Analytical Chemistry
Special Study 72-6
Job No. 1348006

AROCLOR 1016 SOIL MIGRATION STUDIES

INTRODUCTION

Continued acceptance of the use of Aroclor products (polychlorinated biphenyls - PCBs) as dielectric fluids depends to a great extent upon our ability to control the rate at which they are released to the environment. Consequently, Monsanto restricted the sale of these materials to "closed systems" and set up a high temperature incinerator for disposal of the used fluids.

While incineration can be used to dispose of the bulk of the Aroclor sold, it is not, for many reasons, a practical means of disposing of Aroclor impregnated capacitors. As such, Aroclor impregnated capacitors are disposed of by burial in landfills. Because of this a new product - Aroclor 1016 - was introduced by Monsanto for use in capacitors. Aroclor 1016 is a PCB product manufactured in such a manner that it contains significantly lower levels of the degradation resistant higher chlorinated homologs than does Aroclor 1242, the previously used fluid.

The objective of this study was to produce data which would help evaluate the suitability of landfill disposal of Aroclor 1016 impregnated capacitors. Of prime concern was the rate at which percolating ground water would leach Aroclor 1016 from various types of soils. Three different types of soils were used in these experiments.

CONCLUSIONS

The results of this study clearly demonstrate that PCBs are not readily leached from soil by percolating water. In the worst case, less than 0.05% of the total Aroclor 1016 available (25,000 ppm) was leached from the soil during the entire four month duration of these experiments. During this period of time approximately 30-70 liters of water were passed through the three soil columns, an amount of water roughly equivalent to 30-50 ft. of rainfall, assuming no run off.

The ease of leaching Aroclor 1016 from the different types of soils was in the following order: Norfolk Sandy Loam>Ray Silty Loam> Drummer Silty Clay.

Additionally, it was observed that only the less chlorinated, more degradable homologs were leached from the soils.

The results of this study support the conclusion drawn by the Michigan Water Resources Commission that landfills are only a minor source of PCB environmental contamination.(1)

DETAILS

In essence, the experimental procedure employed consisted of percolating water through a column packed with soil coated with Aroclor 1016 and then monitoring the effluent water for PCBs. The set up used is shown schematically in Figure I. The soil columns employed are approximately 3" in diameter by 12" in height and were dry packed in layers. Each soil layer being 3" thick - first uncoated soil, followed by soil coated with 2.5% of Aroclor 1016, and finally another layer of uncoated soil. Aroclor 1016 was coated on the soil using an acetone solution slurry, followed by removal of the acetone in a rotary evaporator. Three different soils, covering the gamut of soil types, were used in these experiments. The soils and the characterizations of each are shown below.

Soil Name	Norfolk Sandy Loam	Ray Silty Loam	Drummer Silty Clay
Sand	83.6	7.2	8.8
Silt	10.9	83.2	55.4
Clay	5.5	9.6	35.8
Organic Carbon	1.1	0.6	9.9

A Marriott bottle was used to feed the water to the soil column at a constant pressure. A plot of the flow rate in liters/day vs days (Figure II) showed an initial increase in flow rate during the first few days which decreased and eventually leveled out. Apparently, after the wetting phase some channeling occurs, until the soil becomes compressed in the column. This effect was most pronounced with the silty soils.

The eluent water from the soil column was in turn passed through a polyurethane foam column which quantitatively absorbs the PCBs[2]. Sampling was carried out on a periodic basis by interchanging a new polyurethane foam column for the old column. In this manner, the effluent could be continuously monitored. The PCBs were removed from the polyurethane by elution with 20 ml of acetone followed by 100 ml of hexane and after clean up and concentration they were measured by electron capture gas chromatography. The details of the clean up and detection can be found in Analytical Chemistry Method No. 71-35.

Shown in Figure III is a plot of the concentration of PCBs as a function of the volume of water. In all cases, the level of PCB observed is less than the solubility of Aroclor 1016 in water shown by the dashed line. Breakthrough of PCBs is related to the clay content of the soil, as shown in Figure IV. Inspection of this figure illustrates that approximately 160 liters of water would have to pass through the soil column before a breakthrough was observed with the Drummer Silty Clay.

