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Decarbonization through Direct Air Capture: Performance Assessment of $Ca(OH)_2$ and NaOH for CO_2 Removal

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Abstract
Urbanization and industrialization mainly contribute to the rise in Carbon Dioxide (CO_2) concentration in the atmosphere, which has become a challengingly important issue to the stability of the global climate. This paper is an analysis of the efficiency and effectiveness of Sodium Hydroxide (NaOH) and Calcium Hydroxide (Ca(OH)2) solutions as the solvent of a Direct Air Capture (DAC) machine. In order to do this, a specially designed direct air capture device was built to mimic an air filtration device to feed the ambient air into the solvent chamber. The turbidity measurements were used to quantify the CO_2 absorption, with higher turbidity corresponding to a more significant carbonate precipitation, and thus, it could be used as a proxy to capture efficiency. The potential of Calcium and Sodium hydroxide as a potential solvent to capture and store ambient carbon dioxide in efficient way is investigated in the study, thus helping to contribute to reducing atmospheric CO_2 levels.

Keywords: Direct Air Capture (DAC); Carbon Capture and Storage (CCS); Calcium hydroxide (Ca(OH)2); Sodium Hydroxide (NaOH); Solvents

Introduction

The concentration of Carbon Dioxide (CO_2) in the atmosphere of the Earth is about 0.04 percent; nevertheless, it has been significantly elevated recently (Kabir et al., 2023). Ever since the Industrial Revolution, the amounts of CO_2 in the atmosphere have grown exponentially, and their concentration is expected to rise, thus contributing to global warming (Hashimoto, 2019). The presence of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), and Sulphur dioxide (SO_2), warms the atmosphere and therefore contributes to the drivers of Climate Change (Aliyu et al., 2020). There is a need to slow down the depletion of these gases to the atmosphere (Nunes, 2023). Numerous organisations are taking a number of steps across the globe to minimise their Carbon Footprint (Chen et al., 2022). Some of the most popular methods utilized in this regard include Carbon Capture and Storage (CCS) in Geological sites, Direct Air Capture (DAC), and so on (Ayeleru et al., 2023). Direct Air Capture (DAC) is a relatively cheap technique of sampling the air and a widely adopted method. It may be utilised in capturing the Carbon Dioxide (CO_2) in the air, which is released by non-point pollution sources (McLaughlin, 2023).

Direct Air Capture (DAC) is a new technology in carbon management, particularly equipped to decrease the volume of Carbon Dioxide (CO_2) in the atmosphere (Chowdhury, 2023). This is how DAC will be working, and it includes three main units: Air Intake Mechanism (Li and Yao, 2024), CO_2

redox capture and release, and regeneration (Godin, 2021). It begins with a fan pulling ambient air into the DAC system. This procedure ensures that air in the atmosphere is continuously supplied to be processed (Mostafa, 2022). It incorporates the application of specialized chemicals that are selectively specific to the CO_2 molecules in the air (Khosrowshahi, 2024). These are special chemicals that can be solid sorbents (examples: Amines) or liquid solvents (examples: Potassium Hydroxide). They are selected due to their very high CO_2 specificity and affinity to bind (Tiwari et al., 2022). Such a reaction usually forms a chemical bond (e.g. Carbonate) or a loose physical force, depending on the sorbents or solvents (Halliday and Hatton, 2021). After the CO_2 is trapped, it is removed by heating or a pressure swing cycle by releasing it back out of the sorbents or solvents, giving a purified stream of concentrated CO_2 (Pragadeesh, 2025). Meanwhile, the sorbents or solvents are regenerated to enable them to be used again in new capture cycles (Dutta et al., 2019).

The significance of the given technology in the future will rise, because it is vital to decarbonise processes (Nurdiawati and Urban, 2021). The industrialised countries have achieved good success in reducing sulfur dioxide, yet pollutants generated by traffic, such as NOx and VOCs, are still common (Odubo, and Kosoe, 2024). Conversely, the developing countries do not have the infrastructure or protection mechanisms; therefore, they have a multidimensional issue of pollution (Saxena, 2025). The land that is covered by urban areas constitutes less than 2 percent of the global land area yet it contributes to over 70 percent of emissions (Crippa et al., 2021). Transportation, construction, energy production, and residential energy consumption are among the major air pollution contributors (Wang et al., 2019). The invention of the DAC technology would assist in lowering levels of atmospheric PM2.5 (Hata, 2023). Provided the successful implementation, the given technology would help tremendously with the process of decarbonisation of the urban environment, enhancing the air quality and minimizing the possibility of individuals contracting the diseases caused by atmospheric pollutants (Drożdz et al., 2021).

