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CO_2 SEQUESTRATION BY TREE PLANTATION IN BANGLADESH: OPPORTUNITIES AND CHALLENGES

Mohammad Tanjid Nahiyan[1],Durjoy Baidya[2],Atanu Das Dip[1],Md. Zayed Bin Sultan[1],J.U.Ahmed[3]
[1]Department of Petroleum and Mining Engineering, CUET, Chittagong-4349, Bangladesh
[2]Department of Mining Engineering, University of British Columbia, Canada
[3]Department of Mechanical Engineering, CUET, Chittagong-4349, Bangladesh*
tanjidnahiyan@gmail.com, durjoy.baidya@alumni.ubc.ca, atanudas.335@gmail.com,
zbs7@ymail.com, jamal@cuet.ac.bd*

Abstract- *In Bangladesh,carbon emission rate is growing day by day with growing industrial sector. CO_2 emission have increased 0.05 to 0.44 metric tons per capita from 1972 to 2013 according to World Bank's report.Government has planned to jump coal use from 2% to 50% of Bangladesh's electricity supply with 23000MW of new coal based power plant. So,the emission rate will increase a lot in future & Green House Gas (GHG) Effect is the result of increasing amount of CO_2 in environment. For mitigating this problem,it is tried to find out a way to reduce free carbon in air by carbon sequestration of tree. So Barapukuria Thermal Power Station is selected because emission rate is high from coal firing plant. Suitable trees like* ***Shorea robusta, Albizzia procera*** *will have to be planted in the estimated area around the power plant.*
Keywords: CO_2 sequestration, Green weight, Dry weight, Tree plantation

1. INTRODUCTION

Environmental scientists have said that carbon dioxide (CO_2) is the most significant anthropogenic greenhouse gas (Stangeland, et al 2007; Smith et al., 2003). It has been risen by near about 40% since the beginning of Industrial Revolution (Wright & Boorse, 2011). Here, in this work, it is discussed about the carbon sequestration rate of some common trees in Bangladesh from different region and from these it is tried to find out the compatible trees to plant around the coal based power plant and coal field to reduce the carbon percentage in the environment.

Forests of Bangladesh can be grouped into four broad categories depending on their location, nature and type of management[1]. There it is.

- Mangrove forest (4.07% of total land mass and 40% of total forest land)
- Tropical evergreen and semi evergreen forest (4.54% of total land mass and 44% of total forest land)
- Tropical moist deciduous forests. (0.81% of total land mass and 7.8% of the total forest land)
- Village forest.

Many different species of trees have been selected from different areas of Bangladesh.

Coal consumption rate in our country is increasing day by day and government is planning to establish many coal based power plant in near future. According to US Energy Information Administration, at 2010 Bangladeshs' primary coal consumption is about more than 1000 thousand short tons and it is increasing at a very high rate because of the increasing demand of the energy consumption. Figure 1 shows the coal consumption scenario of Bangladesh from 1980 to 2014.

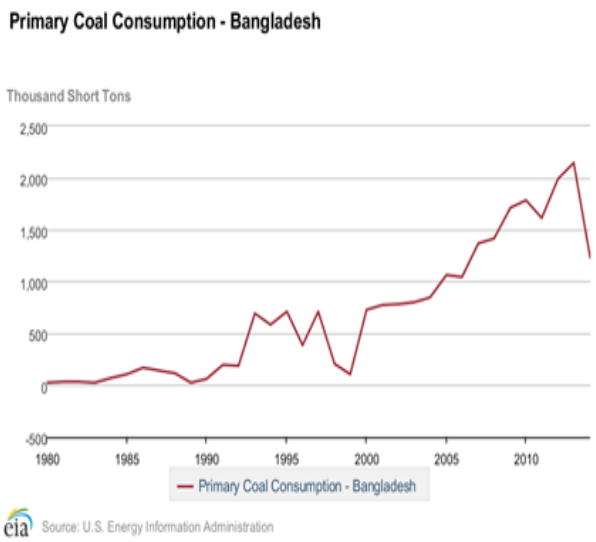

Fig 1**:** Scenario of primary coal consumption in Bangladesh from 1980 to 2014[2].

