# Geochemistry of Core Sediment from Antarctic Region

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***Abstract***
*Southern Ocean (SO) is the fourth largest Ocean comprising the southern portions of the Atlantic Ocean, Indian Ocean and Pacific Ocean. Sediment core sample ($66^0$ 34'S and $58^0$ 40'E)was collected onboard O.R.V Sagar Nidhi from January to March 2010 in the Fourth Southern Ocean expedition cruise launched by the National Centre for Antarctic and Ocean Research, Goa . Sedimentary records from this area reveal the sensitivity and climatic variability's of the region over a large time scale. Organic matter (OM) and textural behaviour of the samples were analyzed and processed concurrently. Distribution of OM, Total Organic Carbon (TOC), Protein, Lipid and Carbohydrate along with the trace metal was highlighted. Textural variation was in the array of Sand >Clay >Silt. Sand content ranges from 30.29% to 80.11%. The order of relative distribution of OM was Lipid >Protein > TOC > Carbohydrate.*

*The average concentrations of TOC, Protein, Lipid and Carbohydrate were 2.2 mg/g, 1.2 mg/g, 3.3 mg/g and 1.1mg/g respectively. Protein to carbohydrate ratio and lipid to carbohydrate ratio were also encountered to understand the respective freshness and nutritional quality of the sediments. Trace metal distribution showed the average concentration was maximum for Mn and minimum for Co.*

**Keywords:** Organic matter, Core sediment, Texture, Trace metal, Antarctica, Southern Ocean.

## Introduction

SO is the most significant part of the world oceans and comprises several physically and biologically distinct regimes with latitudinally separated by fronts. The SO is important in the global biogeochemical cycling and climate change because it contains sites of deep water convection and its surface waters contain a large pool of unutilized nutrients. The dynamic ocean processes encountered in SO have played a key role in the long-term global palaeo-environmental evolution[17]. The Antarctic continent with its surrounding SO regimes contribute as the major climate engines of the earth[20,26].

Sediment cores are the store houses of fundamental raw data source for providing new research finding information on sea bed character, depositional history and environmental changes. Sea-floor sediment cores act as sinks and sources of contaminants in the aquatic systems because of their variable physical and chemical properties. [5,24, 27- 30, 34, 35] The sediment found on the deep sea floor is unique and closely linked with the geochemical history of the earth. The investigations of sediments have recently become a major subject of interest in research since they reflect the current quality of the system and provide insight on the impact of human. They behave both as a carrier and possible source of biochemical constituents. Geochemical studies of surficial sediment as well as sediment cores are helpful in the assessment of environmental composition.[1, 2, 6,7, 13,15]

The OM and trace metal in marine sediments are important and play a major role in the chemistry of oceans not only providing a significant reservoir in the global carbon cycle, but also driving in the early digenesis. Analysis of sediment OM gives the changes in the environmental chemical pattern which exerts a strong control on the diagenic alterations in the sediment. This paper presents the distributional pattern of Core Sediment Organic matter (CSOM) and trace metal in the coastal region of Antarctica.

## Material and Methods

Sediment core sample was collected using piston corer, onboard O.R.V Sagar Nidhi in the Fourth Southern Ocean expedition cruise (January to March 2010 ) launched by the National Centre for Antarctic and Ocean Research, Goa. One 31 cm core ($66^0$ 34'S and $58^0$ 40'E) was taken from coastal region of Antarctica at depth of 707.33 m.

The core sediment was sliced in to approximately 1cm depth intervals and then sub samples were tightly packed and stored in a deep freezer at $4^0$C until analysis. These sub samples were air dried, finely powdered and used for chemical analysis. Textural characteristics (sand, silt, and clay), quantification of OM (TOC, Protein, Lipid and Carbohydrate) were estimated based on standard procedure. Texture was determined using pipette analysis by Lewis[19]. TOC was done by the Chromic acid oxidation method[10]. Protein was measured using Copper and Folin–Ciocalteu phenol reagent[22]. Carbohydrate estimation was carried out by Phenol- Sulphuric acid method[9]. Total lipid was found by the Sulpho-phospho-vanillin method[3]. The bulk 0.5g samples were treated with 5:1 mixture of concentrated $HNO_3$ and $HClO_4$ [21]and metal concentration was analyzed by AAS (Perkin Elmer 3110). Pearson correlation was carried out to test the correlation pattern of *OM* with Textural characteristics.

