

Use and Abuse of Excess CO₂ – An Overview

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ABSTRACT

It is now confirmed that global warming is taking place and its influence on the Earth's environment is found to be significant. Carbon dioxide (CO₂) and other green house gases are noticed to be significantly contributing to enhanced surface temperature of the earth, affecting the climate, degrading the quality of our environment and enhancing climate related vulnerabilities and hazards. A comprehensive exposition of the role of CO₂ is presented. Usage of CO₂ in enhancing oil from oil field is also discussed.

INTRODUCTION

In the last 100 years, Earth's average surface temperature increased by about 0.8 °C with maximum increase occurring over just the last three decades. Most of the observed warming occurred during two periods, 1910 to 1945 and 1976 to 2000. A cooling or plateau was also observed from 1945 to 1976 which has been attributed to sulphate aerosol or a result of uncorrected instrumental biases in the sea surface temperature record. The Intergovernmental Panel on Climate Change (IPCC) stated in its Fourth Assessment Report that the temperature rise over the 100 year period from 1906–2005 was 0.74°C with a confidence interval of 90%. For the last 50 years, the warming trend has been linear i.e., 0.13°C per decade. However, the often blamed CO₂ principally considered as the main source of anthropogenic cause of global warming has several uses in ecosystem (e.g., for the plants and oceans). In this paper, we discuss some of its uses in energy sector, and its long term storage.

CAUSES OF GLOBAL WARMING

There are many causes for global temperature rise, like increase in greenhouse gas concentrations, changes in solar luminosity, volcanic eruptions, variations in Earth's orbit around the Sun, etc. However, sudden rise in global temperature is mainly attributed to natural or anthropogenic factors causing increase in green house gases concentration in the atmosphere. Out of the six green house gases accepted under Kyoto protocol, concentration of CO₂ in the

atmosphere is highest; hence it is blamed for the global warming and climate change.

Atmospheric CO₂

Over the last 100 years, concentration of atmospheric Carbon dioxide (CO₂) has increased from about 280 ppm to 390 ppm and the majority of these additions have occurred in the last 50 years (Fig-1). Though the anthropogenic cause of rise in temperature due to increased CO₂ emission is highly debatable but everyone accepts the rise in CO₂ concentration in the atmosphere.

The concentration of carbon dioxide in Earth's atmosphere is approximately 392 ppm by volume as of 2011 and rose by 2.0 ppm/yr during 2000–2009. 40 years earlier, the rise was only 0.9 ppm/yr. This shows a rapid acceleration of concentrations. The increase of concentration from pre-industrial concentrations of 280 ppm has almost doubled in just the last 33 years.

Natural sources of atmospheric carbon dioxide include volcanic outgassing, the combustion of organic matter, and the respiration processes of living aerobic organisms. Man-made sources of carbon dioxide include the burning of fossil fuels for heating, power generation and transport, as well as some industrial processes such as cement making. CO₂ is also produced by various microorganisms from fermentation and cellular respiration.

Emission of CO₂ by natural sources is nearly balanced by natural sinks, the physical and biological processes, which remove carbon dioxide from the atmosphere. For example, some part of emitted CO₂

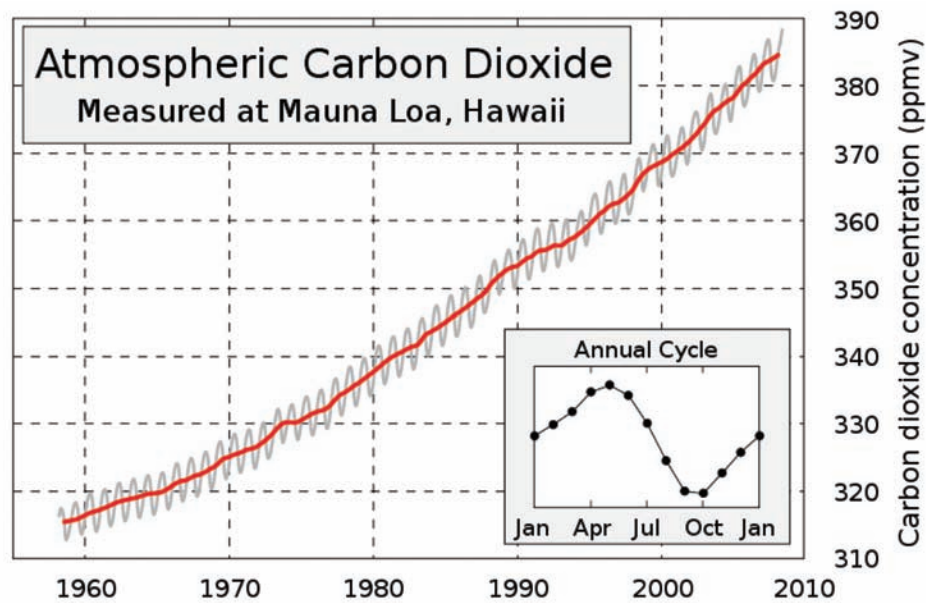


Figure 1. Atmospheric Carbon Dioxide

is directly removed from the atmosphere by plants for photosynthesis and it is soluble in water (ocean) forming carbonic acid. There is a large natural flux of CO_2 into and out of the biosphere and oceans. In the pre-industrial era these fluxes were largely in balance. Even now about 57% of human-emitted CO_2 is removed by the biosphere and oceans.