Plotted in Figure V is the concentration of PCBs vs time. The effect of the different flow rates is clearly illustrated. The average flow rates in liters/day for Norfolk Sandy Loam, Ray Silty Loam and Drummer Silty Clay were 0.26, 0.53 and 0.32, respectively.

The chromatograms shown in Figure VI detail the isomer distribution of the PCBs observed in the eluent water. Aroclor 1016 which was coated on the soil is shown at the top followed by the PCBs leached from the soils in the middle, and finally a less chlorinated member of the Aroclor series, Aroclor 1221, which was used for quantitation. The number above each peak indicates the chlorine content of the dominate homolog in that peak. It is evident that only the less chlorinated, more biodegradable isomers, similar to Aroclor 1221, were leached from the soil. A degradation rate for Aroclor 1221 of 70 ±18% has been observed in semi-continuous activated sludge tests at a feed level of 1 mg/24 hours[3].

REFERENCES

1) Summary of the Michigan Water Resources Commission PCB Monitoring Efforts, Lansing, Michigan, John L. Hesse, 12-15-71.

2) Analytical Letters, 4 (12), 883-886 (1971).

3) Progress Report, MICC Applied Sciences, Biodegradation Studies, #7, 6-5-72.

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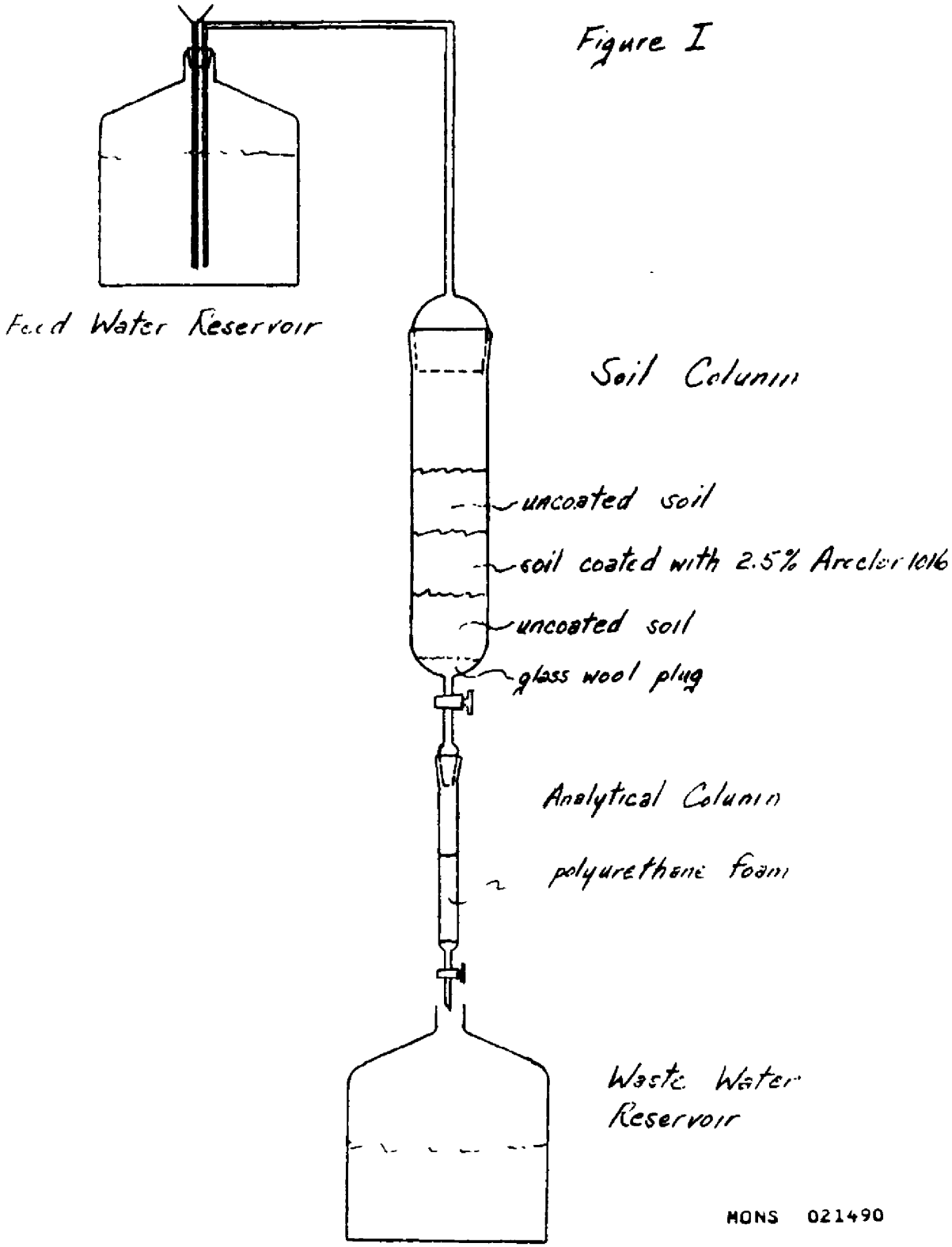
Figure I



