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Functional role of soil microarthropods for litter decomposition (*Rhizophora mucronata)* in a newly emerged virgin Island (Nayachar) on the Coast of West Bengal India.

M.K.DEY AND A.K.HAZRA

Zoological Survey of India, New Alipore, Kolkata-53

Abstracts:

Decomposition of *Rhizophora mucronata* leaf litter was studied using litter bag in Nayachar Island (Latitude 21^{o}58'33''N and longitude 88^{o} 04'54''E). This study focused on leaf litter decomposition and nutrient (N, P and K) dynamics during the decomposition process. This experiment was conducted for 365 days (one year) by using litter bag technique during pre-monsoon, monsoon and post monsoon seasons. A significant ($P<0.05$) higher amount of mass loss, rate of decomposition, decay constant and amount of nutrient return from leaf litter(*Rhizophora mucronata*) were observed during the post monsoon period . Soil microarthropods playas the important role for decomposition process during different phases of decomposition. It also quantifies physio-chemical factors along with the microarthropods population abundance throughout the decomposition process. Soil microarthropods help ecosystem functioning by way of imparting important role food chain, food web system vis-à-vis in tropic relationship and also help nutrient cycling as decomposer.

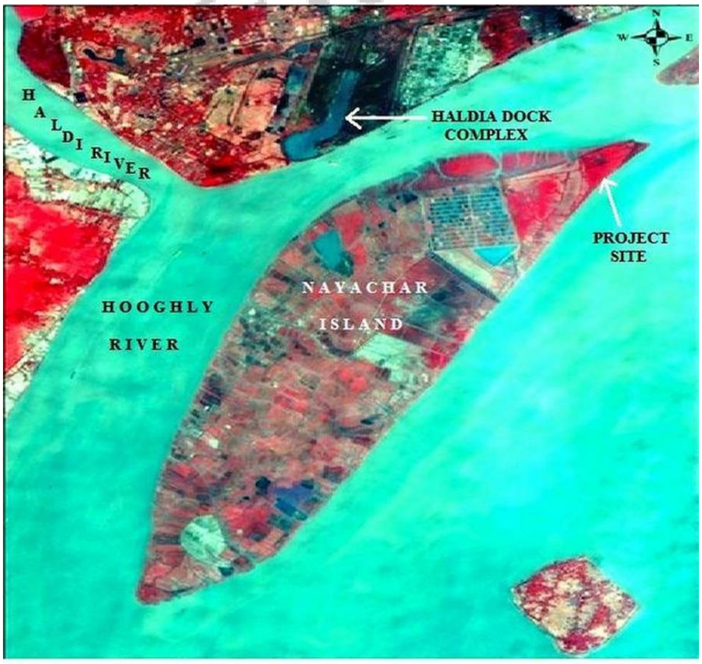
Key words: Decomposition, Mangrove, Soil microarthropods, Nutrient cycling.

Introduction:

Mangroves are highly dynamic ecological entities which supply energy to aquatic as well as terrestrial habitats through their production and decomposition of plant debris. *Rhizophora mucronata* belongs to the order Malpighiales and family Rhizophoraceae. This mangrove plant is a small to median size evergreen tree growing to a height of about 15-20 metres on the banks of river Hoogly. The tallest trees are closest to the water and shorter tree are further inland. The tree has a large number of serial stilt roots buttressing the trunk. The leaves are elliptical and usually about 12 cm long and 6 cm wide. They have elongated tips but these often break off [1] . The decomposition of plant material is the process in which organic substances are physically broken down and converted into simple chemical substances, resulting in the production of carbon dioxide , water, and released energy [2] . Decomposition of organic substances and recycling of detritus have great importance in nutrient released from ground organic substance (Rffaelli & Hawkins 1996) [3] enabling the substance to become available for new growth of plants. The present investigation also laid emphasis on the study of decomposition process of *Rhizophora mucronata* leave litters and the succession of different microarthropods population in different phases of litter decomposition process of Nayachar Island of Midnapore coast , West Bengal, India. Therefore, those microarthropods of mangrove fauna have been dealt with in the present communication in much detail with a comparative account of different selected study sites located in different parts of Nayachar Island.

