PERFORMANCE ANALYSIS AND ASSESSMENT OF MAINTAINING CO2 GAS QUALITY IN BOTTLING APPLICATIONS

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ABSTRACT

Carbon capture and storage (CCS) is a key technology to reduce CO_2 emissions from industrial processes, in particular from fossil-fuel based electricity generation. One important aspect of CCS is the safe long-term storage of the captured CO_2 in geological formations, especially in deep regional saline aquifers. Predicting the long-term evolution of the injected CO_2 requires an understanding of the basic physical mechanisms and the ability to capture them in field-scale numerical simulations. Simple mathematical models of trapping processes are developed to allow the identification of the dominant physical processes during CO_2 storage and their associated length and time scales. First-order estimates of the duration of the active storage period and the migration distance are obtained as a function of the average properties of the aquifer. These estimates support the selection of storage sites, in particular at the early stages when limited data is available. They also show that the length scales associated with the physical processes in regional aquifers can span several orders of magnitude.

Key words: Fossil-fuel, saline aquifers, methane natural gas

INTRODUCTION

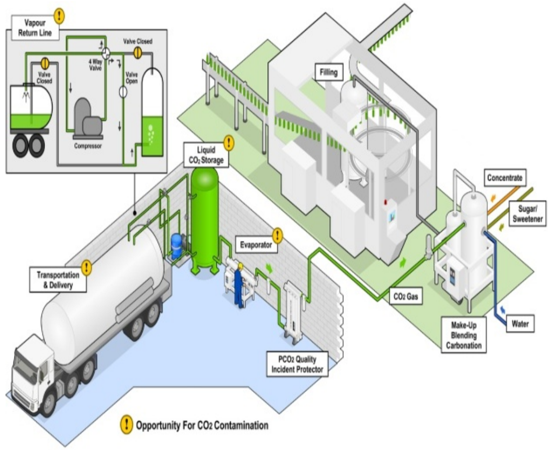
Carbon dioxide (CO_2) is produced in large quantities during electricity generation and by industrial processes. Each different process produces a CO_2 stream having a different composition. In addition, the CO_2 generation rate can vary substantially for at least some of the processes. For example, generation of CO_2 from electric power plants fluctuates with power demand, which varies both on a short-term (minute-to-minute) and a longer-term (seasonal) basis. The impact of a varying mass flow rate on pipeline and storage operation is not fully understood in terms of either operability or infrastructure robustness. It is important that the magnitude of the challenges posed by variation of CO_2 stream flow rate or composition be understood so that solutions can be offered to minimize any deleterious effects. The goal of the project was to ascertain the extent of the technical challenges posed by the transport and storage of CO_2 from emission sources that do not produce a consistent CO_2 stream in terms of composition and/or mass flow rate.

To maintain environment from CO_2 injection method is practicing around the world. The CO_2 inject into subsurface has to be maintain from leakage to the surface and contaminate to any natural resource due to exploration or extraction. The CO_2 has been created from industrial activities or natural environment. The main propose of CO_2 monitoring is human health. The CO_2 monitoring has to be done during injection and storage phase..Researchers reported the results on plant responses to elevated level of CO_2 by conducting experiments with different types of structures, which include growth chambers, controlled environmental chambers, greenhouses, phytotrons, open top chambers (OTCs) and free air carbon dioxide enrichment (FACE) facility. The effects of atmospheric CO_2 enrichment have been studied for more than a century in greenhouses, control environment chambers, OTCs and other elevated structures to confine the CO_2 gas around the experimental plants[3-6].

The accuracy on maintenance of CO_2 inside the chamber installed around the crops did not succeed in many other studies because of technical constraints.

CO2 EMISSIONS IN INDUSTRIAL

- Carbon emissions from industry are dominated by production of goods in steel, cement, plastic, paper, and aluminum. Demand for these materials is anticipated to double at least by 2050, by which time global carbon emissions must be reduced by at least 50%. To evaluate the challenge of meeting this target, the global flows of these materials and their associated emissions are
- projected to 2050 under five technical scenarios.
- A reference scenario includes all existing and emerging efficiency measures but cannot provide sufficient reduction. The application of carbon sequestration to primary production proves to be sufficient only for cement. The emissions target can always be met by reducing demand, for instance through product life extension, material substitution, or “light-weighting”. Reusing components shows significant potential particularly within construction. Radical process innovation may also be possible.