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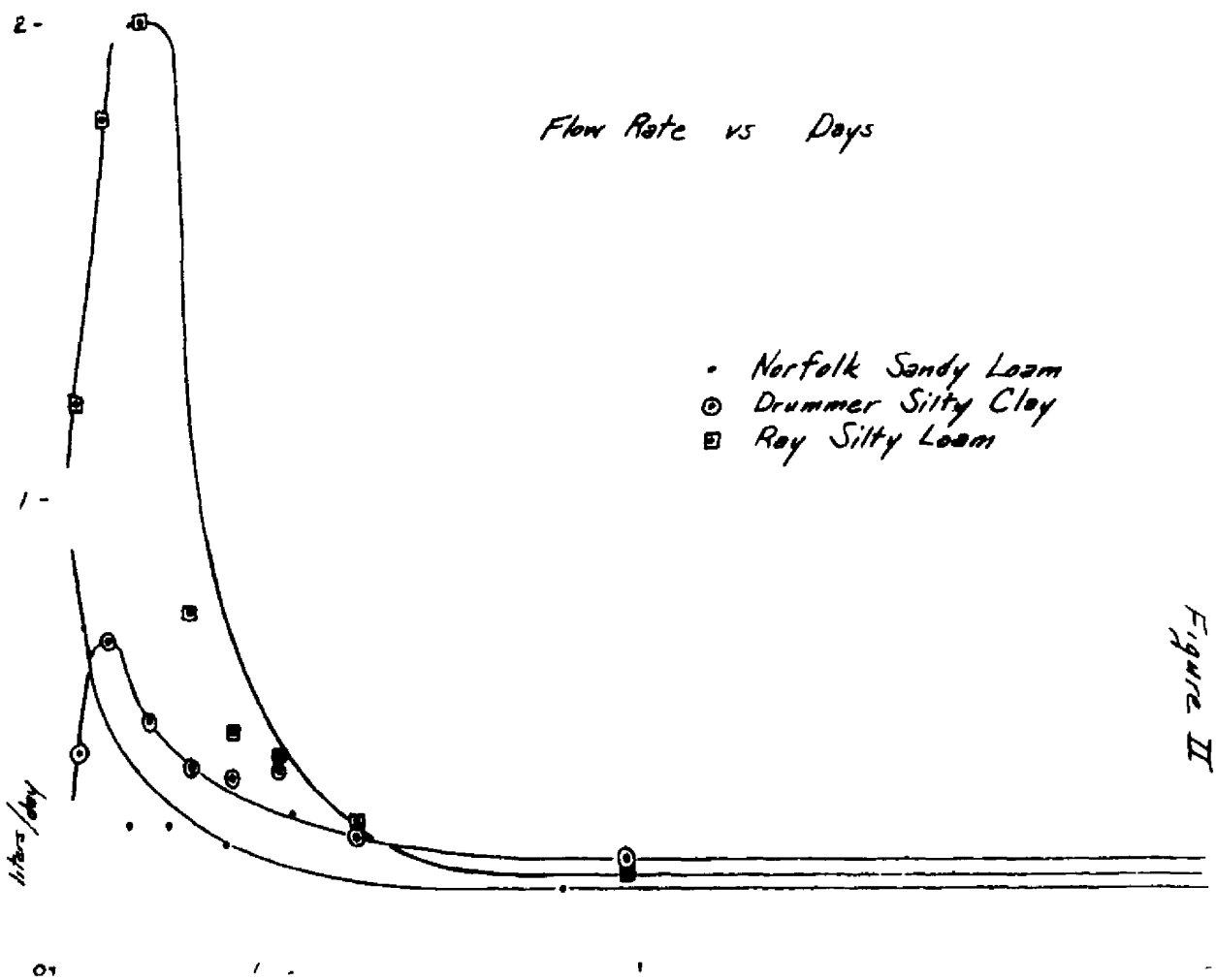
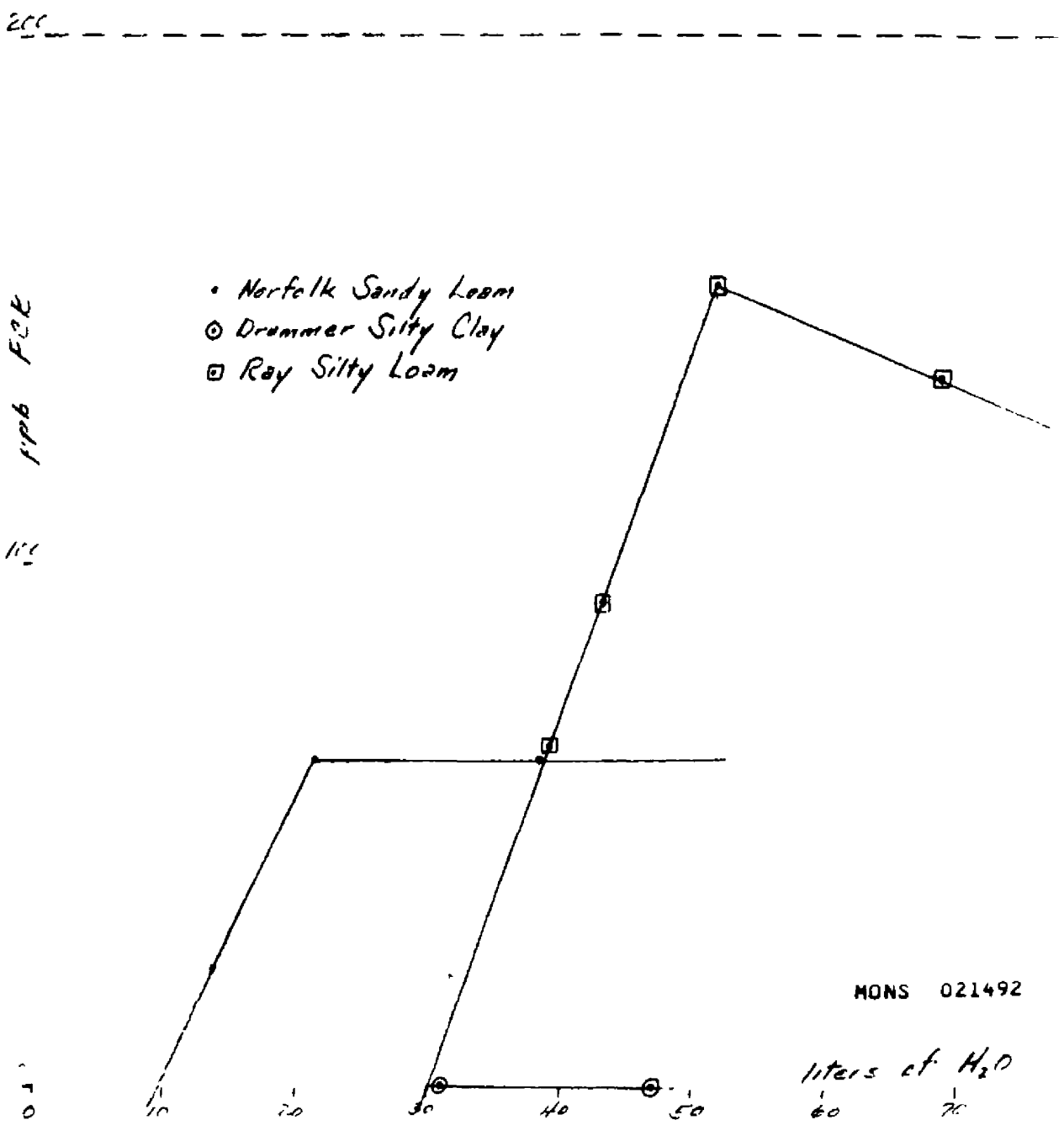


