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Studies on the Effects of Commercial Detergents on Cucumber and Barley

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STUDIES ON THE EFFECTS OF COMMERCIAL DETERGENTS ON CUCUMBER AND BARLEY

by

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INTRODUCTION

The fact that large quantities of detergents daily are being added to our water table and the appearance of billows of foam at the shores of many inland bodies of water have caused alarm among biologists and sanitation engineers. However, few observations of the effects of synthetic detergents on living organisms other than bacteria have been recorded.

The purpose of these studies was (1) to determine the effects of several commercial non-biodegradable detergents, Tide, Dreft, and Alconox, and one biodegradable detergent, Living, upon the germination and root elongation of seeds of a monocotyledon, barley (Hordeum vulgare L.) and a dicotyledon, cucumber (Cucumis sativa L.), and (2) to determine the effects of detergents solutions that were first filtered through several different kinds of soils or other substances upon these species.

HISTORICAL REVIEW

The literature contains numerous reports of research on the effects of detergents on bacteria in sewage systems, and on the degradation of biodegradable detergents by bacteria. However, little research on the effects of detergents on living things other than bacteria has been reported. Those that have been reported concern the effects of detergents on algae, amoeba, some invertebrates, and fish.

Matulova (1964) reported the effects of various concentrations of four detergents on several species of algae: Chlamydomonas gelatinosa, Scenedesmus abundans, and Chlorella saccharophila. He found that the lethal dosage of alkylsulfonates for C. gelatinosa was 110 ppm., of alkylarylsulfonates from 70-200 ppm., of cationactive detergents 2 ppm., and of neutral detergents 200 ppm. Negative effects were observed at concentrations ranging from 1 ppm. of cationactive detergents to 25 ppm. of some alkylarylsulfonates.

Pautrizel, Pintaud, and Neuzil (1949) observed that 10,000 ppm. of two cationic detergents was toxic to Endamoeba dysenteriae while an anionic detergent showed no harmful effects.

Surber and Thatcher (1963) reported that a 10 day exposure of the mayfly nymphs, Stenonema and Isonychia bicolor, to 16 ppm. of a packaged detergent containing 27% alkylbenzene sulfonate was fatal, whereas Hydrosychidae larvae were more resistant; exposure to 32 ppm.

for a period of 10 days proved fatal. The same study showed further that crayfish (Oreonectes rusticus), fresh water shrimp (Synurella sp.), and sowbug (Lirceus) were seriously reduced in numbers by a 14 day exposure to 10 ppm. alkylbenzene sulfonate.

Faure-Fremiet and Thaureaux (1949) observed cytolysis of Teredo norvegica eggs exposed to anionic detergents dissolved in sea water at pH 8.2. However, neutral or cationic detergents were observed to have no effect. Neutralification and acidification of the sea water reversed the effects of anionic detergents.

Leclerc and Devlaminck (1952) tested four synthetic detergents on fish and observed that 3-20 ppm. was a lethal concentration.

Wurtz-Arlet (1960) reported that an anionic detergent had more rapid toxic action at concentrations between 15-50 ppm. on rainbow trout than did the nonionic compound. A pollution at weak concentrations lasting more than 24 hours would lead to the death of fish. The margin of safety between the maximum concentration which caused no apparent harmful effects on the fish during 24 hours and the minimum lethal concentration was small in the case of anionic compounds.

In another study on fish, (Dooley and Cavil, 1964) mosquito minnows (Gambusia affinis), were used to determine the minimum lethal concentration (highest concentration in which 100% of the fish survived for at least 72 hours), of a number of detergents viz. Ad, Alconox, Cheer, Dreft, Tide, and Trend. Results indicated the minimum lethal concentrations ranged from 0.020% to 0.00125%.

For ten of the fifteen detergents, the minimum lethal concentration values were 0.010% or higher. Although the range of pH was from 6.4-9.5, lethality did not appear to be due primarily to pH, but rather to the concentration of the surfactant.

