

Carbon Dioxide: Present Scenario, Future Trends and Techniques to Reduce CO₂ Concentration in Air

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Abstract- The problem of emission of greenhouse gases, especially carbon dioxide, into the atmosphere is inevitable but the amount of carbon dioxide prevalent in the atmosphere today is menacing. The level of carbon dioxide in the atmosphere being almost 400 ppm is itself a threat to the future generations. The world had come together to fight the rising level of CO₂ but with no watershed achievement apart from setting some international forums. The techniques available to us for keeping a check on rising level of carbon dioxide; Scrubbing Towers, Artificial Tree, Bio char, STEP, have been successful to certain extent but have been warped by the capital involved with the particular technique. The funding involved in these techniques is way too high which has led to the question: What if the non-renewable source of energy can be used to capture carbon dioxide from the atmosphere and provide us with a cleaner air? The best answer would be the use of solar powered carbon capture device.

Index Terms- CO₂, PPM (parts per million), DAC (direct air capture), CCS (carbon capture and storage)

I. INTRODUCTION

Carbon dioxide in atmosphere is as important as oxygen for survival. It is the breathing gas for plants just like oxygen is prominent for living beings. Carbon dioxide is produced both naturally and by humans. Natural processes that produce carbon dioxide include ocean release, plant and animal Respiration, soil decomposition, and from volcanoes. Carbon dioxide is one of the major greenhouse gas and human activities are contributing CO₂ at a high pace. Today average CO₂ concentration in atmosphere is about 400 ppm which is above the maximum atmospheric concentration of CO₂ for a safe planet. Carbon Capture and storage is the technique available which absorbs CO₂ from flue gases and thus reduces amount of CO₂ addition to the atmosphere. Attempts are also made to absorb CO₂ from direct air, but the problem with it is that to absorb CO₂ from atmospheric air energy is supplied and while supplying this energy another amount of CO₂ is generated. It urges us to think that if the energy to operate such CO₂ absorption plant is from renewable energy source our task to reduce CO₂ from atmosphere can be accomplished. Thus we propose use of solar energy to run a plant/device that would absorb CO₂ either from direct air or from the flue gases. This way while operating absorption of CO₂ we will not be contributing any CO₂, thus making our effort count. Also, the absorbed CO₂ further could be separated from the absorbent and can be stored for other

industrial purposes. This way we can serve the environment along with cost reduction in industrial purposes.

II. WHY INCREASING CARBON DIOXIDE LEVEL IS MENACE TO EXISTENCE OF LIFE IN EARTH

Atmosphere has witnessed meteoric rise in CO₂ level since industrial revolution. The global annual mean concentration of CO₂ in the atmosphere since then has increased markedly from 280 ppm to 400 ppm as of 2015 [1]. With this rate it is expected that concentration is to rise to as much as 500-1000 ppm by the year 2100 [2]. Averaged over all land and ocean surfaces, temperatures warmed roughly 1.53°F (0.85°C) from 1880 to 2012, according to the Intergovernmental Panel on Climate Change (IPCC). Subsequent and prominent effect of increased CO₂ in atmosphere is global warming. As the name suggests it is the rise in global temperature whose effects can be disastrous in near future. Some of the consequences are enlisted below:

1. Rise in sea level.
2. Mutation in agricultural productivity.
3. Change in ecosystem i.e. ecological balance is disrupted.
4. Ozone layer depletion (this ozone layer saves us from harmful radiations of the sun)

Table 1: CO₂ CONCENTRATION IN PPM FOR VARIOUS YEARS

YEAR	CO ₂ (PPM)
2014	398.55
2013	396.48
2012	393.82
2011	391.63
2010	389.85
2009	387.37
2008	385.59
2007	383.76
2006	381.90
1997	363.71
1992	356.38
1987	349.16
1959	315.97

III. PRESENT AND FUTURE SCENARIO OF CO₂ IN ATMOSPHERE

1.1 PRESENT CONDITION:

The concentration of CO₂ in atmosphere has been increasing at menacing level. The whopping rise of CO₂ in the atmosphere over the few decades had jeopardised the climatic

conditions of the world. According to the data as on January 2, 2016 by National Oceanic and Atmospheric Administration(NOAA) and Scripps, the average annual concentration of CO₂ in atmosphere is 402.07 ppm(parts per million).