Material & Methods:

Rhizophora mucronata mangrove plants were chosen for the study of mangrove leaves decomposition. Litter decomposition rate has been determined by litterbags methods. The litterbags were made of nylon, mesh sizes ($6mm^2$) were used for present study [4] . Freshly fallen leaves of different mangroves plant were collected from the mangrove belt of Nayachar Island. The leaves were chopped with size (1inch) into uniform lengths then dried in air. Each nylon bags was filled with 200gm air-dried litter. A set of 4 such bags was made for each selected sites. A total of 12(4×3) bags were made in three different localities. Bags were placed at a depth 5 inch under the soil. The litter bags at the rate of decompose leaves were drawn at an intervals of 3 months for one year. Microarthropods from each litter bags were extracted by modified Tullgreen funnel [5] . The collected fauna were sorted out into different groups and identified with the help of Stereoscopic binocular microscope followed by taxonomic key. Decompose soil



sample were study with the help of laboratory standard method [6-7] and statistical analysis done by STATISTICA , Version 7.0. Nayachar Island Map (Source Researchgate.net)

Result & Discussion:

Litter decomposition study with *Rhizophora mucronata*

Rhizophora mucronata, locally named "Garjan" an important mangrove plant species was selected for litter decomposition study. The successional occurrence of different microarthropodal faunal components, rate of decomposition and changes of different physicochemical parameters associated with decomposing litters have been presented bellow

a. Rate of Decomposition

The rate of decomposition of *Rhizophora mucronata* have been increased gradually from 3rd month (47.5%) and reached to 54% on the 6th month, 65% on 9th month and 72% at the end of 12th months. (Fig-1)

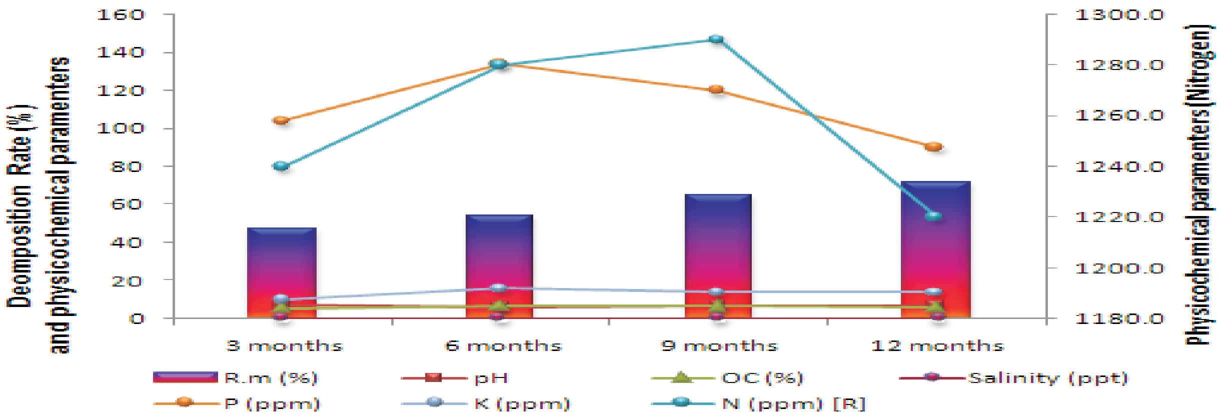


Fig-1 Density of soil microarthropods population with relation to physichochemical paramentrs during different phases of decomposition of *Rhizophora mucronata*

b. Faunal occurrence (Mean value) in different phase of decomposition

The number of different faunal groups when litter bags were withdrawn after 3 months were - Acarina (6), Collembola (5), Coleoptera (1), Diptera (3) and other microarthropods (1). After 6 months of decomposition of litter , the number of different faunal groups were – Acarina (20), Collembola (35),Coleoptera (3) , Diptera (1) , Isopoda (1.33), Hymenoptera (1) and other microarthropods (2). After 9 months, when litter bags were withdrawn, the different faunal groups which were encountered were- Acarina (8), Collembola (7), Coleoptera (5), Diptera (2.67), Isopoda (5), Hymenoptera (4) and other microarthropods (2). At the end of 12 months when the litter bags were withdrawn, Acarina (6), Collembola (5), Coleoptera (4), Diptera(3), Isopoda (6.67), Hymenoptera (5) and other microarthropods (2) constituted the litter faunal community (Figure-2)

c. **Relative abundance** (%)