Figure II

MONS 021491

Figure III

ppb PCB vs Volume of H_2O



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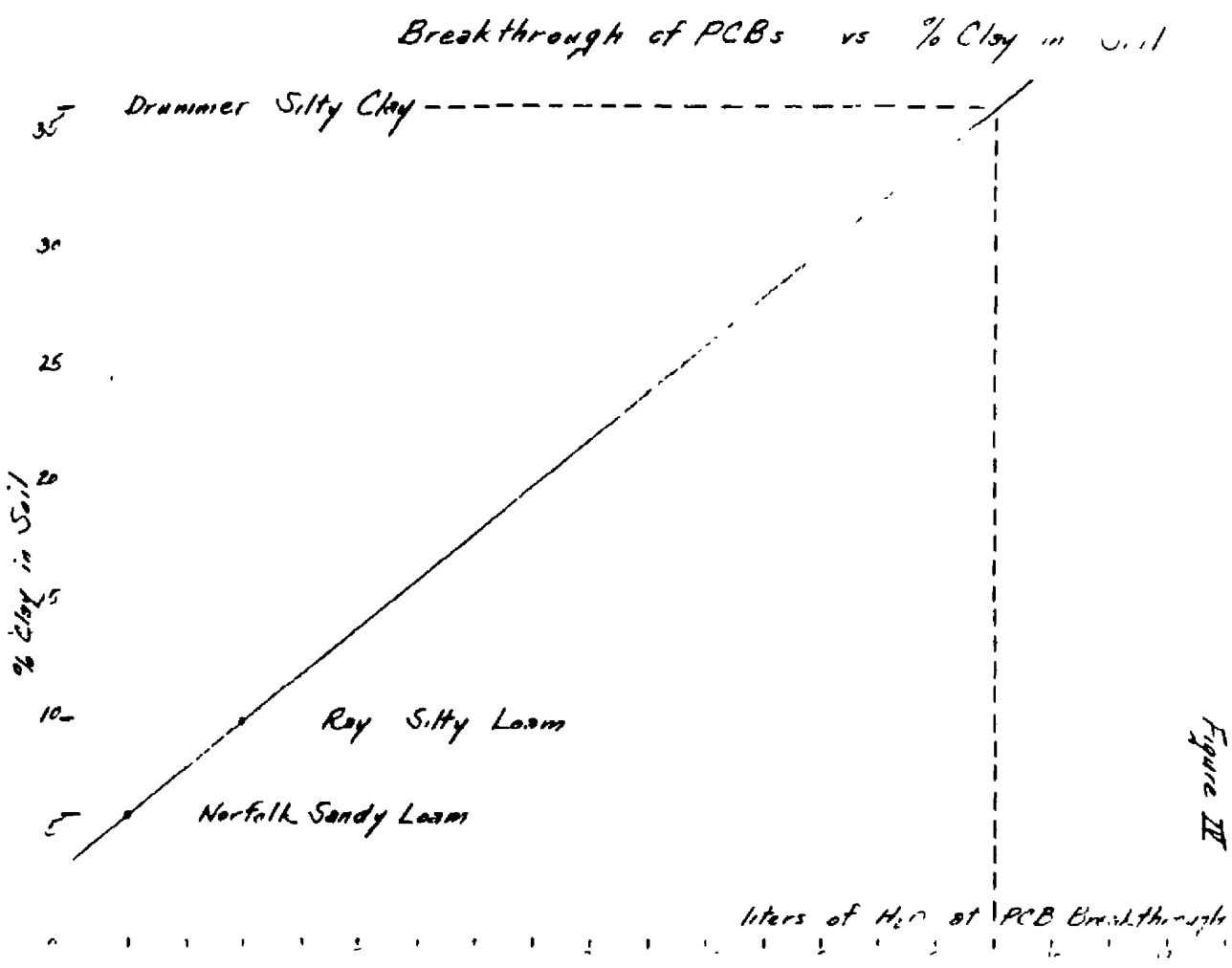

