Carbon Storage in Sediments of Freshwater Fishponds of Odisha, Andhra Pradesh, and West Bengal, India

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Abstract

Considering the impact of climate change on aquaculture practices, carbon storage by fish pond sediment could mitigate some emission of greenhouse gases form the fish ponds. The potentials of carbon storage by the sediments of fish ponds of Ganjam, Keonjharaghar, and Puri districts of Odisha, Krishna district of Andhra Pradesh, Moyna and Tamluk of East Medinipur, Purulia, Bankura, Murshidabad, South and North 24 Parganas districts of West Bengal, India were estimated. It is evident from the results that with an increase in fish production, the C storage decreased. The production per crop in the present study increased from 1815±576 kg/ha to 6351±1882 kg/ha and accordingly, the C storage/kg fish decreased from 1.44±0.73 to 0.62±0.21. The three types of combined humus carbon (loosely, stably and tightly combined humus carbon) were also analyzed for some sediment in the present study. The loosely combined humus varied from 36 to 43 per cent, stably combined humus varied from 4 to 6 per cent, and tightly combined humus varied from 53 to 58 per cent, respectively. Among the three combined humus, loosely combined form constitute about 40 percent of the total soil organic carbon, and thus, carbon sequestration could be 60 percent of the total soil carbon storage.

Keywords: Carbon storage; Sequestration; Sediments; Aquaculture ponds

Introduction

Increase in greenhouse gases (GHGs) concentration in the atmosphere is the main reason for climate change as accumulated GHGs in the atmosphere intercepts outgoing infra-red radiation which traps heat and raises the temperature in the atmosphere. The carbon dioxide (CO₂) level has increased by 31 per cent, from which traps heat and raises the temperature in the atmosphere. GHGs in the atmosphere intercepts outgoing infra-red radiation atmosphere is the main reason for climate change as accumulated the atmospheric concentration of CO₂ by 2050 at approximately 550 ppmv/yr [1]. With this increase, there is a growing public and scientific concern about the carbon sequestration potential of various terrestrial ecosystems especially wetlands [2]. It has been suggested that the sequestration of atmospheric CO₂ into soil organic carbon (SOC) could contribute significantly to adhere with the Kyoto Protocol to reduce emissions of greenhouse gases [3,4]. In stabilizing the atmospheric abundance of CO₂, and other greenhouse gases to mitigate the risks of global warming [5], [6] suggested that there are three strategies of lowering CO₂ emissions: (i) reducing the global energy use, (ii) developing low or no carbon fuel, and (iii) sequestering CO₂ from point sources or atmosphere through natural and engineering techniques. Fifteen options of stabilizing the atmospheric concentration of CO₂ by 2050 at approximately 550 ppm have been outlined by [7]. Three of these 15 options were based on carbon sequestration in terrestrial ecosystems [8]. In this respect, aquaculture ponds can play potential role in carbon sequestration.

During the last three decades world fish production of aquaculture has expanded by almost 12 times, with a very average annual rate of 8.8 per cent. Presently 600 aquatic species are raised in captivity in about 190 countries for production in farming systems of varying input intensities and technological sophistication (FAO, 2016). Thus, there is immense scope to store and capture carbon by the fishponds to reduce and offset the chance of emitting different GHGs from the different aquaculture systems. Thus the objectives of the present study are: (i) to assess the potentials of carbon storage in different aquaculture ponds of three different states in India; (ii) to determine the extent of carbon sequestration of pond sediments.

