EVALUATION OF CARBON DIOXIDE STORAGE IN DEPLETED GAS FIELDS IN NORTHWEST COMPLEX OF CENTRAL LUCONIA PROVINCE

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ABSTRACT

The purpose of this study is to investigate the application of genetic algorithm (GA) in modelling The rising concentration of CO_2 in the atmosphere which is believed to increase tremendously around 1.7% every year and has caused a controversial environmental concern, has urged numerous ongoing research on how to overcome this issue. Apart from re-using the emitted carbon dioxide as a source for EOR, this situation has also led to consideration of Carbon Capture and Storage or CO_2 Sequestration; where we store large scale Carbon Dioxide in the subsurface. This study is made following the footstep to further study CO_2 storage in Sarawak Basin, particularly in the depleted gas reservoirs in the northwest complex of Central Luconia. ArcGIS was used to classify the potential area from high to low potential region in the Central Luconia Province and it was revealed that at least 57% of the entire study area has high potential value. Three fields were considered as the case-studies in this research selected from their availability of data namely A1, B2 and C3. Qualitative assessment was also conducted to pull out an estimation of theoretical storage capacity using CSLF and US-DOE-NETL methods. Although represented relatively smaller in area than the other two, A1 topped the estimation of theoretical storage capacity by 14.1 Gt and 7.8 Gt by CSLF and US-DOE-NETL respectively. B2 and C3 scored 6.4 Gt and 7.4 Gt from CSLF and 3.5 Gt and 4.1 Gt from US-DOE-NETL respectively.

ABSTRAK

Peningkatan kepekatan CO_2 di atmosfer yang diyakini meningkat sangat tinggi sekitar 1,7% setiap tahun dan telah menimbulkan masalah lingkungan yang kontroversial, telah mendorong banyak penyelidikan yang sedang berjalan mengenai bagaimana mengatasi masalah ini. Selain menggunakan semula karbon dioksida yang dipancarkan sebagai sumber EOR, keadaan ini juga menyebabkan pertimbangan Carbon Capture and Storage atau CO_2 Sequestration; di mana kita menyimpan Karbon Dioksida berskala besar di bawah permukaan. Kajian ini dibuat berdasarkan langkah untuk mengkaji lebih lanjut penyimpanan CO_2 di Lembangan Sarawak, terutama di takungan gas yang habis di kompleks barat laut Luconia Tengah. ArcGIS digunakan untuk mengklasifikasikan kawasan berpotensi dari kawasan berpotensi tinggi hingga rendah di Provinsi Luconia Tengah dan dinyatakan bahawa sekurang-kurangnya 57% dari keseluruhan kawasan kajian mempunyai nilai potensi tinggi. Tiga bidang dianggap sebagai kajian kes dalam penyelidikan ini dipilih dari ketersediaan data mereka iaitu A1, B2 dan C3. Penilaian kualitatif juga dilakukan untuk mengeluarkan anggaran kapasiti penyimpanan teori menggunakan kaedah CSLF dan US-DOE-NETL. Walaupun mewakili kawasan yang lebih kecil daripada dua yang lain, A1 mendahului anggaran kapasiti penyimpanan teori masing-masing sebanyak 14.1 Gt dan 7.8 Gt oleh CSLF dan US-DOE-NETL. B2 dan C3 masing-masing menjaringkan 6.4 Gt dan 7.4 Gt dari CSLF dan 3.5 Gt dan 4.1 Gt dari US-DOE-NETL.

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LIST OF ABBREVIATIONS

CO_2	-	Carbon Dioxide
CCS	-	Carbon Capture and Sequestration
CSLF	-	Equation from Carbon Sequestration Leadership Forum
US-DOE-NETL	-	Equation from National Energy Technology Laboratory
NW	-	Northwest
MCO2		Geometric volume of the sturtural or stratigraphic trap down the spill point
GCO2		Geologic storage of CO2

LIST OF SYMBOLS

A	-	Trap Area
At	-	Total geographical area
h	-	Average thickness
hg	-	Gross thickness
ϕ	-	Average porosity
ϕt	-	Total porosity
ρ	-	Density of CO2
Cc	-	Capacity coefficitent
Swirr	-	Saturation of irreducible water
E	-	Storage efficiency

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Today's need for energy has been increasing rapidly as a progress to the rising growth of current world's modernization. The rising demand in energy has undoubtedly caused an alarming increase in the greenhouse gases concentration, including carbon dioxide (CO2). The obvious change in climate has become a phenomenal topic of issues most-discussed worldwide and this topic is also often associated with the oil and gas industry and that it has taken its toll as one of the main contributors to the cause.

