MANGROVE DEGRADATION: A THREAT TO BLUE CARBON STORAGE

By

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SEMINAR REPORT

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CERTIFICATE

This is to certify that the seminar report entitled **“Mangrove degradation: A threat to blue carbon storage”** has been solely prepared by **MILI M. (2018-11-024)**, under my guidance and has not been copied from seminar reports of any seniors, juniors or fellow students.

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Certified that the seminar report entitled **"Mangrove degradation: A threat to blue carbon storage"** is a record of seminar presented by **Mili M. (2018-11-024)** on 07th November, 2019 and is submitted for the partial requirement of the course SOILS 591.

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1. Blue carbon – An introduction

Carbon dioxide levels are rising at an alarming rate of 3 ppm each year. Based on current emissions, scientists estimate carbon dioxide levels could hit 500 ppm in as little as 30 years. Increasing emissions of carbon dioxide accelerate global warming. Carbon dioxide emissions are the most important cause of global warming. Therefore it is high time that we sequester this carbon. Blue carbon offers a long-term solution.

Ocean blue carbon refers to the absorbed and fixed carbon in the ocean from atmospheric CO_2. Here, the 'blue carbon' is analogous to the 'green carbon' that is fixed by terrestrial ecosystems. The net absorption (the sum of incoming and outgoing fluxes) of ocean bluecarbon from the atmosphere is approximately 2.3 Pg Cyr^{-1}, while green carbon absorbs approximately 2.6 Pg Cyr^{-1} (IPCC, 2013). Traditionally, ocean blue carbon is primarily fixed through the physically dissolved carbon pump (atmospheric CO_2 is dissolved into sea water),the biological carbon pump (marine phytoplankton absorbs and transforms CO_2 through photosynthesis and then deposits it into the sea bed), and the marine carbonate pump (the carbon is absorbed, transformed and released by shellfish, coral reefs and other marine organisms). Terrestrial green carbon is fixed mainly through the terrestrial higher plants that absorb, convert, and fix CO_2 via photosynthesis as biomass or into soil (Tang *et al*., 2018).

Coastal blue carbon lies between the ocean blue carbon and terrestrial green carbon. The coastal zone, controlled by seawater and tides, hosts wetland plants (salt marsh and mangrove) and marine plants (seagrass). During recent years, coastal blue carbon has been defined as the carbon fixed by coastal plants, including salt marshes, mangroves, and seagrasses (Howard *et al*., 2014).

2. Components of blue carbon ecosystem

Mangroves

Sea grasses

Tidal marshes

Plate 1. Components of blue carbon ecosystem

Blue carbon is the carbon stored in coastal and marine ecosystems. Coastal ecosystems such as mangroves, salt marshes and seagrass meadows sequester and store large quantities of blue carbon in both plants and the sediments below. Carbon sequestered in coastal soils can be extensive and remain trapped for very long periods of time (centuries to millennia) resulting in very large carbon stocks. In fact, total carbon deposits per square kilometre in these coastal systems may be up to five times the carbon stored in tropical forests. By sequestering and storing significant amounts carbon from the atmosphere and ocean, coastal ecosystems help mitigate climate change. On the other hand, the conversion and degradation of these ecosystems can cause a significant release of CO_2 to the ocean and atmosphere

The difference in soil carbon accumulation in terrestrial versus coastal systems is that potential carbon storage in upland soils is limited by high availability of oxygen, allowing for aerobic microbial carbon oxidation and release back into the atmosphere In blue carbon systems, however, the soil is saturated with water keeping it in an anaerobic state (low to no oxygen), and it continually accretes vertically at high rates resulting in continuous build-up of carbon over time

They have high biodiversity values. They provide breeding grounds and nurseries for fisheries and food security for many coastal communities around the world. They also provide ecosystem services that are essential for climate adaptation and resilience along coasts, including protection from storm surge and sea level rise, erosion prevention along shorelines and coastal water quality regulation.

