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# The Use of Lime for Carbon Dioxide Production: Brief Analysis


**Carlos Hernandez-Rodriguez[1*], Yolanda Guadalupe Aranda-Jimenez[2] and Edgardo Jonathan Suarez-Dominguez[1,2]**

*[1]Centro de Investigación Aplicada y Tecnológica, Circuito Golfo de México 200, Pórticos de Miramar, CP 89506 Cd. Madero, Tamaulipas, México.*
*[2]FADU, Universidad Autónoma de Tamaulipas, Circuito interior S/N Campus, Tampico-Madero, Tampico, Tamaulipas, México.*


***Authors' contributions***

*This work was carried out in collaboration between all authors. Author CHR designed the models and wrote the protocol and wrote the first draft of the manuscript. Author YGAJ managed the literature searches and validation of model application. Author EJSD identified poured earth model and conclusion and review last final version. All authors read and approved the final manuscript.*


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## ABSTRACT


Nowadays, the selection of construction materials depends not only on the economic or resistance characteristics but also the environmental effect, mainly for the energy usage, $CO_2$ emissions and pollution produced during the processes to obtain them.
Portland cement and lime can be used to produce solid vertical structures. Poured earth is a technique that can substitute concrete or cement mortars in edification, characterized by using less inorganic materials as cement, and soil of the surrounding environment.
This paper proposes a method to analyze the use of lime and cement in solid, and show the basic analysis of lime and explain why it is impossible to have a 100% ecological product or renewable, but also it is possible to reduce emission with decrease of products according to the desired characteristic of the final material produced.



**Corresponding author: E-mail: c.hernandez@qia.mx; Edgardo.suarez@uat.edu.mx*

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## 1. INTRODUCTION

Carbon dioxide ($CO_2$) and energy required to produce materials have been analyzed widely, mainly because of greenhouse effect and process production sustainability. It is known that energy sources, when they burned, release pollutant that may affect human health as happens in London since 50 decade [1], 80`s in Mexico City [2] or nowadays in Beijing [3]. Cardiovascular effects are the most important problems caused by air pollution in London and Beijing too [1,4], and children sickness in Mexico [2].

Architecture and construction generally used materials where nonrenewable energy is applied like mortar cement or lime. Earth construction as adobe or poured earth will soon be used to mitigate high-processed elements using clean earth directly with stabilizing products in minimal quantities [5]. Poured earth has similar mechanical resistance and structural characteristics as obtained with other materials like concrete. When it is prepared, it does not requires nonrenewable energy, the environmental area is not affected to that surface doesn't change their thermal characteristics [6]. Cement requires a lot of energy and produces $CO_2$ [7] or toxic pollutants like Sulphur or nitrogen oxide [8]; although it can reabsorb a part of the first one [9,10] process is not sustainable. Lime is another compound that requires big quantities of energy and it is an important pollutant contributor [11]; even with the above, this kind of materials has potential for application in architecture [12].

In this paper we explain the impossibility of lime to be highly ecological, comparing results of energy required to produce it with Portland cement and describes some ways to take decisions about optimal use. The objective of this analysis is also to show a theoretical model with van der Waals equation and other obtained by [13].

## 2. METHODS

First, we analyzed stoichiometric equation for lime production with $CO_2$. Then we calculated enthalpy of reaction and, by the specific heath combustion of some materials to observe some comparisons from energy needed to obtain lime. Finally, we show and poured earth model from material characteristics.

### 2.1 Calculating $CO_2$ and Energy Required for Obtaining Lime

It was calculated the energy used to obtained lime, this is obtained from calcium carbonate, initially by calcination and then by hydration according to the stoichiometric equations:

$$CaCO_3 \xrightarrow{500-700°C} CO_2 + CaO \quad (1)$$

$$CaO + H_2O \longrightarrow Ca(OH)_2 \quad (2)$$

It can be seen that, at ideal conditions, every ton of $Ca(OH)_2$ requires 1.35 ton of $CaCO_3$ emitting into the atmosphere 594 Kg of $CO_2$. Process is reversible, so that the same quantity of $CO_2$ will be the same that will be needed to absorb initial compounds.