Materials and Methods

Aquaculture ponds were chosen for the carbon storage study from the Ganjam (19.5860° N, 84.6897° E), Keonjharaghar (21.6289° N, 85.5817° E) and Puri (19.8134° N, 85.8315° E) districts of Odisha, Kaikaluru Mandal (16.5527° N, 81.2129° E) of Krishna district of Andhra Pradesh, and Moyna (22.2738° N, 87.7697° E), Tamluk block (22.2788° N, 87.9188° E) of East Medinipur, Purulia (23.3321° N, 86.3652° E), Bankura (23.1645° N, 87.0624° E), Murshidabad (24.2290° N, 88.2461° E), south 24 Parganas (22.1352° N, 88.4016° E) and North 24 Parganas (22.6168° N, 88.4029° E) districts of West Bengal, India. Overall, the culture period in these areas varied from 180 to 300 days. The culture practices in these ponds are shown in Table 1.

Calculation of carbon storage

Soil carbon storage was measured by CORE Method. In this method, sediment samples from the pond was collected by a soil sampler (Corer) in such a way that only the sediment core was collected, no bottom soil below the sediment was collected. The sediment dry bulk density was measured and the sediment organic carbon was determined by CHN Analyzer. The carbon storage (Mg C/ha, mega gram C/ha) was calculated as per [9] as follows = \[ \frac{C \text{(%)*dry bulk density (Mg/m³)*depth (m)}}{10^6 m³}] /100.
Area/Location | Culture of Species with Stocking size (g) | Stocking density (10³/ha) | Harvesting size (g) | Management practices
--- | --- | --- | --- | ---
Ganjam, Puri, Keonjharargh, Puri, Odisha | Rohu (5.0-8.0) Catla (5.0-8.0) Mrigal (5.0-8.0) | 5.0 | Rohu 700 Catla 900 Mrigal 500 | Organic manure (cow dung), Inorganic fertilizers (Urea, Single Super Phosphate), lime. Supplementary feeding with ground nut oil cake and rice bran in a ratio of 1:1.
Kaikaloru, Krishna, Andhra Pradesh | Rohu 50 Catla 150 Mrigal 100 | 5.0 | Rohu 1100 Catla 2200 Mrigal 1300 | Mainly pelleted feed along with organic manure (cow dung), inorganic fertilizers, lime.
Moyna, West Bengal | Rohu 50 Catla 110 Mrigal 70 | 5.0-14.0 (av. 10.0) | Rohu 800 Catla 1200 Mrigal 600 | Mainly pelleted feed along with inorganic fertilizers, lime.
Tamulk, West Bengal | Rohu-50-100 (av.70) Catla 75-200 (av.120) Mrigal 25-150 (av.70) | 5.0-14.0 (av.9.0) | Rohu 770 Catla 1170 Mrigal 600 | Mainly pelleted feed along with organic manure (cow dung), inorganic fertilizers, lime.
Bankura, West Bengal | Rohu-20 Catla 25 Mrigal 18 | 5.0-7.0 (av.6.0) | Rohu 460 Catla 1000 Mrigal 425 | Mainly pelleted feed along with organic manure (cow dung), inorganic fertilizers, lime.
Munshidabad, West Bengal | Rohu-80 Catla 130 Mrigal 60 | 2.5-7.5 (av.5.8) | Rohu 775 Catla 1600 Mrigal 650 | Mainly pelleted feed along with organic manure (cow dung), inorganic fertilizers, lime.
North and South 24 Parganas, West Bengal | Rohu-100 Catla 500 Mrigal 50 | 6.6-11.2 (av.9.0) | Rohu 900 Catla 2800 Mrigal 600 | Mainly pelleted feed along with organic manure (cow dung), inorganic fertilizers, lime.

Table 1: Culture practices in the ponds under different places under study.