2.1. Soil organic carbon stocks of blue carbon ecosystems

Sl no.	Ecosystem	Carbon stock (Mg/ha)	CO_2 Mequiv/ha
1	Mangrove	386	1415
2	Tidal marsh	255	935
3	Sea grass	108	396

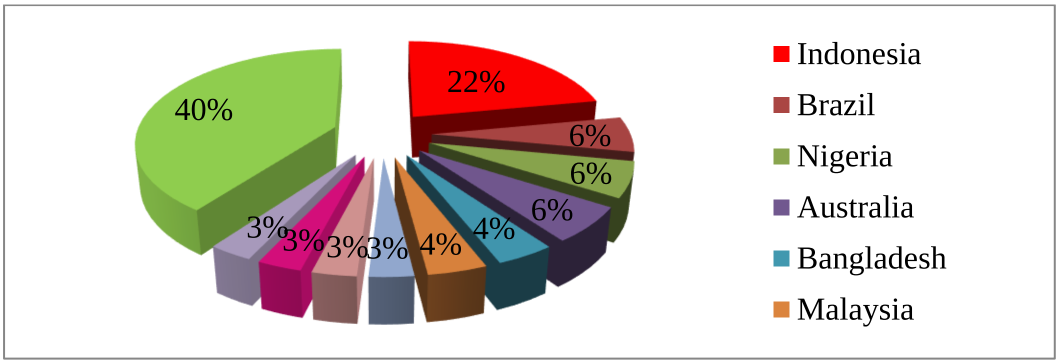
Table 1. Soil organic stocks of blue carbon ecosystems

Compared to other members of blue carbon ecosystems, mangroves store more amount of carbon.

3. Distribution of mangroves

3.1. Distribution of mangroves in the world

Mangroves occur worldwide in the tropics and subtropics, mainly between latitudes 25° N and 25° S. Mangroves can be found in over 118 countries and territories in the tropical and subtropical regions of the world. Approximately 75% of world's mangroves are found in just 15 countries. Asia has the largest amount (42%) of the world's mangroves, followed by Africa (21%), North/Central America (15%), Oceania (12%) and South America (11%) (FAO, 2011).



(FAO, 2011)

Fig .1. Percentage distribution of mangroves around the world

3.2. Mangrove cover in India

Mangroves are spread over an area of 4921 sq km in India which is nearly 3.3% of the world's mangrove vegetation and 0.15 % of the country's total area. Sundarbans in West Bengal accounts for almost half of the total area under mangrove in India. Forest Survey of India has been assessing the mangrove cover using remote sensing data since 1987.

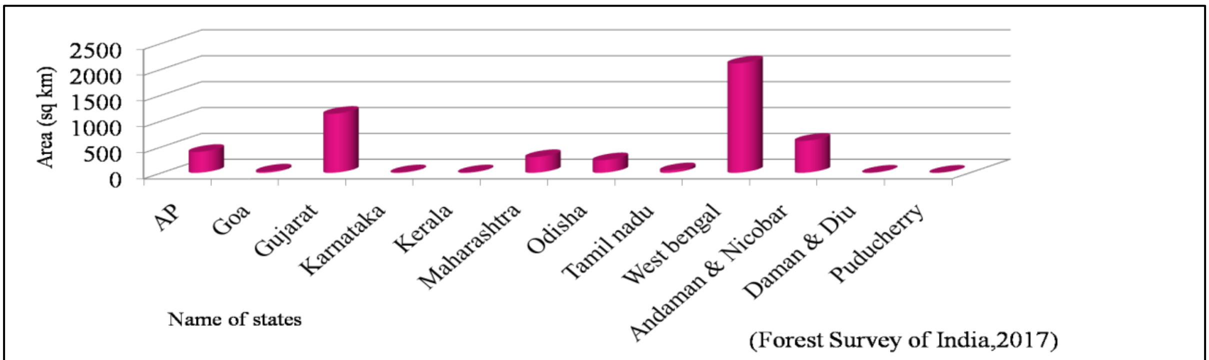


Fig 2. Statewise distribution of mangroves in India

3.3. Mangrove cover in Kerala

Kerala has a mangrove cover of 9 sq km which is distributed in the districts of Ernakulam, Kannur and Kasargod.

District	Very dense mangrove (km^2)	Moderately dense (km^2)	Open mangrove (km^2)	Total (km^2)
Ernakulam	0	1	1	2
Kannur	0	4	2	6
Kasargod	0	0	1	1
Total	0	5	4	9

(Forest Survey of India, 2017)

Table 2. Mangrove coverage in Kerala

4. Mangroves – A better carbon scrubber

Mangroves are salt-tolerant trees, also called halophytes, and are adapted to life in harsh coastal conditions. They contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action. They are adapted to the low oxygen conditions of waterlogged mud.

