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Decomposition in Soil of Waste Cooking Oils Used in Potato Processing[1]

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ABSTRACT

Cooking oils used in potato processing are sometimes wasted in small quantities into the effluent that goes to land disposal. To determine the effect of this oil on land, palm and soybean oils were added to Portneuf silt loam at rates of 0.1, 0.5, 1.0, and 5.0 g oil in 100 g soil (2.2, 11.2, 22.4, and 112 metric tons/ha, respectively). Nitrogen was added and the mixtures were incubated at constant temperature in a CO_2-free continuously flowing air stream. Evolved CO_2 was scrubbed from the air stream and decomposition calculated. Both oils decomposed at the same rate at each application rate. Maximum weekly decomposition was approximately 8 and 2.5 metric tons/ha for the 112 and 11.2 metric ton-applications, respectively. There was no evidence for toxicity to the decomposition systems with the high application of oil and no evidence that difficulty would develop with land disposal of wastes containing these edible cooking oils.

Additional Index Words: nitrate, N immobilization, pollution control, land treatment.

Waste materials have been applied to agricultural land for centuries. Crop residues, animal wastes, municipal, and more recently industrial wastes and by-products are among the many materials applied to land for treatment and disposal. The Center for the Study of Federalism at Temple University (3) compiled a treatise in which they recommended treatment and disposal on land as being the ultimate method for many types of waste material. Recent activities aimed at environment decontamination have led to many innovations in waste handling and treatment. Two systems (2, 5) developed recently for the potato processing industry involve spraying or surface irrigating agricultural land with potato processing wastes, instead of dumping them into streams and rivers.

Palm, soybean, and other edible oils obtained from agriculturally grown plants are used for cooking french fries and other products in the potato industry. In spite of using efficient oil recovery equipment in potato processing, some cooking oil is lost and is disposed of in the waste. Questions have been raised about the effects cooking oils may have on land when applied in the waste water from the potato processing operations.

Extensive research has been done on decomposition of various plant materials in soil (1, 4, 6, 7). The major differences between plant materials that are ordinarily applied to soil and cooking oil is the lack of nitrogen, sulfur, phosphorus, and other inorganic nutrients in the cooking oil and the high carbon content of the oil. These deficient nutrients will have to be supplied by the soil and will lead to nutrient immobilization during decomposition of the oil in soil in proportion to the amount of oil added.

This research was conducted to determine the decomposition rate of palm and soybean oils in soil and to determine if large amounts of edible oil can be applied to soil without being toxic or hindering decomposition.

MATERIALS AND METHODS

Palm and soybean oils were melted in a water bath, mixed in Portneuf silt loam soil at rates of 0.1, 0.5, 1.0, and 5.0 g/100 g air dried soil, placed in 540-ml ground glass stoppered bottles, and incubated. On a field basis, the applications corresponded to calculated rates of 2.24, 11.2, 22.4 and 112 metric tons/ha. Twenty ml of distilled water was added to each soil sample, equivalent to 80% of the soil moisture content of one-third atmosphere tension, and an aeration fitting was installed in each bottle. The bottles of soil were incubated at 26C. The samples were continuously aerated with CO_2-free compressed air, and the air coming from the bottles was scrubbed in small bottles containing standard sodium hydroxide solution to remove CO_2 produced during decomposition of the oil and soil organic matter. All samples were incubated in triplicate. Control samples containing no oil were used for determining soil organic matter decomposition and blank samples without soil or oil were also incubated. Nitrogen was added as ammonium nitrate at the rate of 1.25 percent of the weight of the added oil. At appropriate intervals the NaOH scrubbers were replaced. The carbonate was precipitated with barium chloride, the excess NaOH was titrated with standard sulfuric acid, and the amount of CO_2 evolved was calculated. The incubations were continued for 12 weeks, at which time the soil was analyzed for nitrate using the phenoldisulfonic acid method.

RESULTS AND DISCUSSION

Both palm and soybean oils decomposed very rapidly in Portneuf silt loam (Table 1). There was no difference between the two oils in their amount of decomposition for the 12 weeks. Decomposition percentages were 70, 76, 44, and 44 for the lowest to highest oil application rates based on 76% calculated C content. Decomposition rates for the 5.0- and 0.5-g application rates are given for the two oils in Fig. 1. The 1.0- and 0.1-g application rate curves were similar to those given but were omitted to conserve space. They may be constructed from calculations based on the data in Table 2. These curves follow a fairly typical organism population growth curve with a rather short lag phase and a peak decomposition between

Table 1—CO_2 evolved during decomposition of cooking oil in Portneuf silt loam soil

Incubation time	Palm oil added, g				Soybean oil added, g			
	5.0	1.0	0.5	0.1	5.0	1.0	0.5	0.1
Weeks	CO_2 evolved, mg C*							
1	179	71	78	19	138	64	84	30
2	410	113	124	27	423	102	129	37
3	651	153	163	34	663	142	168	43
4	824	176	182	36	868	168	184	46
5	974	193	198	38	1,094	187	197	48
6	1,109	218	222	40	1,174	212	219	49
7	1,229	239	239	40	1,288	235	238	50
8	1,337	258	250	41	1,396	257	251	52
9	1,431	277	259	43	1,487	276	261	53
10	1,517	295	267	44	1,564	294	268	54
11	1,594	313	276	46	1,632	311	276	56
12	1,667	332	284	46	1,696	328	282	57

* Standard deviation for CO_2 evolution averaged 10.9%.