| Sample no. | Sediment depth (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/crop (kg C/ha) | Production/ crop (kg/ha) | C storage/ kg fish(kg) |
|---|---|---|---|---|---|---|
| 1 | 3.0 | 1.33 | 0.240 | 150 | 150 | 150 |
| 2 | 2.6 | 1.27 | 0.456 | 1550 | 1500 | 1.03 |
| 3 | 3.0 | 1.19 | 2.016 | 7220 | 2000 | 3.61 |
| 4 | 2.6 | 1.27 | 0.600 | 2020 | 1800 | 1.12 |
| 5 | 3.2 | 1.24 | 0.366 | 1480 | 1250 | 1.18 |
| 6 | 3.0 | 1.41 | 0.192 | 810 | 1700 | 0.47 |
| 7 | 3.3 | 1.20 | 0.264 | 1060 | 1680 | 0.63 |
| 8 | 3.0 | 1.13 | 0.600 | 2040 | 1800 | 1.13 |
| 9 | 3.0 | 1.11 | 1.056 | 3520 | 1680 | 2.09 |
| 10 | 3.3 | 1.10 | 0.600 | 2200 | 1950 | 1.12 |
| 11 | 3.4 | 1.21 | 0.648 | 2720 | 3000 | 0.90 |
| 12 | 2.0 | 1.04 | 0.696 | 1450 | 1200 | 1.20 |
| 13 | 3.0 | 0.78 | 1.440 | 3390 | 1780 | 1.90 |
| 14 | 3.4 | 1.27 | 0.864 | 3800 | 2150 | 1.76 |
| 15 | 3.5 | 1.78 | 0.552 | 3450 | 2000 | 1.72 |
| 16 | 2.9 | 1.25 | 0.432 | 1550 | 1600 | 0.97 |
| 17 | 3.3 | 1.49 | 0.480 | 2380 | 1780 | 1.33 |
| 18 | 3.2 | 1.43 | 0.840 | 3930 | 1200 | 3.27 |
| 19 | 3.3 | 1.15 | 0.672 | 2590 | 1600 | 1.61 |
| 20 | 3.3 | 1.57 | 0.600 | 3170 | 1800 | 1.76 |
| 21 | 3.2 | 1.19 | 0.648 | 2480 | 1760 | 1.40 |
| 22 | 5.2 | 1.18 | 0.648 | 2650 | 1810 | 1.46 |
| 23 | 3.4 | 1.41 | 0.600 | 3100 | 1920 | 1.61 |
| 24 | 3.4 | 1.31 | 0.600 | 2670 | 2230 | 1.19 |
| 25 | 3.0 | 1.40 | 0.600 | 2520 | 2350 | 1.07 |
| Mean±SD | 3.18±0.53 | 1.22±0.19 | 0.65±0.38 | 2590±1310 | 1815±376 | 1.44±0.73 |

Table 2: Sediment carbon storage in fish ponds of Ganjam district of Odisha.
Analysis of combined humus forms

The combined humus forms are classified into three types by using three different extractants and were extracted as: (i) the loosely combined humus was extracted using 0.1 M NaOH; (ii) the stably combined humus was extracted using 0.1 M Na4P2O7 + 0.1 M NaOH mixed liquid (pH 13); and (iii) the residue was considered as the tightly combined humus. Both of the loosely and stably combined humus solution was measured at 465 and 665 nm using the ultraviolet spectrophotometer, respectively [10]. The E465/E665 ratio was calculated by dividing the absorbance of the sample at 465nm by that at 665nm. The loosely and stably combined humus C contents were measured by a liquid C/N analyzer, whereas the tightly combined humus C content was calculated by subtracting the sum of the loosely and stably combined humus C contents from the total humus C content [10].

All the data were presented as average with standard deviation (SD).

Results and Discussion

The sediment carbon storage in fish ponds of Ganjam district of Odisha is presented in Table 2. The organic carbon and carbon storage in the sediments of the fish ponds were 0.65±0.38 per cent and 2590±1310 kg C/ha/crop, respectively. The fish production was 1815±376 kg/ha/crop. The C storage was 1.44±0.73 kg/kg fish.

The sediment carbon storage in fish ponds of KeonjharGarh district of Odisha is presented in Table 3. The organic carbon and carbon storage in the sediments of the fish ponds were 1.12±0.56 per cent and 2120±890 kg C/ha/crop, respectively. The fish production was 1915±789 kg/ha/crop. The C storage was 1.21±0.56 kg/kg fish.