Mangrove forests move carbon dioxide from the atmosphere into long-term storage in greater quantities than other forests, making them "among the planet's best carbon scrubbers" according to a NASA-led study based on satellite data.

Mangrove plants require a number of physiological adaptations to overcome the problems of low environmental oxygen levels, high salinity and frequent tidal flooding. Each species has its own solutions to these problems; this may be the primary reason why, on some shorelines, mangrove tree species show distinct zonation. Small environmental variations within a mangal may lead to greatly differing methods for coping with the environment. Therefore, the mix of species is partly determined by the tolerances of individual species to physical conditions, such as tidal flooding and salinity, but may also be influenced by other factors, such as crabs preying on plant seedlings.

5. Types of mangroves

5.1. Red Mangrove (*Rhizophora mangle*)

Plate 2. Red mangroves with stilt roots

The red mangrove is the most salt tolerant of the Mangroves. The Red Mangrove has very shiny, glossy and pointy green leaves which are green on both sides of the leaf.The Red Mangrove is easily recognised by numerous reddish, arching aerial roots called prop (or stilt) roots, which provide an important protective nursery habitat for many marine species. Red Mangroves have small yellowish flowers with four petals and are pollinated by wind. The Red Mangrove reproduces by long dangling propagules (embryonic plants) 6 to 8 inches long which fall from the branches into the water or soft earth. Stilt roots have lenticels.

5.2. Black Mangrove (*Avicennia germinans*)

Plate 3. Black mangroves with pneumatophores

The Black Mangrove is characterised by its opposite leaves which are narrow and elliptical in shape; often found encrusted with salt. They are able to take up saltwater, use the water, and put the salt out onto their leaves.

The black mangrove has pointy, green leaves and is a little less shiny (than the red mangrove) and the leaf has a grey, silvery back. The black mangrove has a single trunk with almost black bark. Another way the black mangrove has adapted to its environment is by having roots that poke up out of the sediment instead of growing into it. These roots are called pneumatophores, which means ‘air breathing roots’.

All plants need to breathe, so the black mangroves have developed these roots that act like snorkels, allowing them to get air, even though it is standing in seawater or soggy mud. They have white flowers in spring and summer. They reproduce by propagules (embryonic plants) approx. 3/4 of an inch long pneumatophores have lenticels.

5.3. White Mangrove (*Laguncularia racemosa*)

Plate 4. White mangroves

White Mangroves are found more inland in tidal areas, ponds and distinguished from the other mangroves as having no aerial roots. Characterised by rounded leaves at the base and tip. The leaf is often notched at its apex (tip). Two glands at the base of each leaf act as perspiration glands removing excess salt and sugar to attract helpful insects. The leaves have microscopic pores which excrete salt.

They produce greenish-white flowers in spikes, blooming from spring to early summer. They reproduce by small propagules (embryonic plants) approx. 0.2 inches long. A propagule is not a seed, but actually a tiny tree. Propagules develop from flowers. They mature on the tree and fall off in September.

6. Adaptations of mangroves

6.1. Adaptations to low oxygen

Red mangroves, which can survive in the most inundated areas, prop themselves above the water level with stilt roots and can then absorb air through pores in their bark (lenticels). Black mangroves live on higher ground and make many pneumatophores (specialised root-like structures which stick up out of the soil like straws for breathing) which are also covered in lenticels.

6.2. Nutrient uptake

Because the soil is perpetually waterlogged, little free oxygen is available. Anaerobic bacteria liberate nitrogen gas, inorganic phosphates, sulfides and methane, which make the soil much less nutritious. Pneumatophores (aerial roots) allow mangroves to absorb gases directly from the atmosphere, and other nutrients such as iron, from the inhospitable soil. Mangroves store gases directly inside the roots, processing them even when the roots are submerged during high tide.

6.3. Limiting salt intake

Red mangroves exclude salt by having significantly impermeable roots which are highly suberised (impregnated with suberin), acting as an ultra-filtration mechanism to exclude sodium salts from the rest of the plant.

6.4. Limiting water loss

Because of the limited fresh water available in salty intertidal soils, mangroves limit the amount of water they lose through their leaves. They can restrict the opening of their stomata (pores on the leaf surfaces, which exchange carbon dioxide gas and water vapour during photosynthesis). They also vary the orientation of their leaves to avoid the harsh midday sun and so reduce evaporation from the leaves.