Carbon Capture and Storage (CCS) applies the solvents and sorbents of various types. The solvents and sorbents are some of them: Metal Organic Frameworks (MOFs), Zeolites and Hydrolite, Biomass-Derived Activated Carbons, and Amine-Functionalised Sorbents (Chai et al., 2022). The purpose of the study is to focus on the research question of how well the two notable chemical solvents, Sodium Hydroxide (NaOH) and Calcium Hydroxide (Ca(OH)2), promote the process of carbon capture.

Materials and methods

Working of Carbon Capture Device

The principle behind the CO_2 capture device (Fig. 1) is similar to that of a vacuum cleaner. The ambient air is taken into the system through a motor-powered propeller, with a pre-fitted filter of PM10 to make sure the dust and particulate matter are eliminated. The filtered air moves in a chamber and enters a pipe. The pipe is attached to the back of the device on one end and at the other end is immersed in CO_2 absorbing solution- in this case, a Ca(OH)2 solution. The rear part of the equipment has been shaped to ensure that it can be united with a chamber-like closure in which the vessel containing the sorbent fits. This seal is an effective way to contain the environment, which ensures that the external air does not have the opportunity to pollute the solution and introduce other gases that ruin the CO_2 uptake process. The experimental device consisted of a plastic fan with a diameter of 6 cm and four blades, powered by a 12V DC motor connected to a 12V power supply. The total length of the design (Fig. 2) was 30 cm with extended outer covering, with a 10 cm section from the device mouth to the fan and a 15 cm section from the fan to the exit pipe.

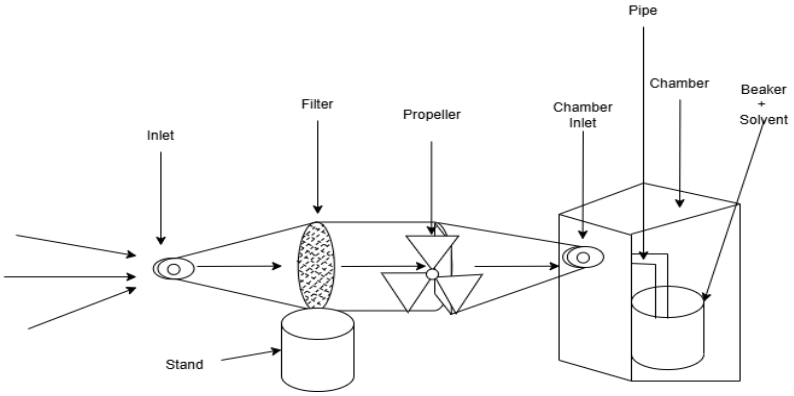

Fig. 1. Outline Diagram of Carbon Capture Device

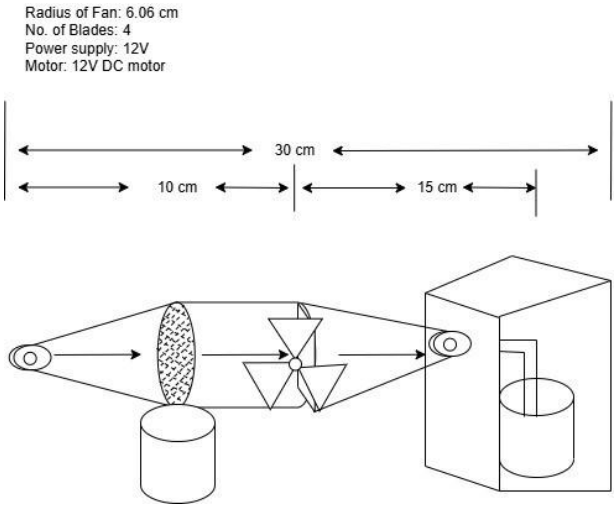

Fig. 2. Technical Specifications of the Carbon Capture Device

A small beaker of a measured amount of solvent is poured into it and positioned in the closed chamber. The solvent is poured into the open end of the pipe, and the device is turned on. The system has an AC-DC converter that does not require one to replace the batteries frequently. When switched on, the surrounding air passes into the contraption through an electric-powered propeller and is passed through the internal mechanism to the output pipe on the other side. This directed air flow eventually reaches the solvent in the back chamber. Since the carbon dioxide in the air reacts with the $Ca(OH)_2$ solution, the solution becomes higher in ($CaCO_3$). The resultant precipitate settles at the bottom of the beaker, making the solution turbid. The extent of this turbidity may be measured with a Nephelometric Turbid meter, giving a measure of the device's CO_2 capture efficiency. Increased absorption of CO_2 reflects in increased turbidity.

