Carbon Sequestration by the Standing Mangrove Trees at the Achara Estuary along the Coast of Maharashtra State (India)

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ABSTRACT

Mangroves or all the plants are known to absorb the atmospheric carbon by photosynthesis. This absorbed carbon is stored in various organic forms and helps to produce the biomass. Trees dominate this process. Greater and taller is the size of the tree more is the amount of carbon fixed. Hence trees are the major plant forms to absorb maximum atmospheric carbon and biomass production. Thus, the present investigation was carried out to calculate the carbon sequestration of 12 standing mangrove tree species in Achara estuary of Sindhudurg district of Maharashtra state. The biomass and total organic carbon of standing trees is estimated by the non-destructive method. The population of *Avicennia marina* var. *acutissima* Staf. & Mold. and *Rhizophora mucronata* Lamk. are more in the estuary and they sequester about $585.70 \times 10^6$ and $375.10 \times 10^6$ lbs carbon respectively. A total of $1892.96 \times 10^6$ lbs of the carbon is sequestering by all the mangrove trees present in the estuary.

Keywords: Mangroves, Achara, Maharashtra, Carbon Sequestration

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INTRODUCTION

Mangroves are typical group of plants which are adopted for survival in sheltered brackish water habitats along coasts of tropical and sub-tropical regions. Mangroves play a key role in maintaining the quality and productivity of coastal waters. Mangroves are known as primary producers, shoreline protectors, nursery grounds and habitat for variety of animals, bridging components and unique biological resources. They provide erosion control and shoreline stabilization; they are also involved in complex detritus food webs. Maharashtra is one of the coastal states of India, with many rivers emerging from Sahyadri ranges and meeting the Arabian Sea. The coast line available for Maharashtra state is 720 km. Ratnagiri, Sindhudurg, Raigad, Thane and Mumbai are the five coastal districts of the state of Maharashtra. All the districts together have more than 55 small, medium and large estuaries. The estuaries in all the districts exhibit rich mangrove flora. However, in last few decades this fragile and sensitive ecosystem has been over exploited. All the mangroves in these districts are exposed to severe anthropogenic pressure.

Achara is one of the large estuaries situated in the Sindhudurg district of Maharashtra state. The estuary shows the greater mangrove diversity with the healthy performance. As the estuary show greater mangrove diversity with the healthy performance, the importance of the mangroves for carbon sequestration is still not highlighted or seems to be ignored.

The current environmental disasters like global warming are creating havoc in the behavior of all the living organisms including man on the earth. Today's global warming is the outcome of lot of unnatural processes taking place since last many decades. Many manmade gases are responsible to disturb the natural form of air and atmosphere. Among all these gases, dominance of carbon dioxide is mainly responsible for global warming. Maintaining the optimum level of CO₂ in the atmosphere is the major challenge in today's modern world. Trees play an important role in lowering the atmospheric level of CO₂. They not only maintain the CO₂ level but also helps for ecosystem functioning. Trees absorb 50 % CO₂ in their standing biomass (Ravindranath et.al. 1997). Importance of forested areas in carbon sequestration is already accepted, and well documented (FSI 1988, Tiwari & Singh 1987). Patil and Co-workers (2013) have estimated the carbon sequestration of Shivaji University, Kolhapur campus. According to Myers and Goreau, (1991) tropical tree plantations of pine and eucalyptus can sequester an average of 10 tons of carbon per hectare per year. However, in the modern era due to industrial and technological advancement the vegetation has undergone destruction and degradation by human activities. This development has resulted in emissions of carbon in the atmosphere. Therefore, there is an urgent need to deal with environmental issues. Thus, the present investigation was carried out to calculate the carbon sequestration by 12 standing mangrove tree species in Achara estuary of Sindhudurg district of Maharashtra state.

MATERIALS AND METHODS

Study area

Achara (16°12'–16°14'N 73°25'–73°30'E) is one of the large estuaries situated in the Sindhudurg district of Maharashtra state. The river Achara runs to about 20 kms. From the mouth and is surrounded by tall hills towards the north and south sides. On the east it shows flat plains. The total area of the estuary is estimated to be 275 ha. The mangroves were spread in small and large islands continuously over a distance of three kilometers along the west and north side of the river. Twelve mangrove species were distributed along the stretch of the estuary.