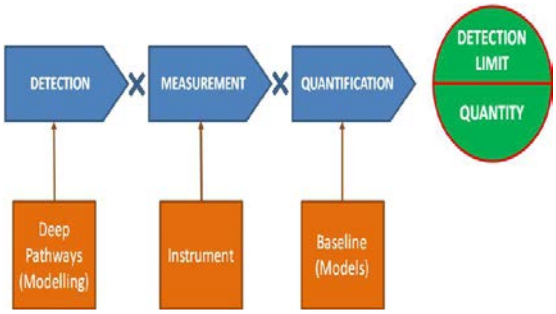


- The results show that the first two strategies, based on increasing primary production, cannot achieve the required emissions reductions, so should be balanced by the vigorous pursuit of material efficiency to allow provision of increased material services with reduced primary production.

VARIABILITY OF CO2 SOURCES

Capture of CO_2 can be applied to a utility or an industrial process at the rate that makes the most economic sense. Solvent-based capture is the technology that is applied more frequently at a commercial scale and therefore is likely to be applied to most utilities or industrial processes during at least the first few deployments. Most solvent-based capture processes capture at least 90% of the CO_2 they contact, and typically this value is closer to 95%. If the economics require a lower capture rate, some of the flue gas can bypass a smaller capture system. This might be the case if a contract for a certain amount of CO_2 has been negotiated or if there are no regulatory drivers specifying a larger capture rate.

Different industrial processes and different capture technologies produce captured CO_2 streams that have different compositions. Examples of CO_2 stream compositions for electric power generation scenarios (both pulverized coal [pc] and integrated gas combined-cycle scenarios), cement manufacture scenarios, petroleum refining scenarios, a coke production scenario, and a lime manufacture scenario were reported by Porter [1]. While reported typical impurities for postcombustion processes are relatively low (except perhaps for water, which could exceed by more than twice the Kinder Morgan pipeline limit), precombustion technologies could contain up to a few percent hydrogen or H_2S/COS and oxyfuel combustion could carry a couple of percent of oxygen and nitrogen as well as multiple times the Kinder Morgan water limit [1]. De Visser [2] has prepared a CO_2 quality recommendation that was based upon the ENCAP project as well as health, safety, and operational considerations. These recommendations are take into account in multicomponent, cross-effect evaluations (such as between water, methane, H_2S, and CO_2).



SEVERITY IN STEEL INDUSTRY

In 2015, the five largest emitting countries and the European Union, which together account for two thirds of total global emissions, were: China (with a 29% share in the global total), the United States (14%), the European Union (EU-28) (10%), India (7%), the Russian Federation (5%) and Japan (3.5%). The 2015 changes within the group of 20 largest economies (G20), together accounting for 82% of total global emissions, varied widely, but, overall, the G20 saw a decrease of 0.5% in CO_2 emissions in 2015.

CARBON STORAGE IN GEOLOGICAL FORMATIONS

Key to appreciating the challenges associated with storage is an understanding of the rock into which the CO_2 is injected. The CO_2 will be injected deep underground at depths of around 1,000m or more. This is to ensure that it cannot escape, as well as being at sufficient pressure to liquefy the gas, making it much denser and more efficient to store, since a given mass of CO_2 occupies less volume under these conditions. The CO_2 will be injected into sedimentary rock. The void space of the rock deep underground is full of water, unless it also contains oil and gas (see below). At high pressure, salts dissolve in the water and so we have highly saline brines, often saltier than sea water, that cannot be used for drinking or agriculture. It is proposed to store the CO_2 in these saline aquifers.Much research has been conducted on such rock formations as they occasionally contain oil or gas. These valuable hydrocarbons are the product of the partial decay of living organisms after burial at high temperatures and pressures. The higher the pressures and temperatures, the more the complex molecules are broken down, so shallow environments lead to heavy, viscous oils, while deep reservoirs contain natural gas (methane).

