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TECHNICAL REPORT SUMMARY

Date: March 23, 1979

TO: TECHNICAL COMMUNICATIONS CENTER – 201-2CN

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Division: Environmental Laboratory (EE & PC)	Dept. Number: 0535
Project: Fate of Fluorochemicals	Project Number: 9970612643
Report Title: Final Comprehensive Report: FC 143	Report Number: 012
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Notebook Reference:	No. of Pages Including Coversheet: 11

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3M CHEMICAL REGISTRY ▶ New Chemicals Reported ☐ Yes ☒ No

KEYWORDS: (Select terms from 3M Thesaurus. Suggest other applicable terms.)

EE&PC - Div.
Fluorochemical
(Analytical)
(Aquatic)
(Degradation)
(soil)
Toxicity

CURRENT OBJECTIVE:

Final Report: Encompasses all work performed during the period; 1977-1979.

REPORT ABSTRACT: (200-250 words) This abstract information is distributed by the Technical Communications Center to alert 3M'ers to Company R&D. It is Company confidential material.

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INTRODUCTION

The rationale for performing environmental effects studies on fluorochemicals has been discussed previously[1,2].

The subject fluorochemical of this report is FC 143, a anionic surfactant, which has the potential for widespread distribution in the environment as this material is used by the Teflon(R) coating industry, both domestically and internationally. FC 143 chemically is the ammonium salt of perfluoro-octanoic acid.

This material is a white granular powder having a molecular weight of 431 and the chemical structure shown below.

$$C_7 F_{15} COO^- NH_4$$

FC 143

This report consolidates all available information in the areas of water solubility, partition coefficients, degradation, soil sorption and aquatic toxicity. The probable environmental risk of FC 143 is defined.

METHODS

Water solubility, biodegradation and soil sorption methodology's have been the subject of technical reports[1-3].

A) Aquatic Toxicity Testing

The testing protocols utilized for this study were modeled after that described by USEPA (1975)[4].

1. Bluegill Sunfish

The bluegill sunfish *(Lepomis macrochirus)* used in this study were obtained from a private hatchery.[a] Stock fish were held in fiberglass holding tanks filled with carbon-filtered well water maintained at 14-15°C. A daily photoperiod of 16 hours light and 8 hours dark, with a 30-minute transition period, was maintained throughout the acclimation and testing period. The fish were fed Tetra-Min[b] daily, food being withheld 48 hours prior to and throughout the test period. Fish were acclimated for 14 days prior to testing.

Acute short-term (96-hour) static aquatic bioassays were performed on FC 143, lot 340. Carbon-filtered well water of known composition was used as the diluent. All glass aquaria, 35 x 20 x 20 cm, containing 16 liters of water or water plus FC 143 comprised a study chamber.

[a]Dale Fattig Fish Farm, Brady, Nebraska

[b]Commercial fish food of known composition.

Twenty bluegill sunfish, *(Lepomis macrochirus)*, uniform in size and weight, were tested at each concentration of FC 143. Test fish were randomly assigned to various test chambers within 30 minutes following FC 143 addition. Test temperatures were maintained at $19^{o} \pm 1^{o}C$. Mortality, temperature, dissolved oxygen level, and pH of all test solutions were measured at 24-hour intervals or until total mortality had occurred. General observations relative to behavioral or erratic swimming patterns were similarly recorded when appropriate. Organisms used in this study were considered to be generally healthy and free of disease.

2. Aquatic Invertebrates - 48 hour Static LC_{50}

   Daphnia magna, twenty organisms per test chamber, were exposed to FC 143, lot 340 at varying concentrations for 48 hours. First instars were counted and placed in carbon-filtered well water, with chemical added and solubilized prior to the addition of the *Daphnia magna*.

Invertebrate test concentrations were 7.5, 10, 18, 32 and 56 mg/l while vertebrate test concentrations were 420, 560, 750, 1000, and 1350 mg/l.