Relative abundance of soil microarthropods revealed that after 3 months of decomposition, % of occurrence of Acarina was 37.5 % followed by Collembola (31.25%), Diptera (18.75%), Coleoptera (6.25%) and other microarthropods (6.25%). After 6 months of decomposition, % of occurrence of Collembola was 55.26% followed by Acarina (31.5%) , Coleoptera (4.73%), other microarthropods (3.15%), Isopoda (2.1%) and Hymenoptera (1.57%) . After 9 months of decomposition, % of occurrence of Acarina was 23.76% followed by Collembola (20.79%), Coleoptera (14.85%), Isopoda (14.85%), Hymenoptera (11.88%), Diptera (7.92%) and other microarthropods (5.94%). After 12 months of decomposition, % of occurrence of Isopoda was 19.5% followed by Hymenoptera (18.29%), Coleoptera (18.29%), Acarina (14.63%), Collembola (10.97%) and other microarthropods (7.31%) (Table-2&3)

d. **Diversity of microarthropods in different phases of decomposition**:

During the yearlong (12 months) studies on litter decomposition, differential appearances of different groups of microarthropods at different phases of litter decomposition were noticed. During 1st phase (Initiation to 3 months), the Acarina population was found to be maximum followed by Collembola, Coleoptera and Diptera . On the second phase of decomposition (3 to 6 months) , gradually different groups of microarthropods *viz.* Acarina, Collembola, Coleoptera and Diptera steadily increase their population while Hymenoptera and other microarthropods started to recorded their appearance in the decomposing litters . In the 3rd phase (6 to 9 months), the population density of Acarina, Collembola and Coleoptera showed declining trend while the population density of Hymenoptera, Isopoda and other microarthropods revealed an increasing trend. In the last phases (9 to12 months), the population density of Acarina, Collembola and Coleoptera totally dwindled with the maximum density of Isopoda and other microarthropods (Figure-2 &3).

