Biodegradation of Organic Matter in Sea Water

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Received 1 December 1977

Biodegradation of 3 different biological materials (Trichodesmium erythraeum, Lucifer and mixed plankton) was studied to estimate their rate and extent of decomposition in surface sea water under controlled laboratory conditions. Rate of decomposition during the first 20 days was approximated by the 1st order Kinetics. Rate constants for the degradation suggested that there were 3 stages in the microbial decomposition and that 2 labile organic fractions and a refractory organic fraction could be identified. Approximately, 15-20% of the initial dissolved organic matter (DOM; fraction F1) was oxidized. The other labile fraction F2 was about 30-45% of the total DOM. The refractory portion was about 40%, and it was resistant to biological oxidation. Rate constant for F1 of T. erythraeum was 0.0331 day⁻¹ and of Lucifer was 0.0723 day⁻¹ and for mixed plankton, it was 0.1188 day⁻¹.

Primary sources of energy of the coastal aquatic ecosystem are available at the producer-decomposer level. Number of dynamic and interacting environmental parameters influence this basic trophic level and control the development and optimization of energy flow. Higher components of the system such as predators, influence production rates within the system with their own variable populations and production dynamics.

Autotrophic productivity and related heterotrophic utilization of organic compounds are greatly influenced by the trace but highly dynamic pool of labile organic substrates. Free amino acids and other growth factors such as vitamins occur in exceedingly low concentrations in sea water but may undergo rapid utilization and synthesis. Degraded hydrolytic products of proteins, carbohydrates and fatty acids generally occur in large quantities within the DOM (dissolved organic matter) pool. In spite of low concentrations, these organic compounds are of major functional and ecological significance for the metabolism of the ecosystem.
Riley has pointed out that major portion of DOM in the open ocean is derived ultimately from phytoplankton in the surface layer. If the allochthonous addition of DOM in estuaries and inshore waters is considered to be of local importance, the major input to the labile fraction of the pelagic pool is from bacterial degradation of plankton and autolysis. The present preliminary report deals with the decomposition of 3 plankton materials during incubation under controlled laboratory conditions.

Trichodesmium erythraeum (a blue green alga), Lucifer (a zooplankton form) and mixed plankton were used for decomposition experiments. The materials (about 100 mg) desiccated by freeze drying were suspended separately in 5l fresh surface sea water which was coarse filtered. After mixing well, the suspension was taken in 300 ml sterile oxygen bottles which were sealed securely and incubated at 28°C in the dark.

After selected intervals, the materials were analysed for total nitrogen content in each plankton material, total dissolved organic nitrogen and other inorganic nitrogen compounds by standard procedures. Dissolved oxygen was estimated by Winkler method. pH was also monitored. Glass fibre filters with 0.45 pore size were used for collecting the particulate organic matter.

Rate of decomposition of nitrogen in the experimental material during initial stage has been shown in Fig. 1. The log N0/No-x was plotted against time in days to present the rate of decomposition where No stands for the initial concentration of total particulate nitrogen and No-x is the particulate organic nitrogen in the residual material (detritus and microbes). Log value of the ratio of total particulate nitrogen (TPN) and the total residual nitrogen has been considered as the rate constant of decomposition. The linear relationship during the first 20 days indicate that the decomposition of nitrogen from the cells could be approximated by the first order kinetics, as suggested by Grill and Richards.

Decay constants for the total organic nitrogen in different plankton material are given in Table 1. The rate constant K1 for the mixed plankton was relatively high compared to the other 2 organic materials. Decay constant K2 for the decomposition of mixed plankton was also high but that for the other two organic materials, it was more or less the same. Though the rate constants for the labile fractions varied for each biological material in the initial stages of decomposition, they were more or less constant for the decomposition of refractory organic constituent for all the 3 plankton materials and K5 determined were very low.

From the rate constants for the decomposition, it could be suggested that there are 3 stages in the microbial decomposition of marine plankton, viz. (i) very quick decomposition of soluble organic compounds, (ii) relatively rapid decomposition of labile organic constituent and (iii) very slow rate of decomposition of refractory material. Altogether, there are 2 labile and 1 refractory organic constituents. It is found that approximately 15-20% of the initial organic matter (fraction 1) is oxidized within 10 days. The other labile fraction F1 is about 30-45%. The refractory portion is about 40% and it is resistant to biological oxidation.

The observations are consistent with those of Grill and Richards for total organic phosphorus, of Ogura for dissolved organic carbon and of Otsuki and Hanya for dissolved organic nitrogen. Grill and Richards developed a mechanism from Kinetic considerations of phosphorus remineralization consisting of a simple 1st order chain process and showed that during the decomposition of diatoms, 2 labile organic fractions and a refractory organic fraction were present. DOM in surface sea water was described by Ogura in terms of 2 labile fractions, F1 and F11 and refractory one F111. He found that F1 ranged from 10-20% of the total DOM and was utilized within the first 50 days. F11 was 30-40% of the total DOM and F111 50-60% of the total DOM was not easily available for microorganisms.