METHODS AND MATERIALS

Determination of Inhibiting Concentration of Detergents

Cucumis sativa var. Straight Eight, and Hordeum Vulgare var. Larkin were used in these studies. The commercial detergents tested were Tide, Alconox, Dreft, and Living, the last a biodegradable compound. Tap water was used in preparation of all test solutions.

To determine the inhibiting concentration for each detergent, round plastic dishes 3" x 6" lined with Armstrong #6 filter paper were employed as germination chambers. Five chambers each containing 15 ml. test solution and 20 seeds were placed in the dark at room temperature for 120 hours. At 120 hours the number of seeds germinated was recorded and a measurement of the primary root for cucumber and the longest root for barley was recorded. An inhibiting concentration is one in which at least 90% of the seeds had germinated, but the primary root or longest root is no longer than 5 mm. at 120 hours.

Percolation Through Various Substances of Detergents

Various methods and materials were used in attempts to reverse inhibitory effects of each detergent. A piece of glass tubing 3 feet long and two and one half inches in diameter was covered at one end with 4 thicknesses of cheese cloth and a piece of aluminum screen. The tube was then filled with various substances: sand (450 g), vermiculite (220 g), loam-peat-sand combination (400 g). A quantity of test solution containing an inhibiting

EXPERIMENTAL RESULTS

It can be observed in Table 1 that both germination and root elongation of barley was affected by Tide at concentrations above 4,000 ppm. Significant deviation from this percentage was observed at 4,000 ppm where germination was only 77%. At concentrations greater than 2,000 ppm root elongation was noticeably impaired. Germination of cucumber was not affected until the concentration of Tide reached 7,000 ppm. (See Table 2). Root elongation did not appear to be significantly different from that of controls at 2.000 ppm, but at 5,000 ppm and 7,000 ppm root elongation was greatly inhibited.

At 1,500 ppm Dreft germination of barley was significantly inhibited (Table 3). Furthermore, root elongation was impaired at concentrations greater than 1,000 ppm. At these concentrations only 46% or less of the seeds showed roots longer than 10 mm as compared to 94% in controls. Dreft did not affect germination of cucumber at concentrations below 5,000 ppm, although cucumber root elongation was inhibited at concentrations as low as 500 ppm (Table 4).

When Alconox was tested on barley (Table 5), percentage of germination decreased as concentration increased until at 10,000 ppm there was complete inhibition of germination. Root elongation was significently inhibited at 500 ppm, with only 71% of the

seedlings showing roots longer than 10 mm as compared to 87% in controls. When Alconox was tested on cucumber (Table 6), germination was not impaired at concentrations below 5,000 ppm. However, root elongation of cucumber was significantly inhibited at concentrations of 2,000 ppm and higher.

The biodegradable detergent Living was tested on both barley and cucumber (Tables 7 and 8). As concentration of Living was increased germination of barley decreased; at 10,000 ppm germination was only 8%. Root elongation of barley was significantly impaired at 4,500 ppm, only 25% of the seedlings roots were longer than 10 mm as compared with 91% in controls. Cucumber germination was not inhibited by Living even at the highest concentration although root elongation was impaired at 4,000 ppm.

After determining the concentration of each of the four detergent solutions that inhibited growth of cucumber seeds (i. e. the solution in which germation was at least 90% and the average root length was 3 mm.) said solutions were passed through the various filter media mentioned above and the filtrates were tested on cucumber seeds. The results of these experiments are shown in Tables 9 - 12.

Passing Tide through sand four times failed to reverse the inhibitory effects, but passing Tide through a combination of sand-peat-loam only three times completely removed any inhibitory properties. Using vermiculite as a filter required that a solution containing an inhibiting concentration of Tide be passed through

the filter 15 times before a removal of the inhibitory properties were observed.

In Table 10 it can be observed that passing inhibitory solution of Dreft through sand-peat-loam only once removes inhibitory properties. Passing a similar solution through vermiculite 15 times also removed inhibitory properties.

A solution of an inhibiting concentration of Alconox (Table 11) passed through a sand-peat-soil combination four times resulted in removing only 50% of the inhibitory effect, whereas passing a solution of Alconox through vermiculite 15 times removed the inhibitory properties.