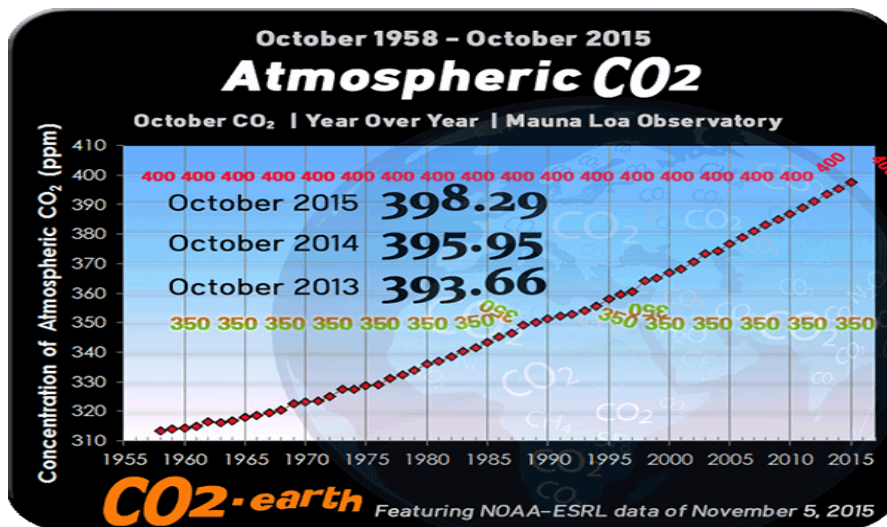


Fig 1: The concentration of CO₂ in atmosphere over the years [3].

1.2 FUTURE SCENARIO:

The current trend of rise in CO₂ in the atmosphere is precarious. According to C-ROADS version 3.014 April 22, 2013 based on approval in April 19, 2013 the concentration of CO₂ in the atmosphere by 2100 will be more than 800 ppm.

TABLE 2: Climate interactive CROADS versions 3.014 run April 22, 2013 based on confirmed proposals as of April 19, 2013.

	2009	2100
Global CO ₂ Emissions per year	36.31 Gtons	98.96 Gtons
Atmospheric CO ₂ parts per million	390.43ppm	882.87 ppm
Global Temperature Increase mean projection relative to pre-industrial	0.81 Celsius 1.46 Fahrenheit	4.47 Celsius 8.04 Fahrenheit

IV. IMPORTANT POLICIES ADOPTED TO CONTROL CO₂ AND OTHER GREENHOUSE GASES

It has been only few centuries after the Industrial Revolution that climate change had marred the Earth's atmosphere. The emission of greenhouse gases, in which carbon dioxide is the prominent one, is having a global impact. So, in order to control this emission of greenhouse gases into atmosphere the nations all around the globe have taken certain

steps and adopted policies to control the carbon dioxide and other greenhouse gases emission.

Some of the important policies are-

4.1 United Nations Framework Convention on Climate Change(UNFCCC)

In 1988 the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) set up the [Intergovernmental Panel on Climate Change](#) (IPCC), an expert body that would assess scientific information on climate change. The UN [Framework Convention on Climate Change](#) (UNFCCC) was adopted in May 1992 and entered into force in 1994. The convention included the commitment to stabilise greenhouse gas emissions at 1990 levels by 2000. The first Convention of the Parties to the UNFCCC (COP 1) was held in 1995. Negotiations at this and two subsequent COPs led to agreement on the **Kyoto Protocol** in 1997[4]. The Kyoto Protocol involved several decisions:

- By 2012, developed countries would reduce their collective emissions by 5.2% from 1990 levels, each country being committed to a particular figure.
- The emissions covered by the Protocol are not only carbon dioxide, but also methane, nitrous oxide, hydro fluorocarbons, perfluorocarbons and sulfur hexafluoride.
- These commitments would be reckoned on a net basis, considering sinks as well as sources, and each country must credibly measure its contribution and meet its commitment.
- Countries may fulfil their commitments jointly (such as with regional agreements) and they may improve the

efficiency of compliance through "flexibility mechanisms".

4.2 International Carbon Action Partnership

The International Carbon Action Partnership is an international forum which was founded in 2007 in Lisbon, Portugal by more than 15 nations that have implemented or are planning to implement emission trading system (ETS). Its main function is to share best practices and create a well functioned global carbon market [5]. The trade involving carbon dioxide which basically caters to meet the obligations specified in Kyoto Protocol which aimed at reducing the carbon dioxide emission in atmosphere.