STORAGE MECHANISMS

Super-critical CO_2: it weighs like a liquid and flows like a gas. The CO_2 will generally be injected underground as a so-called super-critical fluid. The somewhat alarming term ‘super-critical’ simply means that the CO_2 has a liquid-like density and flows like a gas, and with a decrease in pressure will expand to form a gas without a phase transition (it will not boil). The CO_2 density will still be less than water. The viscosity—an inverse measure of how well the CO_2 flows—will be typically less than a tenth of the brine resident in the rock. CO_2 cannot burn or explode; the only reaction that it can undergo in the subsurface is the precipitation of solid, described below. The injected CO_2 will migrate to the top of the rock layer be-cause of buoyancy forces. As we are interested in the long term trapping of the CO_2 for hundreds to thousands of years, it is imperative that the CO_2 cannot escape. There are four principal ways in which the CO_2 is prevented from reaching the surface: Cap rock. Structural or stratigraphic trapping refers to low-permeability layers of rock (cap rock) that prevent the upwards movement of CO_2.

CO2 SYSTEM OPERATION AND MAINTENANCE

This requires the removal of all hazards, including $CO_{2,}$ and any new hazards that may be introduced while in the space. For CO_2, this requires that a clearance be applied that ensures the CO_2 system cannot operate (usually defeating the control system and mechanically blocking discharge via lockout-tagout). A clearance is only one step in eliminating the atmospheric hazard. Other requirements defined by RSHS and the local safety office also must be met to reclassify the space as no permit required. The qualified confined space supervisor must approve any such reclassification (declassification) on a Certificate of Declassification that identifies the space, the actions taken to eliminate the hazards, and the time for which the declassification is valid. The certificate must be posted at the point of entry for the period of time of validity, which will not exceed one shift, and filed in the confined space program files at expiration. A new certificate is required for each shift.[9] Reclamation does not have an official form for this purpose; one must be developed based upon the aforementioned information.All affected personnel, and those potentially affected, must be notified of reclassification. Any additional documents required by other standards, such as switching procedures, clearances, hazardous energy control documents, or hot work permits related to the work in the confined space, must be attached to the confined space permit or Declassification of a Space certificate.The protected space must be reclassified as permit-required confined space when the CO_2 system clearance is released. Doors to air housings must be kept locked at all times when the CO_2 system is armed.

SCOPE AND METHODOLLOGY

A contract for this study was awarded to CO2GeoNet, with a project team led by Imperial College, London. The primary aim was to identify potential methods for quantifying CO2 leakages from a geological storage site from the ground or seabed surface. The contractor was asked to review and identify techniques that have the potential to measure CO2 leakage into the atmosphere and into the water column, for both point-source and dispersed leakage scenarios; once identified, provide a detailed review of quantification performance including sensitivity cost and future developments; suggest quantification improvements of a monitoring portfolio; review current requirements and, provide recommendations. The contractor was also asked to liaise with the

LEAKAGE DETECTION IN PIPE LINE

Carbon Capture and Storage is a technology to reduce greenhouse gas emissions. CO_2 leak from high pressure CO_2 transportation pipelines can pose a significant threat to the safety and health of the people living in the vicinity of the pipelines. This paper presents a technique for the efficient localization of CO_2 leakage in the transportation pipelines using acoustic emission method with low frequency and narrow band sensors.

DETECTION TECHNOLOGY

Reliable CCS monitoring is vital in order to confirm that injected CO2 stays in the reservoir as intended, and that any occurring leakage is promptly detected allowing corrective actions to be initiated. Motivations for implementing monitoring strategies beyond the legal minimum required by government regulations, can be divided into economic, environmental and reputational factors, where the latter is significant; adequate monitoring is important for attaining public acceptance. CCS monitoring methods can be divided into deep focused (reservoir, overburden) and shallow focused (seabed, water column) methods. Shallow monitoring methods include acoustic and chemical sensors placed in the water column. For the CCS application, these sensor technologies are complementary; acoustic sensors are sensitive to CO2 in gas phase and chemical sensors can detect water-dissolved CO2 or formation fluids.