A solution containing an inhibiting concentration of the biodegradable detergent, Living, passed through vermiculite 14 times removed only approximately one-half of its inhibitory properties. Passing a similar solution through a combination of sand-peat-soil only four times removed all inhibitory properties.

The osmotic pressure of 5,000 ppm Tide, 3,000 ppm Alconox, 5,000 ppm Living, and 2,000 ppm Dreft was the same as tap water. The pH of 5,000 ppm Tide was 7.9; of 5,000 ppm Living, 8.5; of 2,000 ppm Dreft, 7.8; and of 3,000 ppm Alconox, 7.9. After 2 liters of 5,000 ppm Tide had been filtered through soil once, the pH had dropped to 5.3.

DISCUSSION

Effects of detergents upon root elongation of cucumber apparently varies with the detergent. Tide, at 5,000 ppm, was significantly inhibitory (Table 2). However, Dreft (Table 4) inhibited elongation at 2,000 ppm and Alconox inhibited elongation at 3,000 ppm (Table 6).

Detergents affected germination of barley. As concentration increased, percentage of germination decreased. Living (Table 7), at 6,000 ppm, allowed 65% germination; at 10,000 ppm only 8% germination. Alconox at 500 ppm allowed 85% germination, at 2,000 ppm, 70% germination, at 4,000 ppm 38% germination, and permitted no germination of barley at 10,000 ppm (Table 5). Tide (Table 1) apparently is not as inhibitory as Living or Alconox on germination of barley; at 5,000 ppm, germination was still 73%. Finally, Dreft (Table 3) exhibited inhibition at 1,500 ppm with only 73% germination observed; at 3,000 ppm with only 32% germination observed.

It is likely that the germination of some species is not affected by detergents at concentrations less than 5,000 ppm. Cucumber, in these studies, showed good germination when tested on all four detergents at concentrations of 5,000 ppm or less (Table 2). Only at 7,000 ppm did Tide cause any significant change in germination percentage. Perhaps the seed coat of cucumber serves

as an effective barrier against the inhibitory properties of detergents.

Percolating Tide through sand did not remove inhibitory properties since roots of cucumber averaged only 4 mm. after an inhibiting solution had been passed through sand four times (Table 9).

Passing Tide, Dreft, and Alconox through vermiculite 15 times removed inhibitory properties, whereas passing Living through vermiculite failed to remove all inhibitory properties. Roots of cucumber still were only 43% of controls when the filtrate was tested (Tables 9 - 12).

A combination of sand-peat-loam was very effective in removing the inhibitory properties of the detergents tested. Passing Dreft (Table 10) through such a combination once completely removed inhibitory properties. Passing Tide through such a combination of substances three times removed inhibitory properties, and in the case of Living (Table 12) four times removed inhibitory properties. Removal of inhibiting properties of Alconox (Table 11) was not quite as complete; after four times through the soil, the filtrate permitted root elongation that was 50% of controls.

SUMMARY

Studies were carried out to determine the effects of several detergents (Tide, Dreft, Alconox and Living) upon the germination and root development of cucumber and barley seedlings.

It was shown that the effects of detergents upon root elongation of cucumber varied with the detergent. Germination of cucumber seeds was apparently not affected at any of the concentrations of the four detergents tested.

Germination of barley seeds is affected by detergents. Also, root elongation is inhibited by detergents.

Percolating Tide through sand did not remove inhibitory properties on cucumber seedlings, but a combination of sand-peat-loam was effective in removing inhibitory properties of the detergents tested. Percolating Tide, Dreft, Alconox through vermiculite 15 times removed inhibitory properties on root development of cucumber seedlings.

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Table 1. The effect of various concentrations of Tide upon germination and root elongation of barley, (*Hordeum vulgare* L.).

Concentration ppm	Per cent Germination	Per cent of roots* shorter than 10 mm.	Per cent of roots* longer than 10 mm.
Controls	89	9	91
2,000	90	20	80
2,500	88	46	54
3,000	84	77	23
3,500	87	91	9
4,000	77	91	9
5,000	73	82	18

*Only the longest root was measured

Table 2. The effects of various concentrations of Tide upon germination and root elongation of cucumber, (*Cucumis sativa* L.).

