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The effect of sewage on the distribution and cover of littoral algae near Reykjavík

Preliminary results

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ABSTRACT: The effect of domestic sewage, in the vicinity of Reykjavík, on the distribution and cover of littoral algae, is described on the basis of measurements made in the autumn of 1976, along 5 transects adjacent to the sewage outfall. The results reveal that fewer species and less cover occur close to the outfall than farther away. Conspicuous species form zones that differ between individual transects investigated.

Fucus distichus grows exclusively at the outlet, while *Pelvetia canaliculata, Sphacelaria radicans, Ascophyllum nodosum, Polysiphonia lanosa* and *Elachista fucicola* grow better or solely away from it.

INTRODUCTION

Since 1975 an extensive environmental research programme has been carried out in the near-shore area in the vicinity of Reykjavík. The programme includes biological, chemical and physical investigations of the marine environment. The present paper describes the preliminary results of one aspect of this programme, viz. the effect of domestic sewage on the distribution and cover of littoral algae.

The sewage outfall studied is located south of Seltjarnarnes (Fig. 1). The amount of sewage is 160 m^3 per day discharged on the shore, at about 60 cm above the mean low water level at spring tide (MLWS) and is of domestic origin (Isotopcentralen, 1971). The adjacent beach has a direction NW-SE. It is a flat, rocky shore, homogeneous in structure, and with a relatively even slope. It is sheltered by Suðurnes in the west and Löngusker in the south (Fig. 1).

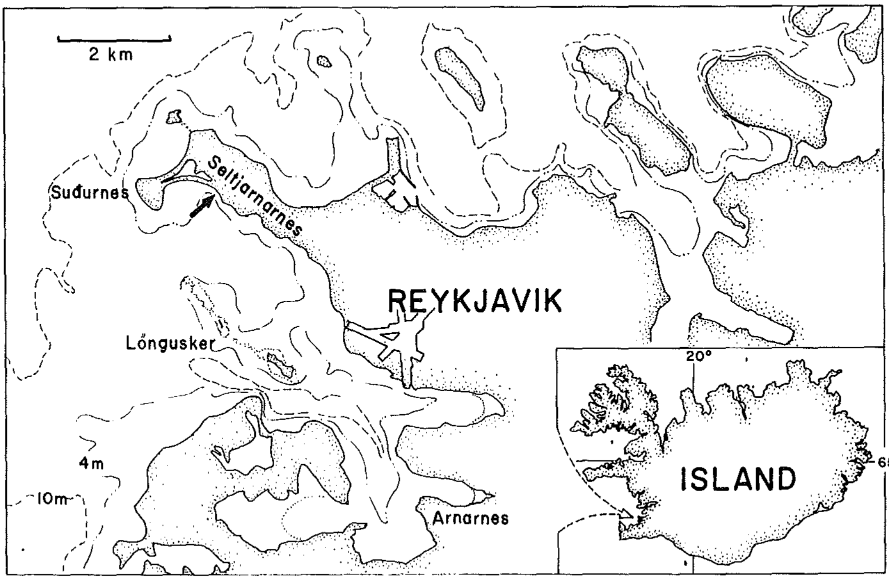

Fig. 1. The location of the area studies. The point of discharge is indicated by an arrow.

As far as is known by the authors no previous studies have been conducted on the effect of sewage on shore life in Iceland.

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MATERIALS AND METHODS

Measurements were made in the autumn of 1976 between September 23 and October 26 on 5 transects at 5, 45, 85, 125 and 165 m distance from the sewage outlet (Fig. 2). On each transect the algae within 14-16 rectangles measuring 50 x 100 cm were investigated at low tide. The difference in height between rectangles was 25 cm on all transects.

Each rectangle was divided into two equal parts and the algal cover in each half estimated independently by two persons. The accuracy of the cover estimated was found to be ± 5%, and hence the estimates were reported to the nearest 5%. Species found inside the frames but with no reported cover were each arbitrarily assigned a cover value of 0.5%. The species encountered were either recorded in the field or collected for late identification.