6.5. Increasing survival of offspring

In this harsh environment, mangroves have evolved a special mechanism to help their offspring survive. Mangrove seeds are buoyant and are therefore suited to water dispersal. Unlike most plants, whose seeds germinate in soil, many mangroves (e.g. red mangrove) are viviparous, meaning their seeds germinate while still attached to the parent tree. Once germinated, the seedling grows either within the fruit (e.g. *Aegialitis*, *Avicennia* and *Aegiceras*), or out through the fruit (e.g. *Rhizophora*, *Ceriops*, *Bruguiera* and *Nypa*) to form a propagule (a ready-to-go seedling) which can produce its own food via photosynthesis.

The mature propagule then drops into the water, which can transport it great distances. Propagules can survive desiccation and remain dormant for over a year before arriving in a suitable environment. Once a propagule is ready to root, its density changes so that the elongated shape now floats vertically rather than horizontally. In this position, it is more likely to lodge in the mud and root. If it does not root, it can alter its density and drift again in search of more favourable conditions.

7. Ecosystem services provided by mangroves

According to a study, the total amount of carbon held in the world's mangroves is around 4.2 bn tonnes. If this whole amount were released as carbon dioxide, it would be equivalent to the annual emissions of China and the US put together. The ecosystem goods and services provided by mangroves are estimated to be worth US$186 million each year (Hamilton and Friess, 2018).They include:

7.1. Fisheries

Mangrove forests are home to a large variety of fish, crab, shrimp, and mollusc species. These fisheries form an essential source of food for thousands of coastal communities around the world. The forests also serve as nurseries for many fish species, including coral reef fish. A study on the Mesoamerican reef, for example, showed that there are as many as 25 times more fish of some species on reefs close to mangrove areas than in areas where mangroves have been cut down. This makes mangrove forests vitally important to coral reef and commercial fisheries as well.

7.2. Timber and plant products

Mangrove wood is resistant to rot and insects, making it extremely valuable. Many coastal and indigenous communities rely on this wood for construction material as well as for fuel. These communities also collect medicinal plants from mangrove ecosystems and use mangrove leaves as animal fodder. Recently, the forests have also been commercially harvested for pulp, wood chip, and charcoal production.

7.3. Coastal protection

The dense root systems of mangrove forests trap sediments flowing down rivers and off the land. This helps stabilizes the coastline and prevents erosion from waves and storms. In areas where mangroves have been cleared, coastal damage from hurricanes and typhoons is much more severe. By filtering out sediments, the forests also protect coral reefs and seagrass meadows from being smothered in sediment.

7.4. Tourism

Given the diversity of life inhabiting mangrove systems, and their proximity in many cases to other tourist attractions such as coral reefs and sandy beaches, it is perhaps surprising that only a few countries have started to tap into the tourism potential of their mangrove forests. Places as diverse as Bonaire and offer snorkelling expeditions in and around mangroves to witness a marvellous variety of baby fish, jellyfish, and urchins against a magical background of interwoven roots delving deep into the sandy substrate. Great potential exists elsewhere for revenue generation in this manner, which values the mangroves intact and as they stand (WWF, 2018).

8. Carbon stock in mangrove ecosystems

Carbon stock is the amount of organic carbon stored in a blue carbon ecosystem, typically reported as mega grams of organic carbon per hectare (Mg C_{org}/ha) over a specified soil depth. These stocks are determined by adding all relevant carbon pools within the investigated area. Relatedly, carbon pools are reservoirs such as soil, vegetation, the ocean, and atmosphere that store and release carbon.

Of the 4.2 bn tonnes total, around 3bn tonnes is within the soil (down to a depth of one metre) and the remaining 1.2bn in the vegetation above the ground. The largest mangrove carbon stores are in Indonesia, Brazil, Malaysia and Papua New Guinea, which make up half of the global total (Hamilton and Friess, 2018).

8.1. Carbon pools in mangroves

Similar to most terrestrial forest ecosystems, mangroves can be roughly divided into four carbon pools :

1. Aboveground living biomass (trees, scrub trees, lianas, palms, pneumatophores)
2. Aboveground dead biomass (litter, downed wood, dead trees)
3. Belowground living biomass (roots and rhizomes)
4. Soil carbon which includes the dead below-ground biomass.