MEASUREMENT OF CO2

- **Ideal Gas Law**,

The ideal gas law is useful when estimating the effect of temperature and pressure changes on CO_2 measurement. It can be used to compensate the CO_2 readings.

$$pV=nRT$$

Where

p = pressure [Pa]
V= volume of the gas [m3]
n = amount of gas [mol]
R = universal gas constant(8.3145 J/mol K)
T = temperature [K]

CALCULATION METHOD

Activity-based approach (calculation method recommended for use by chemical companies)

Since the vast majority of freight transport operations of the European chemical industry are outsourced, most shippers have no direct access to energy or fuel consumption data. In the absence of such data, shippers can estimate CO_2 emissions of their transport operations by using an activity-based calculation method.

The activity-based method uses the following formula:

CO_2 emissions = Transport volume by transport mode x average transport distance by transport mode x average CO_2-emission factor per tonne-km by transport mode

[Tonnes CO_2 emissions = tonnes x km x g CO_2 per tonne-km / 1.000.000]

Energy-based approach (calculation method recommended for use by transportcompanies)

The easiest and most accurate way for transport companies of calculating their transport emissions is to record energy and/or fuel use and employ standard emission conversion factors to convert energy or fuel values into CO_2 emissions.Every liter of fuel consumed will result into a certain amount of CO_2 emissions.

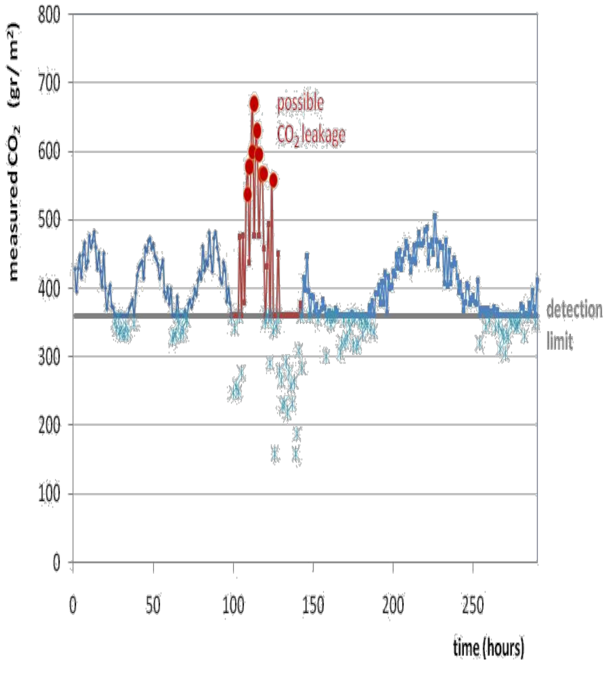
The activity-based method uses the following formula:

CO_2 emissions = fuel consumption x fuel emission conversion factor

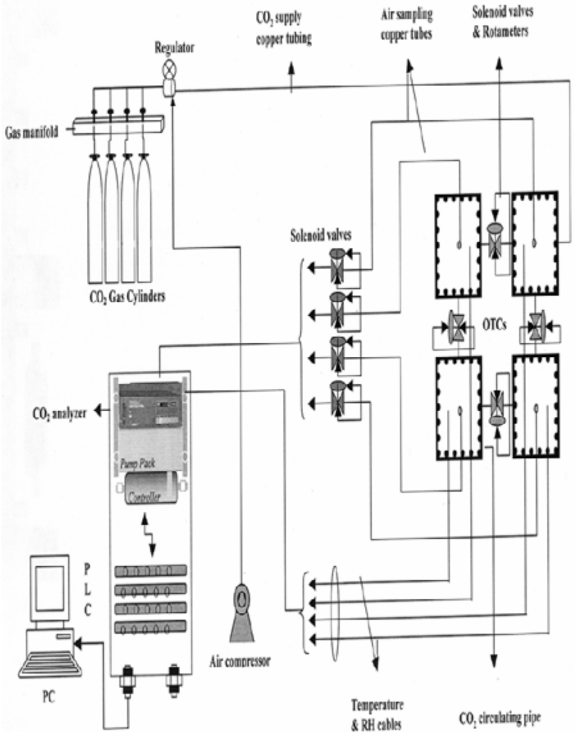
[Tonnes CO -emissions = liters x kg CO_2 per liter fuel / 1.000]

