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ARTIFICIAL TREES FOR ATMOSPHERIC CARBON CAPTURE-A REVIEW

VENKATARAGHAVAN.R , ARVIND PRABHU.T , IVO ROMAULD S* AND BRINDHA DEVI P

Department of Bio-Engineering, Vels University, Pallavaram, Chennai 600117

ABSTRACT

Carbon emission is the major cause for global warming; Scientists have been working to reduce the carbon emissions ever since the effects were identified. There are number of methods to reduce the excess carbon dioxide that are present in the atmosphere, in this work, we have suggested a way to reduce the atmospheric carbon dioxide by a technology which will manifest in the form of "Artificial trees". The artificial trees are thousand times more effective in carbon capture than aerobic tress anddoes not release the absorbed carbon back again into the environment. The carbon capture by the trees is accomplished by special leaves that are coated with suitable sorbent. The absorbed carbon dioxide from these artificial trees could be utilized or converted into useful forms hydrocarbons-sources of fuel or buried underground. Therefore, in this review we discuss the various techniques of carbon capture and sequestration.

KEYWORDS: ***Global warming, artificial trees, greenhouse gases, renewable energy, peridotite***

IVO ROMAULD S*

Department of Bio-Engineering, Vels University, Pallavaram, Chennai 600117

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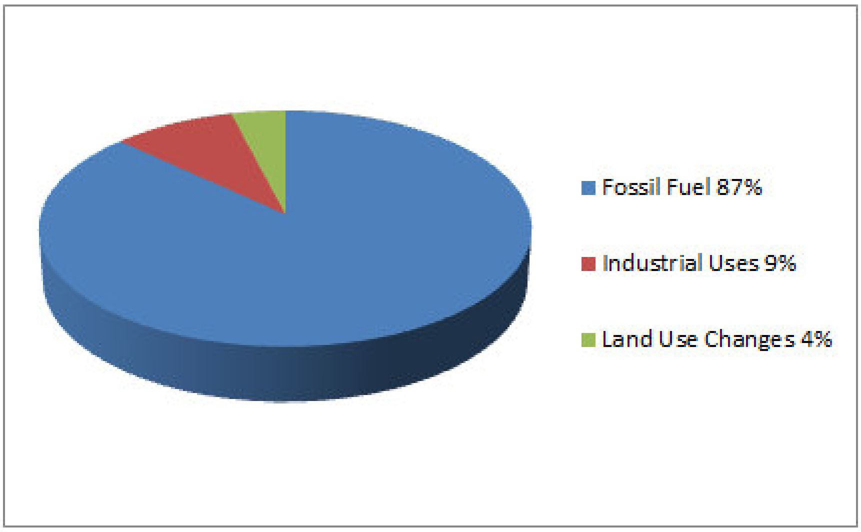
INTRODUCTION

Industrial revolution and anthropogenic sources has considerably risen the concentration of atmospheric carbon dioxide (Fig-2).The increased level of the carbon dioxide gas causes the atmosphere to trap large amount of heat energy on the earth's surface resulting in the increased level of global climatic changes. As a result, it has become a popular topic to find ways to reduce the CO_2 levels in the scientific and policy worlds.It has been predicted that by the middle of the next century, the earth's temperature may 1-3 degree rise than the present. As an aid to control this global warming, various method are being implemented ,this includes reduction in use of fossil fuels, implementation of energy conservation measures, installation of pollution controlling devices all this mentioned controlled measures is satisfied by advanced method called "The Artificial Trees".[1] As mentioned above, wide variety of sorbents are being employed for use in filters for entrapping CO_2 molecules: these include a solid resin, liquid hydroxides, and a variety of amine compounds.[1] Recent reports on sorbents, suggest using amine as is it a highly efficient and cost effective compared to other conventional sorbents (Lackner 2009). In addition, an amine sorbent requires low temperature for the extraction of the captured CO_2 from the sorbents for storage purposes. Nevertheless, people acceptance is needed for its conventional installments. Further analysis of different types of sorbents in low scale level is required to find a suitable sorbent for operation.