Solvent Preparation

Sodium hydroxide (NaOH) and finely powdered calcium oxide (CaO) were chosen as the solvents to use in the experiment. Pellets of NaOH were obtained from the college laboratory, and the CaO powder with 99 percent purity was ordered from a local supplier of chemicals. The two compounds were dissolved in dilute water to obtain a solution of different concentrations. In particular, $Ca(OH)_2$ solution was prepared in the range of 1% - 60% w/v as increments (1%, 3%, 5%, 7%, 10%, 15, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%), whereas NaOH solution was prepared in 10 percent increments to 100 percent w/v. These solutions were used to check the efficiency of CO_2 absorption of the respective solutions.

The two chosen solvents react with carbon dioxide as follows

$$\mathbf{Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)}$$
$$\mathbf{2NaOH\ (aq) + CO_2\ (g) \rightarrow Na_2CO_3\ (s) + H_2O\ (l)}$$

The enthalpy of regeneration of $Ca(OH)_2$ is around +178 kJ mol^{-1} of CO_2, whereas that of NaOH is far greater at around +400 kJ mol^{-1} of CO_2. The specific heat capacity of $Ca(OH)_2$ is approximately 77.1 J/mol K, while that of NaOH is 59.0 J/mol K. This means that $Ca(OH)_2$ takes up more energy to rise in temperature as compared to NaOH per mole. Regarding thermal stability, $Ca(OH)_2$ decomposes at about 580°C, whereas the melting point of NaOH is lower (about 318 °C), thus more amenable to work in some liquid-phase capture processes, but also a more reactive and corrosive compound at high temperatures.

Estimated Flow Rate

Fan area

$A = \pi r^2 = \pi (0.03)^2 \approx 2.827 \times 10^{-3}\ m^2$

Typical air velocity for small 12 V DC fans: 2–5 m/s (depends on RPM & blade pitch).

Flow rate

$Q = A \times v$

At 3.5 m/s $\rightarrow$ $Q \approx 0.0099\ m^3/s \approx 9.9\ L/s \approx 21$ CFM

In general, the realistic range of our experimental setup is 8–20 CFM (≈ 4–9 L/s) for normal-speed 12 V fans. For calculation purpose we have considered 9 L/s of flow rate.

Estimated Efficiency for CO_2 Capture Device

Efficiency (η) in this context = fraction of the *theoretical maximum CO_2 absorption* achieved in the actual setup. Small air-scrubber devices with short residence time (6 cm fan, ~25 cm flow path) usually operate with a moderate efficiency of 40–50% (good turbulence) and for calculation purpose 50% efficiency of the capture device was considered.

Formula

Actual CO_2 absorbed (g) = Std. CO_2 absorption (g/L) × V_{sample} (L) × η device

Where:

- Std. CO_2 absorption (g/L) = theoretical value for NaOH or $Ca(OH)_2$ from standard table
- V_{sample} = 15 mL = 0.015 L
- ηdevice = device efficiency factor based on airflow rate (from 6 cm fan, 12 V power supply) and residence time

Actual CO_2 absorbed (g)= Std. value × 0.015 × η

The CO_2 amount in each 15 mL sample was estimated using the standard theoretical capture capacities for 1% w/v $Ca(OH)_2$ (5.94 g CO_2/L) and NaOH (11 g CO_2/L), multiplying these values by the solution volume (0.015 L). This calculation provided the estimated CO_2 mass (g) for the given sample size based on established reference values. The actual amount of CO_2 absorbed in a 15 mL sample, based on device specifications, was calculated in grams by applying above mentioned formula.