Bird eye view of the Achara estuary

Site Map of Achara estuary (Scale – 1:25,000) SOI
Satellite Image of Threatened Lush green Mangrove stands at Achra estuary Dist : Sindhudurga (Courtesy – Google Earth)

The estuary shows the greater mangrove diversity with the healthy performance. As the estuary show greater mangrove diversity with the healthy performance the importance of the mangroves for carbon sequestration is still not highlighted or seems to be ignored. The total mangrove area of the estuary is more than 95 hectares. The species like *Avicennia marina* var. *acutissima*, *Avicennia officinalis*, *Rhizophora mucronata*, *Rhizophora apiculate*, *Sonneratia alba*, *Aegiceras corniculatum* and *Excoecaria agallocha* are dominant and species like *Xylocarpus granatum*, *Cynometra iripa*, *Bruguiera gymnorrhiza* show a very limited occurrence.

The data has collected by frequent visits to the site. The trees or the population density has been sampled by putting quadrats of various sizes as 20m×20m or by putting variable transects depending upon the size of population at different sites. Carbon sequestration was calculated by using the formula given by Georgia Forestry Commission (1986). It is also referred by Chavan (2010).

**Formula**

\[ W = 0.15D^2H \] (For trees with D=11 inches)
\[ W = 0.25D^2H \] (for trees with D<11 inches)

\[ W \times 120\% = A \]
\[ A \times 72.5\% = B \]
\[ B \times 50\% = C \]
\[ C \times 3.6663 = D \]

Where,  
W - above ground height of tree  
D - Diameter of tree trunks in inches  
H - height of tree in feet  

**RESULTS AND DISCUSSION**

Bhosale (2002) has categorized the mangroves of Maharashtra as per the IUCN guidelines. Kulkarni (2006) has studied the mangroves of Ratnagiri and Sindhudurg districts of Maharashtra state. He has collected the population densities of almost all the estuaries in these two districts. The data has been updated from time to time. The present study has calculated the standing biomass of the above ground woody parts of the mangroves in the Achara estuary along the coast of Maharashtra state. Table.1 depicts the species wise carbon sequestration by the mangroves of the study area. The table show that their 12 major mangrove tree species standing at Achara estuary.

The organic carbon sequestered by some the dominant mangrove species are *Avicennia marina* var. *acutissima* (585.70×10⁶), *Avicennia officinalis* (754.06×10⁶), *Rhizophora mucronata* (375.10×10⁶), *Rhizophora apiculate* (861.0×10⁶), *Sonneratia alba* (145.0×10⁶), *Aegiceras corniculatum* (203.0×10⁶) and *Excoecaria agallocha* (147.86×10⁶) which are dominant and species like *Xylocarpus granatum* (170.9×10⁶) and *Cynometra iripa* (730.8×10⁶) *Bruguiera gymnorrhiza* (564.4×10⁶) which are uncommon. All these species are very slow growing due to the constantly changing edaphic factors and they take lot of time to for regeneration and to gain a considerable woody size (Graph 1). Since last many years the felling of mangroves in this area is very fast and hence it is important for putting a strict ban on cutting the trees.

Kulkarni (2006) and till date is studying and updating the population densities of mangroves of Ratnagiri and Sindhudurg districts of Maharashtra state. On the basis of the observations, it can be predicted that the population densities of mangroves in these two districts will be 238×10⁴ and these can sequester around 396.87×10⁸ lbs carbon and can fix around 108.24×10⁸ lbs of carbon. This proves the very importance of the mangroves of Ratnagiri and Sindhudurg districts of Maharashtra state in the present environmental crisis. After considering the carbon sequestration by the mangroves of Ratnagiri and Sindhudurg districts, one can predict the same for mangroves of Maharashtra state. Kulkarni (2018) has studied the carbon sequestration and standing biomass of the above ground woody parts of the trees in the Amrai Park of Sangli city.