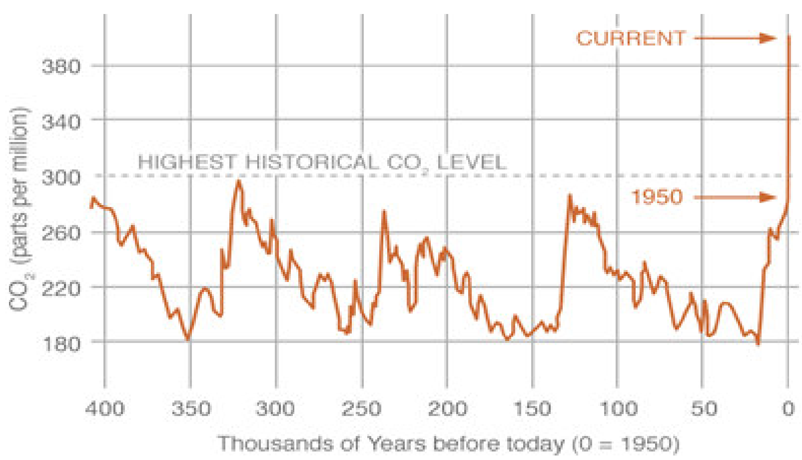
SOURCES OF CARBONDIOXIDE



FigureIVarious sources of carbon dioxide in percentage

Figure 1
Various sources of carbon dioxide in emitted in the atmosphere are shown

Graph I
Constant rise in the carbon dioxide level over the decades



Increase in the global carbon dioxide level in parts per million.

DESIGN OF ARTIFICIAL TREES

There are many ideas and processes in the control of carbon dioxide pollution in the atmosphere, one of such ideas is that artificial trees for atmospheric carbon capture, which focuses in the control of excess amount of carbon dioxide in the atmosphere without any damage to the external environment. This process is known as Direct Carbon Capture. The artificial trees should be aerodynamically designed for better absorption of the gas (Lackner 2009).When placed anywhere, it may be deemed convenient, as the carbon dioxide is spread everywhere in the atmosphere. Whether installed alongside urban highways or on open, rural fields, near sea shore and near power plants effectively creating an artificial forest, but it is recommended to install it near highways for direct capture of carbon dioxide. The concentration of carbon dioxide is consistent across globe at about 402.25parts per million (Lackner 2009) (Graph-I).[1,2] Reports from Institution of Mechanical Engineers recommend using compact models of sorbent containing leaves above vehicular tailpipes.To note that the size of the air collector decides the amount of carbon dioxide that can be absorbed. Smokestacks from power stations, thermal power plants and various industries release carbon dioxide as a mixture along with flue gases,-nitrous oxide and sulphur oxide, in addition to carbon dioxide.[3,4]Hence it is necessary to separate all other gases leaving only Carbon dioxide. Use of highly selective sorbents overcomes this problem by sequential selection of carbon dioxide from a mixture of various gases that are widespread in the atmosphere. This would reduce the increasing temperature of 1-6 degree Celsius of the globe predictedat the end of this century as a result of increasing carbon dioxide level in the atmosphere.[3]

EFFECTIVE SORBENT FOR CARBON CAPTURE

Many researches are been carried out day to day in order to find an effective sorbent for carbon capture. Initially sodium hydroxide in liquid form were extensively used for carbon capture, later due to difficulties in removing the absorbed carbon dioxide from the filters required high energy pre-investment to overcome high bonding, later many researches were conducted and finally as an aid solid sorbents were found to drastically increase the efficiency of the trees and storage of carbon dioxide without any leakage back into the atmosphere.[5-9] Lackner suggested using carbonates instead of aqueous form of NaOH to overcome bonding energy.[10] Additional features of this NaOH are easily available and are cost effective.[10]

STORAGE OF CARBONDIOXIDE

The major and the most difficult step encountered in artificial trees method to eliminate atmospheric carbon is the storage of the absorbed carbon dioxide without any leakage back to the atmosphere.[5]
Various carbon storage methods are described below:

CO_2 STORAGE POTENTIAL OF BASALTIC ROCKS-SOLIDIFIED MOLTEN VOLCANIC MAGMA AFTER MILLIONS OF YEARS

Permanent storage of the absorbed carbon dioxide can be done by injecting CO_2 into basaltic rocks. Basaltic rocks (Fig-II) are rich in minerals and divalent cations (e.g. Ca^{2+}, Mg^{2+} and Fe^{2+}). The CO_2-charged water accelerates metal release forming deposits of solid carbonate minerals such as Calcite ($CaCO_3$), Magnesite ($MgCO_3$) and Siderite ($FeCO_3$) for long term storage of CO_2. Iceland is the largest landmass (103,000 km^2) found above sea level and it is found that it is made of about 90% basaltic rocks (Lackner 2009).[10, 11, 12, 13] Basalt rocks are solidified forms of hot molten lava that cooled down after theexposure of volcanic eruptions. The basalt rocks igneous rocks; fine grained which is a combination of plagioclase and pyroxene minerals.Moreover, deep burying of the captured carbon dioxide is done effectively such that the absorbed carbon doesn't escape into the atmosphere from where it originated from. Basalt rocks are also found under the sea floor as the magma joins the sea. In addition, this method of disposal of carbon dioxide results in formation of fossil fuels which would satisfy the fuel and energy requirement of over further generation. However, any leakage of these would drastically affect the aquatic ecosystem.

