The nature of particulate organic matter settled on solid substrata

Madhumati O. SHARMA, Arun B. WAGH
National Institute of Oceanography, Dona Paula, Goa, 403004, India.

Received 25/01/90, in revised form 16/02/90, accepted 22/03/90.

ABSTRACT
Particulate material settled on aluminium and glass panels during their immersion in estuarine water was analysed for bacteria, chlorophyll a, dry weight and various organic constituents such as organic matter, organic carbon, nitrogen, proteins, carbohydrates and lipids. There was no apparent difference in the composition of the organic matter or in the concentrations of the particulate material recovered from these two surfaces. Highly significant correlations were observed between the bacterial numbers and the measured parameters. This probably suggests that bacteria were the major source of the particulate matter settled on these substrata.


INTRODUCTION
Solid substrata placed in an aquatic environment adsorb organic molecules from the ambient waters onto their surfaces, making them readily available to organisms present in the environment (Zobell, 1943; Marshall, 1981). This adsorption of organic molecules is, however, a selective process and not all organic entities present in seawater are adsorbed on a given surface (Little, Zsolnay, 1983). In natural environments, however, all exposed surfaces rapidly adsorb a proteinaceous film (Horbett, 1982). Besides glycoproteins (Baier, 1980) and humic acids, macromolecules have also been implicated as the conditioning agents which may help in the subsequent attachment of organisms to surfaces (Zutic, Tomaic, 1988). The complex organic layer formed is reported to initiate fouling of exposed structures (Daniel, 1955; Loeb, Neihoff, 1977; Characklis and Escher, 1988). The deleterious phenomenon of fouling thus seems to be significantly influenced both qualitatively and quantitatively by the adsorbed organic matter.

There are several instances wherein adsorbed material has been characterized either biologically or chemically, (Paul, Loeb, 1983; White, Bensen, 1984 and Paul et al., 1985). For example, adsorbed material has been utilized to study bacteria, diatoms and other microscopic organisms; while the fatty-acid composition of settled particulate material has been used to define microbial community structure of a microfouling layer (White et al., 1979a; b; Morrison, White, 1980). However, no particular attempt has been made to understand the nature of the particulate material present on surfaces. Therefore, in the present paper, we analysed the particulate material from solid substrate for its biological and chemical components. A possible correlation between the particulate material and the biological components, especially bacteria and chlorophyll a, was also been sought in order to determine the nature of the settled particulate organic matter.
MATERIAL AND METHOD

The study was carried out at a station in the Mandovi estuary (15°30'N, 73°52'E). The water depth at the sampling station is about 4 m.

Test panels of aluminium and glass were cleaned with hydrochloric and chromic acids respectively (Cameron, Robinson, 1968; Bhosle et al., 1989). Replicate panels (5) were deployed in the surface waters (~1) of the Mandovi estuary, during June 1988, as described earlier (Sharma et al., 1989). Panels were retrieved after 10 days of exposure and transported to the laboratory in an ice box containing estuarine water. Panels were scraped under sterile condition, using a nylon brush and filtered (0.2 μm), sterile esturine water (FSEW) (Sharma et al., 1989). The volume was adjusted to 125 ml. Aliquots (10 ml) were filtered through preig- nited (450°C, 3 h) GF/C filters which were analysed for chlorophyll a and various organic parameters as described earlier (Sharma et al., 1989). One ml each was taken for viable and total bacterial counts.

Analyses

Viable counts by pour-plate method were made using Zobell’s-Marine Agar (No. 2216) and the colonies were counted after incubating the plates for 72 h at room temperature (28±2°C). The Acridine Orange Direct Count (AODC) method as described by Parsons et al. (1984) was employed for total counts of bacteria.

Dry weight of the organic matter was obtained by reweighing the GF/C filter on the microbalance (Mettler M-3). Particulate organic carbon (POC), lipids and chlorophyll a were estimated as described by Parsons et al. (1984). The method of Smart et al. (1983) was used for the estimation of organic nitrogen. Carbohydrates were determined by the method of Dubois et al. (1956). Proteins were analysed following the method of Clayton et al. (1988).

RESULTS AND DISCUSSION

The biomass of settled particulate material has been estimated by various methods (Holm Hansen, 1969; Hobbie et al., 1977; White et al., 1979a; Moriarity, 1980; Paul et al., 1985; Balkwill et al., 1988). We used dry weight and particulate organic carbon (POC) and nitrogen (PON) as they provided highly consistent set of data (Bhosle et al., 1989; Sharma et al., 1989).

