Paper ID: RT 57

Feasibility Study of CO_2 Sequestration in the Potential Gas Fields of Bangladesh

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Abstract

As global warming has become more and more of an important environmental issue, a lot of workings have been undertaken including the reduction of the amount of atmospheric CO_2 by capturing CO_2 from industrial point sources and then injecting it into the subsurface (geologic sequestration). In this paper, suitability of the potential gas fields of Bangladesh in response to CO_2 sequestration has been evaluated. The geological, hydrodynamic, geothermal, maturity indication, economic, political and societal conditions of the potential gas fields have been analyzed correctly according to Bachu's method of classification for CO_2 sequestration. Titas gas field shows the best suitability. Habiganj gas field also shows high suitability whereas Kailashtila & Rashidpur gas fields show medium suitability.

Keywords: CO_2 sequestration, Ranking, Potential Gas Fields, Bangladesh.

1. Introduction

Sequestration means storage. Sequestration is the removal of CO_2, either directly from anthropogenic sources, or from the atmosphere, and disposing of it either permanently or for geologically-significant time periods. Carbon dioxide can be sequestered in geological media by geological (stratigraphic and structural) trapping in depleted oil and gas reservoirs, solubility trapping in reservoir oil and formation water, adsorption trapping in uneconomic coal beds, cavern trapping in salt structures, and by mineral immobilization [1]. The possibility of geological sequestration of Carbon di oxide in Bangladesh is analyzed in this study.
A series of suitability criteria were previously developed [1] which can be broadly classified into:

1. Basin characteristics, such as tectonism, geology and geothermal and hydrodynamic regimes (these are ''hard'' criteria because they do not change).
2. Basin resources (hydrocarbons, coal, salt), maturity and infrastructure (these ''semi-hard'' or ''semi-soft'' criteria because they may change with new discoveries, technological advances and/or economic development).
3. Societal, such as level of development, economy, political structure and stability, public education and attitude (these are ''soft'' criteria because they can rapidly change or vary from one region to another).

These criteria are developed & applied by Stefan Bachu. It can also be applied for small regions like oil & gas reservoirs. Potential gas reservoirs of Bangladesh[2]: Titas, Habiganj, Kailashtila, and Rashidpur are ranked according to their geologic, storage & economic potentiality.

2. Geology of Bangladesh

The tectonic framework of Bangladesh may be broadly divided into two main units: 1) Stable platform in the northwest and 2) Deep (geosynclinal) basin to the east and southeast. A narrow northeast-southeast trending 'Hinge zone' separate the above two units diagonally. The geosynclinal basin is subdivided into two parts: 1) fold belt in the east, and 2) foredeep in the west.

Fig. 1. Tectonics units of Bangladesh[3]

The Bengal Basin is located at a junction point of the three lithospheric plates viz. the Indian Plate, the Eurasian Plate and the Burma Plate posing high seismic susceptibility in the region [4]. The earthquakes in the Tripura Fold Belt are much more frequent than in the Eocene Hinge Zone because of the plate boundary activity [4]. In addition, adjacent Indo-Burma subduction zone helps identifying the fold belt region as 'Convergent Oceanic'.

The fold structures favoring gas accumulation occur in the eastern fold belt part and thus most of the gas fields are located in the eastern part of the country which are mainly onshore gas reservoirs. No salt beds or dome is present in the gas reservoirs of Bangladesh. Also, a huge amount of CO_2 sources present in this region. Total CO_2 emissions from large point sources in Bangladesh in the IEAGHG R&D program database amount to some 17 Mt CO_2[2]. The coal fields occupy in the northwest Stable platform.

Average temperature of this region is said to be 25^0 C. The geothermal gradient of the fold belt region of Bangladesh ranges from 20°C/km to 30°C/km [5]. This results to an overall P-T diagram like fig. 2. It relates to warm basin behavior according to phase behavior of CO_2 [1].