LC_{50} values with 95% confidence limits were calculated using the USEPA (Duluth) Probit computer program on the 3M Trac system.

RESULTS

Table 1 lists water solubility and partition coefficient data obtained using FC 143, lot 340. This material is extremely water soluble, >20 g/l. FC 143 where added to water appeared to form a gel although further additions of FC 143 were similarly absorbed. This material is slightly lipophilic as evidenced by a partition coefficient of 5. Based on these data it can be concluded that FC 143 would not bioconcentrate to an appreciable extent in the environment. Chiou et al[5] have described an empirical relationship between the water solubility of a chemical and its bioconcentration factor. In their system, the ascribed error is considered to be approximately one order of magnitude. When applying data generated for FC 143 to this proposed relationship, this material would be projected to possess a bioconcentration factor of approximately 10.

TABLE 1 Water Solubility and Partition Coefficient of FC 143

Parameter	Test	Results
Solubility	Coarse method	>20 g/l as gel
Partition Coefficient	n-octanol/water	5

FC 143 was found to be completely resistant to biodegradation under the test conditions employed[2]. The 2 1/2 month shake culture biodegradation study utilized microbial test cultures derived from activated sludge inocula obtained from the Chemolite, Decatur and Twin Cities Metro Plan waste treatment system. During the time course of this study a strain of microbes which could degrade FC 143 did not develop, hence this material would be expected to persist in the environment for extended periods of time unaltered by microbial catabolism.

Soil sorption studies have shown that approximately 5%, (range 2-7%), of the FC 143 present in a water solution was adsorbed to Brill sandy loam soil (Table 2)[3]. Conversely, approximately 80% of the amount of FC 143 adsorbed to this soil would be desorbed after three (3) desorption trials (Table 2). Mobility of FC 143 was calculated using the scheme described by Hamaker[6] whereby adsorption coefficients are converted to a constant, K_{oc}, which reflects the organic content of the soil. This investigator has shown that the relative mobility of a group of pesticides could be determined in this fashion and that the K_{oc} value could be correlated with pesticide mobility. In applying this test, FC 143 had a K_{oc} value of 17, being slightly less mobile than chloramben, K_{oc} of 12-8, which was the most mobile pesticide based on Hamaker's work[6].

Table 2 Soil Sorption Tests on FC 143

Parameter	Test	Solution	Results
Soil Sorption	Adsorption	Water	~ 5%, range 2-7%
	Desorption	Water	80% of amount adsorbed
	K_{oc}		17

Results of the acute static aquatic tests are tabulated (Table 3). Based on the aquatic toxicity criteria established by NIOSH, FC 143 would be considered practically non-toxic to the vertebrates and invertebrates used in this test[7]. It is to be noted that the invertebrate data correlate well with those data obtained when testing fresh warm water species. This correlation has been observed repeatedly[8-10].

Egg-fry studies were contracted to EG&G Bionomics Laboratory and their results comprise Tables 4 and 5. These studies were undertaken to assess the effect of FC 143 at sublethal levels on hatchability, survival, weight and length changes (Table 4). It is generally accepted that the immature or young stages of an aquatic species are quite sensitive indicators

Table 3 FC 143, Results of 96 Hour Acute Static Testing

Test Organisms	96 Hr. LC_{50} mg/l	Limits Lower, mg/l	Upper mg/l
Bluegill Sunfish	569	500	636
Daphnia magna	632	570	699
	632	570	698

Table 4 Percentage Egg Hatch, Percentage Survival, Total Length and Wet Weight of Fathead Minnow Fry *(Pimephales promelas)* during Exposure to varying concentrations of FC 143 [a,b]

Concentration mg/l	Hatch %	30 Days Post Hatch Survival %	Length mm	Weight mg
100	96	85	20.5	59.5
50	92.5	94	20	62.5
25	99	92.5	21	72
12.5	90.5	97.5	21	71
6.2	94.5	93	21	69
Control	96.5	93.5	20.5	68.5

[a]Work performed by EG&G Bionomics Laboratory, Inc.