Only Rhodophyceae, Phaeophyceae and Chlorophyceae were considered. The taxonomic system is that used by S. JÓNSSON and B. CARAM (1972) except for *Lola implexa* and *Rhodymenia palmata*, here called *Chaetomorpha capillaris* (CHRISTENSEN, 1975) and *Palmaria palmata* (GUIRY, 1974) respectively. Crustose corallines are treated as a single taxonomic unit (Corallinaceae).

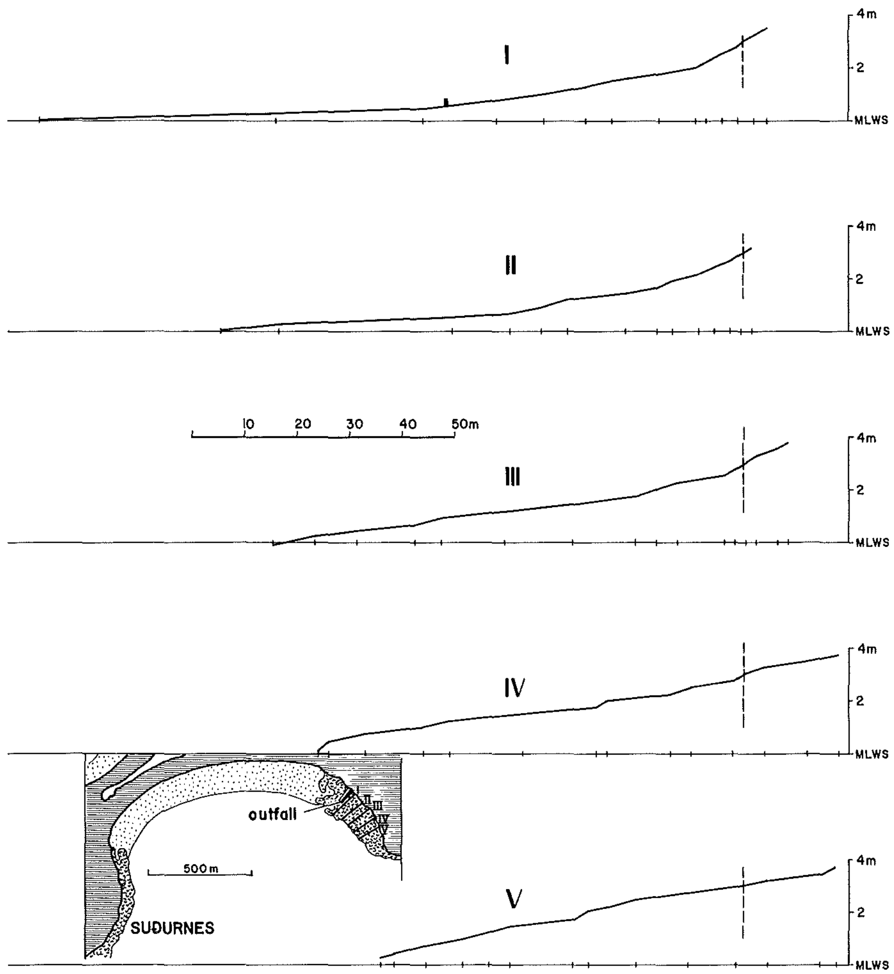

Fig. 2. Profiles of the shore at transects I-V. Inset figure shows the location of the transects in relation to the outfall and Suður-nes. MLWS = mean low water at spring tide.

RESULTS

a. Distribution

In this paper, only the 41 species found inside the frames are considered. Fewer species were found on the two transects closest to the outfall than on the other three (Table 1). *Ulothrix flacca, U. pseudoflacca* and *Prasiola stipitata* were found exclusively on transect I. *Fucus distichus* also proved to grow solely close to the outfall. The same tendency was seen in the distribution

TABLE I. Frequency (%) of each species within the quadrants of transects I-V.

