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Seasonal Distribution of Arylsulfatase in the Marine Environment at Porto Novo, East Coast of India*

K DHEVENDARAN†, D CHANDRAMOHAN‡ & R NATARAJAN
Centre of Advanced Study in Marine Biology, Annamalai University, Porto Novo 608 502

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Arylsulfatase activity was recorded in all the sediment samples collected from different biotopes (estuarine, backwater and mangrove). The season as well as the nature of biotope influenced the enzyme activity. Highest activity was recorded in mangrove biotope, followed by backwater and estuary (10.39, 4.93 and 4.71 μg phenolphthalein $g^{-1}.h^{-1}$ respectively). Irrespective of variations in biotope, higher activities, in general, were found during summer and premonsoon periods. Organic carbon, phosphate and sulfate influenced the enzyme activity. Organic carbon (0.75%) in particular was the chief influencing factor for maximum arylsulfatase activity (10.39 μg phenolphthalein $g^{-1}.h^{-1}$) in sediments. Eventhough phosphate did not affect much of the activity, sulfate concentration (5.06 $mg.g^{-1}$) inhibited the activity under natural conditions also.

The enzyme arylsulfatase hydrolyses sulfate esters though the natural substrate for this enzyme is still not known[1,2]. Its activity is known in marine animals[3-7], and there is paucity of information about its activity in marine sediments. In this investigation sediments of different biotopes have been analysed for the distribution of arylsulfatase, arylsulfatase-producing bacteria, organic carbon, phosphorus and sulfate and the relationship between arylsulfatase activity and the other parameters.

Materials and Methods

Monthly samples were collected (April 1974-March 1975) from 15 different stations, representing estuarine, backwater and mangrove biotopes (Fig. 1). The sampling period comprised 4 seasons, viz. summer (April-June), premonsoon (July-Sept.), monsoon (Oct.-Dec.) and postmonsoon (Jan.-March). The data for each parameter were pooled seasonwise. The total phosphorus and adsorbed phosphate[8] and adsorbed sulfate and organic carbon[9,10] of the sediment samples were estimated. Arylsulfatase-producing bacterial population and arylsulfatase activity in the sediment samples were recorded[11]. To study the relationship between any 2 parameters, correlation coefficients (r) and regression values were computed. For comparing regression coefficients (b) between 2 parameters the Students' 't' test was employed.

Results and Discussion

Organic carbon—Organic carbon (OC) content of different biotopes varied from 0.44 to 0.75% (Table 1). The sediments of mangrove biotopes contained higher levels of OC compared to other biotopes. This may be due to high primary production[12,13] and rich mangrove vegetation (*Rhizophora* spp. and *Avicennia* spp.) adding to the organic content constantly. Most of the organic debris of the mangrove soil is autochthonous. Because of saline water, relatively high pH of surface soil water (often as high as 8.35) and anaerobic conditions at low tide, plant detritus is partially broken down by microorganisms. This results in the formation of peat composed mainly of plant remains. Further, sediments of mangrove biotopes are

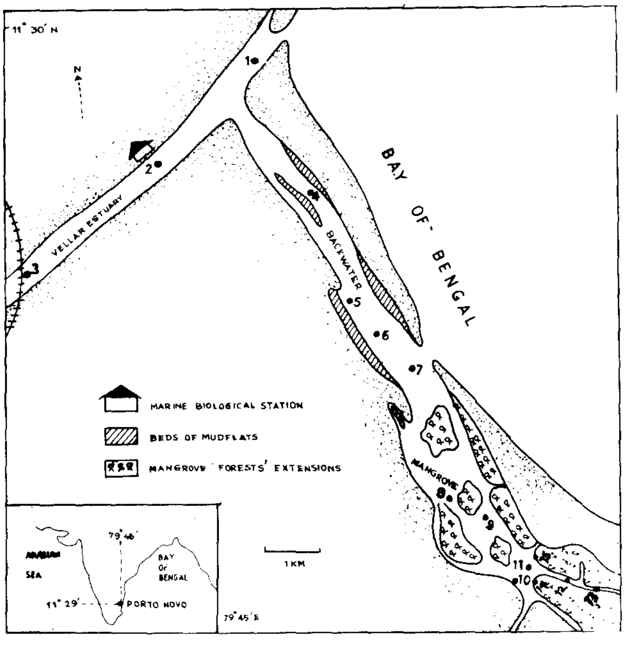

Fig. 1—Sampling stations in the study area

*Forms part of Ph.D. thesis of the first author.
†Present address: School of Marine Sciences, University of Cochin, Cochin 682 016.
‡National Institute of Oceanography, Dona Paula, Goa 403 004.