Experimental Procedure

$Ca(OH)_2$ was dissolved in different amounts (1, 3, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60 percent w/v) as a solution. In the same manner, NaOH solutions were made to different concentrations, including 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 percent w/v. The machine was filled with the beaker containing the 1 percent solution, making sure that the back pipe is completely immersed. The room was put in an airtight and the machine was switched on. For all concentrations of both $Ca(OH)_2$ and NaOH solutions, turbidity readings were taken after 45 minutes. When a visible precipitate formed, turbidity was measured using Nephelometric turbid meter to be measured. This was done with all other concentrations of both solutions and corresponding observations were noted.

Results and Discussion

In the initial phase (up to 40% concentration), the NaOH concentration was increased in 10% additions because of its relatively lower CO_2 absorption capacity at lower concentrations. Beyond 40%, where a noteworthy increase in CO_2 capture efficiency was recorded, the concentration was raised up in by 5% higher levels to examine this enhancement in detail. Similarly, Lower concentrations of $Ca(OH_2)$ (1–10%) showed comparably lower NTU due to fewer suspended particles. With increasing concentration, turbidity enhanced sharply up to around 50–55%, indicating near-saturation of suspended solids. Beyond 55%, NTU values plateaued (~97 NTU), suggesting the turbidimeter reached its upper measurement limit.

Table 1. Concentration and turbidity of $Ca(OH)_2$ Solvent

Sr. No.	Concentration of the Solvent	Turbidity
1	1%	10.2
2	3%	15.6
3	5%	22.4
4	7%	30.1
5	10%	39.5
6	15%	51.2
7	20%	62.8
8	25%	73
9	30%	81
10	35%	86.7
11	40%	91.1
12	45%	94.3
13	50%	96
14	55%	97.1
15	60%	97.6

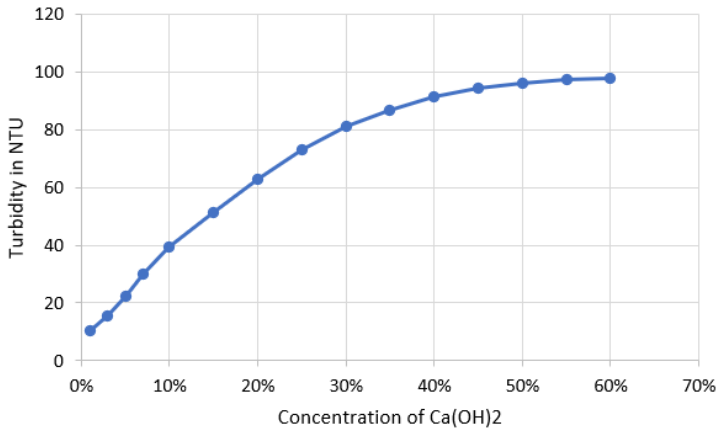

Fig. 3. Concentration Vs Turbidity of Calcium Hydroxide Concentrations

Fig. 3 displays the correlation between the concentration of calcium hydroxide and turbidity, which acts as a proxy of carbon dioxide (CO_2) capturing level (de Luna et al. 2020). X-axis is the concentration of Calcium Hydroxide in weight/volume or Molarity. The Y-axis is the Turbidity of the solution that is reported in arbitrary units: 0-100, where 0-100 indicates how cloudy the solution is as a result of calcium carbonate precipitate formation (Chepkonga, 2022).

As it can be seen from Fig. 3 (Table 1), the concentration of Calcium Hydroxide grows, and the turbidity rises steeply (Momenijavid et al., 2022). The non-linear rise indicates that a strong concentration of $Ca(OH)_2$ will greatly improve the capacity of the solution to absorb CO_2, leading to increased $CaCO_3$ formation, and by extension, turbidity (Tan, 2019). The rate of capture depends upon the concentration of $Ca(OH)_2$ (Chen et al., 2019). There is a chance that the curve might achieve saturation beyond 0.5, meaning that at a particular stage, the further addition of $[Ca(OH)_2]$ can be less fruitful (He and Tyka, 2023). This information can be used to design the best possible range of concentrations of the practical Direct Air Capture by calcium-based sorbents (Sabatino et al., 2021).