	I	II	III	IV	V
Rhodochorton purpureum	20	29	44	53	53
Ahnfeltia plicata				7	7
Chondrus crispus	40	50	69	60	73
Gigartina stellata			6	7	
Hildenbrandia prototypus	53	36	75	73	87
Corallina officinalis	13	14	19	27	20
Corallinaceae	7	29	56	60	67
Halosaccion ramentaceum		36	45	53	33
Palmaria palmata		21	31	40	13
Ceramium rubrum	13	21	25	27	20
C. deslongchampsii			6	7	
Aglaothamnion scopulorum				7	
Polysiphonia lanosa		7	31	40	33
P. urceolata		7	13	7	7
Porphyra umbilicalis	27		13	7	
Pylaiella littoralis				7	7
Sphacelaria radicans			31	40	20
S. britannica	7		6		
Ralfsia verrucosa	40	29	19	7	13
Elachista fucicola		7	19	27	27
Chordaria flagelliformis	20	14	6	13	
Laminaria sp.	13	7	13	13	
Ascophyllum nodosum	33	14	50	53	40
Fucus distichus	47	43	6		
F. serratus	40	43	45	53	47
F. vesiculosus	33	21	31	33	20
F. spiralis	27	14	31	33	27
Pelvetia canaliculata				13	20
Chlorochytrium dermatocolax			13	20	
Prasiola stipitata	7				
Ulothrix flacca	7				
U. pseudoflacca	7				
Blidingia minima	7				7
Enteromorpha intestinalis				13	
E. prolifera		7	6	7	7
Ulva lactuca	20	36	45	60	53
Ulvaria obscura	20	36	37	33	40
Acrosiphonia sp.			6		
Chaetomorpha capillaris			6	7	7
C. melagonium	7	7	19	20	20
Cladophora rupestris	7				27
Number of species	24	23	31	33	27
Number of quadrants	15	14	16	15	15
Total number of species 41					

of *Porphyra umbilicalis* and *Ralfsia verrucosa*. "Species" having lower frequency of occurrence near the point of discharge were *Pelvetia canaliculata*, *Cladophora rupestris*, *Sphacelaria radicans*, *Polysiphonia lanosa*, *Elachista fucicola*, Corallinaceae and *Chaeto-*

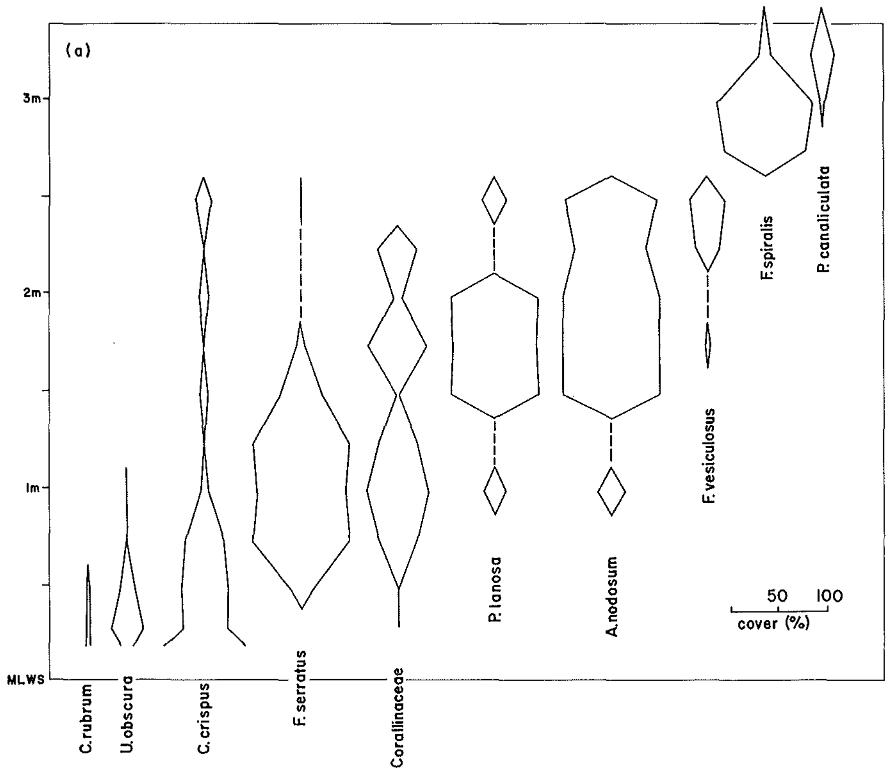

Fig. 3. Algal cover in relation to height on the shore, transect V. Height figures correspond to meters above mean low water at spring tide (MLWS).