[b]Summary table submitted to Environmental Laboratory, 3M, St. Paul, as part of final report.

of chemically induced toxicity. In the parameters under investigation no statistically significant differences were obtained. At the highest FC 143 concentration tested, 100 mg/l, reductions were recorded in survival percent and weight 30 days post hatch. Although these data are suggestive of a latent onset in the development of cumulative toxicity, the dose levels of FC 143 at which these phenomina were observed far exceed, (several orders of magnitude), the environmental concentrations of FC 143.

Based on the results of the histopathological examination, a 30-day exposure to 100 mg/l FC 143 did not contribute to abnormal histopathology (Table 5). Both groups of organisms exhibited fatty liver changes, 6/10 controls and 5/10 treated organisms. Similarly, gill hyperplasia was seen in both groups, 3/10 controls and 2/10 treated fry.

Table 5 Histopathological Examination of Fathead Minnow Fry *(Pimephales promelas)* exposed 30-days to 100 mg/l FC 143[a,b]

Test Material	Number of Observations	Histopathological Findings
Control	10	6/10 fatty liver changes 3/10 normal 3/10 gill hyperplasia
100 mg/l FC 143	10	5/10 normal 5/10 fatty liver changes 2/10 gill hyperplasia

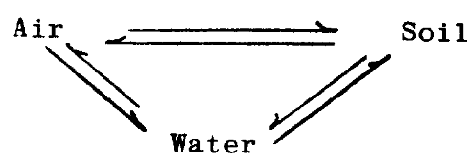
DISCUSSION

The primary purpose of this report is to provide a single source for all environmental data generated relating to FC 143 and to provide an analysis of potential environmental risk.

In developing this analysis two model types will be discussed: (1) a schematized closed system environment and 2) a practical model based on use of FC 143 at a manufacturing site and consumer product usage.

1. Closed System

The environment can be considered to be a closed system, schematically represented as:



Chemicals entering this system might establish an equilibrium between two or all three compartments, remain confined within a single compartment or pertubate all phases of the depicted cycle.