ANALYSIS OF CO2 LEAKAGE

The maintaining environment is priority to any plan in human life. It is planned for monitoring CO_2 injection, storage and leakage by using geophysical, numerical and analytical methods in seismic zone. In this regard the mineralogy, chemical composite, litho logy, seismic wave propagation, small earthquake, accelerating natural earthquake, thermal stress-strain modeling, ground movement level and fault activation will be consider. It is expected to better understand CO_2 leakage, storage and injection process and problems. Reclamation uses only CO_2 for automatic generator fire suppression. Halon systems—proposed as a safe alternative to CO_2 in the early 1970s—received limited use in Reclamation facilities before they were phased out due to concerns about ozone layer depletion. New, clean-agent gasses developed to replace Halon could be used for generator fire suppression but are prohibitively expensive compared to CO_2.



MONITORING AND CONTROLLING OF CO2 EMISSIONS



PRESURE RESPONSE

In the oil industry there is a net removal of fluid from the subsurface. This does not create a vacuum in the pore space of the rock, of course. The pressure in the reservoir drops and the rock, water and hydrocarbon expand to fill the space vacated by hydrocarbon. In most reservoirs, the natural expansion of rock and water surrounding the reservoir is insufficiently fast to prevent a very rapid drop in pressure. When this happens, natural gas comes of out solution in the oil (this is just the same as CO_2 liberated from a bottle of champagne—or, more prosai-cally, cola—when it is opened). This is bad news for recovery, as the gas is preferentially produced (it has a much lower viscosity than oil), leaving the valuable oil behind. To compensate for this, to maintain pressure and push the oil out, water is usually injected—hence the comments on water production in the preceding paragraph. In gas fields this is not necessary—simply allowing the pressure to decrease allows the gas to expand and be produced.The obvious storage solution is to inject CO_2 to replace the oil and gas produced in old hydrocarbon fields in an EOR scheme. This has three advantages and one major drawback.

First, the field must have a good cap rock to have contained the hydro-carbon for millions of years and so safe storage is possible. Second, the injection of CO_2 can enhance oil and gas produc-tion, giving some economic pay-back, as mentioned before. Third, there is a pipeline infrastructure in place for injection, although this may be ageing and not specifically suited for CO_2. The injected CO_2 will cause the reservoir pressure to rise again, replacing the volume of produced hydrocarbons. The main disadvantage is that the extra production causes more CO_2 to be burnt when extra oil and gas is produced—typically at least as much CO_2 as is stored. So this is not going to deliver the large-scale net storage of CO_2 required. Additionally, the capacity in oil and gas fields could be insufficient to deal with all the CO_2 required for CCS projects, while hydrocarbon fields are unevenly distributed and may not be close to the sources of CO_2.CO_2 storage in aquifers is the opposite of hydrocarbon produc-tion – volume is added to the system and the pressure in the reservoir increases.

The experience of Sleipner and other sites where large volumes of CO_2 have been injected without signifi-cant increases in pressure provides evidence that large aquifers do have substantial storage capacity34—as Figure 3 indicates, there are huge volumes in which the pressure can be dissipated. Fracturing the rock, although it sounds alarming, is often done deliberately in oil and gas fields, to speed up production and to allow water to be injected more easily; it is only a concern if the overlying cap rock is fractured and even then only for relatively shallow aquifers where this provides an escape route for the CO_2.

REDUCING CO2 FROM HEAVY INDUSTRY

Direct CO_2 emissions can be further separated into (i) fuel combustion processes for process heating; and (ii) emissions which are the product of a chemical reaction e.g. from the conversion of limestone ($CaCO_3$) into lime (CaO). Figure 1b shows the share of direct industrial CO_2 emissions by sector. The largest contributors to emissions are iron and steel, and cement production[2]. These collectively contributed around 4.3 Gt, or 56%, of direct industrial CO_2 emissions in 2007. A further 17% was from chemicals and petrochemicals, which consist of a wide range of processes, producing both organic and inorganic chemicals. Aluminium production, and pulp and paper processes made up a further 4%. The remaining 23%, or 1.7 Gt of CO_2 emissions, arose from a large number of smaller processes such as manufacturing of textiles, machinery and equipment, and processed foods. Reducing emissions from the highly varied processes making up the industrial sector is by no means simpleensure that the wells are drilled through formations of adequate permeability.