morpha melagonium (Table 1). Analogous, although less distinct, was the distribution of *Ulva lactuca, Rhodochorton purpureum, Chondrus crispus, Hildenbrandia prototypus* and *Ascophyllum nodosum.*

b. Cover

On transect V the most conspicuous species formed the following zones proceeding downwards (see Fig. 3). 1. *Pelvetia canaliculata,* 2. *Fucus spiralis,* 3. *Ascophyllum nodosum / Fucus vesiculosus,* 4. *Ascophyllum nodosum / Polysiphonia lanosa,* 5. *Fucus serratus,* 6. *Chondrus crispus / Ulvaria obscura / Ceramium rubrum.* On transect I the zonation was modified as follows (Fig. 4).

1. *Ulothrix flacca / U. pseudoflacca,* 2. *Fucus spiralis,* 3. *Fucus vesiculosus,* 4. *Fucus distichus,* 5. *Fucus serratus,* 6. *Chondrus crispus / Ulvaria obscura / Ceramium rubrum.*

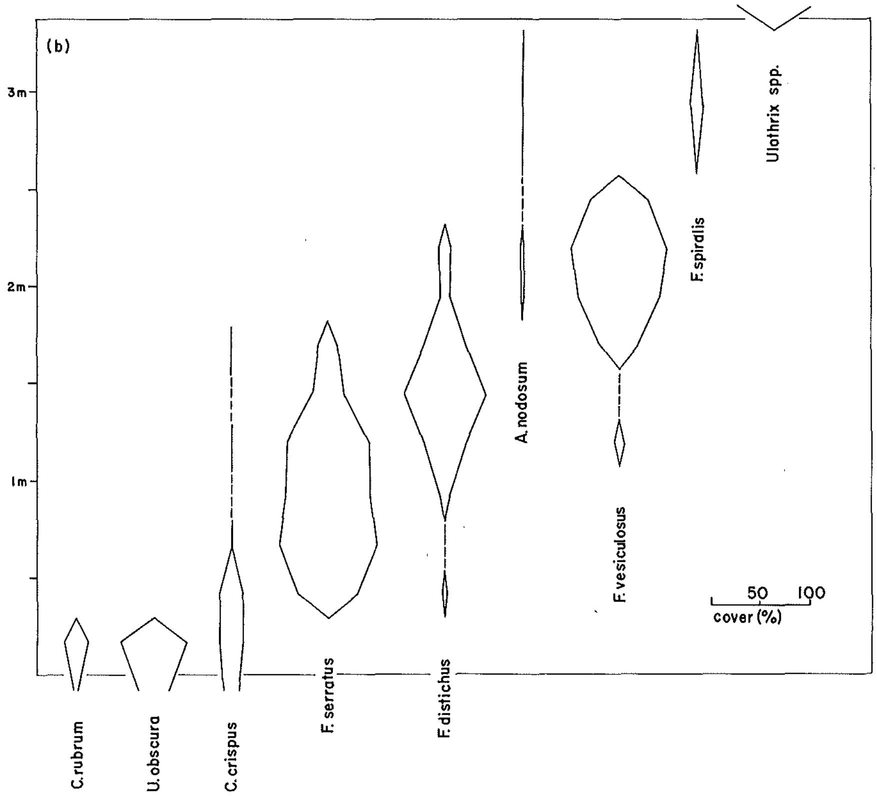

Fig. 4. Algal cover in relation to height on the shore, transect I. Height figures correspond to meters above mean low water at spring tide (MLWS).

It will be seen that the two lowest zones had very much the same composition on all transects whilst other zones differed more or less between individual transects. Instead of the *A. nodosum / P. lanosa* zone on transect V, there was a *F. distichus* zone at the same height close to the outlet. At the same level as the *A. nodosum / Fucus vesiculosus* zone on transect V there was a *F. vesiculosus* zone on transect I. The *P. canaliculata* zone on transect IV and V was absent on transects I-III. A *U. flacca / U. pseudoflacca* zone was found somewhat higher (~ 30 cm) on transect I than *P. canaliculata* on transects IV and V.