The sediment carbon storage in fish ponds of Puruli district of Odisha is presented in Table 4. The organic carbon and carbon storage in the sediments of the fish ponds were 0.66±0.37 per cent and 2340±1470 kg C/ha/crop, respectively. The fish production was 2044±1118 kg/ha/crop. The C storage was 1.64±1.24 kg/kg fish.

The sediment carbon storage in fish ponds of Kaikaluru, Krishna district of Andhra Pradesh is shown in Table 5. The organic carbon content in the sediments was 1.5±0.68 per cent, and the carbon storage was 5486±2980 kg C/ha/crop. The fish production was 8351±1882 kg/ha/crop. The C storage was 0.62±0.21 kg/kg fish.

The sediment carbon storage in fish ponds of Moyna, East Medinipur district of West Bengal is shown in Table 6. The organic carbon content in the sediments was 1.35±0.65 per cent, and the carbon storage was 5682±1591 kg C/ha/crop. The fish production was 7475±1156 kg/ha/crop. The C storage was 0.76±0.19 kg/kg fish.

The sediment carbon storage in fish ponds of Tamluk, East Medinipur district of West Bengal is presented in Table 7. The organic carbon and carbon storage in the sediments of the fish ponds were 1.42±0.63 per cent and 5490±2336 kg C/ha/crop, respectively. The fish production was 7169±3065 kg/ha/crop. The C storage was 1.80±0.30 kg/kg fish.

The sediment carbon storage in fish ponds of Purulia district of West Bengal is presented in Table 8. The organic carbon and carbon storage in the sediments of the fish ponds were 1.08±0.33 per cent

and 3217±818 kg C/ha/crop, respectively. The fish production was 2363±813 kg/ha/crop. The C storage was 1.43±0.39 kg/kg fish.

The sediment carbon storage in fish ponds of Bankura district of West Bengal is shown in Table 9. The organic carbon content in the sediments was 1.52±0.81 per cent, and the carbon storage was 4708±3248 kg C/ha/crop. The fish production was 4326±1441 kg/ha/crop. The C storage was 1.15±0.67 kg/kg fish.

The sediment carbon storage in fish ponds of Bankura district of West Bengal is shown in Table 10. The organic carbon content in the sediments of fish ponds was 1.18±0.40 per cent, and the carbon storage was 5210±910 kg C/ha/crop. The fish production was 6375±1932 kg/ha/crop, and the C storage was 0.87±0.30 kg/kg fish in the fish ponds of Murshidabad district.

The sediment carbon storage in fish ponds of South and North 24

### Table 4: Sediment carbon storage in fish ponds of Puri district of Odisha.

| Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/ crop (kg/ha) | Production/ crop (kg/ha) | C storage/kg fish (kg) |
|------------|---------------------|--------------------------|--------------------|----------------------------|--------------------------|------------------------|
| 1          | 2.3                 | 2.84                     | 0.227              | 1480                       | 1250                     | 1.184                  |
| 2          | 3.7                 | 0.84                     | 0.954              | 3030                       | 2500                     | 1.212                  |
| 3          | 2.45                | 1.25                     | 0.500              | 1530                       | 1500                     | 1.02                   |
| 4          | 1.95                | 2.67                     | 0.410              | 2130                       | 1000                     | 2.13                   |
| 5          | 2.33                | 1.10                     | 0.250              | 1040                       | 1000                     | 0.64                   |
| 6          | 3.3                 | 1.02                     | 0.886              | 3000                       | 880                      | 3.40                   |
| 7          | 2.0                 | 2.07                     | 1.364              | 5670                       | 3800                     | 1.49                   |
| 8          | 3.2                 | 1.60                     | 0.250              | 1280                       | 1154                     | 1.109                  |
| 9          | 2.75                | 0.55                     | 0.636              | 1090                       | 2130                     | 0.450                  |
| 10         | 3.5                 | 1.12                     | 0.727              | 8040                       | 1375                     | 4.617                  |
| 11         | 3.64                | 1.53                     | 0.727              | 8040                       | 1375                     | 4.617                  |
| 12         | 3.5                 | 1.18                     | 0.515              | 2130                       | 3500                     | 0.608                  |
| 13         | 5.2                 | 0.47                     | 0.425              | 1040                       | 3750                     | 0.277                  |
| 14         | 3.24                | 0.80                     | 0.672              | 1760                       | 1375                     | 1.28                   |
| 15         | 2.99                | 2.23                     | 1.454              | 9730                       | 3800                     | 2.56                   |
| 16         | 3.33                | 1.3                      | 1.068              | 4730                       | 1250                     | 3.78                   |
| 17         | 3.25                | 1.10                     | 0.492              | 1770                       | 2000                     | 0.885                  |