According IEO (2016), the compilation of data by the United States Energy Information Administration (EIA) highlighted that CO2 emitted globally is projected to increase by around one third between 2012 and 2040 from 32.3 billion metric tons to 43.2 billion metric tons in 2040. It is also believed that the increase in numbers has a great deal in contribution by countries outside of the Organization for Economic Cooperation and Development such as China and India.

Despite a few arising crises, fossil fuels, oil specifically is still the main source of energy needed by mankind. The increase in demand subsequently increases the need to produce more oil. EOR, or also known as Enhanced Oil Recovery is said to be among the latest technology used to further increase the oil production effectively. Like other countries facing this typical issue, Malaysia is not an exception since it is known as one of the top natural gas producer and exporter countries. According to Carpenter (2015), Malaysia is recorded to at least produce about 697,000 barrels of oil per day mostly coming in from the offshore fields.

Reported by Jalil et. al. (2012), at least 15 offshore gas fields that have high contents of CO2 that contain 13.2 trillion cubic feet of natural gas for 27.32 tcf of CO2. It was also highlighted in the same literature that the development of fields in Sarawak which at least contain 70% of CO2 will require the best way to control and prevent CO2 emission into the atmosphere. Since the growing numbers in the exploration of oil and gas continue to increase, CO2 emission as a product of petroleum production has been the talk of the crowd as one of the major contributors to emission of CO2 in Malaysia.

As increase in oil production in turns increases the emission of Carbon Dioxide (CO2) in the atmosphere, CO2-EOR is reported to be described as one of the EOR technologies that can benefit both in the upsurge of oil production as well as in reducing the amount of CO2 emitted to the atmosphere. Gozalpour et. al., (2005) claimed that, "CO2 injection into tertiary oil reservoirs has been widely accepted as an effective technique for enhanced oil recovery (EOR), and has been used by the oil industry for over 40 years. Concerns over greenhouse gas emissions are leading to the investigation and realization of its potential as a carbon storage method in recent years."

Many studies have been made and amongst the many possible solutions to mitigate this problem is the geological sequestration process more known today as Carbon Capture and Storage, CCS; at which the emitted CO2 is captured and stored in the subsurface. This process is however, not as easy as it may sound as to capture the emitted CO2 and is also very risky as to the application of the system to the critical and challenging behaviour of nature. Jalil et. al., (2012) had also suggested that there's a likelihood that injection and sequestration of CO2 can be done into depleted gas fields near the C3 field.

This process had been experimented since 1996 at the Sleipner in North Sea and the latest in Canada's Weyburn EOR Project that took place in the year of 2006. Continuous research is still ongoing as to design, model and control the injection of CO2 in the underground 'compartment' efficiently.

Bachu et. al., (2004), suggested that CO2 storage can be represented as the best short-to-medium term option to enhance CO2 sinking by reducing net carbon emission into the atmosphere significantly.

1.2 Problem Statement

Among the many controversial issues spoken today that has raised genuine public concern in regards to the environment is what we can now call the carbon-constrained world. This issue brings about the highest contribution to Global Warming. The carbon dioxide concentration, CO2, has risen tremendously over the last century. With the increase of its concentration, carbon dioxide behaves to absorb instead of reflect the infrared radiation emitted from space. Due to this absorption, our Earth experiences abnormal warming which possesses further negative implications such as glaciers melting, rise of the sea level and a few others.

The major possible cause of the increased emission of CO2 can be traced from rapid and excessive anthropogenic activities such as deforestation and burning of the fossil fuels; releasing the CO2 in the air. The effects of the immense emission of CO2 As a response to the concerning environmental issue, serious actions are being taken into consideration from different personnel, organization bodies and in groups in order to manage the problem.

Although, with the current phenomenon of a drop in oil price, it is still believed that the demand of the oil and gas will continue to increase. In order to sustain the production of hydrocarbon for daily usage, an alternative to reduce the emission of CO2 is highly necessary. A winning solution for both oil production rise and decrease CO2 emission must be achieved.

