Asian Journal of Chemistry Vol. 14, Nos. 3-4 (2002), 1660-1666

Study of Carbon, Phosphorus and Nitrogen in the Sediments of River Pamba

MATHEW KOSHY
Department of Chemistry, Bishop Moore College, Mavelikara-689 652, India

The sediment organic carbon (SOC), total phosphorus (TP) and total nitrogen (TN) of the sediment of the river Pamba, the third largest river flowing through central Kerala, has been studied, for a period of one year, by collecting samples from two stations. The samples were analysed. The results on analysis of SOC, TN and TP found that the concentrations were low and terrestrial in origin.

Key Words: Sediment organic carbon, Total nitrogen, Total phosphorus, Sediment river Pamba.

INTRODUCTION

The continental weathering, land run off through vegetation and agricultural lands and human activities contribute the major part of nutrient input into the riverine environment. The use of elemental ratios as indicators of organic matter source is a common approach in geochemical studies. Analysis of organic matter contained in sediments is of great biological importance. The determination of the quality and quantitiy of the organic substances in sediments provides information of nutritional value of the sediments. Bottom sediments regulate the fresh water ecosystem[1]. Metabolism of detritus and particulate organic carbon, which occurs largely in the sediments, provides stability to the ecosystem[2]. Banin *et al.*[3] stated that the upper layer of lake sediment affects the cycles and balance of nutritional elements in the lake water. Sediments can play a critical role in determining the trophic status of lakes[4]. Hargave[5] found that bottom sediments yield valuable information about production and mineralization in the water column. McLachlan[6] concluded that the nature and distribution of the bottom fauna are strongly influenced by substrate characteristics. Although a lot of research work is available on the lake sediment, much information is not available on the elemental ratio of riverine sediments, which forms a useful tool in interpreting the data on organic matter and assessing the extent of nutrient regeneration.

River Pamba is the third largest river in Kerala, which originates from Pulachimalai having an elevation of 1650 m from the sea level, and meandering through the districts of Pathanamthitta, Idukki and Alleppy in Kerala, drains into the Arabian Sea through Vembanadu lake. The total length of this river is 176 km[7]. The water quality aspect of river Pamba has been studied and found that the water is contaminated with coliform bacteria and the other physico-chemical parameters are within the permissible limits[8]. The present work has been carried out with a view to study the impact of seasonal changes on the organic carbon, total nitrogen, total phosphorus of the sediments of river Pamba and their ratio.

EXPERIMENTAL

The samples of sediment were collected every month from November 1996 to October 1997 from two stations. The stations were selected so as to obtain a fairly good assessment of the anthropogenic activities and terrestrial input during the course of the river. Textural analysis of the sediment was carried out by mechanical sieving and pipette analysis[9]. The sediment organic carbon content was determined by the chromic acid oxidation method[10]. The sediment organic carbon content was determined by the chromic acid oxidation method[10]. Total phosphorus content in the sediment samples was measured by the method suggested by Murphy and Riley[11]. Total nitrogen content of the sediment was determined by micro Kjeldahl method[12].

The monthly data were pooled and divided into three seasons for getting reliable trends for explaining the features. The monsoon season comprised of months June, July, August, September and October. The post-monsoon period consisted of November, December and January and the pre-monsoon months were February, March, April and May. The classification was based on the rainfall during the period of study.

RESULTS AND DISCUSSION

The textural characteristics of sediments play a significant role in the distribution and concentration of carbon and phosphorus both in the sediment and in the overlying water. Grain size analysis indicated that the texture of the surfacial sediment of Pamba river was mostly sandy on majority of the stations studied. The clay fraction noticed at stations 6, 7 and 8 might be due to the uncontrolled sand mining. The sand removed from the river was 30 times more than the sand coming into the river[13]. Due to the unscrupulous removal of sand from the river the river-bed has been lowered a lot. Sand has been removed leaving clay.

Sediment Organic Carbon (SOC): The organic carbon content of the sediments can be a sensitive indicator of the nature, source areas and the environment of deposition[16]. The organic carbon content of sediments depends on (1) the supply of organic matter to the environment of deposition, (2) the rate of deposition of organic and inorganic constituents, (3) rate of decomposition, and (4) texture of sediments. The high productivity of the aquatic system is also responsible for the increased organic carbon content. Generally high SOC concentration indicates that the waters overlying the sediment are highly productive, except where organic material from sewage reaches[15]. Study of the organic carbon in the sediments is of potential significance for a proper understanding of water flow in aquatic ecosystems[16].

A seasonal variation of the SOC is presented in Table-1. SOC increased from

0.09 to 0.54 mg/g, 0.12 to 1.39 mg/g and 0.07 to 0.28 mg/g during post-monsoon, pre-monsoon and monsoon season respectively. The high organic carbon observed at Station 2 during pre-monsoon months may be the result of the deposition of terrestrial organic matter from excessive land run-off and domestic sewage. An increase in concentration of SOC observed may be due to the accumulation of clay in the river because of the sand mining[13].

