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Weathering of *Explosives* for *Twenty Years*

Los Alamos

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WEATHERING OF EXPLOSIVES FOR TWENTY YEARS

by

F. W. DuBois and J. F. Baytos

ABSTRACT

Twelve high-explosive materials were buried in soil and exposed to the elements to determine their rate of disappearance from the environment. Only those explosives that contained TNT, barium nitrate, and boric acid disappeared at an environmentally significant rate.

I. INTRODUCTION

Experiments were undertaken to determine the persistence of explosives in the area surrounding a drop tower at Los Alamos National Laboratory (Los Alamos) technical area TA-11, which is used in testing the sensitivity of explosives to impact. A location with soil, topography, flora, and weather conditions typical of the area surrounding the tower was selected. Soil was removed, mixed with explosives, replaced, and analyzed periodically for residual explosives. Total time of the experiment was 20 years. Results after 4-l/2 years were reported in LA-4943 (June 1972)[1]

The exposed explosives were PETN, HMX, RDX, TNT, Octol,* Cyclotol,** Composition B-3 (Comp B-3),*** PBX9404,† PBX9011,†† PBX9010,††† Boracitol§ and Baratol.§§ Tests were also run with *Pseudomonas aeruginosa,* but the bacteria did not survive.

The disappearance of the materials with time is shown in Figs. 1 through 4. Only those explosives containing TNT, barium nitrate, or boric acid disappear at a rate that can be considered significant for their effective elimination from the environment.

* 75/25 wt% HMX/TNT.
** 75/25 wt% RDX/TNT.
*** 60/40 wt% RDX/TNT.
† 94/2.95/2.95/0.1 wt% HMX/cellulose nitrate/CEF/diphenylamine.
†† 90/10 wt% HMX/Estane 5740 X-2.
††† 90/10 wt% RDX/Kel-F Elastomer 3700.
§ 40/60 wt% TNT/boric acid.
§§ 24/76 wt% TNT/barium nitrate.

II. EXPERIMENTAL METHOD-SAMPLE PREPARATION

Soil from the test site was screened through a l/4- by l/4-in. wire screen and dried to a moisture content of 0.25 wt%. Three sets of samples were prepared.

1. The first set consisted of 12 samples, each containing 0.1 wt% of one of the 12 explosives. Five grams of the powdered explosive was mixed with 5 kg of soil in a Patterson-Kelly twin-shell blender.
2. A second set of four samples containing 0.1 wt% PBX 9404, PBX 9010, PBX 9011, and Comp B-3, respectively, was made up. These samples were analogous to the first set, except that 10 ml of a culture of *Pseudomonas aeruginosa* was added to each and the water content of each was raised to 20 wt%.
3. A third set of samples consisted of a 5/8-in.-diam by l/4-in.-high cylinder of each of the 12 explosives buried in the soil.

The sample materials were placed in 7-in.-diam by l/6-in.-high sections of Johns-Manville Transite tubing. The tubes had a fine-mesh stainless steel screen on the bottom and hardware cloth over the top. The sample containers were buried in the test area with their tops flush with the surrounding surface.

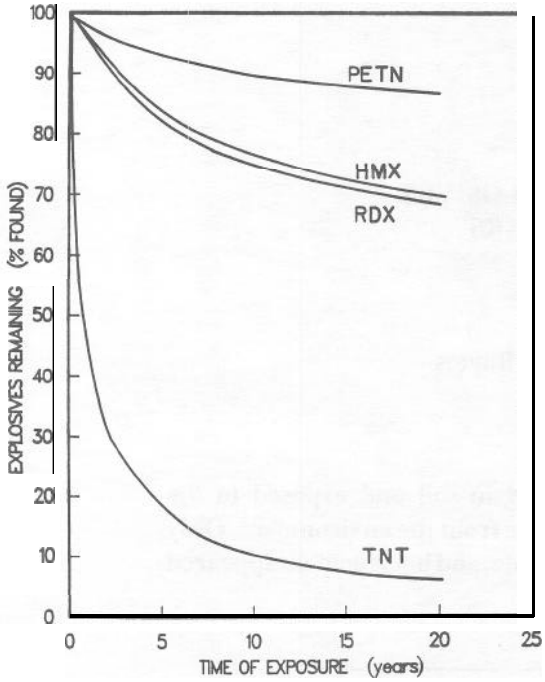

Fig. 1. Per cent of individual explosives (TNT, RDX, HMX, and PETN) found remaining in soil sample after exposure to weathering. Original ratio of explosive to soil weight was l/1000.