Figure III

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ppb PCB vs Days

Figure I

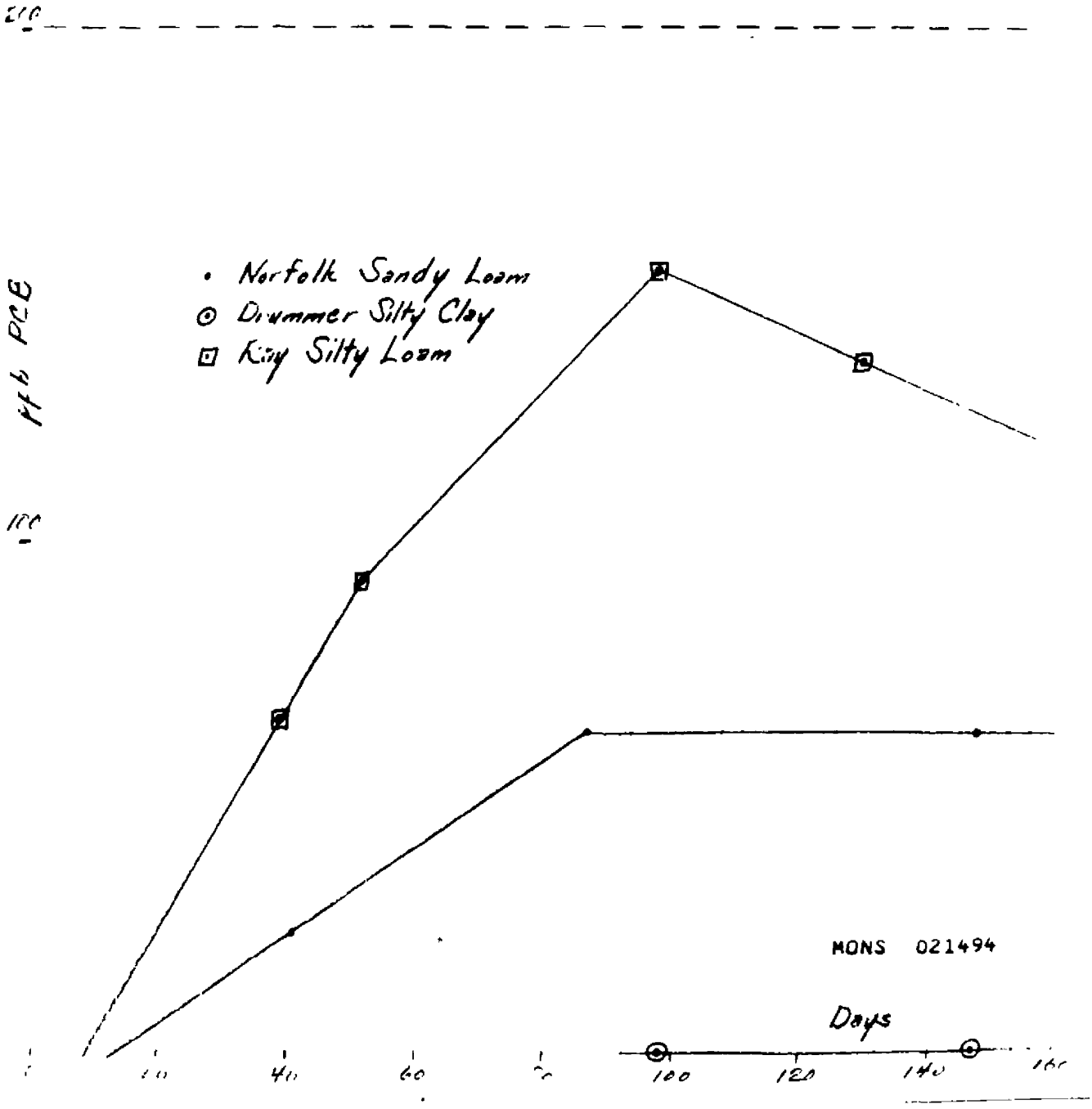