4.3 UN climate change conference November-December 2015, Paris

The major emphasis of the COP21 meeting in Paris was on producing a global, binding agreement to cut carbon emissions. At the Paris meeting there was clear international agreement that reducing carbon dioxide emissions was a global priority built on a groundswell of public opinion in many countries, albeit with a range of different timelines involved. It was agreed to aim for a temperature increase below 2°C and with the aim of moving to 1.5 degrees, which suggests that governments will have to introduce additional mitigation actions to move more rapidly to low-carbon technologies, especially in electricity generation.

V. VARIOUS TECHNIQUES AVAILABLE TO COLLECT CO₂ FOR STORAGE AND INDUSTRIAL PURPOSES

5.1 SCRUBBING TOWERS

CO₂ scrubbing is a particular form of carbon capture that takes place after fossil fuel has been combusted, but before the exhaust is released into the air [6]. So, the process starts with CO₂ capture before the flue gas reaches the atmosphere via a power station's cooling towers [7]. Even though carbon dioxide usually makes up no more than 15 percent of a power plant's emissions by volume, it's responsible for 60 percent of the greenhouse gas effect [8]. In order to prevent the CO₂ from escaping into the atmosphere, post-combustion carbon capture (as its name implies) works by isolating CO₂ from the other flue gases after combustion [6]. The flue gas first reaches a wet scrubber where it is cooled and freed from any residual traces of sulphur dioxide (SO₂) that might weaken CO₂ scrubbing. A fan then transports the flue gas to the absorber, through which it flows bottom-up. This is where it meets the scrubbing solution, an aqueous solution of amines (a group of organic substances), which is added at the head of the absorber and, in a counter current flow, takes up the CO₂ from the flue gas. The low-CO₂ flue gas is scrubbed with water before leaving the absorber to remove any residues of the scrubbing agent, and finally reaches the atmosphere by the normal route via the stack or cooling tower [7].

5.2 ARTIFICIAL TREE

Professor Klaus Lackner, director of the Lenfest Center for Sustainable Energy at Columbia University has designed a synthetic tree, a construction that simulates the function of natural trees whereby leaves pull carbon dioxide (CO₂) out of the

air as it flows over them. When CO₂ comes into contact with sodium hydroxide, it is absorbed, producing a liquid solution of sodium carbonate. It is that liquid solution that the professor believes could be piped away, and the time at which the CO₂ could be recovered as a concentrated gas in preparation for its final storage [9]. The leaves look like sheets of papyry plastic and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as bicarbonate (baking soda) on the leaf. To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up more carbon dioxide [10].

5.3 BIOCHAR

Biochar is a black carbon material produced from the decomposition of plant-derived organic matter (biomass) in a low or zero oxygen environment (i.e. pyrolysis or gasification) to release energy rich gases which are then used for producing liquid fuels or directly for power generation [11]. Plants capture carbon through photosynthesis then the activity of microbes' release it back to the atmosphere; there is about three times as much carbon in soil and plants as in the atmosphere. If more carbon can be stored in the soil there will be less in the sky [12]. In the natural carbon cycle, plants take up CO₂ from the atmosphere as they grow, and subsequently CO₂ is emitted when the plant matter decomposes rapidly after the plants die. Thus, the overall natural cycle is carbon neutral. In contrast, pyrolysis can lock up this atmospheric carbon as biochar for long periods (e.g., centurial or even millennial time scales). Therefore, the biochar approach is an attractive solution to alleviating global warming concerns [13].

5.4 STEP

Solar thermal electrochemical photo (STEP) process combines electronic and chemical pathways to convert CO₂ to carbon or to carbon monoxide for subsequent use in synthesizing a range of industrially relevant products including hydrocarbon fuels. STEP uses an electrolysis cell consisting of molten lithium carbonate (Li₂CO₃) as the electrolyte. Using the thermal energy of the sunlight, the cell is heated to a temperature above the melting point of lithium carbonate. Atmospheric carbon dioxide is then bubbled through the cell. The CO₂ reacts with the lithium carbonate, and depending on the reaction temperature attained, either solid carbon is deposited at the cathode or carbon monoxide is produced. This conversion of carbon dioxide into solid carbon is facilitated by the visible rays of the sun that drive the reaction, when the visible rays are converted to electricity through photovoltaic techniques [14].

5.5 Oxy-fuel

If the fuel like coal, natural gas is burned in atmosphere of pure oxygen the flue gas formed almost completely consists of carbon dioxide and water vapours. Water vapours can be condensed and left CO₂ can be stored and used.