In the other hand it is required heath to obtain CaO, a precursor of $Ca(OH)_2$, which for obtaining, requires of caloric energy usually comes from nonrenewable sources which implies additional release of $CO_2$.

Table 1 shows the formation enthalpy for the reaction of CaO. From the data (standard values) of this and knowing that $\Delta Cp,m$ = -26.62 kJ for equation 1 it can be observed that $\Delta Hr$ = 2396814 kJ.

**Table 1. Formation enthalpy of compounds in equation 1**

| Substance | ΔH(f) kJ/mol | Cp,m J/mol·K |
|---|---|---|
| $CaCO_3$ | -1206.9 | 81.88 |
| CaO | -635.09 | 42.8 |
| $CO_2$ | -393.51 | 37.11 |

Table 2 shows specific heat of combustion for some materials. It can be observed the amount of energy generated by each material, which is necessary to generate ΔHr calculated above.

**Table 2. Specific heat of combustion for some materials**

| Fuel | Combustion specific heat | | Fuel required to generate ΔHr, Kg |
|---|---|---|---|
| | MJ/Kg | kJ/Kg | |
| Charcoal | 30 | 30000 | 79.9 |
| Pinewood | 21 | 21000 | 114.1 |
| Dry wood | 18 | 18000 | 133.2 |

### 2.2 Calculation of $CO_2$ Volume

It is well known that Van der Waals equation can predict state variables:

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT \quad (3)$$

Where p is pressure, n is the number of moles, V is volume, R is the gas ideal constant, T is temperature, and a, b are van der Waals constants. From which it is obtained:

$$pV^3 - (pnb + nRT)V^2 + (an^2)V - abn^3 = 0 \quad (4)$$

From this equation, volume was calculated to obtain the volume of $CO_2$ evolved into the atmosphere at normal condition of pressure and temperature. Solved equation gives 847147.29 m3 of air.

### 2.3 Portland Cement

Several studies involving Portland cement [8] have reported about 4-6 MJ of energy required for production with high impact to the environment.

Many characteristics of cement products are well known such as maximal mechanic compression and uses in construction. Cement products actually demonstrates a posterior reduction of $CO_2$ by reabsorbing [10].

### 2.4 Poured Earth and Model

Earth construction is promoted as sustainable for materials used in fabrication of compounds [12]. It includes a technique called poured earth which is a technique that use soil or pure earth that requires stabilizing [5].

To compare materials it is necessary to know all their components. To evaluate any characteristic on materials it may be calculate as:

$$\sum_{i=1}^{n} x_i C_i = C_T \quad (5)$$

where $x_i$ is the fraction of component i, $C_i$ is the characteristic evaluated, as cost, and $C_T$ is the total cost in this case. With this equation is expressed any linear property that can be estimated with math.

To identify the effect of a part it is necessary to know the cost depending on the two values of the properties evaluated, if:

$$\frac{C_{T1}}{C_{T2}} < 1 \quad (6)$$

It will indicate property of 1 is better than 2.

It is possible to know the resistance in time for poured earth according to [13]:

$$R = A(1 - \exp(kt)) \quad (7)$$

Where R is mechanical resistance to compression (kgcm-2), t is time in days, k is the velocity constant (days-1) associated to the decrease of R with time and A represents global velocity of the processes involved on R growth.

When resistance is constant, it can be constructed a line related to concentration so it is possible obtain density fraction according to:

$$R(x_a) = mx_a + n \quad (8)$$

Separating the main component from the other we can make $x_a C_a + \sum_{b=1}^{n} x_b C_b = C_T$ and $\sum_{b=1}^{n} x_b C_b = D$ where D is constant for the initial calculus of $C_T$ it is rewritten:

$$C(r) = r x_a C_a + (1 - r)D \quad (9)$$

Where $r$ is a parameter that controls fraction of material (cement or lime) $x_a$. When $r$ increases or decreases, the rest of material $D$ decreases or increases, respectively, to compensate amounts of materials in mixture. This parameter is valid for $0 < r < 1$.

Therefore, a calculus of $x_a$ must be performed considering a desired value of R using (8). Then equation (9) can be used for estimating costs.