Blue carbon is mostly stored belowground in organic-rich soils many meters deep where it can remain for very long times (up to millennia). The large size of these belowground pools and their poorly understood vulnerability to land-use change makes their measurement extremely important.

8.2. Estimation of blue carbon stock in mangroves

Blue carbon = Biomass carbon + Sediment carbon

8.2.1. Estimation of biomass carbon in mangroves

Parameters required for measuring above ground biomass carbon are species,main stem diameter at breast height (dbh) ,tree height and location. Diameter at Breast Height (dbh) is the diameter of the tree which is typically used to calculate the tree volume. The diameter of the tree's main stem is typically measured at 1.3 m above the ground, which is also called the dbh.

Biomass carbon (Kg C) = Biomass (Kg) x Conversion factor

To get biomass of a tree, certain allometric equations are used which are specific to species and location of mangroves. A few examples are given below :

Sl no.	Species group	Location	Biomass Equation
1	General equation	Americas	$B = 0.168 \times p \times D^{2.471}$
2	General equation	Asia	$B = 0.251 \times p \times D^{2.46}$
3	Avicennia germinans	French Guinea	$B = 0.14 \times D^{2.4}$
4	Avicennia germinans	Florida,USA	$B = 0.403 \times D^{1.934}$
5	Bruguiera gymnorrhiza	Australia	$B = 0.0679 \times D^{1.4914}$

p = wood density

D = diameter at breast height (Komiyama and Poungparn, 2005)

Table 3. Allometric equations for computing biomass of mangrove species

8.2.1.1. Determination of aboveground biomass carbon (Howard *et al*., 2014)

1. Wood density (g/cm^3) = Dry weight (g) / volume of fresh wood (cm^3)
2. Carbon content of each tree (kg C) = tree biomass (kg) x carbon conversion factor (0.46–0.5)
3. Carbon in live tree component (kg C/m^2) = (carbon content of tree #1 + carbon content of tree #2 + ……. Tree #n) / area of the plot (m^2)

8.2.1.2. Determination of carbon in the belowground biomass

1. Belowground tree biomass (kgC) = 0.199 x [(ρ(g/cm^3)$^{0.899}$]*x [(tree diameter at breast height (cm)] $^{2.22}$
2. Belowground carbon content of each tree (kg C) = Belowground tree biomass (kg C) x carbon conversion factor (0.39)
3. Carbon content of belowground carbon per plot (kg C/m^2) = (belowground carbon content of tree #1 + carbon content of tree #2 + ……. Tree #n) / plot area (m^2)

8.2.1.3. Determination of Carbon in the Pneumatophore (kg C/m^2):

1. Biomass for pneumatophores (kg) = Average dry mass of sampled pneumatophores x number of pneumatophores in the microplot .
2. Carbon in the pneumatophore component (kg C/m^2) = [Estimated biomass of the pneumatophores x carbon conversion factor (0.39)] / area of the plot (m^2).

8.2.2. Estimation of total sediment carbon in mangroves

In most blue carbon systems, soil carbon is by far the dominant carbon pool. Blue carbon is mostly stored belowground in organic-rich soils many meters deep where it can remain for very long times (up to millennia). The large size of these belowground pools and their poorly understood vulnerability to land-use change makes their measurement extremely important. The following gives the steps involved in estimation of total sediment carbon in mangroves:

Step 1: Determination of soil depth

Step 2: Soil Coring

Choose soil coring device based on type of soil and degree to which the soil is saturated with water. Steadily insert the coring device until the top of the sampler is level with the soil surface.

Step 3

a) Sampling an Entire Soil It is best to sample the entire depth of the soil core; however, this may not always be possible or practical. It is imperative to record subsample depth, depth interval and volume.

b) Subsampling a soil core : Samples should be collected from homogenized sample intervals or from the approximate mid-point of each desired depth range.

Step 4: Archiving of samples

The proper labelling of the cores and samples in the field is essential to avoid confusion and common mistakes in sample identification. Each sample/subsample should be labelled with at least a core ID, sample depth, and depth interval.

Step 5: Storing of samples

To minimize decomposition of organic matter, samples should be kept cold (at 4 °C) and, if possible, frozen within 24 hours of collection.

Step 6: Determining Dry Bulk Density (g/cm^3)

Calculate the volume of soil sampled using the equation and determine the dry weight. Calculate dry bulk density by dividing the mass of dried soil by the volume of soil sampled (g/cm^3).