clayey in nature and such sediment are known to contain larger quantities of organic matter[14]. The mangrove biotope is connected with both vellar and coleroon estuaries and it harbours autochthonous and also allochthonous organisms.

Total phosphorus—Total phosphorus in sediments of different biotopes was high during summer and premonsoon months (Table 1) while it decreased during monsoon and remained almost the same during postmonsoon period. It may also be seen that estuarine

Table 1—Seasonal Changes in Different Parameters of Sediments from Various Biotopes

(Results represent average values for 3 months of each season)

Biotope	Summer	Pre-monsoon	Monsoon	Post-monsoon	$\bar{X}$	S.D.
			(i) Organic carbon (%)			
A	0.61*	0.63	0.44	0.47	0.54	0.0836
B	0.54	0.56	0.46	0.45	0.50	0.0479
C	0.75	0.75	0.72	0.74	0.74	0.0141
$\bar{X}$	0.63	0.65	0.54	0.55		
S.D.	0.0871	0.0780	0.1277	0.1330		
			(ii) Total phosphorus (mg.g^{-1})			
A	0.59*	0.61	0.41	0.44	0.51	0.09
B	0.51	0.53	0.48	0.48	0.50	0.02
C	0.53	0.52	0.47	0.49	0.50	0.03
$\bar{X}$	0.54	0.55	0.45	0.47		
S.D.	0.034	0.04	0.12	0.02		
			(iii) Adsorbed phosphate (μg.g^{-1})			
A	1.15*	1.64	1.21	0.03	1.16	0.36
B	0.90	0.83	0.95	0.53	0.80	0.16
C	0.81	0.92	0.67	0.60	0.75	0.53
$\bar{X}$	0.95	1.13	0.94	0.59		
S.D.	0.15	0.35	0.22	0.04		
			(iv) Adsorbed sulfate (mg.g^{-1})			
A	4.66*	3.30	3.16	5.06	3.99	2.48
B	2.77	2.55	2.36	3.55	2.80	0.45
C	3.46	2.89	3.15	4.21	3.42	0.49
$\bar{X}$	3.56	2.91	2.89	4.27		
S.D.	0.69	0.31	0.37	0.62		
			(v) Arylsulfatase-producing bacteria ($\times 10^5$.g^{-1})			
A	13.41*	13.19	12.86	10.50	12.49	0.57
B	14.97	15.63	14.16	13.83	14.49	0.33
C	14.70	13.53	13.47	14.92	14.16	0.32
$\bar{X}$	14.36	14.12	13.50	13.08		
S.D.	0.39	0.62	0.30	1.08		
			(vi) Arylsulfatase activity (μg phenolphthalein .g^{-1} – h^{-1})			
A	4.71*	4.44	3.32	2.22	3.67	0.99
B	4.89	4.93	4.34	3.70	4.47	0.50
C	10.39	9.72	7.91	9.30	9.33	0.91
$\bar{X}$	6.66	6.36	5.19	5.07		
S.D.	2.63	2.38	1.97	3.05		

A = Estuary; B = Backwater; C = Mangrove; $\bar{X}$ = Mean; S.D. = Standard deviation.
*Average of 3 months.

stations generally contained more phosphorus (0.61 mg.g^{-1}) than other biotopes.

Adosrbed phosphate—Adsorbed phosphate varied in sediments of different stations (Table 1). In estuary and mangrove regions, maximum adosrbed phosphate (1.64 and 0.92 μg.g^{-1} respectively) was noticed during premonsoon and in backwater during monsoon time. Sudden changes in salinity due to tidal flushing seem to influence the concentration of adsorbed and interstitial phosphate, in the mud[15]. The nature of sediment[16,17] also seems to influence the concentrations of adsorbed phosphate.