## Results and Discussion

The grain size distribution in the core sediments was measured to understand the depositional environment history. In general the textural variation of the core was found to be sand >clay >silt. The entire core was mostly dominated by sand and was high both at the top and bottom layer of the core. The average sand, clay and silt content of these samples were around 58.17%, 31.39% and 10.44% respectively.

The sandy textural nature of the sediment resulted in low OM content. TOC is an essential part of any site characterization because it behaves as a tool to understand the biogeochemistry of sediments. In this study TOC content of the core ranges from 3.87% to 0.36% (Figure 1a) and faintly elevated at the bottom of the core indicating an ancient sedimentary phase. The peak value was at a depth of 21cm (3.89%). The top section of the core was enriched with lipid and was depleted towards the bottom portion. Lipid was greater at 2cm (10.85 mg/g) and low at 23cm depth (0.43 mg/g) (Figure 1c). Protein and Carbohydrate were highly concentrated at the middle portion and decreased at the top and bottom of the core. Protein was depleted at the top, then enriched and again depleted. Protein was high at 20 cm (5.35mg/g) and low (0.24mg/g) at 31cm (Figure 1b). Carbohydrate was low at the top with minimum concentration at 2cm (0.43mg/g) and high at 14cm with 2.068 mg/g. Finally the concentration diminished (Figure 1d).

The order of relative distribution of OM was Lipid >Protein > TOC > Carbohydrate. The average of the OM constituents: TOC, Protein, Lipid, Carbohydrate was 2.2 mg/g, 1.2 mg/g, 3.3 mg/g and 1.1mg/g respectively. Relative high concentration of lipid may be due to the low hydrophilic nature. They are responsible for their higher survival rates during sedimentation when compared to other biogenic compound classes like amino acids or sugars. Digenetic processes that affect lipid distribution in marine sediments include particle reworking due to digestion of organic matter by benthic fauna, microbial decomposition and abiotic reactions[33]. Decreased rate of these processes may also account for the greater lipid concentration. Similar trend was found in the coastal sediment of NW Adriatic Sea[8].

Protein to carbohydrate ratio and lipid to carbohydrate ratio were also encountered to understand the respective freshness and nutritional value of the sediments [12], [14] .Mean protein to carbohydrate ratio in the present study (Figure 2) was found to be 1.2. As reported by these results, protein to carbohydrate ratio was greater than one indicating the freshness of the sample. Likewise proteins tend to be mineralized faster than carbohydrate and causing higher amounts of fresh particles.[18-25] The nutritional value of the analyzed samples was high because the lipid to carbohydrate ratio (Figure 3) was greater than one. Therefore the visibility of freshness and high nutritional quality of the core sediment in these regions were viewed.

The dynamics of trace metals is more complicated in oceans since they are coupled with strong physical movement with the varying chemistries of water. In most aquatic systems, concentrations of trace metals in suspended sediment and the top few centimetres of bottom sediment are far greater than concentrations of trace metals dissolved in the water column. Bottom sediments serve as a source for suspended sediment and can provide a historical record of chemical conditions. Metal concentration averages are given in table 1.Trace metal distribution showed the average concentration was maximum for Mn and Fe and minimum for Cd and Co. Enrichment factor was interpreted as suggested by Birth [4] for metal studied with respect to natural background concentration. EF< 1 indicates no enrichment, EF< 3 is minor enrichment, EF = 3-5 is moderate enrichment, EF=5-10 moderately severe enrichment, EF=10-25 severe enrichment, EF= 25-50 is very severe enrichment and EF >50 is extremely severe enrichment. The study attributes extremely severe enrichment to Mn and next to Cd. Pb had moderate enrichment and for others observed minor enrichment. The greater enrichment of these metals may be due to the allothonus input.

Correlation analysis of OM with textural behaviour was carried out to check any significant correlation between OM with textural characteristics (Table 2).Generally textural characteristics and OM content are interrelated but the present work highlights insignificant correlation of OM with texture. The average concentration of OM in this core sediment was very low. Several studies agree on the limited role of deep-sea burial because OM produced in the euphotic zone decomposes before it reaches the seafloor [11, 32]. The sandy nature of the sediment also contributes to the same result. Previous studies by Josia Jacob et al[16] and Manju P.Nair[23] also support the result.

