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Case Study

Role of suburban wetland in carbon sequestration and climate change mitigation - Case study of Timbi Reservoir, Vadodara, Gujarat, India

Tailor Manthan A.[1] and Mankodi P.C.[2]*
[1]Department of Environmental Studies, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India
[2]Department of Zoology, The Maharaja Sayajirao University of Baroda,Vadodara, Gujarat, India
pcmankodi@yahoo.com

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Abstract

The wetland systems, characterized by transition between terrestrial and aquatic systems; which also include shallow reservoirs; are important in a number of ways to human and environment. Such systems are known for providing ecological services such as supporting higher biodiversity, nutrient cycling, sediment retention, flood control, combating drought, supply of water, regulating microclimate etc. Nevertheless, there is another dimension for appraisal of such systems i.e. their carbon sequestration potential and their role in mitigation of Climate Change. The study was carried out to assess the spatial distribution of Organic Carbon (OC) stock in the sediments and total carbon stored per unit area of Timbi Reservoir. The study revealed that the OC stored in the sediments was 76.2tons/hectare (sediment depth 15cm) with a total OC stock of $3.33x10^3$ tons equivalent to $12.21x10^3$tons of atmospheric CO_2. The study also indicated that the part of the wetland inundated for longer period of times stored more OC. This, in fact, is an important result as depleting water levels and exposed sediments may release the stored OC back into the atmosphere. The climate change and depleting wetland and other lentic systems may trigger a positive feedback accelerating climate change.

Keywords: Wetlands, ecological services, organic carbon (OC), carbon sequestration, climate change.

Introduction

Wetlands are one of the important ecosystems harbouring a number of diverse flora and fauna. Previous work has identified the wetlands to be supporting various organisms at their critical stages of life as well as help in conservation of endemic species[1]. Apart from harbouring immense diversity, the wetlands also furnish various services and has functions such as nutrient cycling, drought and flood control, supply of irrigation water, aquaculture etc.[2]. Apart from these benefits derived from such transitional systems, there is an additional role being played by them i.e. carbon storage and carbon sequestration[3-5]. The global small water bodies and wetlands (area < 1 km^2) are estimated to be having covered nearly half of the area totally covered by the lakes and have higher capacity of OC burial in comparison to their larger counterparts.

Vadodara District has numerous wetlands and reservoirs of various dimensions and properties. They are used for the purpose of irrigation, aquaculture, recreation etc. Studies have been carried out for many of such systems on different environmental aspects such as water quality, avifaunal diversity, ichthyofaunal diversity, aquatic floral diversity to name a few[6-10]. Inspite of this, there are no studies carried out pertaining to OC storage/stock in the ponds, lakes and such other wetland systems in Vadodara district, Gujarat. However, the study of carbon stock, carbon sequestration potential, carbon pools etc. were the recent research ventures for various ecological components such as forests, scrublands, soils under various land use practices[11-14]. By having an insight of the deficiency on the carbon sequestration aspect, the current research work was taken up.

The study was thus aimed at appraisal of spatial distribution of OC in the sediments of Timbi reservoir and to estimate the total carbon stock per unit area of the reservoir.

Materials and methods

Site description: The study was conducted at Timbi reservoir; an inland wetland; located in the East of Vadodara city between 22º19’19”N to 22º18’28” N latitude and 73º16’42”E to 73º17’46”E longitudes in Gujarat, India (Figure-1). Sir Sayajirao Gaekwad III constructed the reservoir in the year 1947 – 48[15]. Earthen dam with basic masonry work on the Western and Southern boundaries characterizes the reservoir. It has an area and perimeter of approximately 1.6 square km and 5.6km respectively at full water capacity. The reservoir is largely rain-fed and at times quantities of water are discharged by canal from Ajwa Reservoir. By pre-monsoon season (Month of May), the water cover reduces as much as 70%. This occurs when water is not supplied to the reservoir through the canal from Ajwa Reservoir. The primary utility of the reservoir is to provide irrigation water in surrounding fields but also used for aquaculture. The reservoir harbours a number of migratory and native wetland birds as well as diverse floral diversity. Thus, the reservoir under investigation is having reasonably high importance in terms of economy as well as ecology.

