

Wetlands are important carbon sink

in the context of global warming and climate change

Subir Kumar Nag*, Bandana Das Ghosh and U.K. Sarkar

ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore, West Bengal 700 120

Climate change is a truth now as available evidence is undeniable. The emission of greenhouse gases is increasing globally leading to an increase in mean annual temperature which has several consequences. There are mainly two-pronged strategies to cope with this event of GHG emission and global warming i.e. by reducing the emission and/or increasing the capture and removal of carbon from the atmosphere. Wetlands, one of the most productive ecosystems on earth, are a huge carbon sink. So, proper management, restoration of existing wetlands and creation of new wetlands can reduce the carbon footprint and mitigate climate change to some extent.

Keywords: Carbon sequestration, Climate change, Global warming, Wetlands

THE mean global temperature has increased by approximately 1°C above the pre-industrial level with a likely range of 0.8-1.2°C and Global Warming is likely to reach 1.5°C from 2030-2052 if it continues to rise in the same pace. A recent United Nations report has warned that the world is heading for an average temperature rise by 3.2°C by 2100 which would bring more disaster of climate change and this can happen even if all current commitments under Paris Agreement are implemented. The main reason for this warming is the changes in the Earth's radiative forcing caused by greenhouse gases (GHG), the most importantly carbon-di-oxide (CO₂) and other major non-CO₂ gases viz., CH₄ and N₂O. Both CO₂ and CH₄ along with N₂O contribute to the extent of 90% of direct radiative forcing of long-lived GHGs. The concentration of CO₂ in the atmosphere has increased by 48%, from 280 ppmv in 1,750 to 415 ppmv in 2019 due to emissions caused by human activities. Atmospheric CH₄ has increased from 700 ppb to 1,866 ppb over the same period accounting 167% increase. A

similar trend was also found in the case of N₂O.

Strategies for mitigation of global warming

There are mainly two approaches to mitigate the global warming caused by GHGs, one by reducing or avoiding the emissions from different sources, and another by increasing the removal of atmospheric carbon. Governments of different countries, NGOs and scientific communities feel that the mean global annual temperature should not increase beyond 2 °C above the pre-industrial value, which is very challenging. To achieve this, the global greenhouse gas emissions should be reduced by 40-70% by mid-century compared with the level in 2010, and to near-zero by the end of this century. Capturing and storage of atmospheric carbon for a long duration through natural or artificial techniques are one of the important strategies to lower CO₂ concentration in the atmosphere.

Wetlands

Wetlands are 'areas of marsh, fen, peatland, or water, whether natural or

artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine waters, the depth of which at low tide does not exceed six meters' (Ramsar Convention, 1971). They provide many beneficial ecosystem services to humankind like harbouring wide and diverse types of plants, animals, and microbes (biodiversity) and protection of wildlife; source of livelihood; fisheries and aquaculture; carbon sequestration; ecotourism, recreation, and aesthetics; water quality improvement; groundwater recharge; flood mitigation; coastal line protection, etc.

Soils in the wetland as a huge carbon sink

Of the major carbon pools, the pedologic pool is the third largest one after the oceanic pool and geological pool (fossil fuel). Carbon stored in soils exceeds the amount of carbon stored in biomass worldwide. The pedologic pool consists of soil organic carbon (SOC) and soil inorganic carbon (SIC). SOC pool is estimated at 1,550 Pg and SIC at 950 Pg up to 1 m depth. Soils of wetlands

are particularly rich reserves of carbon. Wetlands and associated soils constitute a large pedologic pool estimated at approximately 450 Pg which is about one-third of total SOC stored in soils. Wetland soils may contain 200 times more carbon than the associated vegetation.

Soils of wetlands play an unusual role in the global carbon cycle. Carbon accumulates in wetland soils because of high rates of plant productivity and low rates of decomposition in these ecosystems. The net primary productivity (NPP) of freshwater wetlands is very high compared to various ecosystems including tropical forests. Due to these facts production usually exceeds decomposition in wetlands and results in the net accumulation of organic matter and carbon.