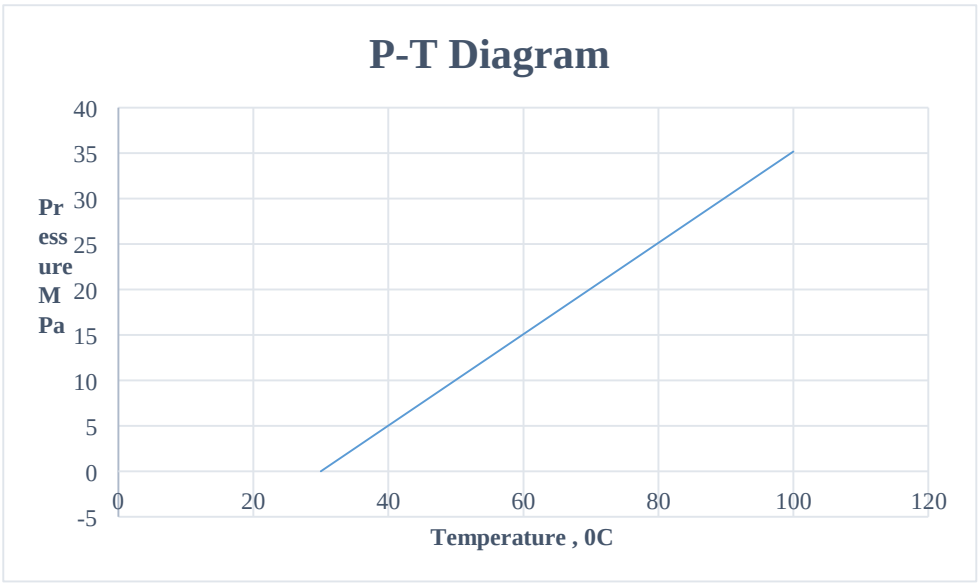

Fig. 2. Overall P-T diagram for fold belt region of Bangladesh

3. Criteria for CO_2 storage & sequestration

Table 1. Bachu's classification of criteria for geological sequestration of carbon[1]

Criterion	Classes				
	Class 1	Class 2	Class 3	Class 4	Class 5
1. Tectonic setting	Convergent oceanic	Convergent intramontane	Divergent continental shelf	Divergent foredeep	Divergent cratonic
2. Size	Small	Medium	Large	Giant	
3. Depth	Shallow (<1500 m)	Intermediate (1500-3500 m)	Deep (>3500 m)		
4.Geology	Extensively faulted and fractured	Moderately faulted and fractured	Limited faulting and fracturing,extensively shales		
5. Hydrogeology	Shallow,short flow systems, or compaction flow	Intermediate flow systems	Regional,long-range flow systems; topography or erosional flow		
6. Geothermal	Worm	Moderate	Cold		
7. Hydrocarbon potential	None	Small	Medium	Large	Giant
8. Maturity	Unexplored	Exploration	Developing	Mature	Over mature
9. Coal & CBM	None	Deep (>800 m)	Shallow (200-800 m)		
10. Salts	None	Domes	Beds		
11. On/Off shore	Deep offshore	Shallow offshore	Onshore		
12.Climate	Arctic	Sub-Arctic	Desert	Tropic	Temperate
13. Accessibility	Inaccessible	Difficult	Acceptable	Easy	
14. Infrastructure	None	Minor	Moderate	Extensive	
15. CO_2 sources	None	Few	Moderate	Major	

Table 1 presents a set of 15 criteria for the assessment and ranking in terms of their suitability for CO_2 sequestration or storage. In each category, three to five classes have been defined from the least favorable to the most favorable for CO_2 sequestration or storage.