Mean±SD 3.07±0.83 1.523±0.80 0.660±0.37 2340±1470 2044±1118 1.64±1.24

### Table 5: Sediment carbon storage in fish ponds of Kaikaluru, Krishna district of Andhra Pradesh.

| Sample no. | Sediment dept (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/ crop (kg/ha) | Production/ crop (kg/ha) | C storage/kg fish (kg) |
|------------|--------------------|--------------------------|--------------------|----------------------------|--------------------------|------------------------|
| 1          | 6.85               | 0.88                     | 0.92               | 5550                       | 8500                     | 0.65                   |
| 2          | 6.92               | 0.60                     | 2.53               | 10500                      | 10,666                   | 0.98                   |
| 3          | 6.92               | 0.30                     | 2.07               | 4290                       | 8000                     | 0.53                   |
| 4          | 6.66               | 0.39                     | 1.01               | 2680                       | 5500                     | 0.48                   |
| 5          | 6.15               | 0.74                     | 0.97               | 4410                       | 9090                     | 0.48                   |

Mean±S.D 6.7±0.32 0.582±0.24 1.5±0.68 5486±2980 8351±1882 0.62±0.21

### Table 6: Sediment carbon storage in fish ponds of Moyna, East Medinipur district of West Bengal.

| Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/ Crop (kg/ha) | Production/ Crop (kg/ha) | C storage/ kg fish (kg) |
|------------|--------------------|--------------------------|--------------------|----------------------------|--------------------------|------------------------|
| 1          | 5.0                | 0.59                     | 1.38               | 4071                       | 8000                     | 0.50                   |
| 2          | 7.9                | 1.01                     | 0.66               | 5266                       | 6500                     | 0.81                   |
| 3          | 6.3                | 0.56                     | 1.41               | 4974                       | 5800                     | 0.85                   |
| 4          | 4.8                | 1.07                     | 1.51               | 7755                       | 9000                     | 0.86                   |
| 5          | 5.2                | 0.59                     | 2.47               | 7577                       | 7500                     | 1.01                   |
| 6          | 6.4                | 0.98                     | 0.71               | 4453                       | 8050                     | 0.55                   |

Mean±S.D 5.93±1.17 0.802±0.24 1.35±0.65 5682±1591 7475±1156 0.76±0.19
The organic carbon content in the sediments of fish ponds was 1.38±0.59 per cent, and the carbon storage was 5376±1597 kg C/ha/crop. The fish production was 4270±1008 kg/ha/crop, and the C storage was 1.31±0.45 kg/kg fish in Parganas districts of West Bengal is shown in 11. The organic carbon content in the sediments of fish ponds was 1.38±0.59 per cent, and the carbon storage was 5376±1597 kg C/ha/crop. The fish production was 4270±1008 kg/ha/crop, and the C storage was 1.31±0.45 kg/kg fish in