Roux, R. and Espuna, A. [14] exposed a study of lime reaction rate in a controlled environment with $CO_2$ estimating 100 years for complete absorption of 50% of this gas. As it is known, reaction rate depends on concentration so that for lower proportions it is required more time, which can be a disadvantage with the solids with Portland cement, which velocity is major. On the other hand, according to the first law of thermodynamics is well known that is not possible to revert a process with 100% of efficiency, and in this case is not possible absorb all the $CO_2$ emitted, neither absorb all $CO_2$ necessary for the reaction occurs.

Calcium hydroxide can react with other materials and it is susceptible to interchange ionic with soil. This characteristic will depend on the hearth of the place so that sometimes will be better the use of only Portland cement.

Nevertheless, it is necessary a deeper analysis to know what products stoichiometrically has a less $CO_2$ requirement to produce itself.

## 3. CONCLUSION

From the above analysis, it is inferred that the lime and Portland cement used can affect the environmental similarly to lime.

The model and the equations pretend to change the paradigm of the thought about the cement Portland regarding the lime.

It is not possible to assure which material will be the best because there is no case where analysis of the material time behavior including concrete exists.

Further experimentation is necessary to understand effects in material characteristics such as mechanical resistance and durability. Cost-benefit analysis will be needed for each case application.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Halonen JI, Hansell AL, Gulliver J, Morley D, Blangiardo M, Fecht D, Tonne C. Road traffic noise is associated with increased cardiovascular morbidity and mortality and all-cause mortality in London. European Heart Journal. 2015;36(39):2653-2661.
2. Calderón-Garcidueñas L, Kulesza RJ, Doty RL, D'Angiulli A, Torres-Jardón R. Megacities air pollution problems: Mexico City Metropolitan Area critical issues on the central nervous system pediatric impact. Environmental Research. 2015; 137:157-169.
3. Zhang H, Wang S, Hao J, Wang X, Wang S, Chai F, Li M. Air pollution and control action in Beijing. Journal of Cleaner Production; 2015.
4. Huang C, Moran AE, Yang X, Cao J, Chen K, Wang M, Kinney PL. Cardiovascular health impact of air pollution control in Beijing and Urban China: Projections from the cardiovascular disease policy model-China. Circulation. 2015;132(Suppl 3): A13699-A13699.
5. Suárez-Domínguez EJ, Aranda-Jiménez YG, Roux-Gutiérrez RS. Tierra Vertida: Una descripción global, in: Paisajes Arquitectónicos, Architectum plus, SC. USA. 2015;7. ISBN: 978-6079137281.
6. Aiguo Dai, Kevin E Trenberth, Taotao Qian. A global dataset of palmer drought severity index for 1870–2002: Relationship with soil moisture and effects of surface warming. J. Hydrometeor. 2004;5:1117–1130.
7. Awad NAM. Global warming case study: Carbon dioxide emissions from cement industry in Atbara (Doctoral dissertation, UOFK); 2015.
8. Ali N, Jaffar A, Anwer M, Alwi SKK, Anjum MN, Ali N, Ming X. The greenhouse gas emissions produced by cement production and its impact on environment a review of global cement processing. International Journal of Research. 2015;2(2):488-500.
9. Talukdar S, Banthia N, Grace JR. Carbonation in concrete infrastructure in the context of global climate change–Part 1: Experimental results and model development. Cement and Concrete Composites. 2012;34(8):924-930.
10. Haselbach L, Alam A. Carbon sequestration in old and new Portland cement concrete pavement interiors. In International Symposium on Systematic Approaches to Environmental Sustainability in Transportation. USA. 2015;71-82.

    Available:http://dx.doi.org/10.1061/9780784479278.007
11. Dubey A. Studies on the air pollution around cement and lime factories. Journal

of Environment and Earth Science. 2013;3(9):191-194.
12. Sameh SH. Promoting earth architecture as a sustainable construction technique in Egypt. Journal of Cleaner Production. 2014;65:362-373.
13. Suárez-Domínguez EJ. Aranda-Jiménez YG. Modelo temporal de resistencia mecánica la compresión para tierra vertida. Revista Épsilon. 2014;23:33-42.
14. Roux-Gutiérrez RS, Espuna Mujica JA. El hidróxido de calcio y los bloques de tierra comprimida, alternativa sostenible de construcción. Revista Electrónica Nova Scientia. 2012;9(5): 176-202.



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