Sampling: The sediment samples (n=20) from various locations were collected using hand shovel and ruler (Stainless steel, length =30cm) up to a depth of 15cm[16] in the year 2016. Soil cores were collected for estimation of bulk density (BD). The soil cores were oven dried at 105°C to constant weight to estimate the dry Bulk Density[17,18]. The representative samples were randomly collected[19] in 01 (one) kilogram capacity zip lock air tight polythene bags and labelled appropriately ensuring authenticity to a fair extent for estimation of Organic Carbon (OC) content. The sampling geo-locations were recorded using GPS Navigator (Garmin Oregon 550T). The samples were air-dried followed by oven drying at 65°C[4] and the clods were broken in mortar and pestle and were sieved to collect sediments sizing less than 2mm. The OC content was analysed by digestion with chromic acid followed by titration against FAS using Diphenylamine indicator[20]. Geospatial analysis of the data was carried out using an open source GIS software QGIS (version 2.14.14 with Grass 7.2.0)[21].

Following formula were developed for calculating the OC stock of Timbi Reservoir: i. Volume of Sediments (m^3) = Total Reservoir Area (m^2) x Sampling depth (m), ii. OC(kg/kg of sediments) = OC (%)/100, iii. Total OC sediments (kg) = OC(kg/kg) x BD (kg/m^3) x Sediments Volume (m^3), iv. OC (tons/ha) = Total OC(tons)/Total Reservoir Area (ha).

Results and discussion

OC content in the sediments of Timbi reservoir ranged from 0.13% to 3.56% with an average value of 1.14%. The average concentration of OC content is much higher in comparison to an agricultural field. In a study carried out in western India the researchers estimated an average OC concentration of 0.62 upto a depth of 30cm to agricultural fields[22]. The OC content showed an increasing trend from the North, Northeast and East boundary towards the deeper point in the reservoir viz., the South Western area (Figure-2). The bulk density ranged from 1.21gm/cc to 1.38gm/cc having an average value of 1.28gm/cc. The OC content and the Bulk density indicate a strong negative relationship (r= -0.8) (Figure-3). The negative correlationship between OC and BD are found in previous studies carried out for a Riverine as well as a Wetland system[16]. The total OC Content in the sediments of Timbi reservoir was calculated to be $3.33 x 10^3$ Tons. By subsequent conversions, the carbon storage was calculated per unit area of the Timbi reservoir, which is 76.2 tons/hectare. A study carried out for estimation of OC stock under various land use in Uttarakhand, India, indicate that the forests stored OC ranging from 69.8tons/hectare to 128 tons/hectare[18].

The same study also implied that the agricultural land had approximately 63 tons/hectare OC stored which was the lowest of all. Considering the area under different land use, the reservoirs have a capacity of store more OC per unit area, thus largely contributing to Carbon sequestration. A further role of Timbi reservoir in carbon sequestration can be assessed by converting the OC content and its equivalent removal of Carbon Dioxide (CO_2) from the atmosphere. In previous studies, it is estimated that each ton of OC in soil/sediment is responsible for removal of 3.667ton of CO_2 from the atmosphere[18]. Considering this, the total amount of CO_2 stripped from the atmosphere by Timbi Reservoir can be calculated to be approximately $12.21 x 10^3$ tons.

