Although the sorptive capacity of the quartz sand is negligible in comparison to agricultural soils, only small amounts of ^{14}C-labeled compounds appeared in the first percolate, while two-thirds of the ^{14}C-labeled compounds that were removed with water from the system appeared in the third percolate on day 14. This seemed to indicate a relatively slow movement with water through the quartz sand or the filters. Phorate sulfoxide was the major insecticidal substance in the water, but some phorate was also present. Phorate sulfone, which was not detected in the quartz sand, appeared in the third percolate (0.01 ppm) and amounted to 0.4% of the applied phorate. The presence of insecticidal substances in the percolated water was also demonstrated by insect mortalities after the exposure of mosquito larvae for 48 hr to 10-ml aliquots of this water. While no insect mortalities were noticed with the first percolate, 22 and 58% of the insects died after exposure to the second and third percolates, respectively.

Experiments as described with a quartz sand and percolated water, but without plants, showed that phorate sulfoxide was the major insecticidal constituent in the percolate. This indicated that the oxidation of phorate to its sulfoxide was independent of the presence of plants.

Data obtained with a 1:1 mixture of a Plano silt loam and Plainfield sand were not too different from those obtained with a Plainfield sand and are, therefore, omitted in tabulated form. However, a summary of the effects of soil types includes data obtained with the soil mixture in Figures 2 and 3. Data utilized in these summaries were selected from soils through which water had been percolated and include only the sum of residues recovered from the upper and lower soil layers, from greens and roots, and the sum of residues from all three water percolations. The effects of soil type on the fate of [^{14}C]phorate under percolating conditions are evident (Figure 2) when comparisons are made between the total or the benzene-soluble ^{14}C-labeled compounds retained by the soils with those that appeared in the percolated water. The amount of benzene-soluble ^{14}C-labeled compounds was smallest in the quartz sand but largest in the water which had percolated through it. The amounts of water-soluble and unextractable radioactivity appeared to be directly related to the total amounts of radiocarbon in these soils. Residues in corn, primarily concentrated in the greens, were similar with plants from all the soils, indicating that the uptake and translocation of chemicals from soil are to a large extent governed by physiological processes of the corn plant itself.

A summary of the results obtained by glc of the various benzene extraction phases is presented in Figure 3. Water, percolated through the quartz sand, contained the largest amounts of phorate sulfoxide, but also contained phorate, which was not detectable in water that percolated through the two agricultural soils. Based on glc, residues in corn plants consisted of phorate sulfoxide and phorate sulfone and were similar in plants from all soils.

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Further Toxicity Studies with Antimycin, A Fish Eradicant

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Further toxicological studies on antimycin (Fintrol) are presented. Previously reported acute toxicity studies indicated that antimycin has a very low toxicity for mammals and chronic toxicity did not reveal any deleterious effects. These additional studies were designated to determine whether antimycin-treated waters and antimycin-killed fish contained toxic degradation products. Antimycin-treated water was given to dogs and rats as the sole source of drinking water and antimycin-killed fish were administered to dogs and rats as one-half of their diet. Both tests lasted 3 months. In both studies no toxic effects were noticed in the animal which drank the treated water or which ate fish killed by antimycin. A decrease in food consumption was observed in a few dogs and rats at the beginning of the test. It was not considered toxic manifestation but it was clearly the reaction of the animals to the bitter taste of the compound.

Antimycin (Fintrol) is a compound with antifungal and antibacterial properties (Leben and Keitt, 1948) which has an unusually high toxicity for fish (Derse and Strong, 1963), but a relatively low toxicity for mammals (Herr *et al.*, 1967). Its applications as a piscicidal agent have been reviewed recently by Lennon and Vezina in Pezlman (1973).

Acute and chronic toxicity studies with this compound previously performed in several species of mammals provide evidence for the safety in its use at concentrations toxic to fish (Leben and Keitt, 1948). In solution, antimycin is rapidly degraded (Derse and Strong, 1963). By

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Table I. Toxicity Study of Antimycin in Water on Dogs (Average Monthly Body Weight and Daily Water and Food Intake)