### Table 7: Sediment carbon storage in fish ponds of Tamluk, East Medinipur district of West Bengal.

| Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/crop (kg/ha) | Production/crop (kg/ha) | C storage/kg fish (kg) |
|------------|---------------------|--------------------------|--------------------|-----------------------------|--------------------------|-----------------------|
| 1          | 5                   | 0.78                     | 0.66               | 2574                        | 6633                     | 0.38                  |
| 2          | 5                   | 0.73                     | 1.02               | 3723                        | 4300                     | 0.86                  |
| 3          | 5                   | 0.55                     | 1.38               | 3795                        | 6600                     | 0.57                  |
| 4          | 6                   | 1.01                     | 1.65               | 9999                        | 6795                     | 1.47                  |
| 5          | 5                   | 0.61                     | 2.35               | 7167                        | 10,000                   | 0.71                  |
| 6          | 5                   | 0.58                     | 2.47               | 7163                        | 14,400                   | 0.49                  |
| 7          | 6                   | 0.76                     | 0.91               | 4149                        | 4100                     | 1.01                  |
| 8          | 6                   | 0.88                     | 0.83               | 4382                        | 5750                     | 0.76                  |
| 9          | 6                   | 0.65                     | 1.12               | 4368                        | 5313                     | 0.82                  |
| 10         | 5                   | 0.82                     | 1.85               | 7585                        | 7800                     | 0.97                  |
| Mean±S.D   | 5.4±0.51            | 0.73±0.14                | 1.42±0.63          | 5490±2336                   | 7169±3065                | 0.80±0.30             |

### Table 8: Sediment carbon storage in fish ponds of Purulia district of West Bengal.

| Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/crop (kg/ha) | Production/crop (kg/ha) | C storage/kg fish (kg) |
|------------|---------------------|--------------------------|--------------------|-----------------------------|--------------------------|-----------------------|
| 1          | 4.2                 | 0.99                     | 0.68               | 2827                        | 1687                     | 1.67                  |
| 2          | 2.7                 | 1.17                     | 1.39               | 4391                        | 3376                     | 1.30                  |
| 3          | 3.0                 | 1.23                     | 0.97               | 3579                        | 1700                     | 2.10                  |
| 4          | 2.7                 | 0.77                     | 1.47               | 3056                        | 1880                     | 1.62                  |
| 5          | 5.0                 | 0.62                     | 0.71               | 2201                        | 1716                     | 1.28                  |
| 6          | 5.5                 | 0.45                     | 0.98               | 2425                        | 2683                     | 0.90                  |
| 7          | 3.7                 | 0.78                     | 1.4                | 4040                        | 3500                     | 1.15                  |
| Mean±S.D   | 3.82±1.12           | 0.85±0.28                | 1.08±0.33          | 3217±818                    | 2363±813                 | 1.43±0.39             |

### Table 9: Sediment carbon storage in fish ponds of Bankura district of West Bengal.

| Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/crop (kg/ha) | Production/crop (kg/ha) | C storage/kg fish (kg) |
|------------|---------------------|--------------------------|--------------------|-----------------------------|--------------------------|-----------------------|
| 1          | 3.0                 | 0.93                     | 2.4                | 6696                        | 3800                     | 1.76                  |
| 2          | 5.0                 | 0.78                     | 1.4                | 5460                        | 3500                     | 1.56                  |
| 3          | 2.0                 | 1.46                     | 0.7                | 2044                        | 3247                     | 0.62                  |
| 4          | 2.6                 | 1.04                     | 1.3                | 3515                        | 2536                     | 1.38                  |
| 5          | 6.0                 | 0.18                     | 1.7                | 1836                        | 6600                     | 0.28                  |
| 6          | 3.2                 | 0.31                     | 2.6                | 2579                        | 5100                     | 0.50                  |
| 7          | 10                  | 0.57                     | 1.9                | 10830                       | 5500                     | 1.96                  |
| Mean±S.D   | 4.54±2.78           | 0.86±0.51                | 1.52±0.81          | 4708±3248                   | 4326±1441                | 1.15±0.67             |