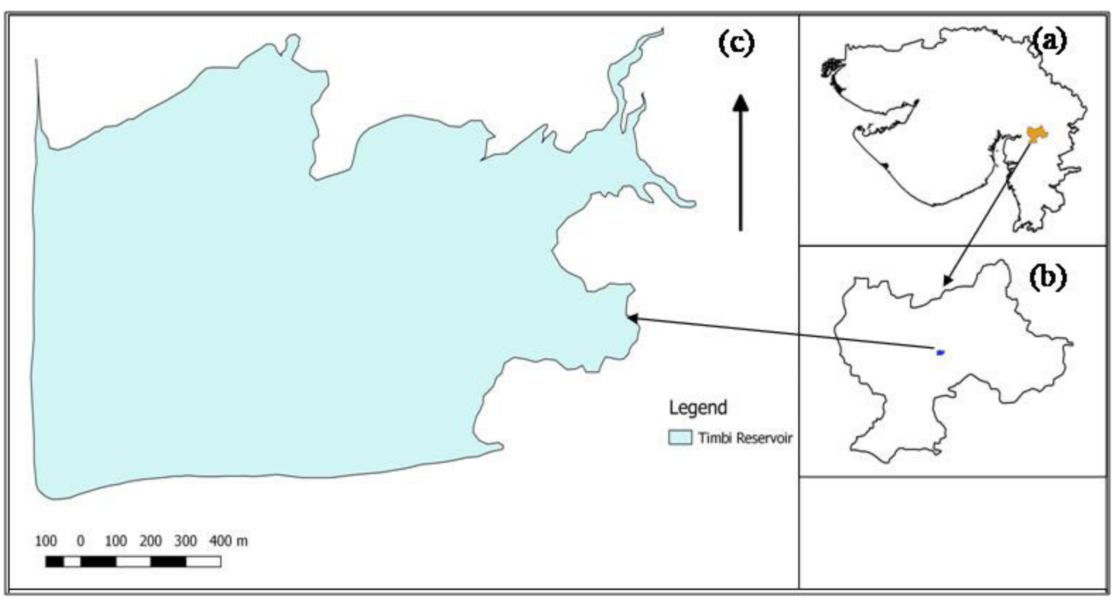

Figure-1: Study area and study site: (a) Map of Gujarat, (b) Map of Vadodara District; (c) Map of Timbi Reservoir.

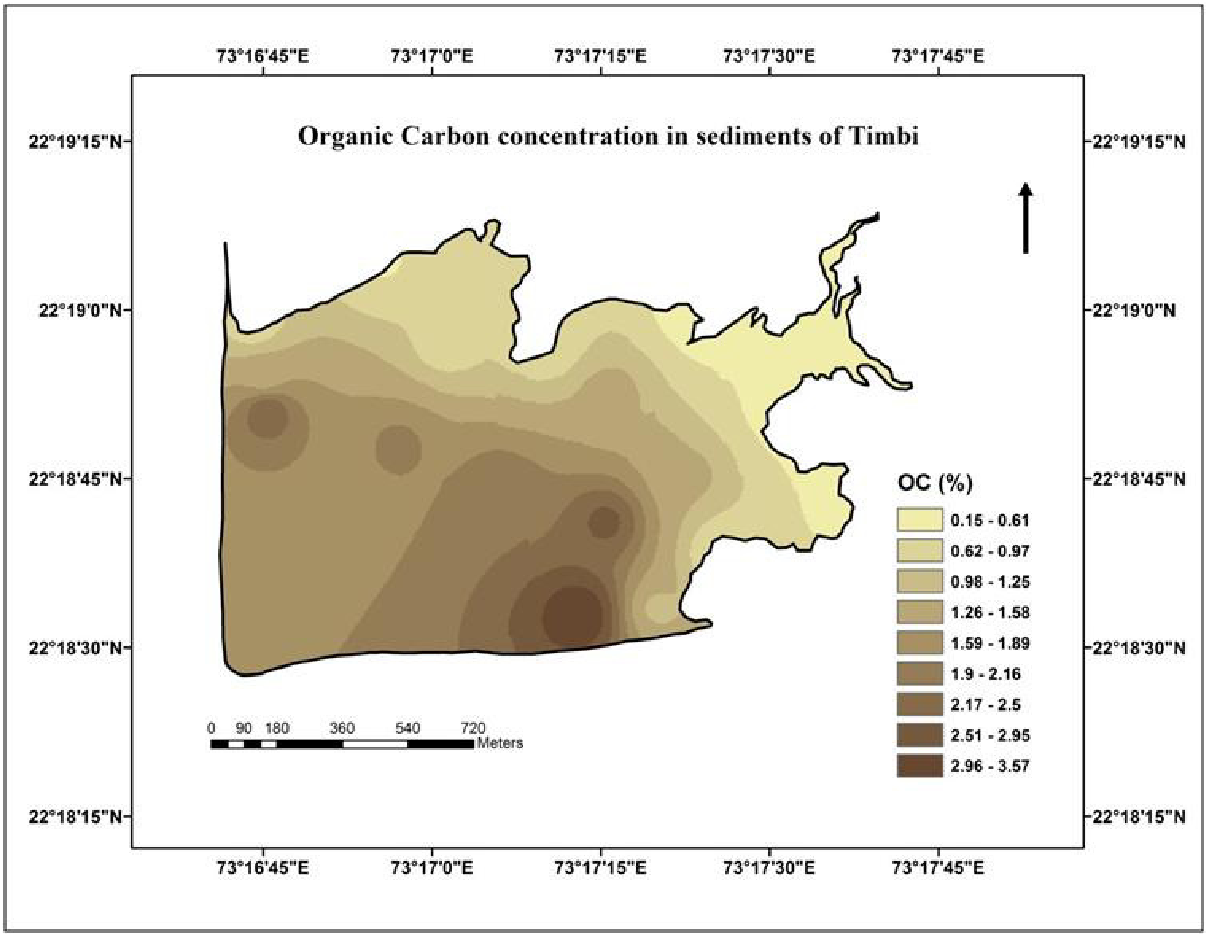

Figure-2: Organic Carbon Concentration in sediments of Timbi Reservoir.