Factors affecting carbon accumulation and sequestration in wetland

The accumulation of carbon and its subsequent sequestration in sediments of different wetlands vary as it is controlled by several factors like wetland type, climatic cycle, topography and landscape position, primary productivity, macrophyte diversity and coverage, depth into the sediment, temperature, hydrology, oxidation-reduction potential, salinity, land use, etc. The carbon sequestration rate in gram carbon per square meter area per year ($\text{g C m}^{-2}\text{yr}^{-1}$) of different types of wetlands around the world is given in Table 1.

Aquatic plants have a very important role in carbon accumulation in a wetland. Plants use atmospheric CO_2 for photosynthesis and after their death and decay, organic matter is added to the wetland bottom. This has a profound effect on carbon sequestration in wetland soil. It has been observed through experiments that carbon assimilation of many wetland plants (eg., *Phragmites* sp.) is increased due to the elevation of CO_2 . Thus, carbon sequestration in wetland soil could be enhanced if the primary productivity of the aquatic plant is increased.

Wetlands are also a source of GHGs

Although wetlands can sequester

carbon and store it in sediments for a very long period, at the same time they can also act as a source of GHGs, particularly methane (CH_4) which is 21 times more potent in global warming than CO_2 . Wetlands are considered as the largest natural source of CH_4 which results from methanogenesis occurring in the sediments. They contribute 109-145 $\text{Tg CH}_4 \text{ yr}^{-1}$ i.e. 20-25% of global CH_4 emission. Wetlands can also act as a source of CO_2 when decomposition of organic matter outpaces production. In addition, seasonal wetlands and those which are occasionally drained for agricultural and other purposes in many parts of the world can also become a significant source of atmospheric CO_2 .

However, in spite of the release of carbon through the emission of CH_4 and CO_2 , the net sequestration of carbon takes place over time in wetlands. Therefore, in the context of the above discussion, it is quite apparent that appropriate management strategies should be adopted to maintain and further enhance the carbon reserve in wetlands for the sake of protecting the earth from global warming and climate change.

Management practices to protect C-stores in wetland

- Conservation of wetlands and their sustainable use as natural habitats

- Restoration of degraded wetlands and creation of new wetlands
- Control drainage and other land and water management practices which lead to dewatering of wetlands and oxidation
- Control fires including deep burns
- Allow natural revegetation to occur
- Control peat harvesting and other removals of carbon from wetlands
- Public awareness and legal protection

Indian scenario

India has a vast area under wetland. The flood plain area covers around 0.55 million ha. Besides, there are about 0.72 million ha upland lakes. The flood plain wetlands are mostly spread in Uttar Pradesh, Bihar, West Bengal, Assam and few other North-Eastern states like Arunachal Pradesh, Manipur, Meghalaya, and Tripura. The soils of most of these wetlands have a high concentration of carbon (~4-10%) as compared to agricultural/upland soils.

As part of an adaptation and mitigation strategy for climate change due to global warming, at our institute we attempted to find out the carbon sequestration potential of different wetlands by measuring primary carbon capture and ultimate carbon accumulation in soils of different wetlands in West Bengal and Assam through our work under National Innovation on Climate Resilient Agriculture (NICRA)

Table 1. Carbon sequestration in different types of wetlands

Wetland type	$\text{g C m}^{-2}\text{yr}^{-1}$	Reference
General average for peatlands	12-25	Malmer (1975)
General range for wetlands	20-140	Mitra <i>et al.</i> (2005)
Peatlands (North America)	29	Gorham (1991)
Peatlands (Alaska and Canada)	8-61	Ovenden (1990)
Boreal peatlands	15 -26	Turunen <i>et al.</i> (2002)
Temperate Peatlands (North America)	10-46	-do-
Thoreau's Bog, Massachusetts	90	Hemond (1980)
Thoreau's papyrus wetland, Uganda	480	Saunders <i>et al.</i> (2007)
Created temperate marshes, Ohio	180-190	Anderson and Mitsch (2006)
Prairie pothole wetlands, North America Restored (semi-permanently flooded)	305	Euliss <i>et al.</i> (2006)
Reference wetlands	83	
Tropical wetland, Indonesia	56 (24000 yr) 94 (last 500 yr)	Page <i>et al.</i> (2004)
Flow through freshwater wetlands		Bernal and Mitsch (2008)
Ohio (temperate)	124-160	
Costa Rica (humid tropical)	250-260	
Sewage fed wetland, Kolkata	124.5-249.05	Nag <i>et al.</i> (2019)

