Effect of Hard Detergents on Algae in a High-Rate-Oxidation Pond

Y. AZOV,†* G. SHELEF, AND N. NARKIS

Environmental and Water Resources Engineering, Technion—Israel Institute of Technology, Haifa 32000, Israel

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Regular concentrations of hard detergents in domestic wastewater do not affect algal growth in a high-rate-oxidation pond. The addition of nonionic hard detergent at concentrations above 60 mg/liter decreased the algal concentration in the batch culture, and complete lysis of algal cells was observed within a few days at a detergent concentration of 100 mg/liter.

Inhibitory effects of water-soluble detergents on algae are occasionally reported in the literature. A reversible inhibitory effect of alkyl benzene sulfonate detergents on photoassimilation of carbon by algae has been reported (4). A complete inhibition of growth concomitant with loss of flagellum was observed when Euglena gracilis was exposed to surfactants (3). On the other hand, contamination of lakes by detergents may lead to eutrophication owing to the high phosphorous content of many detergents (1, 2).

Because of legislative restrictions, the use of anionic non-biodegradable (i.e., "hard") detergents is decreasing in Israel. However, the domestic raw sewage in Israel still contains considerable amounts of hard detergents. The inhibitory effects of these detergents on algal growth may have a considerable effect on algal production in a high-rate-oxidation pond (HROP), which combines wastewater treatment and algal biomass production to be used as protein-rich animal feed (6). On the other hand, the use of nonionic detergents, including non-biodegradable detergents, is increasing in Israel (5) and all over the world. The expected increased concentration of such detergents in domestic wastewater might affect HROP algal production in the future.

Plastic HROP models (area, 0.34 m²; depth, 0.35 m) were used in outdoor experiments to study the effect of detergents on algal production. Raw domestic wastewater was provided from a municipal sewer serving a large neighboring community. In the first series of experiments, most of the detergents were removed from the wastewater feed by intensive bubbling of air through the wastewater and by skimming off the foam then produced. The average reduction of hard detergents (e.g., alkyl benzene sulfonate) was about 80% (20 to 4 mg/liter). The effect of wastewater feed with reduced detergent content was compared with untreated wastewater feed in semicontinuous outdoor algal cultures in which wastewater feed was added twice daily to produce a retention time of 3 days. In the second series of experiments, a commonly used nonionic hard detergent, nonylphenolethoxylate, was added at various concentrations to a batch outdoor algal culture containing effluent from the pilot-plant HROP, and its effect on the algae was studied.

Two methods were used to determine relative algal concentrations in the experiments. Optical density of the cultures was determined in the field by using a Summerson photometric colorimeter with a 420-nm filter. Chlorophyll a was determined by a methanol extraction method modified by us for high algal biomass concentrations; 2 ml of whole culture was filtered on a GF/C fiber glass filter (Whatman); the filter was folded and placed in a Pyrex screw-capped test tube containing approximately 6 ml of methanol. The test tube was agitated and placed in a bath at 60°C for 10 min. The sample was cooled in a dark place for about 10 min and refiltered on a GF/C fiber glass filter into a 10-ml volumetric vial. The remaining filter in the test tube was washed with approximately 3 ml of warm methanol and also filtered into the volumetric vial. The filtrate was brought to a final volume of 10 ml by adding methanol. Optical density was measured in a spectrophotometer against a methanol blank at 665 and 750 nm. The chlorophyll a concentration was determined by using the coefficient given by Talling (7): chlorophyll a (milligrams per liter) = OD_{665-750} × 13.9 × (U/V), where V is the sample volume, U is the final methanol volume, and OD_{665-750} is the optical density at 665 nm minus the optical density at 750 nm.

†Present address: Israel Oceanographic and Limnological Research, Haifa 31080, Israel.

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The results of the first series of experiments indicated that algal production in the HROP was not affected by the hard detergent content in the wastewater feed. The same algal concentration was attained in semicontinuous culture fed either with untreated wastewater or with wastewater with a low hard-detergent content (Fig. 1). The addition of the hard nonionic detergent to batch cultures containing effluent from the existing pilot plant HROP started to show inhibitory effects concomitant with a decrease in algal concentration at levels higher than 60 mg/liter (Fig. 2). When the concentration of the detergent in the culture was 100 mg/liter, a severe effect on algal morphology was observed. The dominant alga Micractinium pusillum usually present in colonies of eight cells was rapidly separated into solitary cells which lost their typical setae; in a few days the complete lysis of the cells was observed.

It can be concluded, therefore, that the regular concentrations of hard detergents in domestic raw wastewater do not affect algal production in HROP. Only a considerable increase in the use of hard nonionic detergents or feeding the pond with industrial wastewaters which contain high concentrations of hard detergents would cause a severe inhibition of algal production.

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