<table>
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<tr>
<th>Title</th>
<th>Authors</th>
<th>Date</th>
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<td>Composite Sampling of Sediments Contaminated with White Phosphorus</td>
<td>Marianne E. Walsh, Charles M. Collins, Ronald N. Bailey, Clarence L. Grant</td>
<td>Dec 1997</td>
<td>26</td>
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<td>Method for Producing Performance Evaluation Soil/Sediment Samples for White Phosphorus Analysis</td>
<td>Marianne E. Walsh, COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH</td>
<td>Sep 1996</td>
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<td>Persistence of White Phosphorus Particles in Sediment</td>
<td>Marianne E. Walsh, Charles M. Collins, Charles H. Racine, COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH</td>
<td>Nov 1995</td>
<td>51</td>
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<td>A simple field screening method to detect white phosphorus particles in sediment is described. A thin layer of wet sediment is heated until all water evaporates. The presence of white phosphorus is indicated by visual detection of the inflammation of white phosphorus particles that .... The field screening method consistently gave positive results for samples where solvent extraction followed by gas chromatography indicated white phosphorus concentrations above 1 micrograms/g. A more sophisticated method, based on solid-phase microextraction and gas chromatography determination, was ....</td>
<td>Marianne E. Walsh, Charles H. Racine, Charles M. Collins, Carl Bouwkamp, Philip G. Thorne, COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH</td>
<td>Oct 1995</td>
<td>13</td>
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<td>In 1991 we delineated the extent of 50 ha of the 1000-ha salt marsh. Sediment and tissue samples were analyzed for white phosphorus by gas chromatography. 20 cm. The distribution and highest concentrations of white phosphorus were localized in two of the six feeding areas. The transformation of phosphorus oxides in the presence of moisture. We recommend that screening studies should consider environmental conditions. Originator supplied key words include: White phosphorus, Red phosphorus, Transformation products, Rate constant, Fate ....</td>
<td>Charles H. Racine, Marianne E. Walsh, Charles M. Collins, Susan Taylor, Bill D. Roebuck, BATTLE MEMORIAL INST COLUMBUS OH</td>
<td>Oct 1993</td>
<td>72</td>
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<td>Analysis</td>
<td>Authors: Charles H. Racine, Marianne E. Walsh, Charles M. Collins, Carl Bouwkamp, Philip G. Thorne</td>
<td>COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH</td>
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White phosphorus from exploded munitions is a difficult contaminant to characterize in the environment. Spatial heterogeneity of concentration estimates is extreme. The site and monitoring the remedial process for an area contaminated by white phosphorus. For each method, closely spaced discrete samples were taken. The composites were then divided by size fractions. Mean white phosphorus concentrations were estimated for the fine-grain-size fraction that was obtained by suspension with water. The presence of highly toxic solid white phosphorus particles, the form that may be ingested by feeding...

**Mammalian Toxicology and Toxicity to Aquatic Organisms of White Phosphorus and 'Phossy Water', A Waterborne Munitions Manufacturing Waste Pollutant - A Literature Evaluation**

Authors: Dickinson Burrows, Jack C. Dacre, AWARE INC NASHVILLE TN

Elemental white phosphorus is highly toxic to both experimental animals and man. Ingestion of even small amounts may produce severe gastrointestinal distress, bloody diarrhea, liver... is characterized by such effects on the osseous system as bony necrosis ('phossy jaw'), spontaneous fractures, as well as by anemia and weight loss. White phosphorus appears to be noncarcinogenic when fed to experimental animals. White phosphorus is also highly toxic to aquatic animals. Crustaceans and many molluscs are more tolerant, but still succumb to white phosphorus concentrations of 1 ppm or less.

**The Subchronic Effects of Repeated Exposure to White Phosphorus/Felt Screening Smokes in Rats**


Toxicity studies were conducted to determine the subchronic effects of repeated exposure to three concentration levels of a white phosphorus screening smoke. When white phosphorus burns, it forms a number of oxides of phosphorus which are rapidly converted by moisture to phosphorus and phosphonic acids. It would appear that the chance of injury is high at 1161 mg/m cm and low at 195 mg/m cm. At 589 mg/m cm, one-half of the rats showed some exposure effects. The rats apparently developed a tolerance to repeated exposures, particularly at the lowest level.