Soil carbon density (g/cm^3) = Bulk density (g/cm^3) X (% C /100).

Step 7: Determination of Organic Carbon Content . Determine inorganic carbon content.Determine organic carbon content.

Amount of carbon in core section (g/cm^2) = Soil carbon density (g/cm^3) x thickness interval (cm).

Step 8: Calculate Total Soil Carbon Stock .Determine the amount of carbon per cm3 of the core and then multiply that by the length of the sample interval, then add all the intervals together to determine the total carbon /area represented in the coreTotal core carbon (Mg C/hectare) = Summed core carbon (g/cm^2) x (1 Mg/1 000 000 g) x (100 000 000 cm^2/1 hectare).

9. Mangrove degradation and its causes

More than 35% of the world's mangroves are already gone. The figure is as high as 50% in countries such as India, the Philippines, and Vietnam, while in the Americas they are being cleared at a rate faster than tropical rainforests. Threats to mangrove forests and their habitats include:

9.1. Clearing

Mangrove forests have often been seen as unproductive and smelly, and so cleared to make room for agricultural land, human settlements and infrastructure (such as harbours), and industrial areas. More recently, clearing for tourist developments, shrimp aquaculture, and salt farms has also taken place. This clearing is a major factor behind mangrove loss around the word.

9.2. Overharvesting

Mangrove trees are used for firewood, construction wood, wood chip and pulp production, charcoal production, and animal fodder. While harvesting has taken place for centuries, in some parts of the world it is no longer sustainable, threatening the future of the forests.

9.3. River changes

Dams and irrigation reduce the amount of water reaching mangrove forests, changing the salinity level of water in the forest. If salinity becomes too high, the mangroves cannot survive. Freshwater diversions can also lead to mangroves drying out. In addition, increased erosion due to land deforestation can massively increase the amount of sediment in rivers. This can overcome the mangrove forest's filtering ability, leading to the forest being smothered.

9.4. Overfishing

The global overfishing crisis facing the world's oceans has effects far beyond the directly overfished population. The ecological balance of food chains and mangrove fish communities can also be altered.

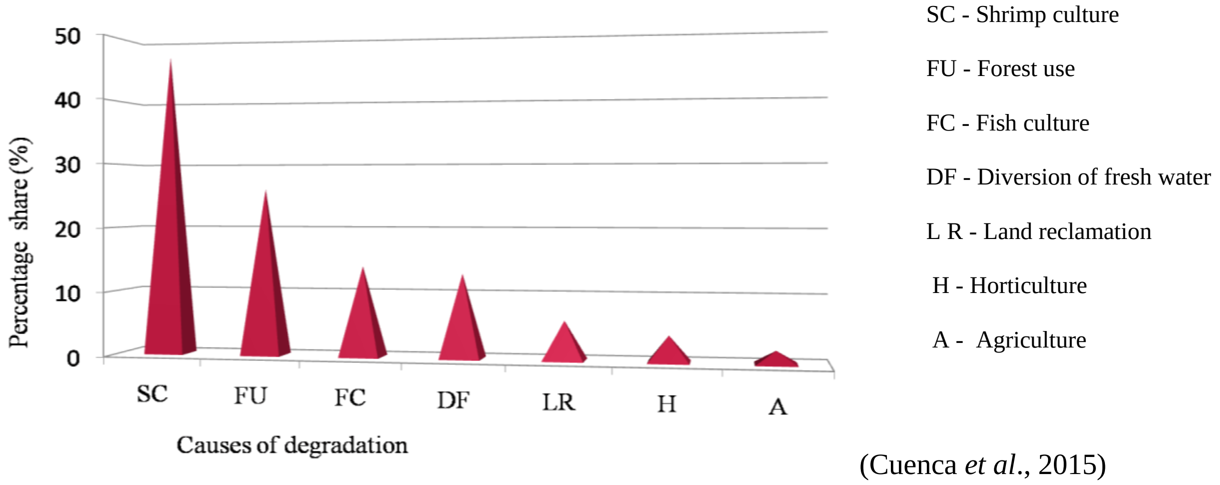
9.5. Destruction of coral reefs

Coral reefs provide the first barrier against currents and strong waves. When they are destroyed, the stronger-than-normal waves and currents reaching the coast can undermine the fine sediment in which the mangroves grow. This can prevent seedlings from taking root and wash away nutrients essential for mangrove ecosystems.