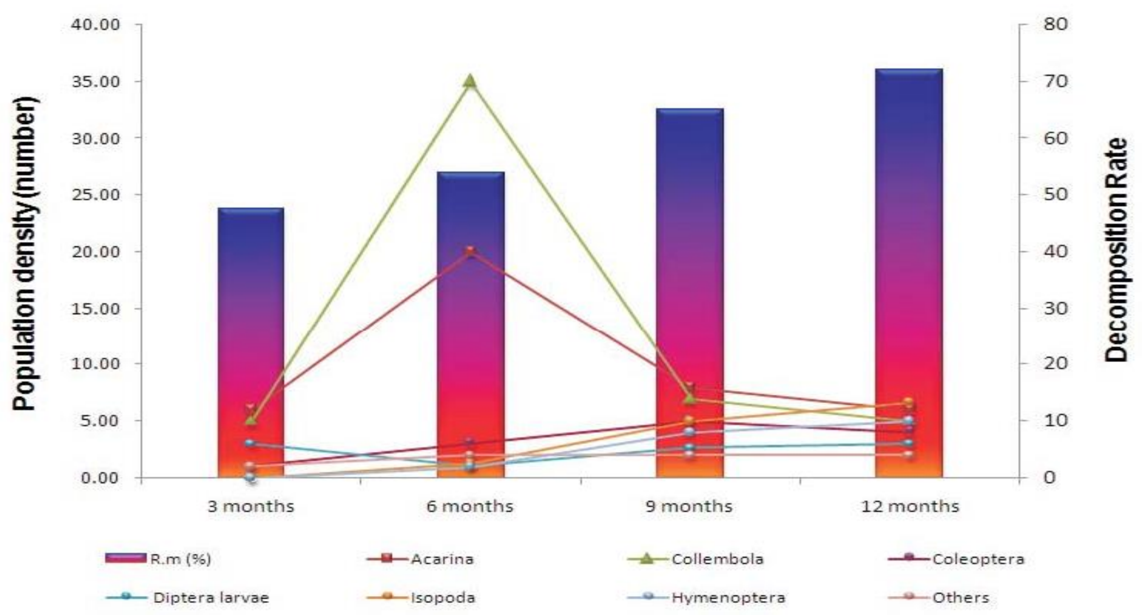


Fig -2 .Different decomposition rate and with the occurrence of soil microarthropods population during different phases of decomposition of *Rhizophora mucronata*

Table-1 Correlation between physicochemical parameters and different orders of soil microarthropods appeared in different phases of decomposition of mangrove plant litter (*Rhizophora mucronata)*

Variable	pH	OC	Salinity	N	P	K
Acarina	-0.7954	0.644	-0.3961	0.5694	0.8392	0.7082
	p=.205	p=.356	p=.604	p=.431	p=.161	p=.292
Collembola	-0.7619	0.6004	-0.3629	0.508	0.8021	0.6849
	p=.238	p=.400	p=.637	p=.492	p=.198	p=.315
Coleoptera	-0.6058	0.7648	-0.8783	0.3692	0.1021	0.6592
	p=.394	p=.235	p=.122	p=.631	p=.898	p=.341
Diptera	0.8051	-0.6571	0.4062	-0.5883	-0.85	-0.7148
	p=.195	p=.343	p=.594	p=.412	p=.150	p=.285
Isopoda	-0.2219	0.3974	-0.6972	-0.1867	-0.434	0.3907
	p=.778	p=.603	p=.303	p=.813	p=.566	p=.609
Hymenoptera	-0.2301	0.4106	-0.7001	-0.1483	-0.4103	0.3895
	p=.770	p=.589	p=.300	p=.852	p=.590	p=.611
Others	-0.852	0.9215	-1	0.3531	0.279	0.9272
	p=.148	p=.078	p= ---	p=.647	p=.721	p=.073

Table-2. Correlation between physicochemical parameters and different species of soil microarthropods appeared in different phases of decomposition of mangrove plant litter (*Rhizophora mucronata)*

Variable	pH	OC	Salinity	N	P	K
ASP1	-0.8181	0.6751	-0.4201	0.6145	0.8645	0.7233
	p=.182	p=.325	p=.580	p=.385	p=.136	p=.277
ASP2	0.4472	-0.5348	0.8165	0.2471	0.299	-0.6489
	p=.553	p=.465	p=.184	p=.753	p=.701	p=.351
ASP3	-0.852	0.9215	-1	0.3531	0.279	0.9272
	p=.148	p=.078	p= ---	p=.647	p=.721	p=.073
ASP4	-0.3178	0.1047	0.1741	0.2898	0.6557	0.2075
	p=.682	p=.895	p=.826	p=.710	p=.344	p=.792
ASP6	-0.8899	0.7994	-0.5222	0.8166	0.9472	0.7609
	p=.110	p=.201	p=.478	p=.183	p=.053	p=.239
ASP7	0.8433	-0.8398	0.5774	-.9611*	-0.9062	-0.6882
	p=.157	p=.160	p=.423	p=.039*	p=.094	p=.312
ASP8	-.9690*	0.9079	-0.8165	0.4942	0.6408	.9733*
	p=.031*	p=.092	p=.184	p=.506	p=.359	p=.027*
ASP9	-0.852	0.9215	-1	0.3531	0.279	0.9272
	p=.148	p=.078	p= ---	p=.647	p=.721	p=.073
ASP10	-0.7303	0.561	-0.3333	0.454	0.7673	0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
ASP11	-0.7303	0.561	-0.3333	0.454	0.7673	0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
CSP1	-0.7303	0.561	-0.3333	0.454	0.7673	0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
CSP2	-0.4837	0.2835	-0.1325	0.1002	0.4989	0.4737