SOLIDIFIED MOLTEN BASALT ROCK

Figure 2
Basalt rock in Iceland: storage of captured carbon dioxide

SALINE AQUIFERS

Saline aquifers are aquatic deposit rocks that are water permeable and saturated with salt water. This salty water content of this rock is called brine. According to the report stated by International Energy Agency -2008 the super critical carbon dioxide that has been pressurized to the phase between gas and liquid may be injected into these saline aquifers (Lackner 2009).[14] The porous nature of the saline aquifers helps in entrapment of the absorbed carbon dioxide. Here the injected carbon dioxide reacts with the dissolved minerals and converted to harmless product or gets dissolved in the brine.[14]And this process is applicable for long term storage of carbon dioxide. It is important to note that the absorbed carbon dioxide should not be compacted or subjected to violent mechanical stress during storage. Leak proof unbreakable containers should be employed for protecting these aquifers, so that any sort leakage can be prevented prior huge devastation of ecosystem. Cement is used to plug wells after injection is finished to prevent the release of carbon dioxide back into the air (Fig-III).

SALINE AQUIFER DEEP INSIDE EARTH'S CRUST

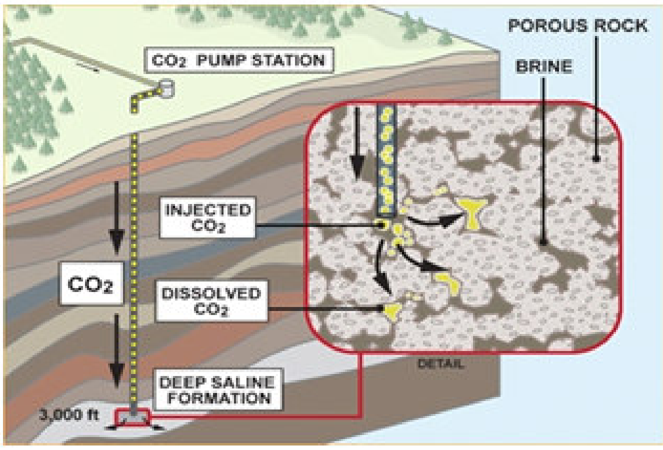


Figure 3
Saline Aquifer beneath the earth's crust representing the injection of carbon dioxide

PERIDOTITE

The most common and predominant lithosphere layer found in the Earth's mantle or below the surface of the crust is the peridotite (Fig-IV). It has been found that regions of Oman are rich in this peridotite rock such that they appear even in the top surface of the soil. These natural rocks are porous in nature, and after absorption, carbon is injected into it forms solid minerals such as calcite. Recent reports from both Columbia University's Lamont-Doherty Earth Observatory in New York, states that Peridotite would serve as an effective source for long term storage process.[15] High pressurized heated water containing dissolved carbon dioxide is the only method for injecting this absorbed carbon dioxide (Lackner 2009).[15] It has been estimated that about 4-5 billion tons of excess carbon dioxide could be stored in countries such as Oman by using peridotite as a storage medium for carbon dioxide.[16] Peridotite also occurs in the Pacific islands of Papua New Guinea and Caledonia, and along the coast of the Adriatic Sea and fewer amounts in California. However this method of storage doesn't have strong experimental proof and public acceptance for this method is not satisfactory as this method requires large number of flow pipes, and nobody is sure whether the carbon dioxide gas would leak back out into the atmosphere in future.