9.6. Pollution

Fertilizers, pesticides, and other toxic man-made chemicals carried by river systems from sources upstream can kill animals living in mangrove forests, while oil pollution can smother mangroves pneumatophores and suffocate trees.

9.7. Climate change Mangrove forests require stable sea levels for long-term survival. They are therefore extremely sensitive to current rising sea levels caused by global warming and climate change.



(Cuenca *et al*., 2015)

Fig.3. Comparison of different causes of degradation of mangroves

10. Effects of mangrove degradation

According to a study , sediment carbon was reduced by 50% within 8 years after land clearing in a Panamanian mangrove. Carbon dioxide efflux from the sediment surface of cleared mangroves was found to be 29 Mg CO_2 ha $^{-1}$ yr $^{-1}$. Global annual loss rate of carbon is 280 Mg C per ha (Siikamäkia *et al*., 2012).

Destruction of mangroves and tidal marshes has resulted in reduced sequestration of 0.076 Pg CO_2 per year (Pendleton *et al.*,2012). 0.003 Pg CO_2 per year of sequestration potential are lost due to current rates of mangrove and sea grass loss (Pidgeon, 2009).

Conversion and degradation of coastal ecosystems release 0.15 and 1.02 Pg (billion tons) of CO_2 per year to the atmosphere. Loss of vegetated coastal ecosystems contribute additional 3–19% global emissions from deforestation .Mangrove degradation reduces 12–80% of the carbon sink in the ocean's continental shelves globally i.e., 1.26 Pg CO_2/ yr .The conversion and degradation of coastal ecosystems release between 0.15 and 1.02 Pg (billion tons) of CO_2 per year to the atmosphere. (Pendelton *et al.*,2012).

Mangroves contain the largest per-hectare carbon stocks and contribute approximately half the estimated total blue carbon emissions. Mangrove forests in particular are the focus of many international conservation discussions.

A study conducted by Aarathy (2018) on the cumulative stock of mean blue carbon in sediments of *Avicennia officinalis* at selected locations of Vembanad lake in post monsoon season reveals that with the degradation of mangroves in that area ,the carbon stock also decreased .

Depth (cm)	Control (Mg /ha)	Aged (Mg/ ha)	Recent (Mg/ ha)	Healthy (Mg/ ha)	Degraded (Mg/ ha)
0-10	1.33	19.94	17.00	25.33	8.25
0- 20	29.34	35.31	37.80	45.09	16.97
0 -30	48.22	49.59	45.09	62.47	25.26

Table 4. Cumulative stock of mean blue carbon in sediments of *Avicennia officinalis* at selected locations of Vembanad lake in post monsoon season

11.Conservation of mangroves

Despite the breadth and quantity of services that mangrove ecosystems provide, they are being degraded or lost at an alarming. Need of the hour is to protect and conserve mangroves. Several conservation and restoration measures are being undertaken by international agencies to conserve mangroves such as Blue Carbon Initiative , Global Mangrove Alliance , Ramsar Convention etc.

The Global Mangrove Alliance is an ambitious initiative that seeks to increase global mangrove cover by 20% by 2030. Launched in June 2017, the Alliance is an unprecedented collaboration that brings together NGOs, governments, industry, local communities and funders towards a common goal.

The Blue Carbon Initiative is a global program working to mitigate climate change through the restoration and sustainable use of coastal and marine ecosystems. The Initiative currently focuses on mangroves, tidal marshes and sea grasses. The Blue Carbon Initiative brings together governments, research institutions, non-governmental organizations and communities from around the world.

In India mangroves are protected under National Forest Policy- 1952, Wildlife Protection Act -1972, Forest Conservation Act -1980 , Coastal Zone Regulation Act-1991 and Biodiversity Act -2002.

12. Conclusion

With their value for both mitigation and adaptation, blue carbon ecosystems are a vital part to any climate change solution. Among blue carbon ecosystems, mangroves fulfil many necessary functions from the productive, protective and social points of view. Yet increased population pressures in coastal areas and lack of awareness have led to large-scale conversion of mangrove areas to other uses such as agriculture, shrimp farming etc. If deforestation of mangroves were to continue, it could lead to severe losses of biodiversity and livelihoods, in addition to salt intrusion in coastal zones and the siltation of coral reefs, ports and shipping lanes, with consequent losses of income from tourism and a loss in capacity to sequester carbon and enormous carbon dioxide emissions.