	p=.516	p=.717	p=.868	p=.900	p=.501	p=.526
CSP3	-0.8433	0.8398	-0.5774	.9611*	0.9062	0.6882
	p=.157	p=.160	p=.423	p=.039*	p=.094	p=.312
CSP4	-0.6992	0.5608	-0.5222	0.079	0.4007	0.7609
	p=.301	p=.439	p=.478	p=.921	p=.599	p=.239
CSP5	-0.7071	0.6116	-0.2582	0.8987	.9996*	0.513
	p=.293	p=.388	p=.742	p=.101	p=.000*	p=.487
CSP6	-0.4734	0.2693	0	0.3567	0.7152	0.3746
	p=.527	p=.731	p=1.00	p=.643	p=.285	p=.625
CSP7	-0.8359	0.7007	-0.4402	0.6529	0.8844	0.7347
	p=.164	p=.299	p=.560	p=.347	p=.116	p=.265
CSP8	-0.8181	0.6751	-0.4201	0.6145	0.8645	0.7233
	p=.182	p=.325	p=.580	p=.385	p=.136	p=.277
CSP9	-0.7303	0.561	-0.3333	0.454	0.7673	0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
CSP10	-0.7303	0.561	-0.3333	0.454	0.7673	0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
COPSP1	-0.852	0.9215	-1	0.3531	0.279	0.9272
	p=.148	p=.078	p= ---	p=.647	p=.721	p=.073
COPSP2	-0.2236	0.2798	0	0.8649	0.6408	0
	p=.776	p=.720	p=1.00	p=.135	p=.359	p=1.00
COPSP3	0	0.1631	-0.5222	-0.4478	-0.6557	0.2075
	p=1.00	p=.837	p=.478	p=.552	p=.344	p=.792
DSP1	0.7303	-0.561	0.3333	-0.454	-0.7673	-0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338
ISP1	-0.3651	0.5475	-0.7778	0.0504	-0.2325	0.4857
	p=.635	p=.453	p=.222	p=.950	p=.767	p=.514
ISP2	0	0.1631	-0.5222	-0.4478	-0.6557	0.2075
	p=1.00	p=.837	p=.478	p=.552	p=.344	p=.792
HSP1	0	0.1631	-0.5222	-0.4478	-0.6557	0.2075
	p=1.00	p=.837	p=.478	p=.552	p=.344	p=.792
HSP2	-0.5085	0.6695	-0.8704	0.1317	-0.1093	0.6225
	p=.491	p=.330	p=.130	p=.868	p=.891	p=.377
HSP3	-0.1054	0.3122	-0.5774	-0.0874	-0.4229	0.2294
	p=.895	p=.688	p=.423	p=.913	p=.577	p=.771
OSP1	-.9690*	0.9079	-0.8165	0.4942	0.6408	.9733*
	p=.031*	p=.092	p=.184	p=.506	p=.359	p=.027*
OSP2	0.7303	-0.561	0.3333	-0.454	-0.7673	-0.6623
	p=.270	p=.439	p=.667	p=.546	p=.233	p=.338

e. Changes in the population density of different microarthropods species during different phases of decomposition

Fluctuation of population density of different microarthropods showed different trend in different phases of litter decomposition