### Table 10: Sediment carbon storage in fish ponds of Murshidabad district of West Bengal.

| District | Sample no. | Sediment level (cm) | Dry bulk density (Mg/m³) | Organic carbon (%) | Carbon storage/crop (kg/ha) | Production/crop (kg/ha) | C storage/kg fish (kg) |
|----------|------------|---------------------|--------------------------|--------------------|-----------------------------|--------------------------|-----------------------|
| Murshidabad | 1       | 6.0                 | 0.74                     | 1.32               | 5860                        | 4320                     | 1.35                  |
|           | 2       | 7.5                 | 0.64                     | 1.18               | 5664                        | 7051                     | 0.80                  |
|           | 3       | 7.5                 | 0.68                     | 0.84               | 4284                        | 7500                     | 0.57                  |
|           | 4       | 7.5                 | 0.45                     | 1.80               | 6075                        | 8620                     | 0.70                  |
|           | 5       | 8.0                 | 0.66                     | 0.79               | 4171                        | 4388                     | 0.95                  |
| Mean±S.D  | 7.3±0.75  | 0.63±0.10           | 1.18±0.40              | 5210±910           | 6375±1932                   | 0.87±0.30               |
The carbon storage with the fish production has presented in Figure 1. From the figure, it is evident that with an increase in fish production, the C storage decreased. The production per crop in the present study increased from 1815±376 kg/ha to 8351±1882 kg/ha and accordingly, the C storage/kg fish decreased from 1.44±0.73 to 0.62±0.21. This could be due to the fact that higher production utilized the C at a maximum level for their growth than that the same at lower production level.

In earlier study, [11] reported that the carbon sequestration capacity ranged from 442 to 1882 kg C/ha with an average value of 1018±447 kg C/ha for 9 aquaculture ponds of one place. The present study conducted for different places under different management systems for 116 numbers of ponds.

The three types of combined humus carbon (loosely, stably and tightly combined humus carbon) are shown in Figure 2A, 2B, 2C and Table 12. The carbon contents of the loosely, stably and tightly combined humus ranged from 2.40 to 7.87 g/kg (Figure 2A), 0.27 to 0.96 g/kg (Figure 2B), and 3.30 to 11.02g/kg (Figure 2C) respectively. The combined humus forms were arranged on the basis of C content in the following order: tightly> loosely> stably combined humus C. However, the proportion of the three combined humus C showed no significant differences among the different soils (Table 12). The loosely combined humus varied from 36 to 43 per cent, stably combined humus varied from 4 to 6 per cent, and tightly combined...
humus varied from 53 to 58 per cent, respectively. Among the three combined humus (loosely, stably and tightly combined humus C), loosely combined form constitute about 40 percent of the total soil organic carbon, and thus, carbon sequestration could be 60 percent of the total soil carbon storage.

The E465/E665 values of the loosely combined humus (2.60 to 4.46) were higher than that of the stably combined humus (1.50 to 3.62) (Figures 3A and 3B). Thus, the E465/E665 of loosely combined humus can be considered a more suitable index rather than that of the stably combined humus for identifying the aromaticity and humification degree of soil organic carbon. The E465/E665 ratio is related to the aromaticity and to the degree of condensation of the chain of aromatic carbons of the humic acids, and could be used as a humification index [12,13]. Low E465/E665 ratio reflects a high degree of condensation of these structures while high ratio means presence of large quantities of aliphatic structures and low quantities of condensed aromatic structures [14]. This ratio also is inversely related to the degree of aromaticity, particle size, molecular weight, and acidity [15].

Conclusion

From the present study it is evident that aquaculture ponds could play a vital role to counteract the emission of green house gases from the aquaculture practices by sequestering carbon in the sediments. Even if sometimes, the bottom sediments could remove from the pond to enhance the productivity, at least 60 per cent carbon storage will act as carbon sequester and it will not be able to come out in the atmosphere. Thus, more study is needed in this respect to generate more data so that carbon neutral aquaculture practices can be achieved.

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