Table 2. Concentration and Turbidity of Sodium Hydroxide Solvent

Sr. No.	Concentration of NaOH (%)	Turbidity (NTU)
1	10	1.2
2	20	3.5
3	30	6.8
4	40	10.1
5	45	20.4
6	50	30
7	55	36.7
8	60	43.3
9	65	53.8
10	70	64.1
11	75	76
12	80	89.6
13	85	98.1
14	90	105.8
15	95	107.5
16	100	108

The relationship between the concentration of NaOH and Turbidity (Fig. 4), expressed as an indicator of CO_2 capture efficiency, is depicted in Fig. 4 (Table 2) (Medina-Martos et al., 2022). The NaOH concentration is given by the X-axis that varies between 0% and 100%. The Y-axis is the measure of (Turbidity) how cloudy the solution became, and this is proportional to how much more of Sodium Carbonate (Na_2CO_3) precipitates as it becomes cloudy due to the absorption of CO_2 (Chepkonga, 2022).

It can be seen in the Fig. 4, at 0 % of NaOH solution the turbidity is zero, meaning that negligible amounts of CO_2 were captured, and as the concentration increases, the turbidity rises consistently (Narayanasamy, 2021). The relationship on the graph is positive and not linear, which indicates that raising the concentration of NaOH increases the absorption of CO_2, leading to the formation of more Na2CO3 and, accordingly, higher turbidity (Mgabhi, 2021). Based on the Fig. 4, it can be

understood that beyond 40 percent concentration, the capability of the solution to absorb carbon rises drastically and portrays a linear rise up to 100 percent concentration, and then plateaus beyond the 100 percent concentration (Cai et al., 2024). The plateau shows a suitable concentration range to apply practically with a balance of efficiency and cost of material (Yang et al., 2021).

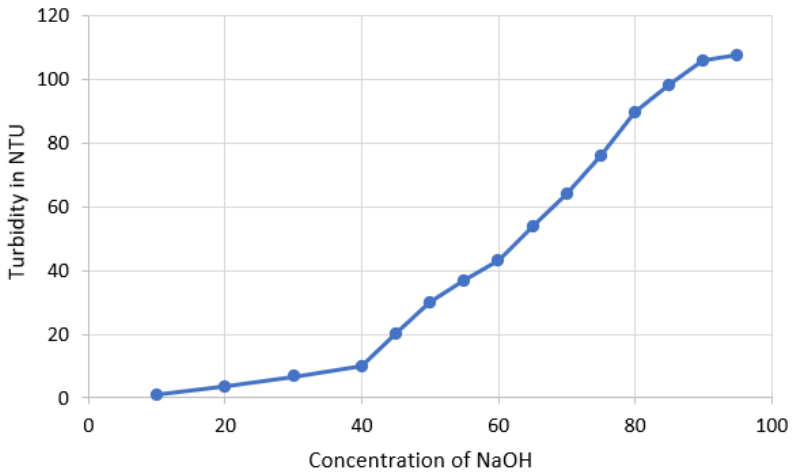

Fig. 4. Concentration Vs Turbidity of NaOH Concentrations

On the basis of observations, the following outcomes can be concluded:
1. Calcium Hydroxide performed well at the beginning. At low concentrations, it also reacted rapidly with CO_2, producing a significant turbidity at a very early stage. Even at a low 30 percent concentration, this had already reached 80 NTU, and at 50 percent, it approached peak efficiency. $Ca(OH)_2$ does not need much to make it effective, and this proves it economical and efficient automatically (Matos et al., 2024).

2. In its place, Sodium Hydroxide was found to react much more slowly. Calcium Hydroxide is more effective even at lower concentrations like 5% whereas, absorption of CO2 by NaOH is significantly less at low concentrations. Once exceeding the threshold, turbidity levels were continuously increased with them reaching over 100 NTU, which shows the ability of the system to sustain the performance (Boyd, 2019).

3. Still, the performance of NaOH started to saturate at the concentration of 100% or higher, i.e., at concentrations beyond 100%, it was not expected to bring significant improvements (Blasiak, 2022). Such a plateau effect is pertinent to the consideration of the practical application.