The definite population density started increasing after 3 months of decomposition of litter whereas their population density showed declining trends after 9 months and continued upto 12 months of decomposition of litters. This categories of microarthropod included species like *Scheloribates thermophilus (asp1), Scheloribates* *parvus (asp2), Xylobates seminudus (asp4), Oppia sp (asp6), Tectocephaeus velatus (asp8), Allonothrus sp (asp10), Masthermannia sp (asp11), Isotomurus balteatus (csp1), Sminthurides appendiculatus (csp3), Sinella sp (csp5), Lepidocyrtus sp (csp6), Calx sp(csp7), Lepidocyrtus medis (csp8), Proisotoma sp (csp9) , Mesaphorura choudhuri (csp10), Family* Staphylinidae *(cop2*) and *Marpissa sp (osp1)*) (Fig-3) .The marked population fluctuation of litter inhabiting microarthropod species *viz. Tectocepheus sp (asp9) , Monomorium floricola (hsp2), Monomorium latinode (hsp3)*, *Family* Carabidae *(cop-1)* which was started increasing after 6 months of decomposition of litter and these trends were continued upto 12 months of decomposition of litter (Fig-3). The clear population fluctuation of litter inhabiting microarthropod species *viz. Isotomiella minor (csp2), Entomobrya sp* (csp4) which were started increasing after 6 months of decomposition of litter while declining population trend was registered after 9 months of decomposition vis-à-vis 3rd phase of decomposition and again an increasing trend of population was recorded after last phase(9 to 12 months) of decomposition of litter (Fig-3). The sharp population fluctuation of litter inhabiting microarthropods species *viz.* Family Dytiscidae(cop3), *Philoscin sp(isp1) , Procellionides sp(isp2) and Monomorium destructor(hsp1)* where the population density started increasing after 6 months of decomposition of litter and these increasing trend was continued upto 12 months of decomposition litter (Fig-3). The marked population fluctuation of litter inhabiting microarthropod species *viz*. *Galumna flabellifera (asp5)* where the population density was found to be maximum during all phases of decomposition (Fig-3).