Concentration ppm	Per cent Germination	Avg. length primary root mm.
Controls	100	68
1,000	100	61
2,000	95	66
5,000	98	1.5
7,000	86	1

Table 3. The effects of various concentrations of Dreft upon germination and root elongation of barley, (*Hordeum vulgare* L.).

Concentration ppm	Per cent Germination	Per cent of roots* shorter than 10 mm.	Per cent of roots* longer than 10 mm.
Controls	95	6	94
600	84	18	82
800	86	19	81
1,000	88	54	46
1,500	73	76	24
2,000	61	88	12
2,500	47	84	16
3,000	32	100	0

*Only the longest root was measured

Table 4. The effects of various concentrations of Dreft upon germination and root elongation of cucumber, (*Cucumis sativa* L.).

Concentration ppm	Per cent Germination	Avg. length of primary root mm.
Controls	100	75
500	100	53
1,000	100	16
2,000	100	3
5,000	97	3

Table 5. The effects of various concentrations of Alconox upon germination and root elongation of barley, (*Hordeum vulgare* L.).

Concentration ppm	Per cent Germination	Per cent of roots* shorter than 10 mm.	Per cent of roots* longer than 10 mm.
Controls	95	13	87
500	85	29	71
1,000	83	61	39
2,000	70	79	21
4,000	38	94	6
6,000	5	100	0
8,000	10	100	0
10,000	0	--	--

* Only the longest root was measured

Table 6. The effects of various concentrations of Alconox upon germination and root elongation of cucumber, (*Cucumis sativa* L.).

Concentration ppm	Per cent germination	Avg. length of primary root mm.
Controls	100	68
1,000	96	55
2,000	98	22
3,000	98	3
4,000	98	3
5,000	96	3

Table 7. The effects of various concentrations of Living upon germination and elongation of barley, (*Hordeum vulgare* L.).

Concentration ppm	Per cent germination	Per cent of roots* shorter than 10 mm.	Per cent of roots* longer than 10 mm.
Controls	92	9	91
4,500	89	75	25
5,000	85	94	6
5,500	82	98	2
6,000	65	94	6
8,000	66	84	16
10,000	8	100	0

* Only the longest root was measured

Table 8. The effects of various concentrations of Living upon germination and root elongation of cucumber, (*Cucumis sativa* L.).

Concentration ppm	Per cent germination	Avg. length of primary root mm.
Controls	98	75
1,000	100	78
4,000	99	16
5,000	97	3

Table 9. The effects of filtrates of Tide upon elongation of cucumber (Cucumis sativa L.).

No. of times soln containing inhibit. concn was filtered	Avg. length of roots -- per cent of controls		
	Filter - sand	Filter - vermiculite	Filter sand-peat-loam
1	4	5	26
2	4	5	
3	4		100
4	6		100
5		5	100
10		18	
15		100	

Table 10. The effects of filtrates of Dreft upon elongation of cucumber (<u>Cucumis sativa</u> L.).

No. of times soln containing inhibit. concn was filtered	Avg. length of roots -- per cent of controls		
	Filter - sand	Filter - vermiculite	Filter sand-peat-loam
1			100
2			100
3			100
15		100	

Table 11. The effects of filtrates of Alconox upon elongation of cucumber (*Cucumis sativa* L.).

No. of times soln containing inhibit. concn was filtered	Avg. length of roots -- per cent of controls		
	Filter - sand	Filter - vermiculite	Filter sand-peat-loam
1			5
2			11
3			40
4			50
15		100	

Table 12. The effects of filtrates of Living upon elongation of cucumber (Cucumis sativa L.).

No. of times soln containing inhibit. concn was filtered	Avg. length of roots -- per cent of controls		
	Filter - sand	Filter - vermiculite	Filter sand-peat-loam
1			6
2			20
3			46
4			100
14		43	