1.3 Objectives of the Study

Studies to evaluate and classify potential sites for CO2 storage in the sedimentary basins of Malaysia has been previously covered. As a continuation of previous study, the main purpose of this research is to evaluate selected depleted gas reservoirs in the Luconia province. This research is an essential stage as a preparation for the CCS project in Malaysia. Specific objectives can be divided further as follows:

1. To determine the most suitable field for CCS in Luconia Field between A1, B2 and C3.
2. To produce a visual interpretation of selected basins including estimation of area in percentage.
3. To estimate theoretical storage capacity in selected basins of Luconia field based on the basin properties.
4. To develop a simulated model as an illustration of injected CO2 with effect of certain controls and parameters

1.4 Scope of Research

This research focused on the assessment of 3 major depleted gas fields in the Luconia province. The study area was decided as there is yet to be any comprehensive study of CO2 storage in depleted gas reservoirs in the carbonate basins of Luconia field. The study area was also chosen as the data to conduct the study was easily accessible from previous studies.

Screening criteria between the targeted basins will be done following suit of the geological setting of Malaysia. Potential sites were mapped by using ArcGIS to estimate the area and rank the fields based on the potential of CO2 storage. Lastly, CSLF and US-DOE-NETL methods will be used to calculate theoretical storage capacity of all the three basins.

1.5 Significance of Research

According to Consoli and Wildgust (2017), in contrast to Europe, the majority of countries in Southeast Asia, including Malaysia have a 'top-down-approach, where the most prospective storage formations are being actively characterized first. Table 1 also depicts the idea that Malaysia has yet to run a full research in regards to CCS even though the resource level reported by Global Storage Portfolio Assessment Summary is said to be effective. This proves that there is a future of CCS in Malaysia and that preliminary insights must be made now.

Table 1 CCS Global Storage Portfolio Assessment Summary

Country	Assessment status	Estimated resource (GT CO_2)	Resource level
ASIA-PACIFIC			
Australia	Full	227-702	Effective
Bangladesh	Limited	20	Theoretical
China	Full	1573	Effective
India	Moderate	47-143	Theoretical
Indonesia	Moderate	1.4-2	Effective
Japan	Full	146	Effective
Korea	Full	100	Theoretical
Malaysia	Moderate	28	Effective
New Zealand	Moderate	16	Theoretical
Pakistan	Limited	32	Theoretical
Philippines	Limited	23	Theoretical
Sri Lanka	Limited	6	Theoretical
Thailand	Limited	10	Theoretical
Vietnam	Limited	12	Theoretical

In the long run, CCS must be implemented in order to sustain the environment and at the same time maintain the well production activity in Malaysia. This study aims to contribute a detailed evaluation of potential sites for CCS in the Luconia field.

Economically, this study can be considered a good investment as there is a huge market of geological CO2 storage in Malaysia. On the other hand, this study can also be a good alternative in management of CO2 emission as one of the products of petroleum production. The 3 sites will be mapped using ArcGIS as an initiative to estimate points of injection. Budgeting and detailed preparation can be done to increase the project efficiency in the future. At the same time, this study allows access to preliminary insights of basin-scale site suitability for early deployment of CCS in Malaysia.

1.6 Structure of Thesis

This thesis is structured as follows:

Chapter 1 consists of introduction and overview of the study, including problem statement, objective of the study, as well as scope and significance of the study.

Chapter 2 provides lengthy elaboration regarding all fundamental information related to CCS. This chapter will also include literature review of past studies related to CCS that took place in Malaysia and other countries too.

Chapter 3 gives a detailed highlight of the stages of methodology done throughout the entire study whereby it includes the work flow of ranking, mapping and theoretical storage calculation of each basin.

Chapter 4 examines and analyzes the results obtained at the mapping using ArcGIS stage based on certain CCS suitability and criteria depending on the field properties.

Chapter 5 discusses the 3 basins in detailed assessment for the most potential and less risk at the same time estimate theoretical storage capacity estimation of each basin.

Chapter 6 advances and withdraws the conclusion of research in a summary of numerous findings related to the objective and scope of the research. A list of highlights in regards to several unavoided issues and recommendations are also presented in this chapter as a future reference.

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