TABLE-1
SOC IN THE SEDIMENTS OF RIVER PAMBA (mg/g)

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	0.09	0.12	0.07
Station 2	0.54	1.39	0.28

The SOC was low during the monsoon season. During monsoon the water is coming from high ranges flowing with a high velocity in a turbid condition carrying all the mud leaving sand particles in the bottom. As the sand mining is less during the monsoon flood, majority of the sand will remain in the river-bed. The lower concentration of organic carbon may be due to the sandy sediment texture. As the particle size increased, the organic carbon content decreased. Low organic carbon content may be due to oxidation of the organic matter because of high dissolved oxygen content or grazing by zooplankton and other high organisms[17].

As the data available with fluvial system are rare to compare with the present study, comparing this with the estuarine system. The values reported for non-fluvial aquatic systems are North Atlantic Ocean 0.03–2.12 mg/g[18], Arctic Ocean 0.50–2.0 mg/g[19], Mandovi estuary (Goa) 0.10–3.0 mg/g[20], Cochin Harbour 0.24–6.15 mg/g[21], Veli Akkulam 6.08–54.44 mg/g[22], Paravthyputhenar 2.71–62.90 mg/g[23], and Poovar 1.96–14.09 mg/g[24].

Phosphorus: Phosphorus is one of the most studied elements in lake sediments, mainly because of the fact that phosphorus has a regulatory role in primary production in most of the aquatic environments. In a lake or estuary the sediment acts as a reservoir for phosphorus, by retaining it by adsorption and releasing it to the overlying water. The sediment bound phosphates play an important role in deciding the bioavailability of phosphorus since the surface of the sediments acts as 'physical catalyst' for releasing or trapping phosphates depending on the phosphate concentration in overlying water[25]. The continuous adsorption and desorption of phosphates by sediments acts both as a source and a sink for phosphate in phosphorus cycle[26].

Seasonal variation of phosphorus content in the mud of the Pamba river is presented in Table-2. The phosphorus in the sediment increased from 0.02 to 0.54 mg/g, 0.02 to 1.26 mg/g and 0.02 to 0.27 mg/g during post-monsoon, pre-monsoon and monsoon seasons respectively. This may be due to the subsiding of the phosphorus leached out from the paddy fields around the station after the monsoon. High value of phosphorus was noticed at station 2 during post and pre-monsoon seasons, maybe due to the receiving of domestic sewage and the leaching of phosphate from the land runoff.

TABLE-2
PHOSPHORUS IN THE SEDIMENTS OF RIVER PAMBA (mg/g)

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	0.02	0.202	0.02
Station 2	0.54	1.26	0.27

In general, low concentration of phosphorus was noticed during monsoon season, might be due to the leaching of phosphorus both in the interstitial and adsorbed form from the mud to the overlying water or erosion of sediment due to the monsoon flood. During monsoon months the increased fresh water inflow, intense circulation of water and the low salinity facilitates the release of phosphorus from the mud to the overlying waters. The low monsoon value of phosphate concentration in the sediments at all stations might be related to the release of phosphorus to the overlying water column and the sandy nature of the sediments and is inconsistent with the finding of Murthy and Veerayya[27].

Nitrogen: Nirogen is the second most abundant nutrient element and like carbon, exists in a wide range of organic forms although most nitrogen containing molecules like proteins, nucleic acids in living things tend to be constructed from a narrow range of organic building blocks, *e.g.*, amino acids and nucleotides. Nitrogen is one of the important nutrients for phytoplankton growth on the marine environment[28, 29].

The seasonal distribution of nitrogen content in the river mud of Pamba river is presented in Table-3. The nitrogen in the mud increased from 0.05 to 0.09, 0.02 to 0.28 and 0.02 to 0.06 mg/g during the post-monsoon, pre-monsoon and monsoon seasons respectively. The wastes of the hospitals and the slaughter-houses are dumped into the river in addition to domestic wastes, which are rich in nitrogen. Due to the sand mining and swirling action of water, nitrogen-containing mud was shifted from one place to another. During monsoon, due to the turbulent nature of the water the clay particles will be taken away by high velocity water.