**Water Quality Criteria for White Phosphorus**

Authors: Kowetha A. Davidson, Patricia S. Hovatter, Catherine F. Sigmon, OAK RIDGE NATIONAL LAB TN

Data obtained from a review of the literature concerning the environmental fate and aquatic and mammalian toxicity of white phosphorus are presented in order to derive Water Quality Criteria for the protection of humans and aquatic organisms and their uses. Laboratory and field studies indicate that white phosphorus is quite toxic to aquatic organisms, with fish being more sensitive than macroinvertebrates. In dynamic bioassays with fishes, bluegill was the most sensitive species. The most sensitive life stages for...

**Design, Development, Test, and Evaluation of a Level C Interplant Shipment Pallet for 60 mm M722 White Phosphorus Filled Body Assemblies**

Authors: Yuen H. Lam, ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL NJ ARMAMENT ENGINEERING DIRECTORATE

...test, and evaluation program to qualify a wooden pallet assembly (drawing 12937963) that is needed for interplant and storage of 60 mm M722 white phosphorus filled body assemblies. The final pallet design met the U.S. Department of Defense standard, MIL-STD-1905, as well as the performance oriented... is recommended for use as reference for other similar shipment and storage requirements. 60-mm mortar, M722 cartridge, Shipment pallet, White phosphorus, Body assembly, Performance oriented packaging, Plywood partitions, Steel straps, POP.

**Development of an Analytical Method for White Phosphorus (P4) in Water and Sediment Using Solid-Phase Microextraction**

Authors: Marianne E. Walsh, Susan Taylor, Philip G. Thorne, COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

Headspace solid-phase microextraction (SPME) methods were developed for white phosphorus in water and sediment/silt to minimize waste generated by methods based on solvent extraction. Headspace SPME provided a rapid, non-exhaustive extraction, based on equilibrium, of white phosphorus. Comparison of results obtained by headspace SPME and solvent extraction shows that headspace SPME may be used quantitatively for some water matrices and qualitatively for more complex matrices such as sediment/soil. Because detection...

**Remediating and Monitoring White Phosphorus Contamination at Eagle River Flats (Operable Unit C), Fort Richardson, Alaska**

Authors: M. E. Walsh, C. H. Racing, C. M. Collins, M. R. Walsh, R. N. Bailey, ENGINEER RESEARCH AND DEVELOPMENT CENTER HANOVER NH COLD REGIONS RESEARCH AND ENGINEERING LAB

...Army Engineer District, Alaska, and U.S. Army Alaska, Public Works, describing the results of research, monitoring, and remediation efforts addressing the white phosphorus contamination in Eagle River Flats, an 885-ha estuarine salt marsh on Fort... this year. The pumps kept the ponds drained for an extended period during the summer, allowing the pond bottom sediments to dry and the white phosphorus to sublime and oxidize. The logistics continued to be fine-tuned, leading to a more effective and efficient operation this year. The combination of a...

http://www.stormingmedia.us/search.html?q=White+Phosphorus&x=12&search.y=9 Page 2 of 8
Environmental Assessment for the Use of White Phosphorus Rockets at Melrose Air Force Range, New Mexico
Authors: AIR COMBAT COMMAND LANGUAGE AFB VA
This report contains the test results performed on the M722 white phosphorus (WP) filled body assemblies for 60mm mortar (208) packed in a wood pallet container... resources. WP rocket use would have minimal adverse consequences to safety, materials management, physical, biological, and cultural resources. White phosphorus can create handling safety risks, potential water and soil contamination, and increased fire risk. Cannon AFB... ground disturbance. Potential risks to soil and water are minimal as the environmental conditions at Mel rose AFR are not conducive for white phosphorus to remain in its reactive state. Alternative A avoids the more environmentally sensitive areas on the south range.