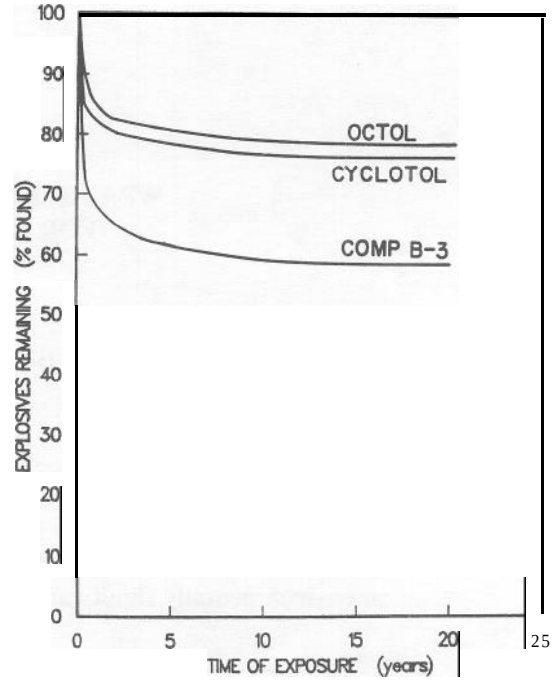

Fig. 2. Per cent of cast explosives (Comp B-3, Cyclotol, and Octol) found remaining in soil sample after exposure to weathering. Original ratio of explosive to soil weight was l/1000.

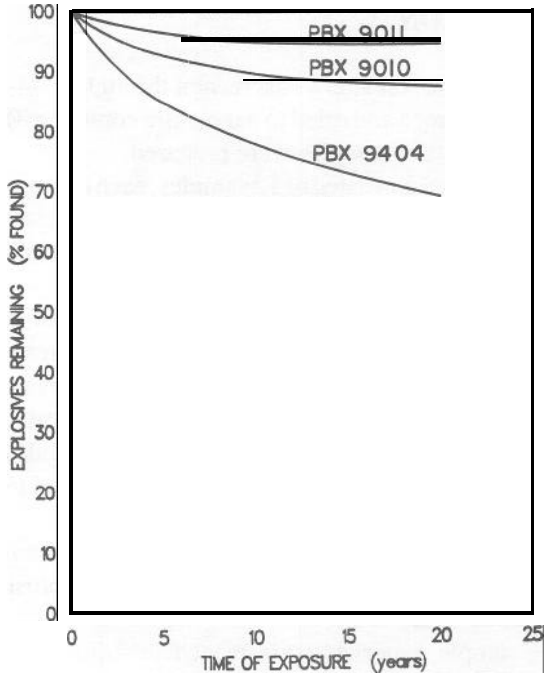

Fig. 3. Per cent of plastic-bonded explosives (PBXs 9404, 9010, and 9011) found remaining in soil sample after exposure to weathering. Original ratio of explosive to soil weight was l/1000.

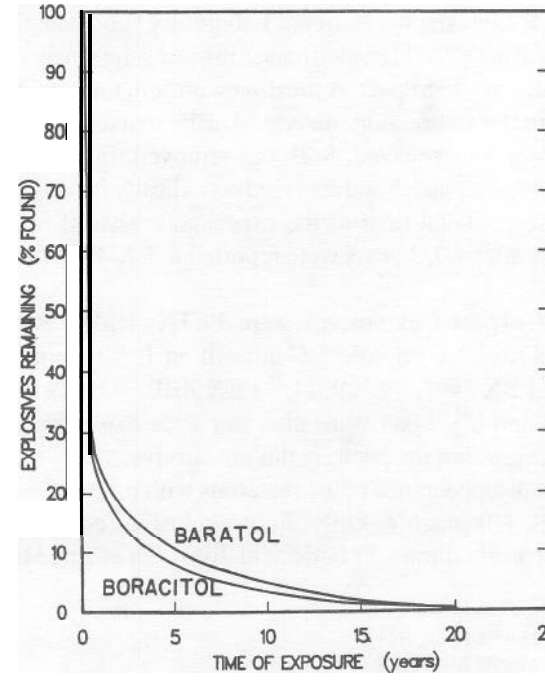

Fig. 4. Per cent of cast explosives made with water-soluble inorganics (Baratol and Boracitol) found remaining in soil sample after exposure to weathering. Original ratio of explosive to soil weight was l/1000.