TABLE-3
NITROGEN IN THE SEDIMENTS OF RIVER PAMBA (mg/g)

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	0.05	0.02	0.02
Station 2	0.09	0.28	0.06

Carbon : Phosphorus (C : P) Ratio: C : P ratio can be used as an index of pollution by domestic sewage in any aquatic environmental system. The seasonal variation of C : P ratio is presented in Table-4. Seasonally the C : P ratio varied from 4.39 to 1.03 during the monsoon period, while the ratio varied from 5.69 to

1.01 and from 6,01 to 1.11 during post and pre-monsoon period respectively. Sankaranarayana and Panampunnayil[30] reported the values of 2.78 to 27.41 for Cochin backwaters. Quasim and Sankaranarayan[31] suggested C : P ratio of 22.61 to 60.40 (average 41.1) for the detritus collected from the Cochin estuary. Shanmukhappa[32] attributed the higher C : P ratio of the sediments of Port Novo (21.1 to 105.4) to the unpolluted nature of the biotopes by domestic sewage. The low value observed in Pamba river could be considered as the result of the increased load of phosphates reaching the lake through domestic sewage. The low C : P ratio observed in this aquatic environment of the present study indicated that the major portion of the phosphorus in the sediment was of abiogenic origin, from domestic sewage and other anthropogenic sources. C : P ratio is widely used to estimate the extent of degradation in sinking particulate material.

TABLE-4
C : P RATIO IN THE SEDIMENTS OF RIVER PAMBA

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	5.69	6.01	4.39
Station 2	1.01	1.11	1.03

Carbon : Nitrogen Ratio (C : N): Carbon-nitrogen ratio is generally used to identify the source of organic matter in the sediment. It has been used as an indicator of terrigenous addition. The C : N ratio showed little association with the sediment size. The variation in C : N ratio is due to the nature of the organic matter rather than the types of sediment[33]. The highly varying C : N ratio may be due to both the complex nature of organic matter as well as diagenic alteration[36]. Higher C : N ratio was noticed in the degradation of domestic wastes. The seasonal variation of C : N ratio is presented in Table-5. Seasonally the C : N ratio varied from 4.28 to 4.63 during the monsoon period, while the ratio varied from 1.67 to 6.02 and from 4.96 to 4.97 during post and pre-monsoon periods respectively. Task[35] compared the values of organic carbon and nitrogen in the sediments of estuaries, lagoons and oceans throughout the world and reported a C : N ratio between 8 and 12.

TABLE-5
C : N RATIO IN THE SEDIMENTS OF RIVER PAMBA

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	1.67	4.96	4.28
Station 2	6.02	4.97	4.63

Higher C : N ratio was noticed in the degradation of domestic wastes. Quasim and Sankaranarayanan[31] reported a ratio between 5.0 and 10.5 from detritus of Cochin backwaters. Sivakumar *et al.*[36] reported a higher value between 2.0 and 137.7 for C : N ratio in the sediments of Vellar estuary, which was considered to be the freshwater discharge of terrestrial run-off bringing high organic matter and also to the nature of the substratum. Ghosh *et al.*[37] reported the C : N ratio ranging from 3.2 to 3.4 for the sediments of the Hoogly estuary.

The higher values of C : N ratio at station 1 during monsoon months could be due to the high organic matter in the sediments resulting from the low nitrogen run-off. The analysis showed that the organic carbon in the sediments is of terrestrial origin.

Nitrogen-Phosphorus Ratio (N : P): The low N : P ratio denotes that the bioavailablity of nitrogen for phytoplankton production in this region is less than of phosphate and hence the growth of phytoplankton can be considered as nitrogen controlled[38]. The high N : P ratio may be due to the thick vegetation, which undergoes decay and is adsorbed into sediments.

The seasonal variation of N : P ratio is presented in Table-6. Seasonally the N : P ratio varied from 1.03 to 0.22 during the monsoon period, while the ratio varied from 5.69 to 1.07 and from 1.21 to 0.22 during post and pre-monsoon periods respectively. The low N : P values were obtained in the present study is compared with the values of Sivakumar *et. al*[36]. The present study indicated that the major porttion of the phosphorus in the sediment was of abiogenic origin.

TABLE-6
N : P RATIO IN THE SEDIMENTS OF RIVER PAMBA

	Post-monsoon	Pre-monsoon	Monsoon
Station 1	5.69	1.21	1.03
Station 2	1.07	0.22	0.22

The main source of SOC was allochthonous material brought in by the different tributaries and canals, opening into the river. As the soil of central Kerala is lateritic, it is poor in available nitrogen, phosphorus, potash and organic matter[39]. As the river Pamba is flowing through lateritic soil, the nurients reported were very low in comparison to the coastal sediments. The low productivity, nature of the soil, unscrupulous sand mining and turbulent fluvial system is responsible for the low concentration of nutrients. The low productivity may affect the aquatic life in the system. The C : P ratio suggests that the major portion of sedimentary phosphorus is abiogenic in origin. The SOC, total phosphorus and nitrogen were too low in comparison to other aquatic eco-systems.