Demilitarization of White Phosphorus Munitions
Authors: Darrell R Rainey; Mark M Zaugg; CRANE ARMY AMMUNITION ACTIVITY IN
This paper highlights one of the first resource recovery projects undertaken by the U.S. Army to meet the intent of the Resource Conservation and Recovery Act, which was the development and successful operation of a White Phosphorus to Phosphoric Acid Conversion Plant for disposal of white phosphorus filled munitions. Background for the plant development is presented, along with an operational history of the plant, and a description of the plant and how it operates.

Environmental Fate of White Phosphorus/Felt and Red Phosphorus/Butyl Rubber Military Screening Smokes
Authors: Ronald J. Spanggord; Robert Rewick; Tsong-Wen Chou; Robert Wilson; R. T. Podoll; SRI INTERNATIONAL MENLO PARK CA
Investigations were conducted to identify those processes that control the loss and movement of white phosphorus/felt, Red phosphorus-butyl rubber, and their combustion products in air, soil, and aquatic environments. The fate of RP/BR will be controlled by oxidative transformation. In air, half-lives of 1.8 years were found while in aerated water, the half-life approach 3 years and was found to be dependent on both particle size and oxygen concentration. In soil, the transformation was limited by oxygen diffusion and...

Summary and Evaluation for White Phosphorus Remediation: A Literature Review
Authors: Yilda B. Rivera; Trudy Olin; R. M. Bricka; ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS
This report summarizes an extensive literature search that was conducted regarding the environmental fate of white phosphorus (WP) and applicable treatment technologies. The health risks associated with WP exposure, documented environmental effects, transformation processes, degradation products, ... of atmospheric oxygen. However, Berkowitz et al. (1981), in assessing the potential hazards associated with the use of phosphorus smoke munitions, reported that WP residues in aquatic systems can be extremely toxic. Berkowitz stated...

RECOMMENDATION FOR A SAFER TREATMENT OF WHITE PHOSPHORUS BURNS
Authors: R. Quentin Blackwell; NAVAL MEDICAL RESEARCH UNIT NO 2 MANILA (PHILIPPINES) DEPT OF BIOCHEMISTRY
One to three per cent solutions of copper sulfate have been used in the treatment of wound areas of casualties suffering white phosphorus burns. Excessive copper absorption with acute toxicity reportedly has occurred in some cases where such solutions have been left in contact with appreciable areas of open wound for extended intervals of time. Laboratory tests suggest that 0.05 per cent copper sulfate is equally effective. Field trials are recommended.

MIL-STD-1660 Test of Utilization Procedure for 105mm White Phosphorus (WP) Projectiles
Authors: Alfred C. McIntosh Jr; ARMY DEFENSE AMMUNITION CENTER AND SCHOOL SAVANNA IL EVALUATION DIV
... has been tasked by the U.S. Army Armament Research, Development and Engineering Center, SMCAR-ESK, thru the Storage and Outloading Division, USADEC, to test a utilization procedure for the shipment of 75mm thru 106mm/4.2-in white phosphorus (WP) projectiles. Projectiles received for testing were inert-filled 105mm WP, weighing about 25 lbs each. These projectiles were utilized in accordance with the utilization procedure and subjected to the MIL-STD-1660 ...

Remedial Investigation Report: White Phosphorus Contamination of Salt Marsh Sediments at Eagle River Flats, Alaska
Authors: Charles H. Racine; Marianne E. Walsh; Charles M. Collins; Susan Taylor; ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY ABERDEEN PROVING GROUND MD INSTALLATION AND RESTORATION DIV
The bottom sediments of the two contaminated ponds in ERF likely contain a large number of very small white phosphorus particles (<0.1 mm) and a small number of much larger particles (1 mm). The larger particles could provide a lethal dose (around 0.25 mg) for a small duck such as a green-winged teal. The very small WP particles in the sediments can become suspended in the water column and could provide another source of exposure for waterfowl, fish or plankton. WP poisoning of non-waterfowl species, particularly phalaropes, was ...