2. METHOD

To determine the carbon sequestration rate, the growth characteristics of the tree species, the condition of where the tree has been planted and the density of the tree's wood should be known. The growth is greatest in the younger stages of the tree growth, between 20 to 50 years[3].Here we got the process from two educational website[4 & 5] .This is the process:

- Determine the total green weight of the tree.
- Determine the dry weight of the tree.
- Determine the carbon weight in the tree.
- Determine the carbon di oxide sequestration weight in the tree.

2.1. Determine the total green weight off the tree:

Based on tree species available in the Southeast part of the United States, the algorithm to calculate the weight of a tree is[6]:

W= Ground weight of the above tree in pounds
D= Trunk diameter in inches
H= Tree height in feet
If trees with D<11:
$W=0.25D^2H$
If trees with D>11:
$W=0.15D^2H$

Depending on the species, the coefficient(e.g 0.25) could change. However, these two equations could be seen as an "average" of all the species equations. Since the root system is about 20% of the above-ground weight of the tree, so multiply the above-ground weight of the tree by 120% ,to determine the total green weight of the tree.

2.2. Determine the dry weight of the tree

From the extended publication report of the University of Nebraska, it has a table which has average weights for one cord of wood for different temperate tree species [7]. From the table it is found that, the average tree is 72.5% dry matter and 27.5% moisture**.**Therefore, to determine the dry weight of the tree, the weight of the tree should be multiplied by 72.5%.

2.3. Determine the weight of carbon in the tree

The mean carbon content is generally 50% of total volume of the tree[8]. Therefore, the dry weight of the tree should be multiplied by 50%, to determine the weight of carbon content in the tree.

2.4. Determine the weight of carbon dioxide sequestered in the tree

CO_2 has 2 molecule of Oxygen and one molecules of Carbon.
The atomic weight of Carbon is 12.001115.
The atomic weight of Oxygen is 15.9994.
The weight of CO_2 is C+2*O=43.999915.
The ratio of CO_2 to C is 43.999915/12.001115 = 3.6663.
Therefore, the weight of carbon in the tree should be multiplied by 3.6663, to determine the weight of carbon dioxide sequestered in the tree[9].

3. RESULTS

The amount of carbon di oxide sequestered in different common trees in Bangladesh is calculated by following the process discussed above here. As coal fired power plants are the highest carbon emitter, the amount of trees and land are also estimated for tree plantation to reduce the carbon content in the air around a coal based power plant.

3.1.Trees' average heights and diameters

There are fifteen common species have been selected from all over the Bangladesh. The average heights and diameters of these trees have been considered from the World Agroforestry Centre's "Agroforestree Database"[10].

Table 1. Average height and diameter of trees from different locations in Bangladesh.

Name of the tree	Height (ft)	Diameter(in)
Artocarpus chaplasha	114.8	157.4
Anthocephalus cadamba	147.63	39.3
Albizzia spp	98.4	18.7
Cassia fistula	32.8	39.3
Diterocarpus spp.	139.4	177.16
Dillenia pentagyna	131.2	39.37
Gmelina arborea	98.4	177.16
Heritiera fomes	65.61	19.6
Hopea odorata	147.6	177.1
Lagerstroemia speciosa	131.2	39.3
Mangifera sylvatica	147.6	39.3
Shorea robusta	82.0	68.8
Sonneratia apetala	65.6	98.4
Swietenia spp.	98.4	39.3
Tectona grandis	98.4	39.3

From table 1 above and below figure 2, it has been found that ***Anthocephalus cadamba, Hopea odorata, Mangifera sylvatica*** have the highest height ***Diterocarpus spp., Gmelina arborea*** and ***Hopea odorata*** have the highest diameter in inches. ***Hopea odorata*** has both the highest height and diameter.

