Water Florae as Indicators of Irrigation Water Contamination by DDT[1]

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Certain crops have been shown to be good indicators of soil contamination by chlorinated insecticides. Lichtenstein and Schulz (1) found that the carrot absorbed more insecticidal residues from soil treated with aldrin and heptachlor than did potato, beet, lettuce, radish, cucumber, turnip, cabbage, broccoli, celery or parsnip.

Carrots (Daucus carota), particularly the White Belgium variety, were shown by Lichtenstein et al. (2) to have a high affinity for the cyclodiene group of organochlorine insecticides. This variety absorbed more aldrin, dieldrin, heptachlor and its epoxide than did four other varieties grown for two years in treated soil.

In exploring DDT residues and buildup in the food web of a Long Island estuary, treated 20 years for mosquito control, Woodwell (4) found that DDT residues in the upper layer of mud ranged up to 32 pounds per acre. At the same time he found marsh plant shoots to contain 0. 33

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ppm DDT and its derivatives, while Cladophora contained only 0.08 ppm, all on a wet weight basis.

Meeks and Peterle (3) found that the alga, Cladophora, in a Lake Erie marsh treated with ^{36}Cl-DDT at the rate of 0.2 lb./acre, concentrated DDT far more than other plants or animals. After three days the alga contained 96 ppm while bladderwort and soft-stem bulrush contained 10.81 and 3.16 ppm respectively.

Some other levels reported after three days exposure were sago pondweed, 205; curly-leaf pondweed, 2.16; duckweed, 2.34; muskgrass, 2.52; and bur-reed, 3.06.

In this same study Cladophora still retained 1.62 ppm nine months after treatment, and was the only one of 15 plants followed closely having a residue in excess of 1.0 ppm.

It was the purpose of this study to examine irrigation canals, flowing through areas normally treated with organochlorine insecticides, for plants which might serve as DDT collectors or indicators of DDT usage by concentrating this material and its metabolites.

Materials and Methods

In late October and early November, 1966, after DDT applications had subsided, canal surveys were made in the four major irrigated agricultural districts of Arizona: Phoenix (Buckeye-Litchfield Park), Casa Grande, Phoenix (Mesa-Chandler), and Yuma. These canals are

all fed by the Salt River Project, with the exception of Yuma which received its irrigation water from the Colorado and Gila Rivers.

Plants from the early samplings were identified by herbarium personnel in the Department of Botany. Subsequent collections were identified by comparison with the previously identified specimens. Two plants were commonly found in all areas sampled, Potamogeton pectinatus, a member of the pondweed family commonly known as sago, and Cladophora, a filamentous alga. Other species collected were another alga, Oscillatoria, submerged bermuda grass, Cynodon dactylon, and the giant reed, Arundo donax.

One-gallon water samples were collected in glass jugs from all canals sampled for plants, while sediment samples were collected only when present in quantity on the canal floor.

On returning to the laboratory dry weight determinations were made on all plant and sediment samples.

Extraction and Cleanup. --Unfiltered water samples were extracted by adding 250 ml of redistilled hexane to 1500 ml of water in a separatory and shaking for one minute. The water was discarded and the remainder of the 3-liter sample added to the separatory for similar extraction. The hexane was passed through a 1-inch column of sodium sulfate into a storage bottle. The separatory funnel was rinsed with 25 ml of hexane which was added to the extract. The extract was evaporated to 10 ml which was placed on the column for cleanup.

Sediment samples (100 gm aliquots) were extracted with 400 ml of hexane:acetone (1:1) for 10 minutes in an omnimixer. After filtering, the extract was washed three times with 1500 ml distilled water. The hexane extract was then dried and evaporated for cleanup as described.

Plant samples were extracted for 10 minutes with 300 ml of hexane:ethanol (2:1) in an omnimixer. The sample was filtered and the remaining plant material and filter paper placed in a Soxhlet extraction thimble. This was refluxed for 16 hours, with chloroform: methanol (1:1), after which the extract was evaporated to dryness and redissolved in hexane for cleanup. The omnimixer extract was washed three times with distilled water, then dried and evaporated for cleanup as described.

For cleanup, the 10 ml hexane extract was passed through an activated Florisil column, 1:4:1 inch (sodium sulfate:Florisil:sodium sulfate). The sample was eluted with 200 ml of 20% methylene chloride in petroleum ether, the eluant evaporated just to dryness, and residue dissolved in 5 ml of hexane.

Results and Discussion

All samples were analyzed for p,p' DDT, o,p DDT and DDE (DDTR) by ECGC. Extraction and cleanup efficiencies for the three methods were (1) hexane:ethanol, 82.4%; (2) hexane:acetone, 75.5%, and (3) chloroform:methanol Soxhleting, 109%.

In Table 1 are presented the analytical results of the canal study. Because some of the canals were molded concrete there was little or no collectable sediment and occasionally no plant samples were found. Generally, the highest DDTR residues were found in Cladophora, 19 ppm, followed by Potamogeton, 9 ppm, and finally Oscillatoria, 5 ppm. Considering the ease with which Cladophora or Potamogeton are collected and their apparent concentrating characteristics, as also found by Meeks and Peterle (3) and Woodwell (4), both plants could conveniently serve as indicators of water contamination by DDT and related metabolites.

References

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TABLE 1

DDTR RESIDUES IN ARIZONA CANALS. OCT-NOV. 1966.

LOCATION	WATER (PPB)	PPM DRY WT. PLANTS		SEDIMENT
Buckeye-Litchfield Park				
1	0.27	Potamogeton	1.86	--
2	0.14	--	--	--
3	0.22	Potamogeton	4.72	--
4	0.32	Cladophora	1.64	--
		Potamogeton	9.63	--
5	0.27	--	--	--
6	0.28	--	--	--
7	0.24	Cladophora	4.58	--
8	0.17	Potamogeton	2.90	--
		Cladophora	5.57	--
Casa Grande				
1	0.12	--	--	0.47
2	0.10	Cladophora	18.50	--
3	0.15	Potamogeton	19.42	2.34
		Cladophora	139.13	--
4	--	--	--	0.19
5	0.13	--	--	0.43
6	0.09	--	--	0.43
Mesa-Chandler				
1	0.11	--	--	--
2	0.15	Cladophora	0.62	--
3	0.23	Cladophora	0.49	0.08
4	0.11	Cladophora	0.10	--
5	1.60	--	--	--
6	0.19	Oscillatoria	0.85	--
7	0.19	--	--	--
8	0.40	Oscillatoria	3.55	--
Yuma				
1	0.10	Potamogeton	26.00	--
2	0.08	--	--	--
3	0.08	Reed	20.02	--
4	0.16	Cladophora	0.76	--
5	0.16	--	--	--
6	0.47	Potamogeton	0.24	--
7	--	Oscillatoria	2.89	--
8	0.60	--	--	--
9	0.26	Bermuda grass (dry)	2.32	--
10	1.12	--		
11	1.83	Oscillatoria	12.42	--
12	0.19	--	--	--