PERIDOTITE ROCK

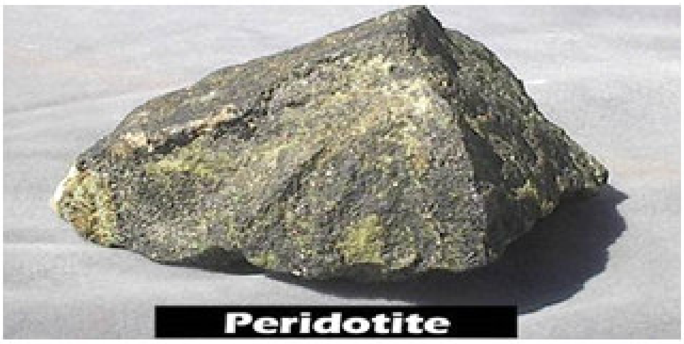
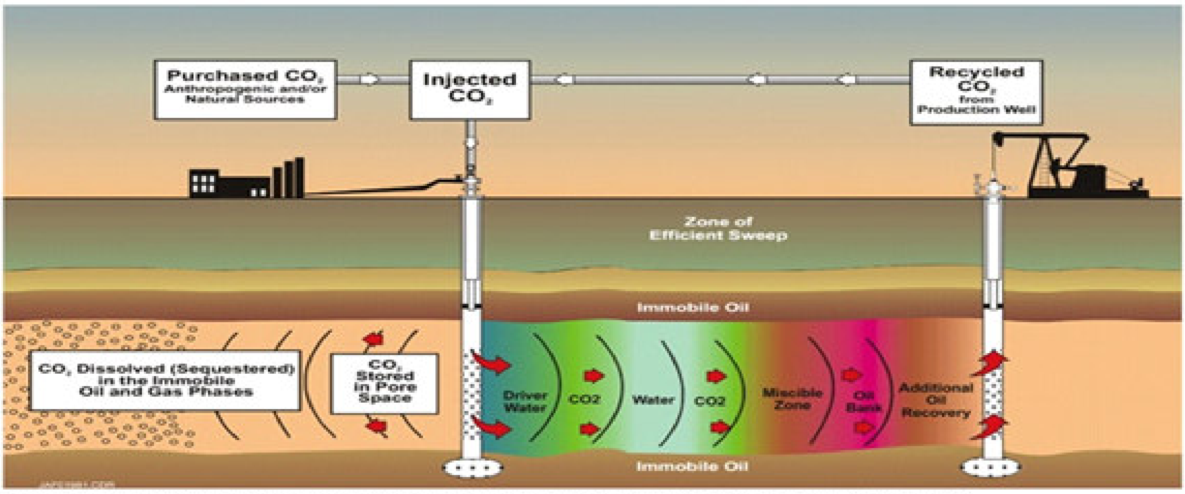


Figure 4
Peridotite rock found in Pacific Papua Islands

CARBONDIOXIDE EMPLOYED IN ENHANCED IN OIL RECOVERY PROCESS

The carbon dioxide captured can be used in a number of ways, one such way is the Enhanced Oil Recovery Process (Fig-5).[17, 18]



Source: Advanced Resources International and Melzer Consulting, Optimization of CO_2 Storage in CO_2 Enhanced Oil Recovery Projects, prepared for UK Department of Energy & Climate Change, November 2010.

Figure 5
Enhanced Oil Recovery Process

COST FOR VIRTUAL AFFORESTATION

It has been estimated that single artificial tree would cost around (15, 00,000-20, 00,000 INR) depending upon its efficiency (Lackner 2009). It is important to note that it is one time investment but, the air filters should be periodically replaced. Moreover cost can considerably reduce by increasing its production process.

ARTIFICIAL TREES ON A LARGE SCALE

Figure 6
Trees installed in plains

Figure 7
Trees installed near highway roads

DISCUSSION AND CONCLUSION

We conclude that the installments of artificial trees are possible. The trees are efficient in the carbon capture and sequestration process than the real trees, as the cost for afforestation of these trees are cheaper as well as easier, and require compact space for the installment; it is highly suggested to employ modern and advanced methods of pollution controlling devices - artifical trees. However, there are no disadvantages of carbon dioxide released back into the atmosphere. There are least chances of surface disturbances during the storage process into the rocks or into the oceans. The carbon dioxide absorbed by the trees can be utilized or converted into useful forms such as hydrocarbon sources of fuel. In contrast it could either be transformed into a liquid (fuel) or buried underground. As far as the process uses renewable energy, this fuel would not release new carbon dioxide into the atmosphere. The carbon dioxide finds its use in enhanced oil recovery process in the extraction of oils from the underground (Fig-V).[18] Compact sized artificial (air filter sized of normal household insecticide cartridges) trees are estimated soon to be employed to be used as household air filters all over the world. And further this technology can be altered and can be utilized for the capture of many other harmful gases in the future.

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CONFLICT OF INTEREST

Conflict of interest declared none.