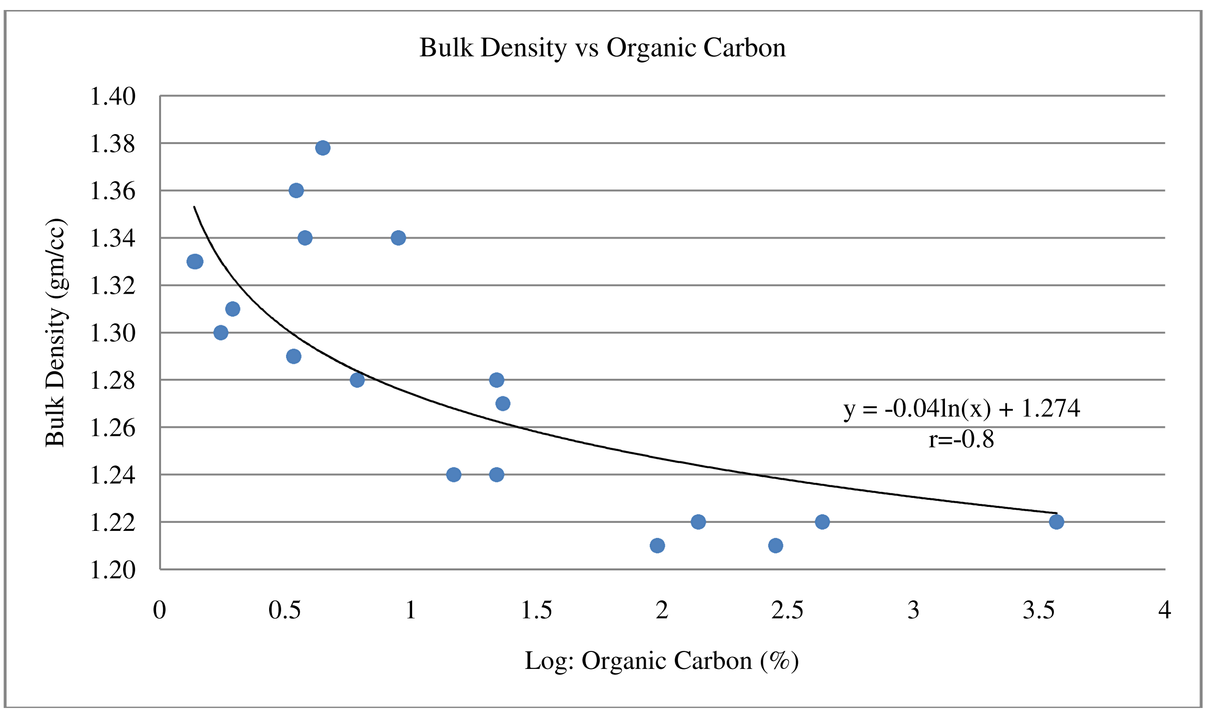

Figure-3: Scatter plot: Bulk Density vs. Log Organic Carbon.

Conclusion

The present research article deals with the estimation of OC content of Timbi reservoir located in Vadodara District, Gujarat, India. It was estimated that the average OC content was 1.14 % and the total OC stored in the sediments be $3.33x10^3$tons, which is higher than major land use practice of the country viz., agriculture. Apart from the functions and services of such marginal reservoirs, they have a great potential for carbon sequestration by acting as a Carbon sink as in the case of Timbi reservoir, which is estimated to be removing $12.21x10^3$tons of atmospheric CO_2. Furthermore, a detailed investigation is advised for clearer understanding of the independent variables affecting carbon sequestration potential of such reservoirs. In addition to the above facts, considering the rate of wetland disappearance due to climate change, stress should be put on the role of such wetlands in carbon sequestration and mitigating climate variability.

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