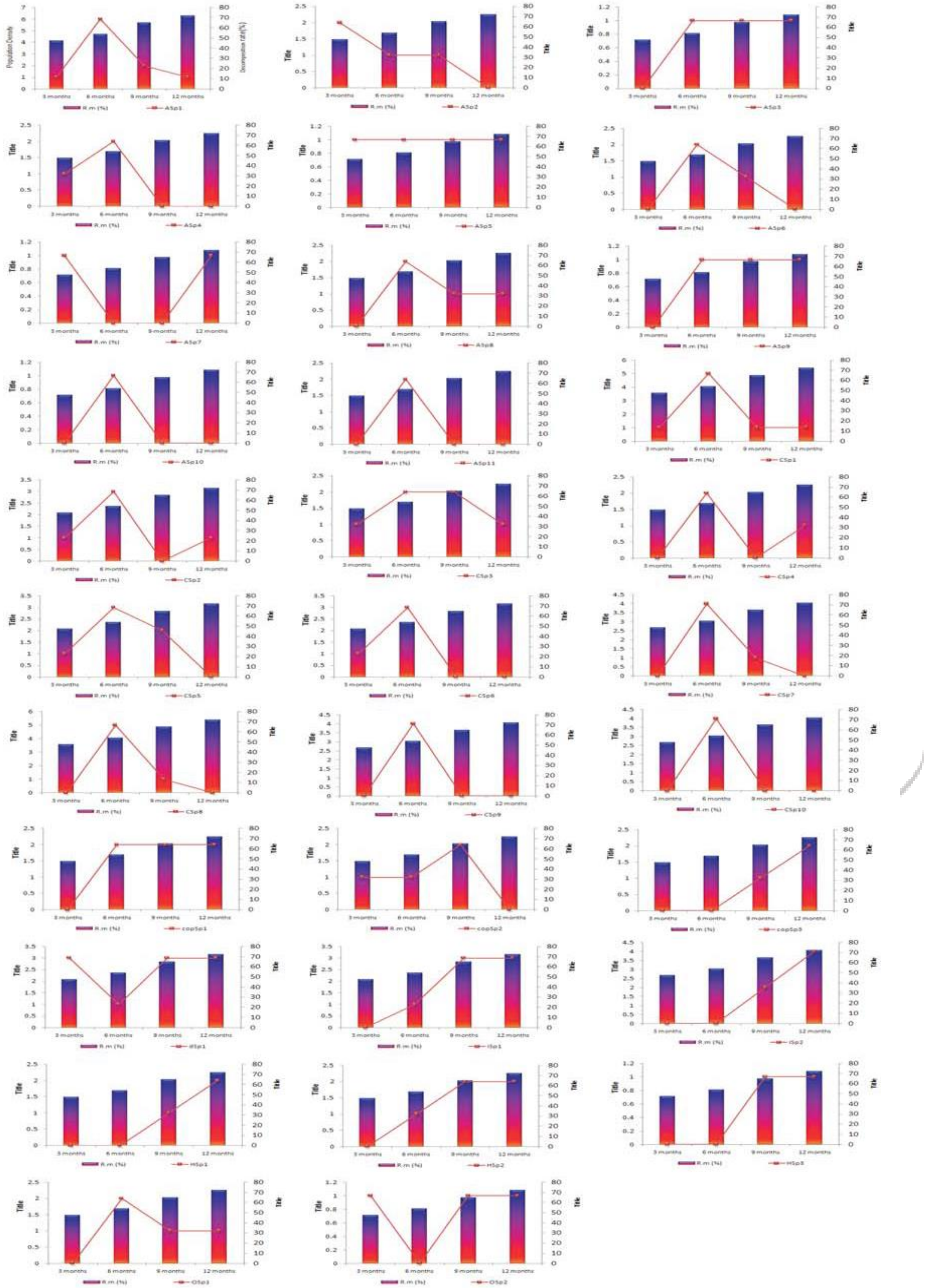


Fig-3. Trends of population fluctuation of soil microarthropods in relation to different phase of decomposition of *Rhizophora mucronata*

f. Physicochemical parameters during different phases of decomposition: -

pH: Minimum p H(6.2) was recorded after 6 months of decomposition and maximum p H(7.5) was recorded after 3 months of decomposition period .**Organic carbon (%):** Organic carbon showed its minimum value(5.43%) after 3 months of decomposition and maximum(6.4%) was recorded after 6 months of decomposition period .**Salinity(ppt):** Salinity was found lowest (0.01ppt) after 6 months of decomposition and that of highest (0.12ppt) was noticed after 3 months of decomposition period **Total Nitrogen (ppm):** Total nitrogen showed its minimum value (1200ppm) after 12 months of decomposition and that of maximum (1280ppm) was found after 9 months of decomposition period . **Total phosphorus (ppm):** Minimum total phosphorus (90ppm) was recorded after 12 months of decomposition and maximum (134ppm) was recorded after 6 months of decomposition period . **Available potassium (ppm):** Minimum available potassium (10 ppm) was estimated after 3 months of decomposition and that of maximum (14ppm) was found after 6 months of decomposition (Fig -1&2)

Different physico-chemical parameters of decomposing litters of mangrove, *Rhizophora mucronata* showed different results with regard to their positive and negative relationships with soil microarthropodd. The species *Multioppia sp* showed significant negative correlation with total nitrogen (-0.961), *Tectocepheus velatus* displayed significant negative correlation with p H (-0.969) and significant positive correlation with available potassium (0.973). *Smithurides appendiculatus* showed significant positive correlation with total nitrogen (0.961). *Sinella sp* showed significant positive correlation with total phosphorus (0.999). *Marpissa sp* exhibited significant negative correlation with pH (-0.969) and significant positive correlation with available potassium (0.973).(Table 1&2)

Discussion :-

Decomposition of litter and mineralization of nutrients strongly influence soil nutrient availability and ultimately ecosystem primary productivity. Disturbances, which alter decomposition and other soil process, can allow nutrient losses and a decline in site productivity [8-13]. The study of microhabitat development and successional changes in soil organism communities during the break down and decomposition or organic materials in the soil could provide useful information towards an understanding of the large system. Successional occurrence of the soil microflora on leaves has been demonstrated in a number of studies [9-11,14-17] but there have been few investigations of the soil fauna associated with decomposing leaf litter. The present study attempted to analysis soil microarthropods population extracted from mangrove litters under the process of decomposition over a interval period of 3 months throughout one year to investigate the successional development of soil microarthropods population, structure and tropic relationships of soil microarthropods communities of *Rhizophora mucronata litter* during different phases of decomposition**.** Leaf breakdown is defined as weight loss due to physical fragmentation (Caused by abiotic factors), animal feeding, microbial activity and leaching [12-13,18-21] reported that during decomposition processes, biological attack was most important, as a large variety of micro flora and fauna were involved in it .To understand the mechanism of this process, it was therefore necessary to evaluate the role of the important groups of organisms, their succession and their natural influences, [14,22-25] recognized the importance of soil animals in transforming plant remains into humus. Leaf breakdown plays a key role in ecosystem function, species richness of leaf litter may be important in determining the nature of relationships between biodiversity and ecosystem properties [15,26-29] The initial rapid weight loss rate were most likely due to the fast release of non-structural carbohydrates such as sugars and starches (dissolved organic materials) easily utilised by microbes [16-17,30] which subsequently colonised and initiated the breakdown of leaf material . Soil microarthropods like Collembola ,Acarina, Coleoptera ,Amphipods, nematodes, turbellarians, isopods were found to colonies in decomposed litterbags. Some of the soil microarthropods were the dominant group suggesting that they were relatively more important in enhancing litter breakdown.