REFERENCES

1. Monastersky R. Global carbon dioxide levels near worrisome milestone. Nature. 2013 May 2;497(7447):13.
2. Lackner KS. Capture of carbon dioxide from ambient air.Eur Phys J Spec Top. 2009 Sep 1;176(1):93-106.
3. Chapman L, Fox TA. Engineering geo-engineering. Meteorological Applications. 2011 Mar 1;18(1):1-8.
4. Schiffman R. Artifical Trees as a Carbon Capture Alternative to Geoengineering. InThe Yale Forum on climate change and the media 2013 Feb (Vol. 13).
5. Lackner KS, Brennan S, Matter JM, Park AH, Wright A, Van Der Zwaan B. The urgency of the development of CO2 capture from ambient air. Proc Natl AcadSci U S A. 2012 Aug 14;109(33):13156-62.
6. Czaun M, GoeppertA,Olah GA, Prakash GS,. Air as the renewable carbon source of the future: an overview of CO 2 capture from the atmosphere. Energy Environ Sci. 2012;5(7):7833-53.
7. Benford G, Caldeira K, Criswell DR,GreenC,HerzogH,HoffertMI,Jain AK, Kheshgi HS, Lackner KS, Lewis JS, Lightfoot HD. Advanced technology paths to global climate stability: energy for a greenhouse planet. Science. 2002 Nov 1;298(5595):981-7.
8. Harvey CF, House KZ,LacknerKS, Schrag DP. Permanent carbon dioxide storage in deep-sea sediments.Proc Natl AcadSci U S A. 2006 Aug 15;103(33):12291-5.
9. Butt DP,JoyceEL,LacknerKS,Sharp DH, Wendt CH. Carbon dioxide disposal in carbonate minerals. Energy. 1995 Jan 1;20(11):1153-70.
10. Goldberg DS,HanP,Lackner KS, Slagle AL, Wang T. Co-location of air capture, subseafloor CO2 sequestration, and energy production on the Kerguelen plateau. EnvironSci Technol. 2013 Jun 21;47(13):7521-9.
11. Gislason SR, Oelkers EH. Carbon storage in basalt. Science 2014 Apr 25;344(6182):373-4.
12. Galeczka I, Wolff-Boenisch D, Gislason S. Experimental studies of basalt-H 2 O-CO 2 interaction with a high pressure column flow reactor: the mobility of metals. Energy Procedia. 2013 Dec 31;37:5823-33.
13. Bacon DH, Ramanathan R, Schaef HT, McGrail BP. Simulating geologic co-sequestration of carbon dioxide and hydrogen sulfide in a basalt formation.Int J Greenhouse Gas Control. 2014 Feb 28; 21: 165-76.
14. Goldberg DS,LacknerKS,Levine JS, Matter JM,Ramakrishnan TS, Supp MG. Relative permeability experiments of carbon dioxide displacing brine and their implications for carbon sequestration. Environ Sci Technol. 2013 Dec 17;48(1):811-8.
15. Paukert AN, Matter JM, Kelemen PB, Shock EL, Havig JR. Reaction path modeling of enhanced in situ CO 2 mineralization for carbon sequestration in the peridotite of the SamailOphiolite, Sultanate of Oman. Chem Geol. 2012 Nov 10; 330:86-100.
16. Kelemen PB, Matter J, Streit EE, Rudge JF, Curry WB, Blusztajn J. Rates and mechanisms of mineral carbonation in peridotite: natural processes and recipes for enhanced, in situ CO2 capture and storage. Annu Rev Earth Planet Sci. 2011 May 30;39:545-76.
17. Blunt M, Fayers FJ, Orr FM. Carbon dioxide in enhanced oil recovery. Energy Convers Manag. 1993 Nov 30; 34(9):1197-204.
18. Dai Z, Middleton R, Viswanathan H, Fessenden-Rahn J, Bauman J, Pawar R, Lee SY, McPherson B. An integrated framework for optimizing CO2 sequestration and enhanced oil recovery. Environ SciTechnol Lett. 2013 Nov 6;1(1):49-54.

Reviewers of this article

Dr G Kathiravan

Prof/Head,
Dept of Biotechnology,
Vels University,Pallavaram,
Chennai,India

Mr. Anubrata Paul M.Sc. Biotech (Research)

Department of Biotechnology, Natural Products Research Laboratory, Centre for Drug Design Discovery & Development (C-4D) , SRM University, Delhi-NCR,Sonepat.

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