**CONCLUSION**

As the mangroves are typical group of plants which are adopted for survival in sheltered brackish water habitats.
along coasts of tropical and sub-tropical regions. They play a key role in maintaining the quality and productivity of coastal waters. As they are known as primary producers, shoreline protectors, nursery grounds and habitat for variety of animals, bridging components and unique biological resources. They also provide erosion control and shoreline stabilization; they are also involved in complex detritus food webs. The present piece of work emphasizes their role in carbon sequestration and standing biomass.

As Achara is one of the large estuaries situated in the Sindhudurg district of Maharashtra state. The mangroves were spread in small and large islands continuously over a distance of three kilometers along the west and north side of the river. Twelve mangrove species were distributed along the stretch of the estuary. The estuary shows the greater mangrove diversity with the healthy performance. As the estuary show greater mangrove diversity with the healthy performance the importance of the mangroves for carbon sequestration is still not highlighted or seems to be ignored. The total mangrove area of the estuary is more than 95 hectares. The species like Avicennia marina var. acutissima, Avicennia officinalis, Rhizophora mcrconata, Rhizophora apiculate, Sonneratia alba, Aegiceras corniculatum and Excoecaria agallocha are dominant and species like Xylocarpus granatum, Cynometra iripa and Bruguiera gymnorrhiza show a very limited occurrence. For their better use for environmental conservation the mangroves of Achara estuary of the Sindhudurg district of Maharashtra state should be well conserved as the national importance.

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Graph 1: Carbon Sequestration by the Major Standing Mangrove Trees at the Achara Estuary

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### Table 1: Field Data and Carbon Sequestration by the Standing Mangrove Trees at the Achara Estuary.

| Sr. No. | Name of plant species                        | Average Height (Feet) | Average Sequestration (lbs) | Average carbon (lbs) | Population Density/Number of Individuals | Total Carbon (lbs) | Total Carbon Sequestration (lbs) |
|---------|---------------------------------------------|-----------------------|----------------------------|----------------------|-------------------------------------------|--------------------|----------------------------------|
| 1.      | *Avicennia marina* var. *acutissima* Staf. & Mold. | 57.49                 | 12750.75                   | 3477.83              | 45935                                     | 159.75×10^6       | 585.70×10^6                     |
| 2.      | *Avicennia officinalis* L.                   | 29.77                 | 16655.59                   | 4542.89              | 45274                                     | 205.67×10^6       | 754.06×10^6                     |
| 3.      | *Rhizophora mucronata* Lamk.                | 25.18                 | 1321.81                    | 360.85               | 283780                                    | 102.40×10^6       | 375.10×10^6                     |
| 4.      | *Rhizophora apiculata* Blume                | 23.78                 | 0.105                      | 0.029                | 82009                                     | 23.78×10^2        | 861.0×10^1                      |
| 5.      | *Ceriops tagal* (Petr.) Robin.              | 12.26                 | 455.34                     | 124.21               | 19698                                     | 244.66×10^4       | 896.92×10^4                     |
| 6.      | *Kandelia candel* (L) Druce.                | 10.76                 | 1504.99                    | 410.49               | 372                                        | 152.70×10^3       | 559.85×10^3                     |
| 7.      | *Bruguiera gymnorrhiza* (L.) Lamk.          | 22.82                 | 137.67                     | 37.55                | 410                                        | 153.95×10^2       | 564.4×10^2                      |
| 8.      | *Sonneratia alba* J. Sm.                    | 23.53                 | 1986.31                    | 541.78               | 73                                         | 395.49×10^2       | 145.0×10^3                      |
| 9.      | *Aegiceras corniculatum* (L.) Blanco.        | 5.64                  | 150.84                     | 41.14                | 134644                                     | 553.92×10^4       | 203.0×10^3                      |
| 10.     | *Xylocarpus granatum* koen.                 | 20.92                 | 4070.7                     | 1110.31              | 42                                         | 466.33×10^2       | 170.9×10^3                      |
| 11.     | *Excoecaria agallocha* Linn                 | 17.28                 | 2495.53                    | 680.67               | 59252                                     | 403.31×10^3       | 147.86×10^6                     |
| 12.     | *Cynometra iripa* L.                        | 15.28                 | 730.85                     | 199.34               | 10                                         | 199.3×10^1        | 730.8×10^3                      |
|         | **Grand Total**                             |                       |                            |                      |                                            | **516.40×10^6**   | **1892.96×10^6**                 |

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