Table 3. Actual CO_2 Absorbed by 15 mL Calcium Hydroxide Samples at Various Concentrations (Considering 50% Capture Device Efficiency)

Concentration of $Ca(OH)_2$ (%)	Standard Amount of CO_2 Absorbed (g/L) (Theoretical Value)	Standard Amount of CO_2 Absorbed in 15 mL Sample (g)	Actual Amount of CO_2 Absorbed in 15 mL Sample Based on Device Specifications (g)
1	5.94	0.09	0.04
3	17.82	0.27	0.13
5	29.70	0.45	0.22
7	41.58	0.62	0.31
10	59.40	0.89	0.45
15	89.10	1.34	0.67
20	118.80	1.78	0.89
25	148.50	2.23	1.11
30	178.20	2.67	1.34
35	207.90	3.12	1.56
40	237.60	3.56	1.78
45	267.30	4.01	2.00
50	297.00	4.46	2.23
55	326.70	4.90	2.45
60	356.40	5.35	2.67

These results show that there are observed differences in the behavior of the two solvents under comparable conditions. Compared to Sodium Hydroxide, Calcium Hydroxide will always give a good show at lower concentrations; it captures more CO_2 than the former with less material (Han et al., 2024). It will suit small-sized urban settings where the carbon-trapping systems will also be more efficient and safer; thus, it is a fantastic choice when it comes to scalable, low-maintenance choices

(Jozay et al., 2024; Liu et al., 2020). Sodium Hydroxide does not trail behind, but at higher strengths only, which, nevertheless, implies the presence of certain trade-offs, such as increased costs, increased causticity, and storage issues (Theodore et al., 2022). Even though it is a feasible option, especially when used in industrial plants that are at containment and reusability, it can be limited in its use when looking at decolonized or home-sized rooftop DAC units (Long et al., 2020). Please refer Table 3 and 4 for standard efficiency and the actual amount of CO_2 absorbed in 15 mL sample based on device specifications (g) for concentrations of $Ca(OH)_2$ and NaOH.

Cost-Benefit Analysis

Implementing Direct Air Capture (DAC) systems on a large scale needs to be measured in terms of the economy, as well as its environmental advantages (McQueen et al., 2021). This Cost-Benefit Analysis aims to learn whether Calcium Hydroxide or Sodium Hydroxide may be used as the sorbents in DAC systems depending on the price of the raw materials, energy required, the impact on the environment, and the potential to transfer it to the long-term stage (Qiu, 2022).

Cost Considerations

Material Costs

• *Calcium Hydroxide (Ca(OH)2):* Calcium Hydroxide is relatively cheap (~2020) and easily accessible (~2020) compared to other potential urban-scaled hydroxide-based hydroxylated halogen removal agents (NaOH); Calcium Hydroxide is less reactive than NaOH, and so safer to utilize in larger quantities in urban settings (Gusiatin et al., 2020). The economic efficiency of $Ca(OH)_2$ is high because its use was effective at a low concentration (Taglieri, et al., 2017).

• *Sodium Hydroxide (NaOH):* Compared to NaOH, it is significantly more expensive (~ 60-90/kg), and quite reactive, particularly at high concentrations. It is corrosive, which requires stronger and more expensive storage and handling equipment (Bender et al., 2022).

Table 4. Actual CO_2 Absorbed by 15 mL Sodium Hydroxide Samples at Various Concentrations (Considering 50% Capture Device Efficiency)

Concentration of NaOH (%)	Standard Amount of CO_2 Absorbed (g/L) (Theoretical Value)	Standard Amount of CO_2 Absorbed in 15 mL Sample (g)	Actual Amount of CO_2 Absorbed in 15 mL Sample Based on Device Specifications (g)
10	110.0	1.65	0.83
20	220.0	3.30	1.65
30	330.0	4.95	2.48
40	440.0	6.60	3.30
45	495.0	7.43	3.71
50	550.0	8.25	4.13
55	605.0	9.08	4.54
60	660.0	9.90	4.95
65	715.0	10.73	5.36
70	770.0	11.55	5.78
75	825.0	12.38	6.19
80	880.0	13.20	6.60
85	935.0	14.03	7.01
90	990.0	14.85	7.43
95	1045.0	15.68	7.84
100	1100.0	16.50	8.25

Movable part, fixed Equipment Cost part, and operating cost

DAC configuration: The designed device of DAC incorporates economical parts, such as fans, simple filtration, and a turbidity meter (Dineen, 2020). This reduces the need to use much energy with the system, and the sorbents used are recyclable (Obodo et al., 2023).

Maintenance: Crystallization of $CaCO_3$ can be easily purified by maintenance reaction, but in the case of NaOH, an extra purification step may be required (Simoni et al., 2022). This implies that the systems based on Ca(OH)2 incur lower maintenance costs (Flegkas et al., 2019).