III. ANALYTICAL PROCEDURES

A. Sampling

A 3/4-in.-diam tube was used to remove a 50-g analytical sample from the samples containing powdered explosives. The cylinders of explosive were dug out of the soil by hand.

B. Analysis

The cylinders of explosive were weighed and photographed. Material from the samples containing bacteria was sent to the Los Alamos Industrial Waste Group, HSE-7, for determination of the numbers of ***Pseudomonas aeruginosa*** remaining in the soil. The soil containing powered explosive was analyzed as follows.[2,3]

1. The core sample was dried.
2. Ten grams of the material was placed in a Soxhlet extractor, and the explosive was extracted with acetone for 3 hours.
3. The acetone was evaporated, and the solute was taken up in acetonitrile and diluted to 50 ml.
4. The concentration of explosive was determined using the Perkin-Elmer Model 350 spectrophotometer and the newer Perkin-Elmer 554 spectrophotometer. The determinations were made in the ultraviolet region at the wavelengths given in Fig. 5.

IV. DISCUSSIONS

The disappearance of the powdered explosives as a function of time is shown in Figs. 1 through 4. The amounts of Baratol, Boracitol, Comp B-3, Cyclotol, and Octol, which contains water-soluble components, decreased with time. RDX, HMX, and PETN changed very little. Estimates of half-lives were made from normalized UV chart data by applying the first-order reaction-rate equations. Results are reported in Table I.

The ***Pseudomonas aeruginosa*** did not survive. Only 10% were left after 1 month, and they were essentially gone after 6 months.

The Baratol and Boracitol cylinders were severely deteriorated by the environment; the others were slowly eroded with time.

The site for this experiment was selected by Group HSE-7. The soil is typical of that in the surrounding area and is probably very much like that of most of the Los Alamos firing sites.

These experiments were instigated by Group GMX-3 (currently WX-3) in the hope of finding that the explosives would disappear with time. It is clear that this is not the case. Explosives that enter the environment from our operations will be around for a long time.

In 1977, 12 years into the experiment, a major forest fire passed over the area that removed all the vegetation and overburden and consumed adjacent trees. There was no observable effect on the buried explosives.

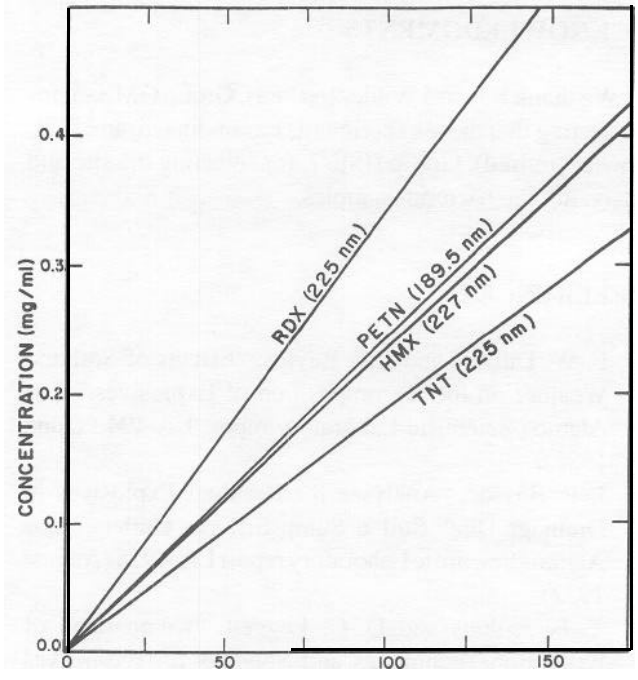

Fig. 5. Lambert-Beer curves of explosives in acetonitrile on the Perkin-Elmer UV-VIS-NIR spectrophotometer. Light path is 0.5 mm in cylindrical quartz cells.

TABLE I
ESTIMATES OF HALF-LIVES OF EXPLOSIVES FROM TWENTY-YEAR DATA

Explosive	Half-Life (years)
HMX	***39***
RDX	***36***
PETN	***92***
TNT	1
PBX 9404	***37***
PBX 9011	***224***
PBX 9010	108
Baratol and Boracitol	~ 1[a]
Octol, Cylotol, and Comp B-3	x [b]

[a]There will be residual TNT.
[b]RDX, HMX, and TNT will disappear at their independent rates.

ACKNOWLEDGMENTS

We thank Edward Wilder (retired), Group GMX-3, for requesting that these experiments be conducted, and E. B. Fowler (retired), Group HSE-7, for selecting the site and analyzing the bacterial samples.

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