Sex			Weeks												
			0	1	2	3	4	5	6	7	8	9	10	11	12
M	Body wt, kg	Control	8.6				10.7				11.6				12.4
		Treated	7.1				7.8				9.5				10.7
	H_2O intake, ml/day	Control		1000	995	928	856	837	830	820	774	866	817	743	608
		Treated		749	644	591	536	678	694	660	692	771	785	695	719
	Food intake, g/day	Control		390	392	371	370	367	344	322	353	365	335	320	362
		Treated		308	248	262	226	303	301	309	288	342	334	273	292
F	Body wt, kg	Control	6.8				7.8				8.5				9.1
		Treated	7.1				8.9				10.0				10.6
	H_2O intake, ml/day	Control		645	705	710	580	716	671	747	642	813	717	657	613
		Treated		789	733	722	641	690	773	791	709	787	750	701	704
	Food intake, g/day	Control		240	265	289	265	254	283	306	307	332	294	275	247
		Treated		338	304	299	259	289	325	334	270	360	307	289	237

drinking waters of lakes treated with antimycin or eating fish killed by antimycin, animals or man may consume residual antimycin and its degradation products. For that reason toxicity studies were performed with water treated with antimycin and with fish killed by antimycin.

In this report, two studies designed to follow the field use of antimycin as closely as possible are presented. Both were 3-month studies. In the first, the effects of administration of antimycin in water were examined while, in the second, the effects of feeding animals with a standard diet containing fish killed with antimycin were determined.

METHOD

The tests to investigate the effects of long-term administration of water containing antimycin and its degradation products were conducted in rats and dogs. To simulate the field conditions as much as possible the water was treated only once with antimycin. Sufficient water to supply the animals for 3 months was stored in plastic barrels. Antimycin, dissolved in 500 ml of ethyl alcohol, was added to part of the water to make a final concentration of 125 ppb. An equal amount of ethyl alcohol was added to the other portion of water which was designated for control animals. The water in the barrels was aerated once a week to compensate for the oxygen losses on standing. This water was administered *ad libitum* with a standard diet during the whole experiment and was the sole source of drinking water. Sixteen 4-month-old beagle dogs (8 males and 8 females) and 80 1-month-old albino rats (40 males and 40 females) were employed in this experiment.

The second experiment was conducted in rats and dogs fed a diet composed of 50% antimycin-killed fish to determine the effects of long term administration of antimycin that remained after cooking as well as of its degradation products. This test was performed to simulate the field case when fish killed by antimycin are harvested, frozen, and thawed for subsequent cooking. Rainbow trouts (0.5–1.0 lb) were obtained from Peterson Trout Farms (Peterson, Minn.) through the U. S. Department of Interior Fish and Wildlife Service. They were housed in experimental fish tanks and were killed by adding 125 ppb of antimycin to the water tanks. The fish for the control groups were killed by suffocation. As soon as the fish were dead they were harvested and frozen. The killing and processing of the fish were done at the Fish Control Laboratory, La-Crosse, Wis. The animal diets were prepared by cooking the undressed fish for 0.5 hr in an oven (about 300°F), grinding the cooked fish, and mixing it with regular laboratory diets for dogs and rats (Purina Chow) in the ratio of 1:1. Twenty beagle dogs (10 males and 10 females), 4 months old, and 160 albino rats (80 males and 80 females) of the Charles River strain, 1 month old, were used for this experiment. They were divided into four groups. The first group (control) received the fish diet in which the fish were killed by suffocation. In the second group the diet was similar to the first, but the fish were killed by antimycin. These two groups were considered the main experimental groups because they simulated the use of the fish as food. In order to get additional information and a comfortable safety factor the largest amount of antimycin which could be added to the diet without the animals refusing completely the food was added to the fish prior to cooking. For this part of the experiment, two groups of dogs received 0.5 and 2 ppm of antimycin in their food, respectively, while two groups of rats received 10 and 50 ppm of antimycin in their food. Although it is known that high temperatures destroy antimycin (Strong, 1956) the compound was added to the fish prior to cooking because we were not investigating the toxicity of antimycin *per se*, but the toxicity of the degradation products of antimycin following cooking, since man usually does not consume raw fish.

During the test the animals were observed daily for signs of ill health or toxicity. Water and food intake were recorded daily and body weight was recorded monthly. Hematological studies were performed in all the dogs and in 30% of the rats once a month. Clinical chemistry and urinalyses were performed on dogs once a month. At the end of the experiment, all the animals were killed by an overdosage of anesthetic and their organs inspected and weighed. Portions from all the organs of all the dogs and of 30% of the rats were processed for microscopic examination.