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Table 2—Nitrate-N determined in soil after 12 weeks incubation with cooking oils

Treatments		Palm oil		Soybean oil	
Oil*	Nitrogen*	Soil nitrate	N immobilized	Soil nitrate	N immobilized
		ppm, N			
5.0	0.0625	6.4	695	12.8	688
1.0	0.0125	3.4	197	4.2	197
0.5	0.0062	39.3	99	34.7	103
0.1	0.0012	86.1	2	86.9	1
Control†		76.1			

* The oil and nitrogen were added at the indicated rates in grams to 100 g of air-dried soil. † Soil alone, no oil added.

the second and third weeks on the higher and the first week on the lower oil rates. On a field basis these peak decomposition rates for the 5.0 g application are very impressive, with 8.6 and 7.1 metric tons oil/ha decomposed per week for the soybean and palm oils. At the 0.5 g application rate maximum decomposition was 2.48 and 2.30 metric tons/week for the soybean and palm oils. The minimum rates for the 5.0 g application at the end of the 12-week incubation was about 2 metric tons oil decomposed/ha per week for both of the oils. Even after 12 weeks of decomposition, rates were high enough to use up the added oil in a reasonable time.

Soil nitrate measurements were made following the decomposition periods. The results for soil nitrate are strikingly similar for both of the oils (Table 2). There is evidence that nitrogen deficiency may have contributed to lowering the decomposition rates of the 5.0- and 1.0-g oil applications. The fact that there was very little nitrate in the soil following the incubations suggested this conclusion. Apparently, insufficient N was added and the soil was unable to supply the additional N required for maximum decomposition at the two highest oil applications. At the lower oil applications, considerable nitrate was found in the soil following incubation. Using the added N, and the N mineralized by the soil, and assuming that the mineralization rate would be the same in the soil with or without the oil, N immobilization was calculated. These numbers are very similar for both oils and range from 1 to 695 ppm N for the various oil applications (Table 2). Sulfur was not added to the system, and this element may have been limiting.

Although oil decomposition rates might have been greater had more nitrogen or some sulfur been added, the objectives of the experiment were achieved at the N rates used. The evidence is clear-cut that these edible cooking oils decompose rapidly in soil. The edible cooking oils found in potato processing waste water will be low in concentration, seldom exceeding 10 ppm. Therefore, when the processing effluent is applied to land, the application of oil would seldom exceed 1 metric ton/ha per year. Oil losses greater than this would require a close look at plant operations to determine causes, and corrective action would be taken. At low application rates it is reasonable to expect almost complete decomposition in a few months. In this case, 70 to 76% decomposition was achieved in 12 weeks at the 2.24 metric ton/ha oil application rate. Decomposition at the highest application rate also proceeded at a satisfactory rate, with over 40% of the oil decomposing in 12 weeks. High applications of oil tended to temporarily hinder soil wettability. However, the soil wetted slowly, allowing decomposition to proceed after a few hours. The comparatively short lag period shown in Fig. 1 is evidence for this conclusion. These high application rates would not be found in the field and no problems with soil wetting are expected to develop even with repeated applications.

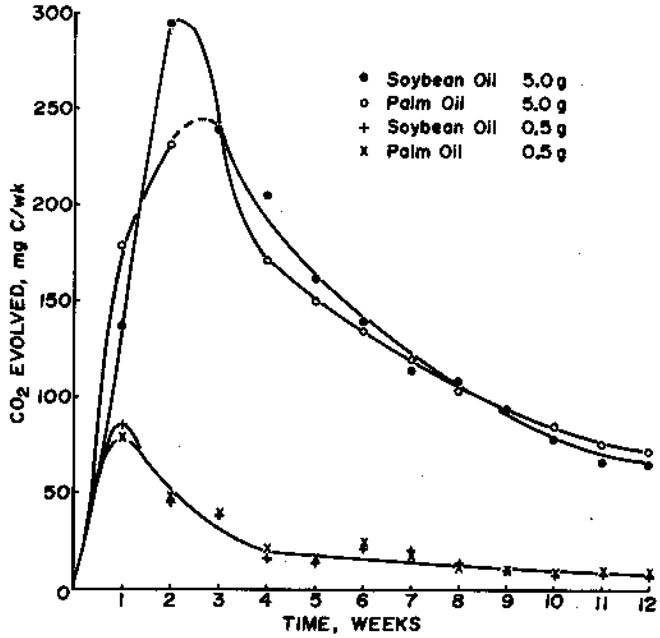

Fig. 1—Rate of palm and soybean oil decomposition.

In an efficiently operated potato processing plant, edible cooking oil from the plant that reaches the waste treatment field will generally be less than the lowest treatment in this experiment. Conversely, nitrogen applied to the soil in the plant processing effluent water will reach relatively high application rates. At one processing plant where studies are being conducted, the effluent water contained approximately 1,500 kg N/ha for 1 year. Even though this nitrogen is organic and must be mineralized before it is available to plants, the large amount precludes the possibility of a small oil application creating nitrogen deficiency in the field soil. In the laboratory experiment where there was an apparent nitrogen deficiency when 1.0 or 5.0% oil was applied, denitrification could have been a factor. The high energy source represented by the oil could have promoted denitrification and part of the added N may have been lost through that mechanism.

In spite of nitrogen and possibly sulfur deficiencies in this experiment, oil decomposition proceeded very rapidly. Consequently, there is little possibility that the oil would accumulate and create problems in the operation of treatment fields where food processing waste water containing low concentrations of these cooking oils is being distributed.

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