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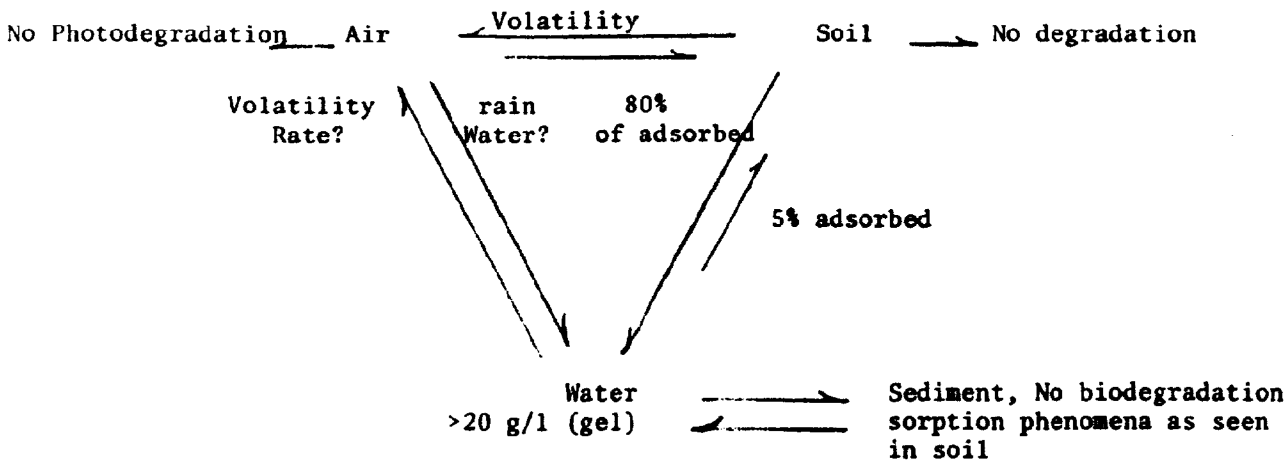
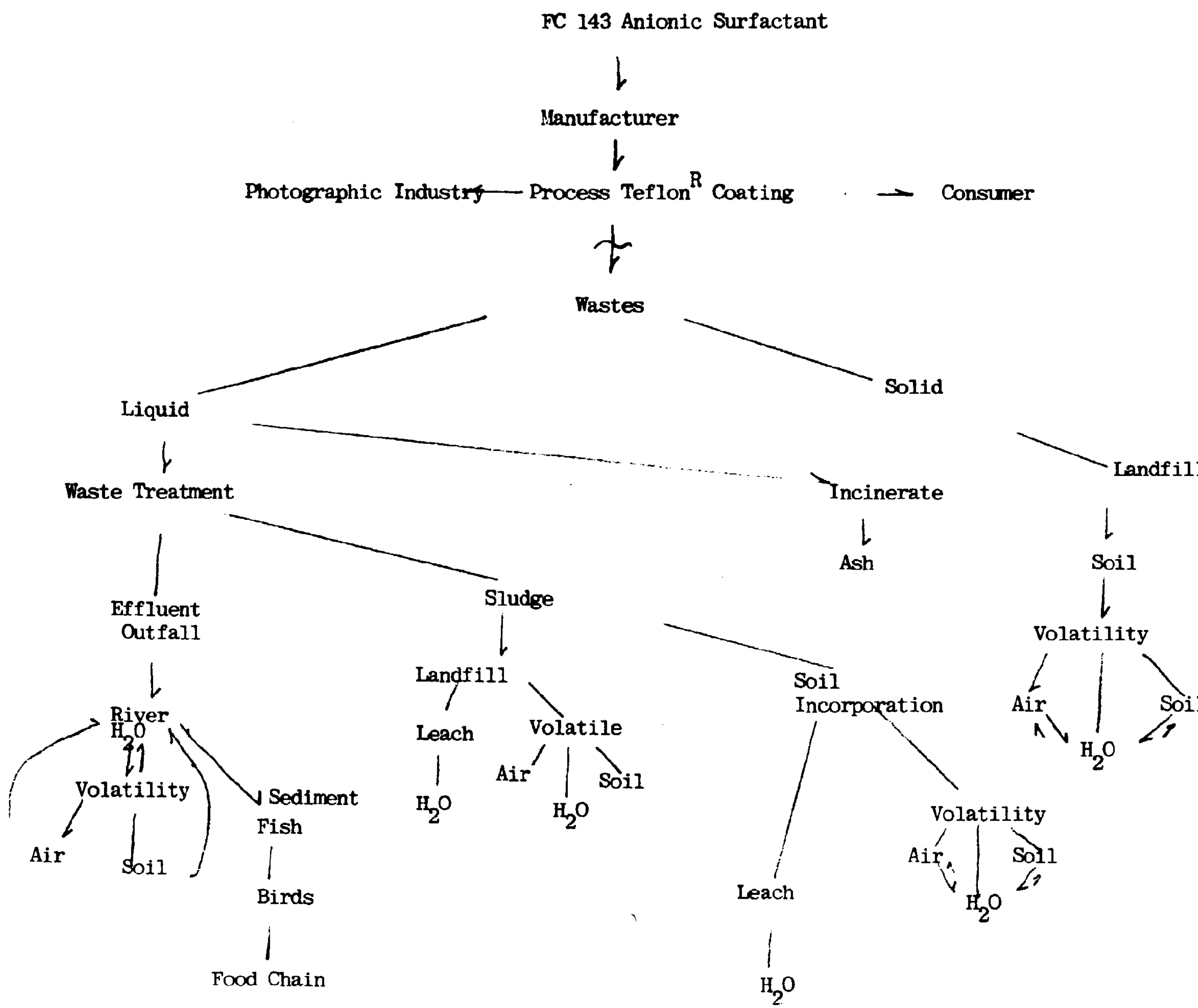
Specifically we can represent the impact of FC 143 in the following manner:



As illustrated, FC 143 enters the environment primarily by means of the waterways and secondarily <u>via</u> the terrestrial ecosystem and atmosphere. This material does not adsorb permanently to either soil and/or sediment, remaining however in the water compartment. It is not known whether FC 143 is volatile, a fact which assumes importance in light of the finding that FC 143 does not undergo photolysis.[11] Based on the foregoing, the waterways apparently are the environmental sink for FC 143. Intermediate receptors have not been identified.

2. Manufacturing and Consumer Model

The following construct illustrates various pathways wherein FC 143 may enter the environment at the processing site.



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The above figure depicts projected pathways wherein FC 143 might enter the environment. In discussing use of FC 143 by the Teflon(R) coating and photographic industries with Dr. M. Pike, Commercial Chemical Division, I was informed that to their knowledge no FC 143 wastes would be generated by the Teflon(R) coating process. Based on this information, I have depicted this no waste situation by the following sign; .

In discussing the manufacture of FC 143 with Jerry Hoffer, Chemolite, a similar observation to that outlined above was made.

In view of the above we can project the environmental concentration under conditions wherein all FC 143 manufactured is lost to the environment.

Since waterways are the environmental sink for FC 143, a simplistic model utilizing a single point source for FC 143 and a river would enable one to project an estimated environmental concentration for FC 143 under a worst case situation.

We have made several assumptions which are considered basic to this simplistic model:

1) Total production is at Chemolite and all FC 143 produced is discharged.

2) No FC 143 is removed by the treatment facility.

3) All effluent is discharged into the Mississippi River.

4) FC 143 is discharged uniformly.

5) River flow and all other parameters are constant, hence not subject to seasonal and/or climatic perturbations.

The formulae used in these projections include:

1) $$\text{MG/min} = \frac{(\text{River Flow, CFM})(\text{Conversion, gal/ft}^3)(\text{Time, min})}{\text{Production, per annum}}$$

2) $\text{MG/min} \times 1440 = \text{MG/Day}$

3) $\text{Lbs/day} = (\text{mg/l} \times \text{wt. lbs. } H_2O \text{ per gal})(\text{MG/Day})$

Mississippi River flow at Hastings, MN, based on a 10 year low flow record is 10,000 CFS.

The total 5 year production figures were provided by D.R. Ricker, Commercial Chemicals Division. In utilizing these figures an estimated environmental concentration of FC 143 in the Mississippi River below Chemolite was calculated. During the period 1973-1978, the EEC for FC 143 was calculated to be 1.6 μg/l at Hastings, Mn., while the EEC projected for the period 1978-1983 is projected at 2.4 μg/l. Since the water compartment is the environmental sink for FC 143, it is determined that at the present and projected levels of production FC 143 will not present an unreasonable environmental risk under worst case situations.

CONCLUSIONS

Under the test conditions employed in characterizing selected physicochemical and environmental properties of FC 143 it has been determined that this material

1) is extremely water soluble, forming a gel at 20 g/l.
2) has an n-octanol/water partition coefficient of ~ 5
3) is resistant to microbial degradation
4) is extremely mobile in Brill sandy loam soil
5) in an egg-fry study did not affect hatchability, survival, length or weight following a 30 day exposure to FC 143 at sublethal levels to a statistically significant degree. Similarly, no adverse effect was noted on tissues examined for evidence of chemical induced pathology.
6) is to be found primarily in the water compartment, hence its environmental sink. No specific intermediate receptors have been identified.
7) would have an estimated environmental concentration of approximately 1.6-2.4 μg/l, under conditions wherein all FC 143 were manufactured at Chemolite and discharged into the Mississippi River.
8) will not present an unreasonable environmental risk based on present and projected production levels, usage patterns etc.

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