Fucus spiralis and Corallinaceae showed a gradual decrease in cover from transect V to I (Fig. 5). *Ascophyllum nodosum* and *Polysiphonia lanosa* had a notable cover on the transects farthest away from the outfall but little or no cover on transects I and II. The opposite was true for *Fucus distichus*. In general there was

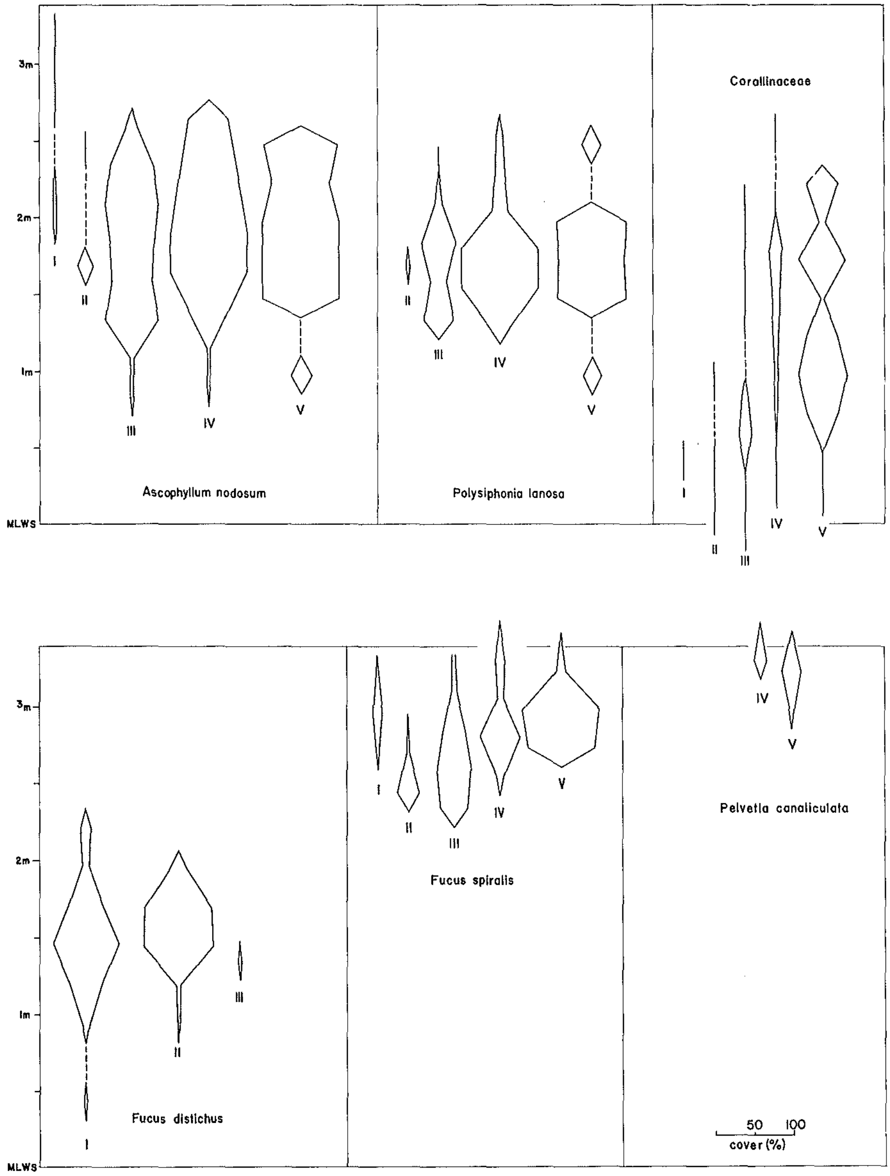

Fig. 5. Comparison between the cover of 6 selected algal species, on different transects shown as function of height above mean low water at spring tide (MLWS). Transect I is closest to the outlet.