In industrial era, burning fossil fuels such as coal and petroleum is the leading cause of increased anthropogenic CO_2 and deforestation is the second major cause. In 2008, 8.67 gigatonnes of carbon (31.8 gigatonnes of CO_2) were released from fossil fuels worldwide, compared to 6.14 gigatonnes in 1990. In the period 1751 to 1900 only about 12 gigatonnes of carbon were released as carbon dioxide to the atmosphere from burning of fossil fuels, whereas from 1901 to 2008 the figure rose to about 334 gigatonnes. This addition is sufficient to exceed the balancing effect of sinks. As a result, carbon dioxide has gradually accumulated in the atmosphere, and as of 2009, its concentration is 39% above pre-industrial levels.

MAJOR EFFECTS OF GLOBAL WARMING AND CLIMATE CHANGE

- Changes in agricultural yields
- Sea level rise
- Increase of intensity of extreme weather events

- Changes in precipitation pattern & amount
- Mass species extinction
- Effects on Glaciers
- Changes in the timing of seasonal patterns in ecosystems
- Other effects of economic importance

Out of the various techniques proposed for removing excess carbon dioxide from the atmosphere, geo-sequestration is the most important and feasible one. This process describes long-term storage of carbon dioxide or other forms of carbon in suitable geological formations.

Possible Geological Formations

There could be several possible traps for efficient CO_2 storage, however few known traps are:

- Abandoned hydrocarbon reservoirs
- Mature oil fields, for enhanced oil recovery
- Saline reservoirs
- Non-economic coal seams or deep coal seams
- Shale formations
- Basalt formations

Options for Utility of CO_2

Potential use of CO_2 can be in the following areas to meet the growing demand of energy and the excess

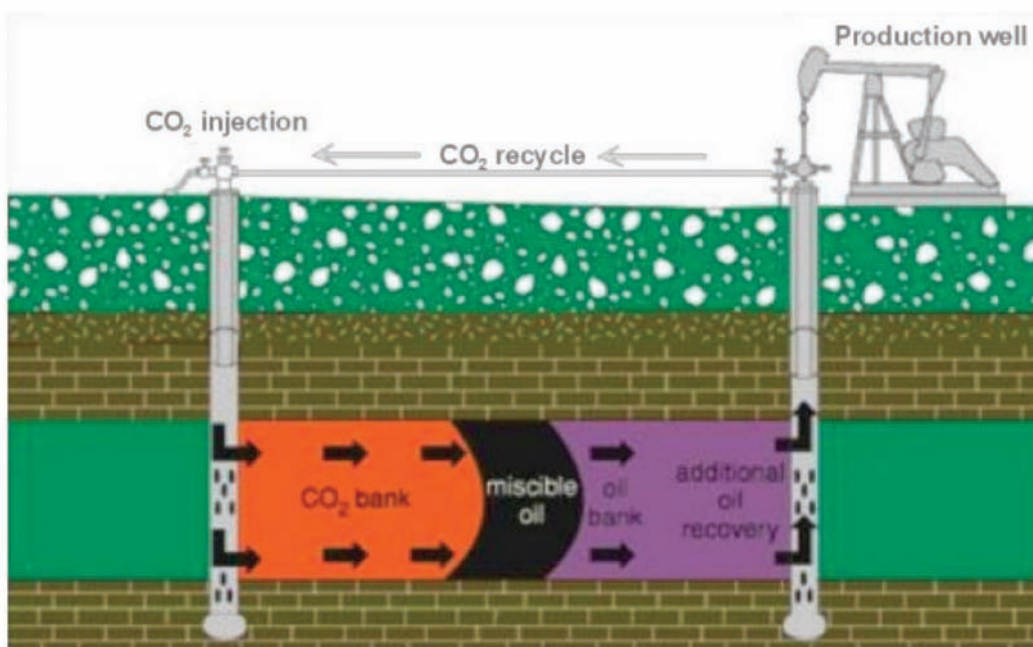


Figure 2. Use of CO₂ in enhancing Oil Recovery from Reservoir/ Oil field

amount can be sequestered permanently to form mineral carbonates:

- Enhanced Oil Recovery (EOR)
- Coal Bed Methane (CBM)
- Mineral Carbonation

In the following section a brief use of CO₂ for enhanced oil recovery is given. NGRI has an ambitious project on CO₂ – EOR in collaboration with SINTEF, Petroleum Research, Norway to study the possibility of CO₂ – EOR from a mature land oil field operated by Oil and Natural Gas Corporation (ONGC).

Enhanced Oil Recovery

Carbon dioxide injection in depleting reservoir serves two purposes, one to reduce CO₂ from atmosphere and other to enhance oil recovery from declining oil fields (Fig-2)(Holtz et al., 2001).