RESULTS

In the experiments in which antimycin was added to the drinking water there was a lower body weight gain in treated dogs compared to control animals (Table I). This lower gain in body weight was more visible in the first month and was attributed to a reduction in food intake which was related to the water consumption and to the hot weather in August. It was evident that the water was not palatable for these animals and as they drank less, they ate less. This was not seen in rats possibly because they became accustomed to the bitter taste in a shorter

Table II. Toxicity Study of Antimycin Residues in Fish on Dogs (Weekly Average Body Weight and Food Intake)[a]

Sex		Group	Weeks 0	1	2	3	4	5	6	7	8	9	10	11	12
M	Body wt, kg	A	6.6	7.1	7.2	7.4	7.6	7.9	8.0	8.0	8.1	8.2	8.4	8.6	8.6
		B	6.9	7.7	7.8	8.0	8.3	8.6	8.9	9.0	9.2	9.4	9.6	9.8	10.0
		C	8.0	8.1	8.5	8.7	8.8	9.2	9.3	9.5	9.7	9.9	10.1	10.4	10.5
		D	7.3	6.8	6.4	6.5	7.0	7.1	6.6	6.2	6.3	6.8	7.3	7.7	8.0
	Food intake, g/day	A		387	380	353	362	356	362	360	362	352	362	360	359
		B		386	379	358	360	354	359	356	356	356	359	357	359
		C		359	353	362	361	366	367	363	363	367	368	367	370
		D		213	212	250	329	282	255	262	275	352	344	348	352
F	Body wt, kg	A	5.5	5.8	6.1	6.4	6.6	6.7	7.0	7.1	7.1	7.3	7.5	7.6	7.7
		B	5.8	6.4	6.5	6.7	7.0	7.0	7.5	7.5	7.7	7.9	8.0	8.1	8.3
		C	6.4	6.5	6.7	7.0	7.2	7.4	7.4	7.6	7.7	7.9	8.0	8.1	8.2
		D	6.2	5.7	5.5	5.6	6.0	5.9	5.7	5.4	5.5	6.0	6.5	6.8	7.0
	Food intake, g/day	A		386	381	358	361	356	361	360	362	359	362	360	359
		B		385	379	358	360	354	359	358	356	356	359	357	359
		C		359	353	362	361	366	367	363	363	367	368	367	370
		D		225	183	225	288	252	214	240	232	323	340	333	330

[a] Group A, controls fed with fish killed by suffocation as 50% of the diet; group B, fed with antimycin-killed fish as 50% of the diet; group C, fed with antimycin-killed fish + 0.5 ppm of antimycin added to the diet; group D, fed with antimycin-killed fish + 2.5 ppm of antimycin added to the diet.

period of time. The results in all the other parameters studied in this experiment were in the normal range; biochemical, hematological, pathological, and histological examinations were normal.

In the second test in which the animals were fed fish as one-half of the ration, no difference was noticed between the animals fed antimycin-killed fish and fish killed by suffocation. All the parameters were normal.

In groups C and D, where excess antimycin was added to the fish before it was cooked, food was not consumed regularly, so that the body weight of the animals did not increase as in the control animals (Table II). This low food intake was attributed to impalatability of the food which is very bitter to man. Occasionally vomit occurred in dogs which was also attributed to the impalatability of the compound. Soft feces were observed in rats and diarrhea in dogs, probably due to the antibiotic action of the compound on the intestinal flora. It should be noted that these animals were not anorexic; they were always looking for food, but ate the diet offered only in order to survive, until they became accustomed to the taste of antimycin.

DISCUSSION

From this study it is evident that antimycin and its metabolites contained in water were not toxic when used as drinking water for dogs and rats for a period of 3 months. Furthermore, there were no toxic signs in dogs and rats that were fed for 3 months with fish killed with antimycin. In evaluating results it is worthwhile to consider two factors.

(1) In regard to antimycin-treated water, it is known that this compound has a half-life of 30 hr in water, where there is an active plankton, as in a lake or in a river. Consumption of this water would not pose any problem or hazard as both antimycin and its products of degradation in water are not toxic and as the bitter taste would disappear from the water at a much faster rate than from the water that was kept in barrels in the laboratory which, if not sterile, was at least devoid of active planktonic life.

(2) Secondly, in relation to antimycin-killed fish, no toxic effects were observed in animals fed this fish for 3 months in spite of the fact that the fish were administered undressed and that toxic material which usually collects in organs such as the liver, or in this case the gills, was not discarded. In the C and D groups the added antimycin was not degraded completely during cooking and the bitter taste of the compound prevented the animals from eating their full rations though they were clearly hungry and not anorexic. In the dogs occasional vomiting and diarrhea were noted and considered to be minor toxic signs, attributed to the high antimycin residue which was not destroyed at cooking. However, even at this high level of antimycin content, there were no toxic changes at autopsy, at the histopathological examination of the organs or in the biochemical determinations.

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