TRANSPORTATION OF CO2

The focus of this Paper has been storage, but a vital component of CCS is the transport of CO_2 from power stations or other industrial plants to the storage site35. Small quantities, for demonstration projects, could be transported offshore by ship, but any serious plans involve transport via a dedicated pipeline. The construction of gas pipelines is a mature technology; the UK, for instance, has an extensive infrastructure for natural gas (primarily methane), while in the US over-ground pipes carry CO_2 to oilfields for EOR operations, as mentioned before. CO_2 is generally transported in a super-critical phase; it is pumped at high pressure, with booster stations to maintain the pressure. To avoid corrosion, the CO_2 has to be of high purity: in particular H2S and water need to be removed from the gas stream. In Eu-rope, with high population densities, the pipes would be buried underground. It is likely that the first projects to collect CO_2 from power stations will be as close as possible to the coast, to minimize the length of onshore pipeline, and to use exist-ing routes for natural gas pipelines, or indeed use these pipes where possible, to avoid creating new routes. There are risks associated with CO_2 transport; were the gas to leak, since it is denser than air, it can collect in low ground with a risk of asphyxia at high concentrations.

This can be mitigated with appropriate design and monitoring and careful siting. cant amounts of CO_2 (1 Mt/year or more) and with some plans on hold or abandoned21. This contrasts with the stated support of the G8 countries in 2008 to launch 20 large-scale CCS projects by 2010 with widespread implementation by 202036. The barriers to rapid implementation include cost, creating a market mechanism to determine who pays and who benefits, lack of in-frastructure, absence of a clear regulatory regime for managing CCS projects, and public reluctance to accept onshore storage and transport. available, but, frustratingly, there seems little will to follow them.

A single demonstration may use a small, dedicated pipeline to one specific storage site;

if, however, CCS is to be deployed at scale, it makes sense to create hubs where CO_2 is collected from all power stations in a relatively small area, collected in a single pipeline network and then stored in different locations.

For example, Humberside represents one possible hub, where several nearby existing power stations emit currently 60 Mt/year of CO_2: creat-ing the necessary transport infrastructure to handle collection of all these emissions and storage under the southern North Sea will save costs later, rather than relying on a piecemeal one-demonstration-at-a-time approach. Coupled with this is a lack of a regulatory and financial framework to allow CCS to happen spontaneously within a free market economy. The carbon price under the European Emissions Trading system is currently far too low to allow investment in CCS without significant Government subsidy and, as yet, no clear long-term funding mechanism that significantly rewards the storage of CO_2 and/or penalizes atmospheric emis-sions has been established, in contrast to some other mitigation technologies. On the regulatory side, CO_2 can be injected under the North Sea for normal oilfield operations, while progress is being made on updating international treaties to allow CO_2 injection primarily for long-term storage.The final issue concerns public acceptance of CCS. Public surveys (see, for instance,38) have revealed a widespread lack of knowledge of CCS coupled with a concern that it could deflect attention away from the deployment of renewable power technologies. It is not known how acceptable CCS will be perceived to be when large-scale projects are implemented and how CCS projects will fare in comparison with the construction of large wind farms or nuclear power stations.

CONCLUSION

Limiting industrial CO_2 emissions is crucial to reduce the risks of climate change, but this looks very challenging and more deserving of policy attention. Owing to energy intensive, fossil-fuel dependent processes, CO_2 emissions from heavy industries form a large segment of global emissions. Production and associated CO_2 emissions are predicted to continue to rise, as developing countries grow and seek to improve their standards of living.

REFERENCES

[1]. Albright, J. C. 1986. Use of well logs to characterize fluid flow inthe Maljamar CO2 Pilot, J. Pet. Tech., vol. 38, no. 9, p. 883, 890.

[2]. Andreas, Bielinski., Andreas, Kopp., Hartmut, Schutt., Holger, Class. 2008. Monitoring of CO2 plumes during storage in geological formations using temperature signals: Numerical investigation. International journal of greenhouse gas control 2, 319–328.