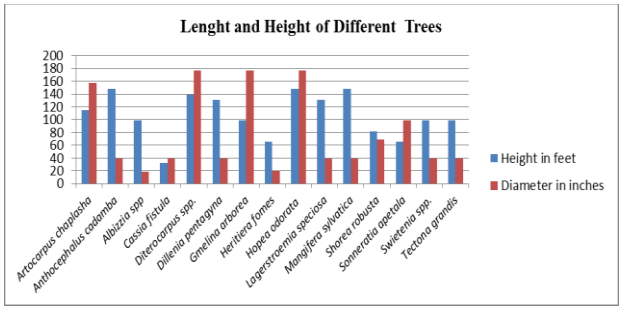

Fig 2: Length and height of different trees in Bangladesh from different locations

3.2. The green weight of the tree(above ground and roots includes)

The green weight of the tree has been calculated using the formula mentioned above. To determine the green weight of the tree including root, above ground weight is multiplied by 120%.

Table 2.Green weights of trees from different locations in Bangladesh

Name of the tree	The green weight of the tree(above ground) in lbs	The green weight of the tree (roots included)in lbs
Artocarpus chaplasha	426621.3	511945.6
Anthocephalus cadamba	34323.9	41188.6
Albizzia spp	5162.4	6194.9
Cassia fistula	7598.8	9118.6
Diterocarpus spp.	656274.2	787529.12
Dillenia pentagyna	30510.9	36613.0
Gmelina arborea	463252.4	555902.9

Heritiera fomes	3780.7	4536.8
Hopea odorata	695019.8	834023.8
Lagerstroemia speciosa	30503.9	36604.7
Mangifera sylvatica	34201.9	41042.3
Shorea robusta	58387.9	70065.5
Sonneratia apetala	95329.6	114395.5
Swietenia spp.	22796.6	27356.0
Tectona grandis	22796.6	27356.0

From table 2, it is found that ***Hopea odorata***, ***Diterocarpus spp.***,***Gmelina arborea*** have the highest green weight above the tree and also the green weight including root by multiplying 120% to the ground weight.

3.3. The dry weight of the tree

To determine the dry weight of the tree, the weight of the tree should be multiplied by 72.5%. The dry weight of the trees is tabulated below.

Table 3. The dry weights of trees from different locations in Bangladesh.

Name of the tree	The dry weight of the tree(lbs)
Artocarpus chaplasha	371160.5
Anthocephalus cadamba	29861.7
Albizzia spp	4491.3
Cassia fistula	6611.0
Diterocarpus spp.	570958.6
Dillenia pentagyna	26544.4
Gmelina arborea	403029.6
Heritiera fomes	3289.2
Hopea odorata	604667.2
Lagerstroemia speciosa	26538.4
Mangifera sylvatica	29755.7
Shorea robusta	50797.5
Sonneratia apetala	82936.7
Swietenia spp.	19833.1
Tectona grandis	19833.1

From table 3,it is found that, the dry weight of ***Hopea odorata***, ***Diterocarpus spp.***,***Gmelina arborea*** are the highest among the other trees from different locations in Bangladesh.

3.4. The weight of carbon in the tree

As the carbon content is generally 50% of the tree, the total dry weight of the tree should be multiplied by 50% to determine the carbon weight.

Table 4. The carbon weight of the tree from different locations in Bangladesh.

Name of the tree	The weight of carbon in the tree(lbs)
Artocarpus chaplasha	185580.2
Anthocephalus cadamba	14930.8
Albizzia spp	2245.6
Cassia fistula	3305.5
Diterocarpus spp.	285479.3
Dillenia pentagyna	13272.2
Gmelina arborea	201514.8
Heritiera fomes	1644.6
Hopea odorata	302333.6
Lagerstroemia speciosa	13269.2
Mangifera sylvatica	14877.8
Shorea robusta	25398.7
Sonneratia apetala	41468.3
Swietenia spp.	9916.5
Tectona grandis	9916.5

After multiplying 50% to the dry weight, the carbon weight has been found. From table 4, it has been found that ***Hopea odorata,***, ***Diterocarpus spp.***,***Gmelina arborea*** have more carbon weight than others.

3.5. The weight of CO_2 sequestered in the tree

The weight of CO_2 sequestered in the tree is 3.6663 times more than the carbon weight in the tree. The weight of CO_2 sequestered in the tree is tabulated below.

Table 5. The CO_2 sequestration weight of trees from different locations in Bangladesh.