The present work incorporated the study of enclosed selected mangrove *(Rhizophora mucronata)* litter in nylon mesh bags and an attempt to relate the activity of soil microarthropods over the season to the loss of litter weight during different phases of decomposition. The most of the abundant organisms in dry funnel extracts of decompose selected mangrove plant litter have been Collembola and Acarina and in most studies they are referred to as litter microathropods [18]. However, most of the other groups as included in the present study in addition to these two, came under the broad definition of this. The present investigation incorporated a detailed study of these microarthropods in relation to selected mangrove litter decomposition as the 6-mm^2 mesh size of the nylon bags were used.

Maximum decomposition was recorded in 12 months and that of minimum was estimated during 3 months of decomposition periods. Maximum faunal occurrence was observed during 6 months of decomposition phase whereas minimum faunal components were noted during 3 months decomposition phases. Maximum relative abundance of Collembola was recorded on 3 months; Acarina on 6th months; Coleoptera on 9th months and Isopoda on 12th months of the decomposition. Maximum values of organic carbon, N, P, K. were recorded during 6th month decomposition phases (Fig 2-3).

The dynamic activity of soil microarthropods during different phases of decomposition were varied. The litter gets primarily broken down by Collembola and this partially decomposed litter gets acted upon by Acarina followed by Coleoptera,Diptera,Hymenoptera and others.

Maximum number of total microarthropods occurred during the 6 months of decomposition phases, when organic carbon, N, P, K values also maximum yet, pH and salinity did not seen to play any role and the possible reason may be due to the minute range of fluctuation in litter bags (Table-1-2). However, it was seen that the organic carbon, N, P, K, in all the litter bags of *Rhizophora mucronata* plant's litters displayed significant positive relationship with the soil microarthropods which corroborated the findings of Gulis and Suberkropp, 2003 [19] , Hence the organic carbon, N, P, K, after leaching out from the litter, seemed to play a greater role in the regulation of microarthropods population. Correlation coefficient analysis between Collembola and ecological factors like N. P, K and organic carbon, showed significant positive correlation in most of the *Rhizophora mucronata* litter's decomposition in different sites.

The present study revealed that though there was a succession of population in microarthropods, their role differed either individually or conjointly in litter decomposition. However, Harding and Stuttard [20] were opined that metabolism, chemical decomposition of litter and microarthropods were less important compared with microflora . In the present study appearance and steady increase of Acarina, Collembola and Coleoptera population were found during the 1st phase of decomposition. On the second phase of decomposition, gradually different groups of microarthropods *viz.* Acarina, Collembola, Coleoptera appeared and also displayed increasing trend in their population while Hymenoptera and other microarthropods started to record their appearance in the last phase of decomposition process. In the 3rd phase, the population density of Acarina, Collembola and Coleoptera showed declining trend while the population density of Hymenoptera, Isopoda and other microarthropods revealed an opposite trend. In the last phase, the population density of Acarina, Collembola and Coleoptera totally dwindled with the recording of maximum density of Isopoda and other microarthropods (Fig 2-3). Overall findings of this study emphasizes that the different groups of soil microarthropods not only plays important role in litter decomposition simultaneously, they also plays important role in the nutrient cycling in the coastal environment of Purba Medinipur coastal area, West Bengal, India .

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