Adsorbed sulfate—High concentration (Table 1) of adsorbed sulfate was observed during postmonsoon period in all biotopes which decreased gradually through summer up to monsoon time. Highest concentration of adsorbed sulfate was in estuarine biotope and lowest in backwater. In mangrove biotope it ranged from 2.89 to 4.21 mg.g^{-1}. The same factors which govern the concentration of adsorbed phosphate seem to govern the concentration of adsorbed sulfate also.

Arylsulfatase-producing bacteria—The population ranged from 10.5 × 10^5 to 15.63 × 10^5 bacteria.g^{-1} dry sediment. In estuary the minimum population was recorded during postmonsoon season whereas in the backwater maximum population was noticed during premonsoon season. Variation in population in different biotopes may probably be due to factors like nutrients, temperature and salinity[18].

Arylsulfatase activity—The enzyme activity was recorded in all stations during the period of study irrespective of variations in other parameters (Table 1). Highest activity could be noticed in mangrove stations followed by backwater and estuary. In mangrove biotope the activity was double when compared to other 2 biotopes. This indicates that the nature of the biotope exerts more influence on arylsulfatase activity.

The presence of arylsulfatase in these sediments indicates that some of the organic sulfur do exists as arylsulfates and their role in the sulfur economy has yet to be studied. Both the nature of biotope as well as the seasons influence the arylsulfatase activity in the sediments. It was also reported earlier that the activity varied in different soil samples[19]. On the basis of correlation coefficients obtained (Table 2) between arylsulfatase activity and other parameters, the following conclusions can be derived:

A positive correlation was obtained between arylsulfatase activity and organic carbon, total phosphorus and adsorbed phosphate, but there was a negative correlation between the enzyme activity and adsorbed sulfate (Table 2). When these factors were studied in further details it was found that organic carbon is the most significant factor controlling the enzyme activity. It is evident from the regression coefficient between various parameters within different stations. Since bacterial contribution to observed arylsulfatase activity in sediments is not significant, the possible contribution from other sources (fungi, algae, etc.) may be considerable[7]. The 3 biotopes in the increasing order of arylsulfatase activity are mangrove > backwater > estuary.

Table 2—Correlation Coefficients between Various Parameters within Different Stations

	Correlation coefficients			
	r_1	r_2	r_3	r_4
		Estuary		
1	+0.81	N.S.	+0.69	N.S.
2	+0.78	N.S.	+0.89	−0.48
3	N.S.	N.S.	N.S.	N.S.
		Backwater		
4	+0.69	N.S.	N.S.	−0.49
5	+0.72	N.S.	+0.78	−0.58
6	N.S.	−0.54	N.S.	N.S.
7	N.S.	+0.47	+0.72	−0.44
		Mangrove		
8	+0.70	+0.88	+0.96	−0.83
9	+0.67	+0.84	+0.87	N.S.
10	+0.86	N.S.	+0.76	+0.91
11	+0.77	+0.68	+0.99	−0.83
12	+0.60	+0.62	+0.99	−0.77
13	+0.53	+0.90	+0.80	−0.85
14	N.S.	+0.73	+0.90	−0.84
15	−0.59	+0.79	+0.55	−0.73

Correlation coefficient between:
r_1—organic carbon and arylsulfatase
r_2—inorganic phosphate and arylsulfatase
r_3—total phosphorus and arylsulfatase
r_4—inorganic sulfate and arylsulfatase
N.S. = Not significant.

Since organic carbon was found to be the key factor influencing arylsulfatase activity and because of the fact that mangrove sediments contain highest level of organic carbon, high activity observed in mangrove sediments is expected. This supports fully the earlier finding[20] that arylsulfatase activity in soil and bacterial culture was significantly correlated to the organic carbon. Further, the result shows that addition of sulfate to the sediment sample resulted in decreased arylsulfatase activity[18]. This supports the observation that a negative correlation exists between the sulfate content and arylsulfatase activity in sediments under natural conditions also (Table 2).

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