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AN OIL DISPERSANT'S EFFECT ON THE MICROFLORA OF BEACH SAND

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(Text-figs. 1–2)

The effects of 'Corexit 7664', an oil dispersant, alone and in combination with oil in sand columns were determined by oxygen uptake, ^{14}C uptake, and chlorophyll analysis. 'Corexit' was observed to have no obvious deleterious effects within the experimental system under the conditions of periodic and continuous additions ranging from 5×10^2 ppm to 10^5 ppm and in combination with Kuwait crude oil (1·2 kg oil/m² to 0·12 kg 'Corexit'/m²). No change was observed in chlorophyll or ^{14}C uptake. Heightened oxygen uptake was noted for continuous addition of 'Corexit' (0·060 ml. O_2 hr^{-1} cm^{-1}), for the oil control (0·090 ml. O_2 hr^{-1} cm^{-1}), and for oil plus 'Corexit' (0·059 ml. O_2 hr^{-1} cm^{-1}). Caloric content of the oil and oxygen uptake indicated an extended degradation period.

Oil pollution in marine waters has been a subject of growing concern and has stimulated a variety of pollution studies. Past methods of dealing with the problem have been mechanical, which are effective on land, and chemical which, in the past, have used highly toxic detergents, usually in open waters (Spooner, 1969).

Recently, the Enjay Chemical Company has introduced an oil dispersant, 'Corexit 7664'. Studies on various animals, including barnacles and mussels (Spooner, 1969), have indicated a low level of toxicity.

A study was initiated to determine the effects of 'Corexit', oil, and a 'Corexit' plus oil mixture on the microflora of beach sand. Analyses consisted of oxygen determinations with a Rank electrode, chlorophyll to phaeophytin ratios as an indication of the degradation of chlorophyll (Yentsch, 1963), and ^{14}C uptake determinations (Baird & Wetzel, 1968). The experimental system consisted of opaque Lucite tubes 10 cm in diameter, 45 cm long with water sampling stations at 15, 20, 30, and 40 cm (Fig. 1). The columns and operating procedures are similar to those described by McIntyre, Munro & Steele (1970) and Johnston (in print). Sand was collected at low tide at Nobska Beach, Woods Hole, Mass., and 25 cm of sand were placed in the tube. The mean particle diameter was 350 μ. Fresh, unfiltered sea water (29·7‰) was allowed to flow through the columns at 450 ml./h. The temperature was maintained at 20 °C, and oxygen determinations were performed approximately every 4 h. The oxygen uptake of the control column was subtracted from that of the experimental column to yield positive and minus values of

uptake in units of ml.O_2/h cm depth. This technique can be used to monitor the response to pollution of the microflora attached to the sand grains.

When subjected to 100 ml. of 'Corexit' at 5×10^2, $2{\cdot}5 \times 10^3$, 10^4, and 10^5 ppm (v:v; detergent:sea water), no deviation in oxygen uptake was noted. The experiments ran for 25, 25, 74, and 30 h respectively. The equality of variance was determined, and the appropriate T tests were run with the null hypothesis that the treatment effects for the control and experimental columns were equal. The null hypothesis was accepted for all experiments (α = 0·05). 100 ml. of 10^4 ppm common household detergent was added. Oxygen uptake dropped to zero for 12 h, after which the column returned to normal.

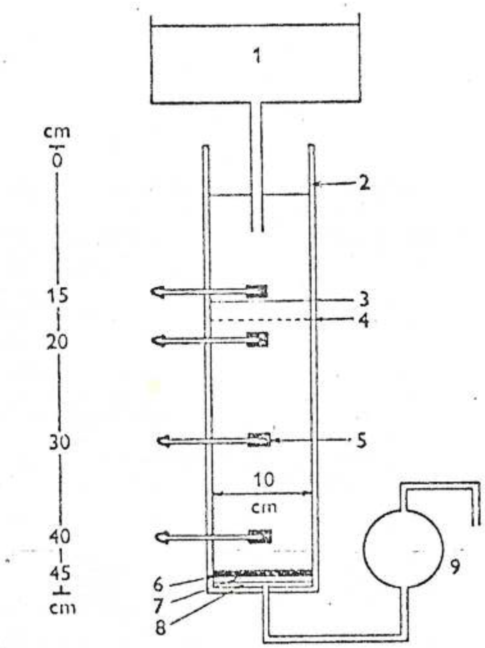

Fig. 1. A diagram of a sand column, in which the stippled area represents sand. 1. Reservoir of fresh unfiltered sea water. 2. 'Lucite' tube. 3. Surface of sand. 4. Site of oil addition. 5. 50 μ pore-size plastic sleeve. 6. Porous plastic disc. 7. Plastic mesh. 8. Water layer. 9. Peristaltic pump.

When subjected to a continuous flow of 10^4 ppm 'Corexit', oxygen uptake rose in excess of the control of 0·060 ml.O_2 h^{-1} cm^{-1} (Fig. 2A). The null hypothesis was rejected at the 0·01 level. When 10 ml. Kuwait crude oil (1·2 kg/m²) were added to a fresh column at a depth of 3 cm into the sand, an initial spike of activity occurred, followed by a 24 h inhibition period. The oxygen uptake then rose to 0·090 ml.O_2 h^{-1} cm^{-1} in excess of the control (Fig. 2B). Anaerobic conditions were observed at the lowest station. The null hypothesis was rejected at the 0·01 level for the comparisons of the control to