[3]. Arts, R., Chadwick, A., Eiken, O., Thibeau, S., Nooner, S.L. 2008. Ten Years' Experience of Monitoring CO2 Injection in the Utsira Sand at Sleipner, Offshore Norway: First Break, vol. 26.

[4]. Arts, R., Eiken, O., Chadwick, A., Zweigel, P., Van der Meer, L., Zinszner, B. 2004a. Monitoring of CO2 injected at Sleipner using time-lapse seismic data. Energy 29, 1383–1392.

[5]. Arts, R., Eiken, O., Chadwick, P., Zweigel, A., van der Meer, B., Kirby, G. 2004b. Seismic monitoring at the Sleipner underground CO2 storage site (North Sea). In: Baines, S.J., Worden, R.H. (Eds.), Geological Storage of Carbon Dioxide: Special Publications, vol. 233. The Geological Society, pp. 181–191.

[6]. Assteerawatt, A., Bastian, P., Bielinski, A., Breiting, T., Class, H., Ebigbo, A., Eichel, H., Freiboth, S., Helmig, R., Kopp, A., Niessner, J., Ochs, S., Papafotiou, A., Paul, M., Sheta, H., Werner, D., O ¨ lmann, U. 2005. MUFTE-UG: structure, applications and numerical methods. Newsletter, vol. XXII, no. 2. International Groundwater Modelling Centre, Colorado School ofMine.

[7]. Bachu, S. 2003. Screening and ranking of sedimentary basins for sequestration of CO2 in geological media in response to climate change. Environ. Geol. 44, 277–289.

[8]. Baines, SJ., Worden, RH. 2004. The long-term fate of CO2 in the subsurface: natural analogues for CO2 storage. In: Baines SJ, Worden RH, editors. Geological storage of carbon dioxide, vol. 233. London, Special Publications: Geological Society; p. 59–85.

[9]. Barbara, Cantucci., Giordano, Montegrossi., Orlando, Vaselli., Franco, Tassi., Fedora, Quattrocchi., Ernie, H. Perkins. 2009. Geochemical modeling of CO2 storage in deep reservoirs: The Weyburn Project (Canada) case study. Chemical Geology 265, 181-197.

[10]. Schulze E D & Mooney H A, Design and execution of experiments on CO_2 enrichment, ecosystems research report No. 6 (Commission

of the European Communities, Brussels, Belgium), 1993.

[11].Uprety D C, Garg S C, Tiwari M K & Mitra A P, Crop responses to elevated CO_2: Technology and research (India study), Global Environ Res (Japan), 3 (2000) 155.

[12].Kimball B A, Pinter P J, Jr, Wall G W, Garcia R L, LaMorte R L, Jak P M C, Frumau K F A & Vugts H F, Comparisons of responses of vegetation to elevated carbon dioxide in free air and open top chamber facilities in Advances in Carbon Dioxide Research, edited by L H Allen (Jr), M B Kirkham, D M Olszyk & C E Whitman (Am. Soc. Agron. Crop Science Society of America and Soil Science Society of America, Madison, WI, USA), 1997, pp. 113-130.

[13].Uprety D C, Carbon dioxide enrichment technology: Open top chambers-a new tool for global climate research, J Sci & Ind Res (India), 57 (1998) 266.

[14].Maini H K, Tiwari M K, Bahl M, John T, Singh D, Yadav V S, Anand R J, Poddar H N, Mitra A P, Garg S C, Uprety D C, Shrivastava G C, Saxena D C, Dwivedi N, Mohan R, Miglietta F & Zaldei A, Free air carbon dioxide enrichment facility development for crop experiments, Indian J Radio & Space Phys (India), 31 (2002) 404.

[15].Kimball B A, Kobayashi K & Bindi M, Adv Agron (USA), 72 (2002) 293.

[16] Underhill, J.R. (2003) The tectonic and stratigraphic framework of the United Kingdom’s oil and gas fields, In Gluyas, J.G. and Hichens, H.M. (eds) United Kingdom Oil and Gas Fields, Commemorative Millennium Volume, Geological Society Memoir, 20, 17-59.