REFERENCES

1. E. Odum, Fundamentals of Ecology, W.B. Saunders Co., New York, p. 574 (1971).
2. R. Wetzel, Limnology, W.B. Saunders Co., Philadelphia, p. 743 (1975).
3. A. Banin, M. Gal, Y. Zohar and A. Singer, *Limnol. Oceanogr.*, **20**, 278 (1974).
4. H. Golterman, in: H.L. Golterman and R.S. Clymo (Eds.), Chemical Environment in the Aquatic Habitat, North Holland, pp. 297–313 (1966).
5. B.T. Hargrave, *J. Fish. Res. Board Can.*, **30**, 1317 (1973).
6. A.J. McLachlan, *Hydrobiologia*, **33**, 237 (1969).

7. Water Atlas of Kerala, CWRDM, Kerala, p. 70 (1955).
8. Mathew Koshy and T.Vasudevan Nayar, *Poll. Res.*, **18**, 501 (1999).
9. W.C. Krumbin and F.J. Pettijohn, Manual of Sedimentary Petrography, Appleton-Century-Crofts, New York, p. 549 (1938).
10. S.K. Wakeel and J.P. Riley, *J. Cons. Intern. Explor. Mer.*, **22**, 180 (1957).
11. J. Murphy and J.P. Riley, *Anal. Chim. Acta,*, **27**, 31 (1962).
12. H. Barnes, Apparatus and Methods in Oceanography (Chemical), Academic Press, Jordan (1959).
13. Report on Pamba, Centre for Earth Science Studies (1999).
14. S. Emerson and J.I. Hedges, *Palaeoceanography*, **3**, 621 (1988).
15. C.D. Hunt and W.F. Fitzgerald, *Mar. Chem.*, **12**, 255 (1983).
16. N.B. Nair, P.K. Abdul Aziz, M. Arunachalam, K Krishnakumar and K. Dharmaraj, *Mahasagar Bull. Natn. Inst. Oceano,* **17**, 33 (1983).
17. W.J. Paulmose and P.N. Aravindakshan, Proceedings of Symposium on Water Zooplankton, Special Publ. N.E. Goa, p. 132 (1977).
18. L. Melissa, Coppedge and William L. Balsam, *Mar. Geol.*, **105**, 37 (1992).
19. Stein Ruediger, Grobe Hannes and Monika Washner, *Mar. Geol.*, **119**, 269 (1994).
20. R. Alagarsamy, *Indian J. Mar. Sci.*, **20**, 221 (1991).
21. P. Serlathan, N.R. Meenakshi Kutty, K.V. Asarafe and D. Padmalal, *Indian J. Mar. Sci.*, **22**, 252 (1993).
22. Renamoni and T.V. Nayar, M. Phil. Thesis, Kerala University (1996).
23. Prasanthan and T.V. Nayar, M. Phil. Thesis, Kerala University (1999).
24. Njemi and T.V. Nayar, M. Phil. Thesis, Kerala University (2000).
25. J.K. Syres, R.F. Haris and D.E. Armstrong, *J. Environ. Qual.*, **2**, 1 (1973).
26. S.M. Nair and A.N. Balchand, *Toxicological and Environmental Chemistry,* **39**, 81 (1993).
27. P.S.N. Murty and M. Veerayya, *Indian J. Mar. Sci.*, **1**, 45 (1972).
28. J.H. Ryther and W.M. Dunstan, *Science*, **171**, 1008 (1971).
29. G.W. Thayer, *Oecologia,* **14**, 75 (1974).
30. V.N. Sankaranarayanan and P.U. Panapunnayil, *Indian J. Mar. Sci.*, **8**, 27 (1979).
31. S.Z. Quasim and V.N. Sankaranarayanan, *Mar. Biol.*, **15**, 193 (1972).
32. H. Shanmugappa, Proc. Natn. Sem. Estuarine Management, Department of Aquatic Biology and Fisheries, Trivandrum, Kerala, pp. 128–133 (1987).
33. R. Pocklingom and J.D. Leonard, *J. Fish. Res. Board. Can.*, **36**, 1250 (1979).
34. Kolla Venkitarathanam, Pulok K. Ray and John, *Mar. Geol.*, **41**, 183 (1981).
35. P.D. Trask, Origin and Environmental Source Sediments of Petroleum, Gulf. Pub. Co, Houston, Texas, p. 323 (1932).
36. V. Sivakumar, G.S. Thangaraj, R. Chandran and Ramamoorthy, *Mahasagar*, **16**, 175 (1993).
37. P.B. Ghosh and A. Choudhary, Proc. Natn. Sem. Estuarine Management, Trivandrum, Kerala, p. 453 (1987).
38. P.K. Panigrahy, J. Das, S.N. Das and R.K. Sahoo, *Indian J. Mar. Sci.*, **28**, 127 (1999).
39. Water Atlas of Kerala (National Bureau of Soil Survey and Landuse Planning) CWRDM, Kerala, p. 15 (1995).

(*Received*: 27 March 2002; *Accepted:* 27 May 2002) AJC–2745