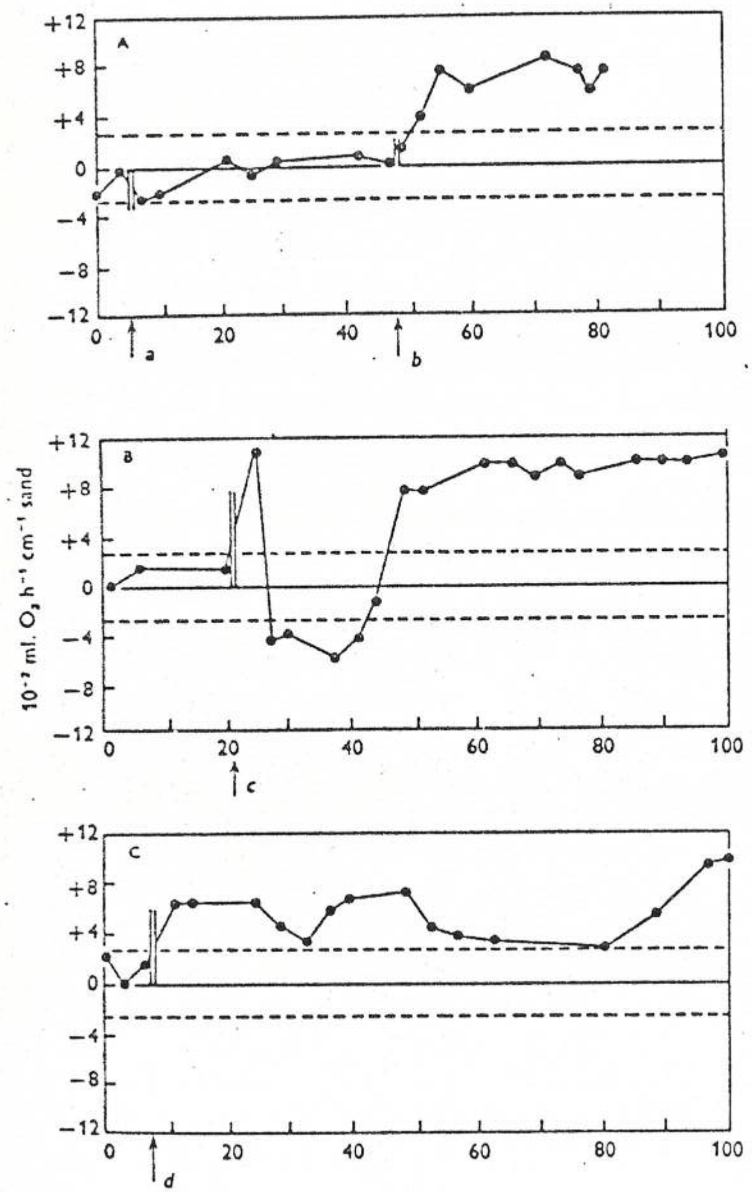

Fig. 2. Effects on oxygen uptake in sand columns by (A) constant input of 10^4 ppm 'Corexit', (B) 10 ml. Kuwait crude oil, and (C) 10 ml. oil plus 1 ml. 'Corexit'. Units expressed in 10^{-2} ml. $O_2 h^{-1} cm^{-1}$ sand (experimental minus control uptake). *a*, 100 ml. 10^4 ppm 'Corexit' added; *b*, continuous 10^4 ppm 'Corexit'; *c*, 10 ml. Kuwait oil added; *d*, 10 ml. oil + 1 ml. 'Corexit'. (The dotted lines represent the 95% confidence interval for the variation of the control, based on the *t* table.)

the inhibition period, to the high uptake plateau, and to the combined inhibition period and plateau.

When 10 ml. oil and 1 ml. 'Corexit' were added to another column, the initial spike and inhibition period were not observed. The oxygen uptake rose to a lesser level than the oil control (0·059 ml.$O_2 h^{-1} cm^{-1}$) (Fig. 2C). The null hypothesis was rejected at the 0·01 level for the comparison of the control to the experimental and for the comparison of the oil plateau to the oil plus 'Corexit' plateau. All columns treated with oil or oil and 'Corexit' maintained their consumption of oxygen until the experiments were terminated.

All chlorophyll to phaeophytin ratios approximated 1·75, indicating no significant breakdown of chlorophyll. ^{14}C analyses approximated to 1400 cpm for all determinations. The usual percentage difference between the experimentals and the controls at each determination was less than 10%.

Microbomb calorimetry gave a value of 10,340 cal/g for the oil. The excess oxygen uptake was approximately 0·09 ml.$O_2 h^{-1} cm^{-1}$. Given a value of 5 cal/ml. O_2 and a depth of oxidation of the sand of 25 cm, approximately 300 days would be needed to degrade the oil. At termination, the oil plus 'Corexit' column was observed to have a reduced quantity of oil relative to the oil control, presumably due to the flushing of the emulsion from the column.

Johnston (1970) has noted similar results for his much more extensive observations of oil degradation in the same experimental system. In his heavily oiled column, he observed the heightened uptake and the anaerobic condition of the lower stations but did not observe the initial spike or inhibition period. This may be due to variances in the microflora and the temperatures at which the experiments were run. He has also pointed out that while degradation does occur to some degree, a majority of the oil is not degraded.

The discrepancy between the oil and the oil plus 'Corexit' plateaux was found to be significant at the 0·01 level based on 48 and 89 h of observation respectively. This may be due to a toxic effect which was not observed in any of the other experiments, but is more likely due to a more rapid removal of the oil from the degradative influences of the microflora.

'Corexit' has been indicated to be non-toxic to benthic microflora by itself and in combination with oil. Since benthic bacterial populations should have a response similar to the more dilute pelagic populations in coastal waters, the results suggest that 'Corexit' will not seriously inhibit the bacterial degradation of oil in coastal waters. This product may be useful where the use of highly toxic kerosene-based detergents is inadvisable.

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