Table 2. Scores and weight assigned to the criteria and classes of Table 1[1]

Serial no.	Criterion	Scores					Weight (w)
		j=1	j=2	j=3	j=4	j=5	
i=1	Tectonic setting	1	3	7	15	15	0.07
i=2	Size	1	3	5	9		0.06
i=3	Depth	1	3	5			0.07
i=4	Geology	1	3	7			0.08
i=5	Hydrogeology	1	3	7			0.08
i=6	Geothermal	1	3	7			0.10
i=7	Hydrocarbon potential	1	3	7	13	21	0.06
i=8	Maturity	1	2	4	8	10	0.08
i=9	Coals & CBM	1	2	5			0.04
i=10	Salts	1	2	3			0.01
i=11	On/Off shore	1	4	10			0.10
i=12	Climate	1	2	4	7	11	0.08
i=13	Accessibility	1	3	6	10		0.03
i=14	Infrastructure	1	3	7	10		0.05
i=15	CO_2 sources	1	3	7	15		0.09

4. Characterization & scoring of potential gas fields of Bangladesh

Required characteristics of each field have been evaluated. Size of Titas gas field has been considered as

Table 3. Classification & scoring of the gas fields

Field	Classification & Scoring														
	Tectonic Setting (w=0.07)	Size (w=0.06)	Depth (w=0.07)	Geology (w=0.08)	Hydro-Geology (w=0.08)	Geo-Thermal (w=0.10)	Hydro-Carbon Potential (w=0.06)	Maturity (w=0.08)	Coals & CBM (w=0.04)	Salts (w=0.01)	On/Off Shore (w=0.10)	Climate (w=0.08)	Accessi-bility (w=0.03)	Infra-structure (w=0.05)	CO_2 source (w=0.09)
Titas	Class:1 Score:1	Class:3 Score:5	Class:3 Score:5	Class:2 Score:3	Class:1 Score:1	Class:1 Score:1	Class:5 Score:21	Class:3 Score:4	Class:1 Score:1	class 1 score 1	Class:3 Score:10	Class:4 Score:7	Class:3 Score:6	Class:3 Score:7	class 4 score 15
Habi-ganj	Class:1 Score:1	Class:1 Score:1	Class:2 Score:3	Class:1 Score:1	Class:1 Score:1	Class:1 Score:1	Class:4 Score:13	Class:4 Score:8	Class:1 Score:1	class 1 score 1	Class:3 Score:10	Class:4 Score:7	Class:3 Score:6	Class:3 Score:7	class 4 score 15
Kailash-tila	Class:1 Score:1	Class:2 Score:3	Class:2 Score:3	Class:2 Score:3	Class:2 Score:3	Class:1 Score:1	Class:4 Score:13	Class:3 Score:4	Class:1 Score:1	class 1 score 1	Class:3 Score:10	Class:4 Score:7	Class:3 Score:6	Class:2 Score:3	class 2 score 3
Rashid-pur	Class:1 Score:1	Class:3 Score:5	Class:2 Score:3	Class:1 Score:1	Class:1 Score:1	Class:1 Score:1	Class:4 Score:13	Class:3 Score:4	Class:1 Score:1	class 1 score 1	Class:3 Score:10	Class:4 Score:7	Class:3 Score:6	Class:2 Score:3	class 3 score 7

large and other fields sizes are classified accordingly. Giant (>3 Tcf), Large (>1 -3 Tcf), Medium (>300 bcf – 1 Tcf), Small (<300 bcf) hydrocarbon potential are assigned to the gas fields[3]. Production & pressure drop analysis of Titas[6], Habiganj[7], Kailashtila[3] and Rashidpur are required for maturity observation. The gas fields are at good depth for CO_2 sequestration[3]. Geology of Titas[8] and Kailashtila[9] is classified as 'moderately faulted and fractured' whereas that of Habiganj[10] and Rashidpur[11] is classified as 'extensively faulted and fractured'. Better hydrological conditions are measured for Kailashtila[12] gas field. Shallow, short or compaction aquifer flow system is observed for Titas[6], Habiganj[13], Rashidpur[11] gas fields. Well condition & overall infrastructure with respect to field's area are considered for 'infrastructure' criterion. Main CO_2 sources of Bangladesh and their positions from respective fields are also carefully analyzed [2].