## Conclusion

Analysis of sediment core sample from the coastal regions of Antarctica reveals the distribution pattern of sediment OM with textural behaviour. The relative allotment of OM was found to be Lipid >Protein > TOC > Carbohydrate. Textural variation was in the order of sand >clay >silt. The sandy nature of the sediment results in the diminished average concentration of OM. Protein to carbohydrate ratio and lipid to carbohydrate ratio were greater than one showing the freshness and high nutritional value of the sediment in these regions. Trace metal distribution showed the average concentration was maximum for Mn and minimum for Co.

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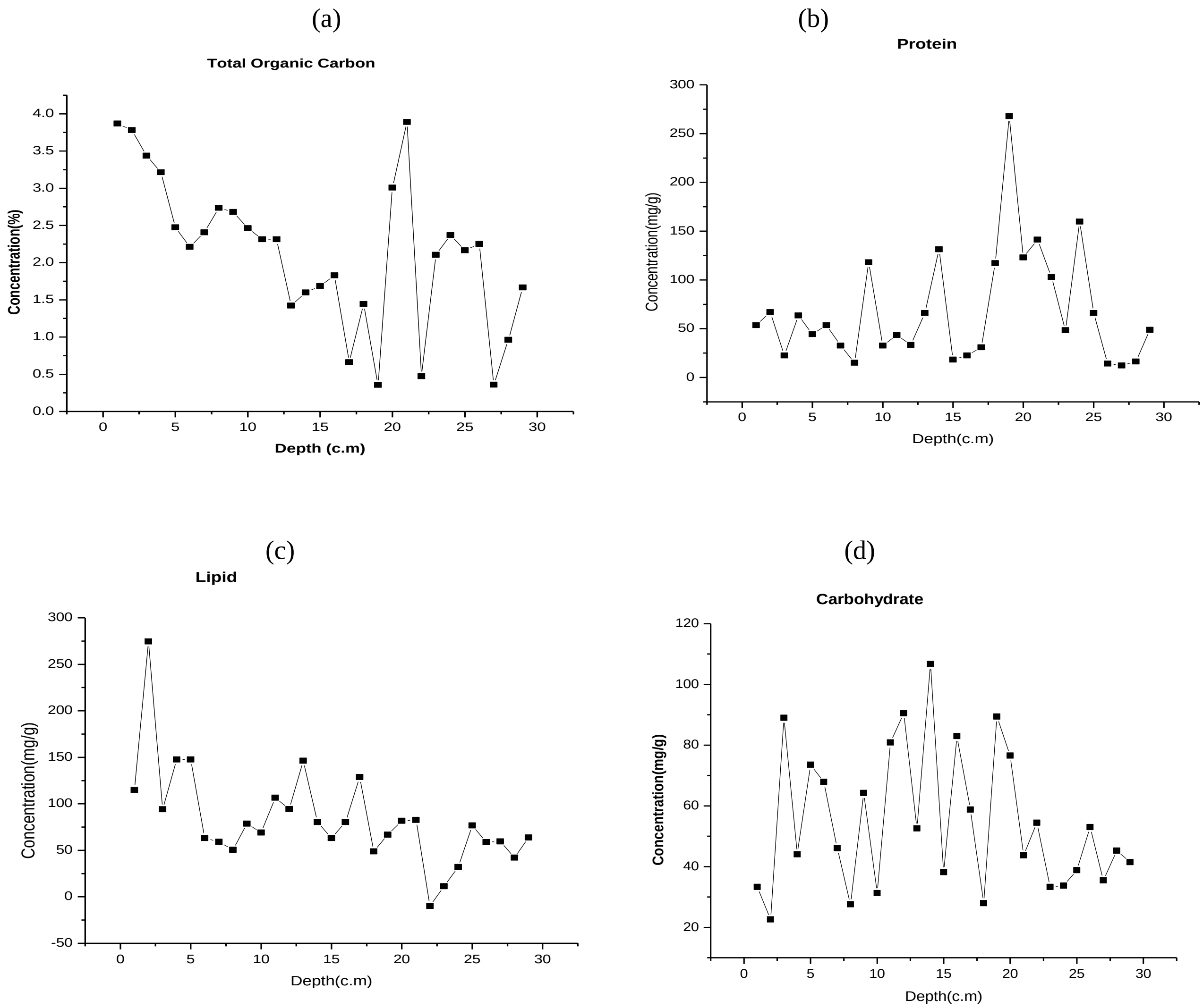