Name of the tree	The weight of CO_2 sequestered in the tree(lbs)
Artocarpus chaplasha	556740.8
Anthocephalus cadamba	44792.6
Albizzia spp	6737.0
Cassia fistula	9916.5
Diterocarpus spp.	856437.9
Dillenia pentagyna	39816.7
Gmelina arborea	604544.4
Heritiera fomes	4933.8
Hopea odorata	907000.9
Lagerstroemia speciosa	39807.6
Mangifera sylvatica	44633.5
Shorea robusta	76196.3
Sonneratia apetala	124405.1
Swietenia spp.	29749.65
Tectona grandis	29749.65

To determine the CO_2 sequestered in the tree, the carbon weights of the trees have been multiplied by 3.6663 and from the above table 5, it has been found the ***Hopea odorata*** has the highest CO_2 sequestration capacity among the other trees discussed above from around Bangladesh.

3.6. CO_2 emission from power plant

The participation of coal in power generation is now 2-3% of total[11].But government plans to generate power in 2020 would be about 20,000MW, and 50% of that would be coal based. In 1980, where the country's total coal consumption was only around 25 thousands short tons, it becomes around 1200 thousands short tons within 2014. This amount is increasing day by day. Now 250MW coal based power station is now in production beside Barapukuria coal mine and another 1320 MW coal based power station is planned to set up[12].Government plans to generate around 5000MW power from locally produced coal. To generate this huge amount of power, a big amount of coal is to be fired yearly and the CO_2 emission from this will be extensive. For example, Barapukuria coal mine produces one million ton coal per year and 65% of that is used to run the 250MW power plant near the site[13]. The fixed carbon content is 48.40% of that coal[14]. So there is a quantitative estimation of CO_2 emission from that power plant in a year.

Table 6. CO_2 emission in a year from Barapukuria coal fired thermal power plant.

Yearly production of Barapukuria coal field in MT	Supply to the 250MW power station in MT	Fixed carbon content of Barapukuria coal field in percentage	Total carbon content of Barapukuria coal field in lbs	CO_2 emission from the power plant yearly in lbs
1000000	650000	48.40%	$6.935*10^8$	$2.5426*10^9$

3.7. Area needed for plantation

Shorea robusta, ***Albizzia procera*** are the common trees around the Barapukuria thermal power station area. The trees are at maximum height & diameter within about 30-40 years.It can be easily planted 1000 trees in a hectare.

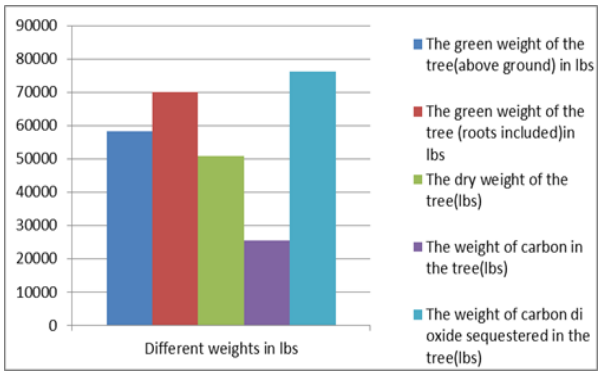

Fig 3: Different weights of ***Shorea robusta*** in lbs.

If it is decided to plant ***Shorea robusta*** around power plant area to sequestrate CO_2 which is emitted by firing coal, here is an estimation of areas which is needed to plant trees.For ***Shorea robusta***,CO_2 sequestered per year=76196.3lbs/30yr=2539.87 lbs/yr. CO_2 sequestered per hectare per year=2539870 lbs/hec/yr. Area needed for tree plantation to sequestrate total CO_2 emission from power plant = (2.5426*109 lbs/yr)/(2539870 lbs/hec/yr) = 1001.07 hectare.

4. CONCLUSION

According to the data it can be concluded that, CO_2 sequestration rate in the same environmental situation depends on the species. If it is planned to reduce CO_2 percentage from the surroundings of the coal firing plant, required area can be estimated and suitable species with the amount of tree can also be calculated. Good management of green area around the power plant area, could make better air quality not only for this area, but also for the whole country and environment will be benefited.

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