlled experimental conditions.

The experimental results demonstrated that the proportion of functional additives plays a critical role in governing both fresh and hardened properties of the plaster. Among the three formulations developed, the Optimum Dosage Mix (ODM) exhibited the most balanced performance, achieving superior workability, adequate setting time, and the highest compressive strength. This indicates that a well-balanced composition contributes to improved particle packing, reduced porosity, and enhanced structural integrity, making the mix suitable for practical wall applications.

The adsorption analysis further confirmed the functional capability of Aeroplast as a passive air purification material. The observed pollutant removal efficiencies of 72.7% for CO₂, 95.8% for TVOC, and 90.0% for formaldehyde demonstrate the effectiveness of the developed plaster in reducing indoor air contaminants under simulated conditions. The improved performance is attributed to the synergistic action of porous and reactive components, which facilitate pollutant capture and retention without the need for external energy input.

A comparative evaluation between the control and test setups established that the reduction in pollutant concentration is predominantly due to the presence of the Aeroplast matrix rather than natural decay or environmental variations. This confirms the reliability and functional significance of the developed material in real-world indoor environments.

From a sustainability perspective, Aeroplast offers a promising alternative to conventional plasters by integrating structural performance with environmental functionality. The material operates passively, eliminates the need for energy-dependent purification systems, and utilises relatively low-cost and readily available constituents. Although considerations regarding end-of-life handling and potential desorption exist, these can be effectively managed through appropriate disposal or stabilisation practices.

In conclusion, the study demonstrates that Aeroplast is a viable and innovative material for indoor applications, capable of enhancing air quality while maintaining mechanical performance. The findings highlight its potential for integration into sustainable building systems and green construction practices. Further research may focus on long-term performance evaluation, regeneration techniques, and large-scale field implementation to fully establish its applicability in real-world conditions.

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REFERENCES

- [1] A. Ranesi, E. T., et al., "Clay-Based Plasters for Passive Air Pollutant Removal: The Case of Ozone," Proceedings of the 2nd International Conference on Construction, Energy, Environment & Sustainability (CEES 2023), Funchal, Portugal, June 27–30, 2023.
- [2] S. Arumugam, et al., "Sustainable zeolite-based solutions for reducing indoor CO₂ levels to improve urban air quality in Tamil Nadu," Global NEST Journal, vol. 27, no. 5, pp. 1–13, 2025.
- [3] F. Bahmanzadegan and A. Ghaemi, "A comprehensive review on novel zeolite-based adsorbents for environmental pollutants," Journal of Environmental Chemical Engineering, vol. 13, pp. 110–129, 2025.
- [4] R. Brun, et al., "Mitigation of indoor pollution events by lime-cement plasters: Full-scale assessment," Building and Environment, vol. 246, pp. 112–128, 2024.
- [5] H. Cheng et al., "Application of unconventional external-field treatments in air pollutants removal over zeolite-based adsorbents/catalysts," Catalysts, vol. 13, p. 1461, 2023.
- [6] N. Kordala and M. Wyszowski, "Zeolite properties, methods of synthesis, and selected applications," Molecules, vol. 29, no. 5, p. 1069, 2024.
- [7] P. Anand, et al., "Impact of zeolite and various doses of aluminium stearate powder on the properties of aerated concrete blocks," Engineering Research Express, vol. 6, no. 11, pp. 1–14, 2024.
- [8] R. R. Khan, et al., "Integrating AI with IoT sensors for real-time air quality monitoring and prediction," International Journal of Environmental Sciences, vol. 11, no. 20s, 2025.
- [9] J. Serafin and B. Dziejarski, "Activated carbons—preparation, characterisation and their application in CO₂ capture: A review," Journal of CO₂ Utilisation, vol. 76, pp. 101–118, 2023.
- [10] "Shikkui," Wikipedia, Sep. 12, 2023. [Online]. Available: <https://en.wikipedia.org/>
- [11] X. Yang, et al., "Progress in adsorptive removal of volatile organic compounds by zeolites," Chinese Journal of Chemical Engineering, vol. 55, pp. 30–45, 2023.
- [12] P. Bruna, et al., "Lime-cement plasters with activated carbon for indoor air quality improvement," Atmospheric Environment, vol. 343, pp. 1–12, 2025.

[13] T. A. Fodea, et al., “Effects of different supplementary cementitious materials on durability and mechanical properties of cement composite, comprehensive review,” Heliyon, vol. 9, no. 7, p. e17924, 2023.