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DISCUSSION

1. What is the pigment which gives red colour to red mangroves?

Ans. The red colour in the bark of red mangroves is attributed to the presence of red compound epigallocatechin gallate and other tannins . Epigallocatechin gallate (EGCG) also known as epigallocatechin-3-gallate, is the ester of epigallocatechin and gallic acid, and is a type of catechin. It is also the most abundant catechin in tea.

2. Why Indonesia has the largest cover of mangroves in the world?

Ans. Indonesia is an island country and has a coastline of 95,000 km .About 3 million hectares of mangrove forest grow along Indonesia's coastline. This is 23 percent of all mangrove ecosystems in the world .

3. What is the conversion factor in carbon to carbon dioxide estimation?

Ans. 3.66 is the conversion factor in carbon to carbon dioxide estimation. It is obtained by dividing molecular mass of carbon dioxide (44) by atomic mass of carbon (12) .

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SOILS 591: MASTER'S SEMINAR

Name	: Mili M.	Venue	: Seminar Hall
Admission No	: 2018-11-024	Date	: 07-11-2019
Major Advisor	: Dr. Betty Bastin	Time	: 11. 30 am

Mangrove degradation – a threat to blue carbon storage

Abstract

The carbon dioxide levels are increasing at an alarming rate of 3 ppm per year and a carbon dioxide concentration of 415.7 ppm was recorded on May 2019, the highest value ever recorded in 3 million years. Its uncontrolled emission is the most important cause of global warming and thereby climate change. Therefore, it is high time that we sequester this carbon. Blue carbon offers a long-term solution.

Blue carbon is the carbon stored in mangroves, tidal marshes, and sea grass meadows within the soil, the living biomass aboveground (leaves, branches and stems), the living biomass belowground (roots) and the non-living biomass (litter and dead wood) (Howard *et al*., 2014). Carbon sequestered in coastal soils can be extensive and remain trapped for very long periods of time (centuries to millennia) resulting in very large carbon stocks.

By sequestering and storing significant amounts of carbon from the atmosphere and ocean, coastal ecosystems help mitigate climate change. On the other hand, the conversion and degradation of these ecosystems can cause a significant release of CO_2 to the ocean and atmosphere (UNESCO, 2014). Mangroves sequester more carbon than any other blue carbon ecosystem. Globally, mangroves stored 4.19 bn tonnes of carbon in 2012, with Indonesia, Brazil, Malaysia and Papua New Guinea accounting for more than 50 percentage of the global stock. Theglobal carbon stock held within the soil is 2.96 bn tonnes and that held in the living biomass is 1.23 bn tonnes (Hamilton and Freiss, 2018).

The total mangrove cover in the world is about 1,56,220 km^2. There was a reduction in mangrove cover by 18 percentage within a span of last three decades. Mangroves cover an area of 4921 km^2 along Indian coastlines which comprises of approximately 3 percentage of world's mangrove forests (Ghosh *et al*.,2015).Global annual loss rate of mangroves is 0.7–3 percentage(Siikamaki *et al*., 2012).

Sediment carbonwas reduced by 50 percentage within 8 years after land clearing of mangroves in Panama. Carbon dioxide efflux from the sediment surface of cleared mangroves was found to be 29 Mg CO_2 $ha^{-1} yr^{-1}$(Siikamaki*et al*.,2012). Besides long term sequestration of carbon, mangroves provide various ecosystem goods and services of worth US$186 million each year .The various ecosystem services and goods provided by

mangroves are timber, fodder, coastal protection, support to marine life, boost to fisheries and tourism industry (WWF, 2018).

With their value for both mitigation and adaptation, blue carbon ecosystems are a vital part to any climate change solution. Among blue carbon ecosystems, mangroves fulfill many necessary functions from the productive, protective and social points of view. Yet increased population pressures in coastal areas and lack of awareness have led to large-scale conversion of mangrove areas for agriculture, shrimp farming, salt farms, industrial areas, tourist areas etc. If deforestation of mangroves were to continue, it could lead to severe losses of biodiversity and livelihoods, in addition to salt intrusion in coastal zones and the siltation of coral reefs, ports and shipping lanes, with consequent losses of income from tourism and a loss in capacity to sequester carbon and enormous carbon dioxide emissions.

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