VI. SUGGESTION TO TACKLE INCREASING CO₂ USING CLEAN ENERGY FROM SUN

A device can be made that would have both suction device as well as fan so that the device/plant could be used for both

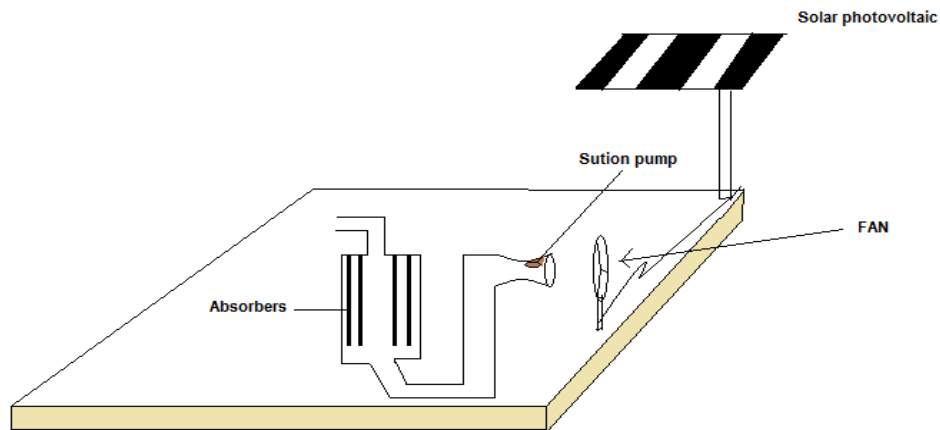
DAC (direct air capture) as well as CCS (carbon capture and storage). The suction device as well as the fan would be driven by the solar energy. The absorbents can be used to capture CO_2 by chemically reacting with it.

Replaceable CO_2 absorbing tubes installed inside scrubber would be replaced after fixed duration and the saturated tubes shall be taken for extracting absorbed CO_2 and making tubes again available for absorption.

One problem associated with this is efficiency. The efficiency of such model is a major issue as CO_2 captured is in meager amount. But if we can make a model with closed loop its

efficiency would be increased significantly. The air moving out of the absorption chamber can be pushed back into it again until the final air comes out purified and free of CO_2 .

This device shall not be bulky and could be installed by the government as mandatory obligation in urban areas in individual house roofs especially in the areas having abundance of solar energy. Such laws can be made to control increasing CO_2 level in the atmosphere. Cities having high CO_2 content in the air can be installed with such model and it will definitely keep check on the rising amount of CO_2 in air.



VII. SOME IMPORTANT POINTS

1. CO_2 absorption by alkanol amine, monoethanolamine (MEA) aqueous solution has been considered as the most efficient way and various research activities were conducted by this method and most commercial processes for the bulk removal of CO_2 from gaseous streams involve the use of amines [15].
2. CO_2 absorption is proportional to specific surface area of packing material and gas-liquid contact time. Pro-Pak when used as packing material shows highest CO_2 removal efficiency [15].
3. The absorption capacity of the amine is increased as its concentration increases, but not as great as might be expected because of the high acid-gas vapor pressure over the solution which increases as the concentration and the temperature of the solution increases [16].
4. It has been suggested that using high efficiency column packings in absorption and regeneration towers could substantially improve the efficiency of the gas treating process which reduce its capital cost [15] [16].
5. Absorption depends on pH of the solvent, temperature and concentration of both the gas and the solvent. The rate of absorption increases with the increase in temperature.

VIII. CONCLUSION

The per lustration of the carbon dioxide, its present and future trends as well as the threat it poses to the atmosphere are the area of scrutiny for our present generation. The rate at which carbon dioxide is rising in the atmosphere, it would put the future generation in the perilous condition for sure. To keep this alarming levels on check various international policies have been adopted in past. This meteoric rise of carbon dioxide needs to be checked and the techniques available to us helpful in providing that. But major concern is the use of energy and financial capital involved with it. So, it is not feasible to use these techniques. Hence, there is an urgent need to change the way we use these techniques. The use of solar energy can provide an alternative to these techniques which would be free of implementation cost. Another merit of this is that it does not add any more carbon dioxide into the atmosphere unlike some techniques which are used for cleaning up air but in the process of cleaning rather adds up to it. The carbon dioxide and other greenhouse gases emission cannot be overlooked and actions should be taken if we do not have to jeopardise the future generation. I don't think we can leave it to future generation to find the solution, can we?

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