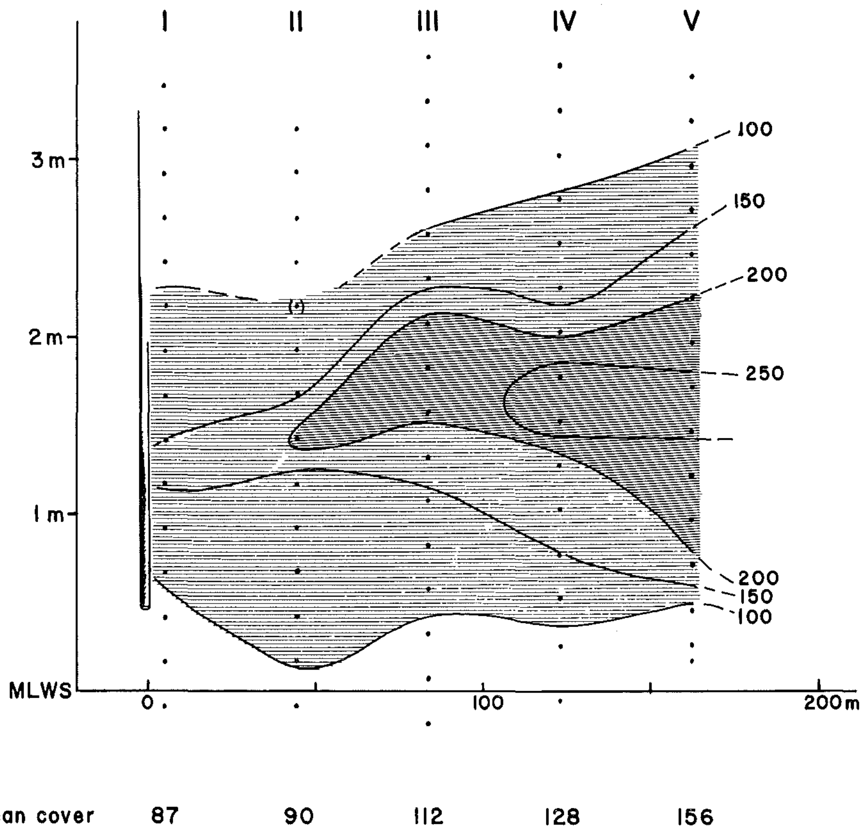

Fig. 6. Total cover of algae in relation to height on the shore and distance from the outfall. MLWS = mean low water at spring tide.

a marked decrease in algal cover from transect V to I, this being most pronounced at about 50-80 m distance from the point of discharge (Fig. 5 and 6). The cover was greatest in the middle part of the shore with a maximum of 250-300% on transects IV and V.

DISCUSSION

The species most sensitive to the presence of the sewage outlet at Seltjarnarnes were *Pelvetia canaliculata*, *Cladophora rupestris*, *Elachista fucicola*, *Sphacelaria radicans*, *Polysiphonia lanosa* and *Chaetomorpha melagonium*. In addition *Ascophyllum nodosum* and *Fucus spiralis* showed a marked reduction in cover near the outfall. *P. canaliculata* was not found nearer the outfall than 110 m, but farther away *P. canaliculata* formed a conspicuous zone in the upper part of the shore. The species that seemed to thrive better in the presence of sewage were *Fucus distichus*, *Porphyra umbilicalis*, *Prasiola stipitata*, *Ulothrix flacca*, *U. pseudoflacca* and possibly *Ralfsia verrucosa*. In Norway a similar tendency has been reported for *A. nodosum* and *F. distichus* as at Seltjarnarnes, i.e. the *A. nodosum* zone (here mixed with *P. lanosa*) gives place to a zone of *F. distichus* at the outlet (GRENAGER 1957, RUENESS 1973 and BOKN 1975).

As found in Oslofjord, there were at Seltjarnarnes fewer species near the outfall than elsewhere (GRENAGER 1957). The same is true for polluted areas in S-California (LITTER and MURRAY 1975) and Sydney, Australia (BOROWITZKA 1972).

At Seltjarnarnes the algal cover was sparser near the outfall than elsewhere. The mean algal cover in the study area was 156% farthest from the outfall, but 87% close to it (Fig. 6). In southern California the corresponding figures are 103.4% and 91.7% respectively (LITTER and MURRAY 1975).

From the distribution and cover of algae in the vicinity of the sewer outlet at Seltjarnarnes it can be concluded, that a simpler community structure exists close to the outfall than farther off.

Clearly a number of variables may cause fluctuations in both algal composition and cover near sewage outfalls, such as lowering of salinity, increase in temperature, increased turbidity, increase in nutrient concentration etc. It is hoped that the relative importance of these environmental factors in relation to sewage outfall will be evaluated.

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