It is observed that chemical properties of the CO₂ are very good to push the oil forward. This is because CO₂ is miscible with the lighter hydrocarbons in some cases, depending on minimum miscibility pressure (Dimri et al., 2012). Immiscible CO₂ also has very good sweep efficiency. This works on the same principle that we follow to clean oil from our

hands. Water will remove a little of the oil off, soap and water will do a better job, but a solvent will clean the oil entirely. This is because a solvent can mix with the oil, form a homogeneous mixture, and carry the oil away.

Adaptation and Mitigation for Climate Change

Climate change mitigation involves reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks (Bickle et al., 2007; Bickle, 2009). Thus, geo-sequestration of CO₂ comes under climate change mitigation which may combat climate change but it will take several years of time to come into effect (Holt et al., 2008). Another strategy to combat climate change is adaptation of the practices which reduce carbon emissions; viz., efficient light lamps, green buildings, less use of individual motor vehicles and more of mass transport, tapping of the CO₂ emissions from the factories right at the source for processing and further sequestration etc. to reduce the vulnerability of natural and human systems to climate change effects.

Even if emissions are stabilized relatively soon because of mitigation processes, climate change and its effects will last many years, and in any case adaptation will be necessary specially in developing world.

According to IPCC, adaptive capacity of a country is closely linked to social and economic development and adaptation to the climate change will be more difficult for larger magnitudes of climate change.

CONCLUSIONS

CO₂-EOR serves two purposes, one to reduce CO₂ from atmosphere and other to enhance oil recovery from oil fields.

We can reduce the CO₂ emissions to save the environment by

- Tree plantation
- Using energy saving devices e.g. use of CFL
- Using mass transport
- Harnessing solar, wind and geothermal energy
- Harnessing hydroelectric power
- Nuclear energy

All these measures of mitigation of global warming must be implemented from individual to national and international level. For this, common man should be made aware of effects of global warming.

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Dr. Vijay Prasad Dimri, FNA, FNASc, FTWAS, FAPAS, served as a Distinguished Scientist of Council of Scientific & Industrial Research (CSIR) from October 27, 2010 for three years. He served as the Director of the CSIR-NGRI from October 2001 to February 2010. Also, he served as the Director, Gujarat Energy Research & Management Institute (GERMI), Gandhinagar (Gujarat), India from March 2010 to October 2010. Presently, he is INSA Senior Scientist and Distinguished Professor AcSIR based at NGRI, Hyderabad.

Dr. Dimri during his career at NGRI reformulated the problems of geophysics for realistic geology after careful analysis of physical properties such as density, susceptibility, reflectivity etc., from several deep boreholes including German continental deep drilling project (KTB), which follow fractal distribution rather than hitherto assumed random distribution for mathematical simplicity. His theoretical work established a relation between potential field and their sources and, thus, developed a new technique of scaling spectral analysis to delineate sub-surface complex geological structures for hydrocarbon, water and mineral exploration for many Indian case studies. A new way for modelling of any complex object lying beneath the earth surface by using fractal geometry, has been granted as US patent and has many applications like enhanced oil recovery, aquifer modelling etc. Also, he published papers using fractal theory to understand seismicity of different regions of India and tsunami modelling and its impact on Indian coast.

Dr. Dimri has more than 125 research publications in referred journals. He is an author of the book entitled "Deconvolution and Inverse Theory" published by Elsevier, 1992. Dr. Dimri has edited two books on "Applications of Fractal in Geosciences", Balkema, USA, 2000 and "Fractal Behaviour in Earth Science System", Springer, 2005. He has co-edited three other books published in 2008, 2010 and 2012. Recently, he along with two co-authors published a book on "Fractal Models in Exploration Geophysics", Elsevier, 2012. Dr. Dimri has been conferred with the highest civilian award of the India 'Padma Shri' by the Govt. of India, in 2010. He delivered prestigious 'Sir Axford Lecture' in Asia Oceania Geosciences Society (AOGS, Singapore) Annual Conference, 2010. Dr. Dimri is the first Asian to get Lorenz Award Lecturer by American Geophysical Union in the field of non-linear geophysics in December, 2007. Among many other important awards conferred on him includes, Prof. G.P. Chatterjee Award by Indian Science Congress, Outstanding Scientist Award by FAPCCI, Hyderabad, 2006, Department of Ocean Development Award, Govt. of India, 2004, and National Mineral Award by Ministry of Mines, Govt. of India, 1992. Geological Society of India presented him Dr. Hari Narain Award for Geophysics in 2011. Hon'ble Chief Minister of Uttarakhand awarded him S&T Excellence Award for his outstanding contribution in the field of Geophysics. He is a member of various scientific committees in India and abroad like ICSU-CSPR, Chairman, GC, IIG, Mumbai. Dr. Dimri is Fellow of many learned academies and societies including Third World Academy of Sciences (TWAS). Dr. Dimri is President of Indian Geophysical Union (IGU). He was also former President of Andhra Pradesh Akademi of Sciences, Hyderabad. Recently in July, 2013 he has been awarded "National Award" by MOES for his outstanding contribution in the field of Geoscience & Technology.