5. Calculation process

For any gas field k that is evaluated in terms of its general suitability for CO_2 sequestration or storage, the corresponding class j for each criterion i is identified (see Table 1), resulting in a corresponding score $F_{i,j}$ (see Table 2). Because the function F_i has different ranges of values for each criterion, making comparisons and manipulations difficult, the individual scores $F_{i,j}$ are normalized according to[1]:

$$P_i^k = \frac{F_{i,j} - F_{i,1}}{F_{i,n} - F_{i,1}}$$

such that P_i=0 for the least favorable class and P_i=1 for the most favorable class for all the criteria i = 1,...15. Here n is the number of classes in that category (n = 3, 4 or 5). As a result of this process, each gas field k being evaluated is characterized by 15 individual scores P_i^k. The effect of parameterization and normalization is that it transforms various characteristics, which have differing meanings and importance, into dimensionless variables that vary between 0 and 1. These can subsequently be added to produce a general score R^k, used in ranking, which is calculated using[1]:

$$R^k = \sum_{1}^{15} w_i P_i^k$$

where w_i are weighting functions that satisfy the condition[1]:

$$\sum_{1}^{15} w_i = 1$$

6. Results

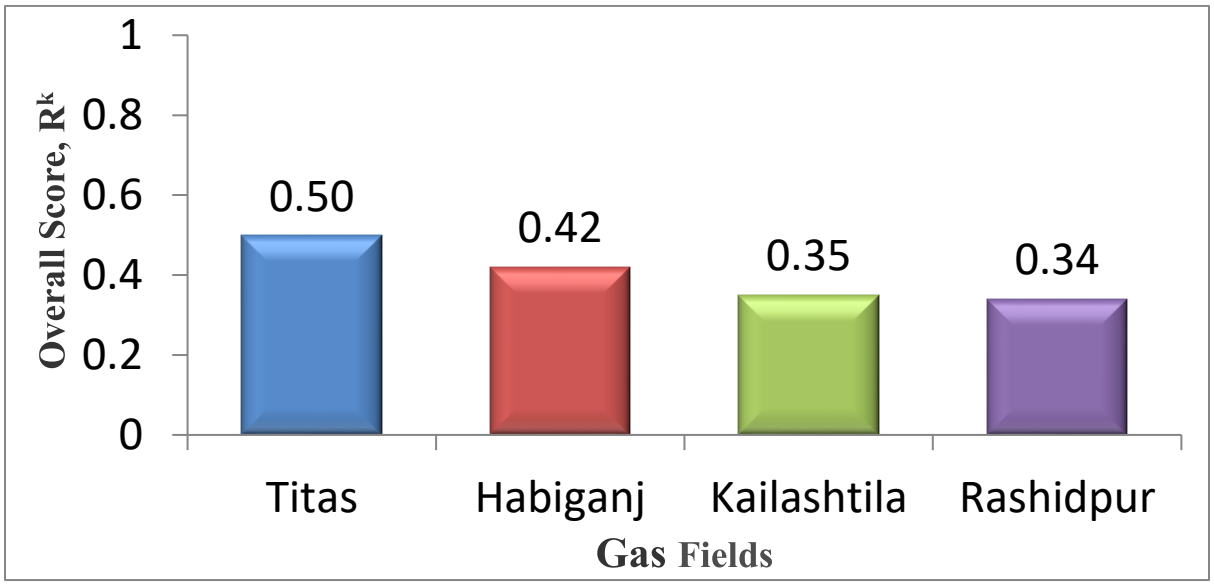

Fig. 3. Overall scores of the gas fields

7. Conclusion

The outcomes of the the study give an idea of perspective suitability of the potential gas fields for CO_2 sequestration. Basin characteristics like 'Coal & CBM', 'Salts' which usually do not present in gas field regions decrease the overall ranking score. This study may also helpful for CO_2 sequestration with enhanced gas recovery; but a simulation study for the specific gas fields must be made in this respect.

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