**Figure 1(a-d): Organic matter Distribution**

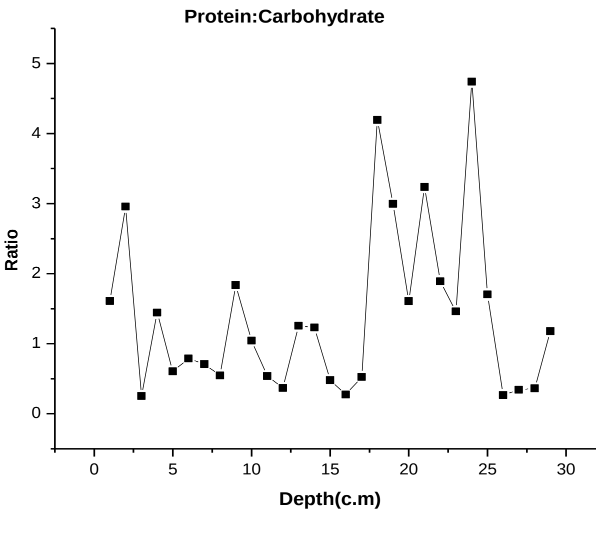


**Figure 2: Protein to Carbohydrate Ratio**

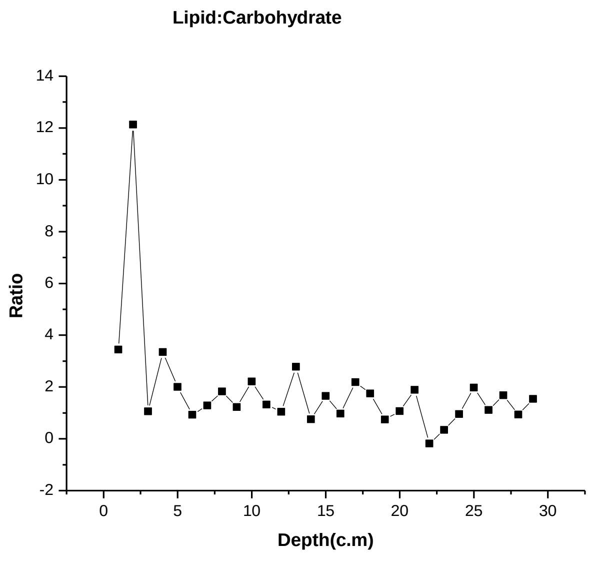


**Figure 3: Lipid to Carbohydrate Ratio**

**Table 1**
**Average concentration of metals**

| Metals | Concentration(mg/g) |
|---|---|
| Cd | 4.64 |
| Co | 1.91 |
| Cr | 827.63 |
| Cu | 38.74 |
| Fe | 14676.86 |
| Mg | 8.4 |
| Mn | 71521.39 |
| Pb | 21.58 |
| Zn | 17.2 |

**Table 2**
**Correlation of Texture with Organic matter**

| | TOC (%) | PROTEIN (mg/g) | LIPID (mg/g) | CARBOHYDRATE (mg/g) | SAND(%) | CLAY(%) | SILT(%) |
|---|---|---|---|---|---|---|---|
| TOC (%) | 1 | | | | | | |
| PROTEIN (mg/g) | -0.16 | 1 | | | | | |
| LIPID(mg/g) | 0.377 | -0.03 | 1 | | | | |
| CARBOHYDRATE(mg/g) | -0.19 | 0.34 | 0.02 | 1 | | | |
| SAND% | 0.01 | 0.026 | 0.13 | -0.06 | 1 | | |
| CLAY% | -0.19 | -0.09 | -0.4 | -0.31 | -0.57 | 1 | |
| SILT(%) | 0.2 | 0.074 | 0.26 | 0.4 | -0.438 | -0.49 | 1 |

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