Environmental and Social Benefits

Carbon Reduction

The two solvents can aid in atmospheric CO_2 sequestration. Nevertheless, $Ca(OH)_2$ is more effective on both lower and diluted concentrations, and it has a significant benefit for scaling systems at urban scales (Reyes-Serrano et al., 2020). The direct benefit of CO_2 reduction in urban centers with high-density populations is an increased air quality and population health, particularly in areas with a high intensity of PM2.5 levels (Reyes-Serrano et al., 2020).

Safety and Health

NaOH is extremely corrosive and presents safety hazards when used in an installation where handling is decentralized or rooftop (Riddick, 2020). $Ca(OH)_2$ is also alkaline but far safer, therefore more applicable to make part of a house or small-scale urban DAC units (Mollersten et al., 2022). Its low material costs to run the process and the relatively high rate of reaction make the calcium hydroxide highly scalable (Jbr, 2025).

Table 5. Comparative Summary

Factor	**Calcium Hydroxide $Ca(OH)_2$**	**Sodium Hydroxide (NaOH)**
Material Cost	Low	Moderate to High
Efficiency (Low Conc.)	High	Low
Safety	Relatively Safe	Hazardous
By-Product	$CaCO_3$ (Stable usable)	Na_2CO_3 (needs further treatment)
Suitability for Urban Use	High	Low
Scalability	High	Medium

Table 6. Environmental Impact Assessment

Impact Category	**$Ca(OH)_2$**	**NaOH**
Resource Extraction	Limestone (abundant)	Salt (brine) + Electricity
Waste Generation	$CaCO_3$ (reusable)	Na_2CO_3 (manageable)
Water Use	Moderate	High (for dilution)
Carbon Footprint	Medium	High (if not renewable energy)

Table 7. Regeneration Techniques Comparison

Technique	**Applicable to**	**Efficiency**	**Energy Need (kWh/kg CO_2)**	**Cost (INR/ton CO_2)**
Thermal Calcination	$Ca(OH)_2$	Medium	2.5–3.0	₹2000–4000
Electrochemical	NaOH	High	5.0–6.5	₹6000–8000

NaOH is both far more expensive and unsafe, which gives it a scale-up limitation as well, but it can be used in closed industrial systems with a well-established regeneration mechanism, and may be especially useful (Yadav et al., 2025). Its solid by-product, $CaCO_3$, can either be utilized in construction or kept in a safe way with value addition (Woodall et al., 2019). NaOH is more costly and unsafe, and hence, its scalability is not so high, but it may be of particular value in closed industrial systems with highly developed regeneration mechanisms (Yadav et al., 2025).

Conclusion

About the following experiment, we can conclude that $Ca(OH)_2$ proved to be an efficient and rapid method of absorbing CO_2, showing a high turbidity even at low concentration, thus a cheap option. By contrast, NaOH only achieved turbidity levels at high concentrations, and its effectiveness stagnated after a certain point at 100% percent. The difference will be critical in assessing practicality and scalability with respect to real-world usage of DAC. On a face-off, $(Ca(OH)_2$ leads in terms of efficiency and practicability in capturing CO_2, particularly, within narrow, urban areas. It achieves the task under slight focus; thus, it is cheap and uncomplicated to handle. NaOH is more appropriate for working in a controlled, industrial location and not in homes or rooftop installations. Thus, developing an easy, scalable carbon sequestration mechanism, which can fit into urban life settings, $Ca(OH)_2$ is the low-fuss starting point. Calcium Hydroxide is the less expensive and viable option in urban DAC systems in economic terms. It uses fewer raw materials, creates fewer risks in its processes, and leaves a desirable by-product. Alternatively, Sodium Hydroxide is more suitable in a controlled setting in the industry because it is more expensive and demands more safety measures, despite being very efficient in large quantities. Therefore, the use of $Ca(OH)_2$ ensures maximum carbon capture and best fits into the objectives of affordability, safety, and environmental responsibility.

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Author Contributions

SSC: First author; executed fieldwork, data collection, and primary analysis; drafted a first version. AVM: Supervisor; presented the teaching during the research and helped in examining the outcomes. AJM: Assisted with the experimental setup and contributed input during manuscript preparation. PMN: Helped in the organization of the article and provided substantial inputs during the writing process. AIM: Helped to organize the article and provided a lot of useful input in writing.

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