The values for dry weight, particulate organic carbon and nitrogen obtained from the two test surfaces were more or less identical (Table 1). Nor did biochemical composition of the particulate material developed on these substrata show any appreciable difference (Table 2). The contribution of proteins, carbohydrates and lipid carbon towards the total carbon content was also nearly the same (Table 2). Values for chlorophyll a and bacteria (total and viable counts) on either surface were also comparable (Table 1).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Aluminium</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry weight (mg/plate)</td>
<td>4.77 ± 0.008 (1.68%)</td>
<td>4.20 ± 0.015 (3.5%)</td>
</tr>
<tr>
<td>Organic matter (μg/plate)</td>
<td>154 ± 130 (0.61%)</td>
<td>1072 ± 101 (9.46%)</td>
</tr>
<tr>
<td>POC (mg/plate)</td>
<td>677 ± 65.13 (9.62%)</td>
<td>536 ± 50.1 (9.42%)</td>
</tr>
<tr>
<td>PON (mg/plate)</td>
<td>192 ± 8.80 (4.58%)</td>
<td>178 ± 3.2 (1.80%)</td>
</tr>
<tr>
<td>C/N ratio (atomic)</td>
<td>4.1 ± 0.20 (5.09%)</td>
<td>3.5 ± 0.35 (10.0%)</td>
</tr>
<tr>
<td>Total counts</td>
<td>14.2 x 10 ± 0.98 (6.9%)</td>
<td>15.1 x 10 ± 0.85 (6.5%)</td>
</tr>
<tr>
<td>Viable counts</td>
<td>5.4 x 10 ± 0.14 (2.5%)</td>
<td>6.1 x 10 ± 0.17 (2.7%)</td>
</tr>
</tbody>
</table>

* = μg/plate; ** = μm/plate.

Diatoms and bacteria have been recognized as the primary biological components of the settled material and early colonizers of surfaces placed in aquatic environments (Characklis, 1973; Corpe, 1980; Marshall, 1981a; Cooksey, 1981). A preliminary microscopic observation of the obtained material revealed a very low number of diatoms during the present investigation, probably suggesting their minimal contribution towards the particulate matter settled on these substrata. This is also evident from the low values for pigments (0.003-0.004 μg/plate) and their poor correlation with all the other components analysed (Table 3). Bacteria were present in large numbers both as total and viable counts on the two surfaces (Table 1). A very significant correlation was shown by the bacterial numbers with the various components of the settled material (Table 3).

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Aluminium</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (μg/plate)</td>
<td>453 ± 76.9</td>
<td>332 ± 5.6</td>
</tr>
<tr>
<td>Carbohydrates (μg/plate)</td>
<td>31.77 ± 5.4</td>
<td>38.45 ± 5.6</td>
</tr>
<tr>
<td>Lipids (μg/plate)</td>
<td>36.5 ± 6.5</td>
<td>35.7 ± 5.0</td>
</tr>
</tbody>
</table>

a=μg/plate; b=% of organic matter; c=contribution as % of carbon; Values in parentheses denote coefficient of variation.
particulate material on weight, organic carbon, nitrogen and biochemical components of settled particulate material on solid substrata.

<table>
<thead>
<tr>
<th></th>
<th>Chlorophyll</th>
<th>Bacterial counts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>Viable</td>
</tr>
<tr>
<td>Dry Weight</td>
<td>0.155</td>
<td>0.993</td>
</tr>
<tr>
<td>POC</td>
<td>0.043</td>
<td>0.092</td>
</tr>
<tr>
<td>PON</td>
<td>0.234</td>
<td>0.984</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>0.205</td>
<td>0.976</td>
</tr>
<tr>
<td>Proteins</td>
<td>0.345</td>
<td>0.725</td>
</tr>
<tr>
<td>Lipids</td>
<td>0.530</td>
<td>0.900</td>
</tr>
<tr>
<td>Chlorophyll a</td>
<td>~</td>
<td>0.193</td>
</tr>
</tbody>
</table>

Thus, from the total and viable count as well as the microscopic examination of the settled particulate matter, it appears that bacteria and not the diatoms were the dominant initial colonisers on these substrata and hence also the possible major contributors the organic matter obtained from these surfaces.

**Table 3**

THE NATURE OF PARTICULATE ORGANIC MATTER

The C/N ratio is an important indicator of the origin of organic matter in the marine environment (Trask, 1955; Pocklington, Leonard, 1979). The obtained C/N ratios were low and ranged between 3.5 and 4.1. These values are similar to those reported for bacteria (Luria, 1960; Lipinsky, Litchfield, 1970; Fenchel, Blackburn, 1979; Cuhel et al., 1982; Linley, Newell, 1984) and support the earlier conclusion that the settled material originated mainly from bacteria.

In summary, it may be concluded that the particulate material settled on these substrata was of bacterial origin.

**Acknowledgements**

The authors are grateful to Dr. B. N. Desai, Director, N.I.O., for his constant encouragement. Thanks are due to Dr. N. B. Bhosle, Scientist, N.I.O., for suggesting the problem and his valuable comments during the preparation of the manuscript. We also thank the authorities of the River Navigation Department, Govt. of Goa, for permitting the use of their jetty for carrying out the present work.

**REFERENCES**