project. The studied wetlands were seasonally open or closed system floodplains, excepting one which was a sewage fed Ramsar site in East Kolkata. The net algal primary productivity of these wetlands varied from 150–880 mg-C/m³/h which can add 4.21–24.67 Mg-C/ha/year (tonnes/ha/year). The seasonal average aquatic macrophytes coverage in these wetlands was between 10–40% which has the potential of adding 18.8–75.3 kg C/ha/year. Carbon dissolved in water is also an input source of carbon into the soil. The ground water recharge helps incorporation of dissolved carbon into sediments and soil. The average dissolved carbon content in the wetlands under our study varied from 14–51 ppm, which can add 90–327 kg C/ha/year. However, as organic matter decomposition and microbial respiration occurring simultaneously in the system, total

amount of carbon from all these input sources will not be incorporated into the sediments or soils. But only a fraction of it, depending on biogeochemical, microbial and other factors, would be accumulated in sediments and soil and remain there for a considerable time as sequestered carbon. It is observed that 49–157 Mg-C/ha were accumulated up to 0.3 m depth into soils in different wetlands. The corresponding figures in reference upland sites was in the range of 26–49 Mg-C/ha, which clearly indicates that wetland soils can store 2–4 times or even higher amount of carbon than the upland terrestrial soils. However, capacity of the wetlands to capture and store carbon in soil varies depending on their nature. The macrophyte abundance and diversity has been found to have a positive impact of carbon accumulation in wetland soils.

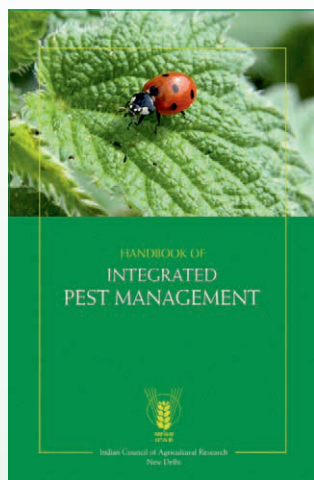
Conclusion

Wetlands are one of the most important and useful resources gifted by nature to us. They do have the best capacity among the different ecosystems to capture, sequester and retain carbon through permanent burial. Sequestration of atmospheric CO₂ into soil organic carbon could be very significant in stabilizing the concentration of this GHG in the atmosphere and in achieving the target of the Kyoto Protocol set by the United Nations in 1997 which was set into effect in 2005. Therefore, we need to take all measures for protection, conservation, and creation of wetlands for the better future of our next generation.

*Principal Scientist (Agricultural Chemistry),
Corresponding author's e-mail:
nagsk_67@rediffmail.com

HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.



The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional, protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

The *Handbook of Integrated Pest Management* comprises 82 chapters which are well written in lucid language with crispy sentences by the renowned scientists. The role of IPM is elucidated with different pests like *Trichogramma*, *Bacillus thuringiensis*, *Nomuraea rileyi* etc. and agricultural crops like rice, wheat, maize, sorghum, pearl millet, pulses, soybean, rapeseed mustard, groundnut, minor-oilseed crops, sugarcane, cotton, jute and mesta, potato, vegetable crops, fruits, grapes, citrus, banana, pomegranate, coconut etc. This *Handbook* will provide information of available useful technologies to educate on how to reduce or judiciously use chemical pesticides, safeguard ourselves from chronic poisoning, save the National environment while also reducing input costs and raise farmers' income. This compilation will be useful to teachers, students, trainers, line-department personnel and policy makers.

TECHNICAL SPECIFICATIONS

No. of pages : i-x + 768 • Price : ₹ 1500 • Postage : Rs 100 • ISBN No. : 978-81-7164-179-6

For obtaining copies, please contact:

Business Manager

Directorate of Knowledge Management in Agriculture
Indian Council of Agricultural Research

Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012

Tel : 011-25843657, Fax 91-11-25841282; e-mail : bmicar@gmail.com