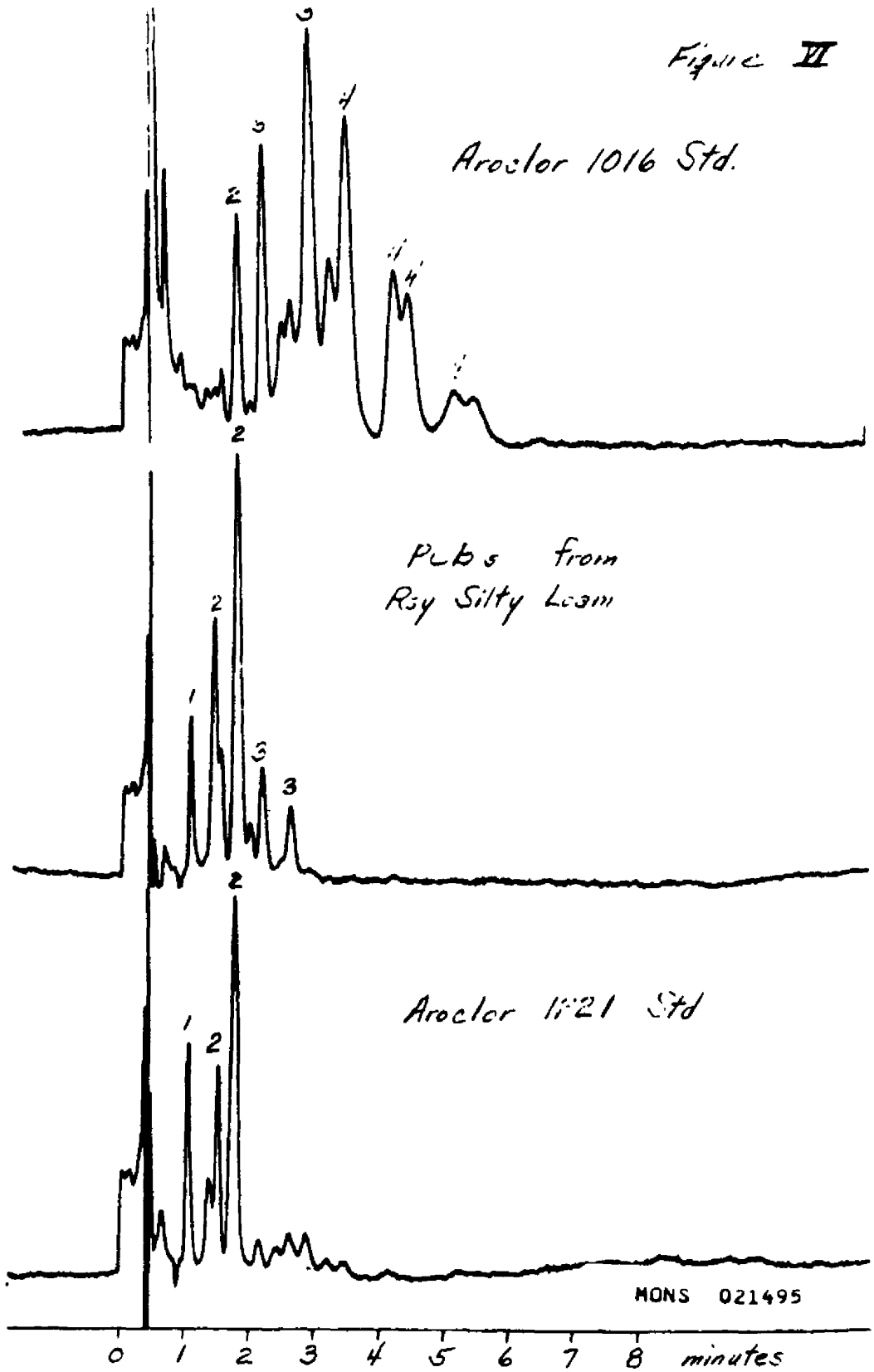


Figure VI


Aroclor 1016 Std.
PCBs from
Ray Silty Loam
Aroclor 1221 Std
MONS 021495
0 1 2 3 4 5 6 7 8 minutes