Three different linear relations of the rate of decomposition with the time in the initial stages and their slopes (Fig. 1) indicate different rates of decomposition under laboratory conditions. In all the 3 experiments, linear lines do not pass through the origin. This was also observed by Otsuki and Hanya who explained that some organic compounds in the algal cells were made water soluble when the cells were killed by lyophilization. They used freeze dried biological material to avoid damage to the organic components but found that the loss of DOM from the cells to the medium, could arise

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**Table 1** — Decay Constants for Total Organic Nitrogen in Decomposition of Different Biological Materials at Room Temperature

<table>
<thead>
<tr>
<th>Material</th>
<th>Period (days)</th>
<th>K1 day⁻¹</th>
<th>Period (days)</th>
<th>K2 day⁻¹</th>
<th>Period (days)</th>
<th>K5 day⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T. erythraeum</strong></td>
<td>0-9</td>
<td>0.0331</td>
<td>9-19</td>
<td>0.0221</td>
<td>19-136</td>
<td>0.0036</td>
</tr>
<tr>
<td>Lucifer</td>
<td>0-9</td>
<td>0.0723</td>
<td>9-19</td>
<td>0.029</td>
<td>19-136</td>
<td>0.0032</td>
</tr>
<tr>
<td>Mixed plankton</td>
<td>0-6</td>
<td>0.1188</td>
<td>6-15</td>
<td>0.041</td>
<td>13-136</td>
<td>0.0035</td>
</tr>
</tbody>
</table>

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by this treatment also. In the present study also, the plankton materials used were hard frozen immediately after collection.

Rate constant for decomposition of dead plankton at 25°C was given as 0.044 - 0.114 day^{-1} for total organic nitrogen by Skopintsev9. Two labile organic fractions and a refractory fraction (K_1 = 0.0380, K_2 = 0.381 and K_3 = 0.0174 day^{-1}) were found by Grill and Richards\(^\text{6}\) in experiments on decomposition of diatoms. Otsuki\(^\text{10}\) found that microbial degradation of dead Scenedesmus cells was at a rate of 0.0296 day^{-1} for organic carbon and 0.0156 day^{-1} for the first 13 days and 0.045 day^{-1} (K_2) thereafter. However, a very low rate constant for the decomposition of DOC in surface water (0.003 - 0.005 day^{-1}) was observed by Ogura\(^\text{2}\) and it was lowered by 2 orders of magnitude that was found during the initial stages of the incubation experiment.

Rate constants found in the present experiments agree well with those of Skopintsev\(^\text{9}\), Grill and Richards\(^\text{6}\) and Ogura\(^\text{2}\). It is worth while to mention that biological processes cannot be expected to follow kinetic laws precisely but that the experimental observations were reconstructed as suggested by Grill and Richards\(^\text{6}\) assuming that decomposition proceeds as simple 1st order chain reactions.

Fractions F_1 and F_II may serve as food for microorganisms, but F_III (about 40% of total organic matter) may not be available to the food cycle and it may, however, be transformed into an oxidizable form at the interface of solids such as particulate matter in sea water\(^\text{12}\). Keys et al.\(^\text{13}\) found that only 10 - 15% of the total DOM was oxidized after several days at 21°C. Barber\(^\text{14}\) observed that about 50% of the concentrated DOM in surface sea water was oxidized in 30 days and that no change was observed in the amount of DOC in concentrates of deep sea water even after 1 or 2 months. Skopintsev et al.\(^\text{15}\) found that residual 20 - 30% of organic matter was refractory and decomposed only at slow rate. However, residual carbon in the particulate matter ranged between 43 - 84% in surface water\(^\text{16}\).

The author thanks Drs R. Natarajan and V. K. Venugopalan, CAS in Marine Biology, Porto Novo, for facilities and suggestions. Thanks are also due to Dr S. Z. Qasim, Director, for his interest and encouragement. Financial assistance from CSIR, New Delhi, is gratefully acknowledged.

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## References


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**Studies on the Diatom Amphora coffeaeformis**

Agardh: Salinity Changes on Growth & Auxospore Formation*

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Received 29 August 1977; revised received 15 December 1977

A. coffeaeformis, one of the dominant diatoms occurring throughout a 2-year period of investigation in the Adyar estuary is usually abundant in waters of intermediate salinities. Laboratory studies on several isolates of A. coffeaeformis from this estuary confirm this behaviour. The diatom does not grow very well in fresh water (Reinmann medium with no chlorides) but prefers a medium with low chloride (NaCl) levels. When the chloride content is too high growth of the diatom declines. According to the classification of euryhaline diatoms proposed by Desikachary and Rao [J. mar. Biol. Ass. India, 14 (1972), 524] A. coffeaeformis is meso-euryvalent in its behaviour though it occurs in a wide range of salinity conditions.

HYDROBIOLOGICAL studies of the Adyar estuary in Madras revealed that Amphora coffeaeformis was one of the dominant diatoms occurring throughout the period of investigation even when the salinity of the waters showed wide fluctuations\(^\text{4}\). Abundance of A. coffeaeformis under similar conditions was also reported in river Cooum that runs very close by\(^\text{2}\). Laboratory and field observations indicated that salinity variations besides other uninvestigated hydrological factors seemed to influence abundance of Cylindroella meneghiniana\(^\text{3}\) in the same estuary. It is possible that the ability of A. coffeaeformis to tolerate fluctuating salinities might be one of the causes of its continued presence in the Adyar estuary. The behaviour of A. coffeaeformis to changes in salinity of the culture medium was studied in the laboratory with a view to understanding its occurrence and abundance in the estuary.

A. coffeaeformis did not reach the same abundance as C. meneghiniana in the 3 sites of the estuary selected for the study, the maximum reached being only 50% of the total diatom count. But whenever it had shown some abundance (30-40 thousands/ml and above 30% of the total diatom count) the waters

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*Paper forms Part I of the series.

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