Performance Oriented Packaging (POP) Testing of M722 White Phosphorus (WP) Filled Body Assemblies for 60mm Mortar (208) Packed in a Wood Pallet Container
Authors: Yuen H. Lam; ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL N J
This report contains the test results performed on the M722 White Phosphorus (WP) Filled Body Assemblies for 60mm mortar packed 208 per wood pallet container.
Physical Processes and Natural Attenuation Alternatives for Remediation of White Phosphorus Contamination, Eagle River Flats, Fort Richardson, Alaska

Authors: Daniel E. Lawson; Lewis E. Hunter; Susan R. Bigl; COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

This report describes the results of investigations into the role of tidal flat physical systems in the natural attenuation of white phosphorus (WP) contamination in Eagle River Flats (ERF) on Fort Richardson, Alaska. Waterfowl feeding in ponds and marshes harvests WP and die. These investigations found that natural attenuation and in-situ degradation of the WP could result from certain physical phenomena operating within the ERF ecosystem. Specifically, the ongoing erosion and headward recession in the gullies ...
A Literature Review - Problem Definition Studies on Selected Toxic Chemicals. Volume 2

Physical and Chemical Characterization of Military Smokes. Part III. White Phosphorus-Felt Smokes

Ab Initio Studies on Hexavalent Phosphorus Compounds

Performance Oriented Packaging Testing of XM929 White Phosphorus Filled Body Assemblies for 120mm Mortar Packed in a Plywood Container

Red Phosphorus Jack Grenade

Phosphorus Filling for Munitions

Chemical Characterization and Toxicologic Evaluation of Airborne Mixtures, The Chemical and Physical Characterization of Phosphorus Smokes for Inhalation Exposure and Toxicology Studies

Occupational Health and Safety Aspects of Phosphorus Smoke Compounds

CDEE PORTON have produced a Red Phosphorus Jack Grenade for AFV local smoke protection, with...of combining the rapid screening qualities of the No 80 White Phosphorus with the quicker loading and reduced fire hazard...the L5 and L7 Jack Grenades. The Red Phosphorus grenades as tested took even longer to provide...37 seconds. In other respects it was satisfactory. Its smoke is light grey and is not as noticeable as the White Phosphorus smoke, but is more noticeable than the L7 screen. It is thought that development may overcome the present slowness in the build-up rate of the Red Phosphorus Grenade.

The chemical and physical properties of the aerosols produced from the combustion of red phosphorus containing butyl rubber (RPBR) and white phosphorus impregnated in felt (WPF) have been examined. The aerosols were produced at a uniform concentration by extruding softened raw material and burning the emerging filament or by igniting fragments of the formulations in a convective air flow. Aerosol particle sizes were found to be within the respirable range, varying from 0.4 to 1.0 micrometer...

An investigation of the U.S. Army generating munition is a pellet consisting of about 80% by weight of granulated white P in fillings for munitions, several...additional commercial casting resins were tested. ...filled projectile when the projectile is stored on its side at 65 C. Of the experimental phosphorus fillings subjected to firing tests, those in which the granulated phosphorus was bound with plaster of Paris were the most promising. Fillings bound with Duraton, Palestic, ...lower the temperature of combustion, appeared in preliminary tests to be worthy of further study as agents for improving the performance of the phosphorus fillings.

PHOSPHORUS FILLINGS FOR MUNITIONS

In a continuation of the search for suitable binders for granulated white P in fillings for munitions, several...of hexavalent phosphorus compounds in which a nitrogen atom provided both electrons for the sixth bond...the nitrogen and phosphorus atoms. When the hexavalent phosphorus species was constructed by addition of ammonia and hydroxide to a phosphonate, the P-N distance was over 4 A. This weak interaction...

PHOSPHORUS FILLINGS FOR MUNITIONS
In experiments on modification of the physical properties of the P fillings, a procedure was developed for conversion of white P to red P in the munition itself. The resultant massive red P filling is very stable ballistically ... somewhat less rapidly than is desirable. Most of the work done concerned mixtures of granulated white P and fluid binders which set to solid masses at room temperature. ... laboratory reagents were unsuccessful, but several commercial products appeared to be satisfactory. A method of producing white P granules of suitable particle size was developed in the course of the work. ...
... aerosols consist of maritime, urban, rural, tropospheric, fog, rain, snow, and dust aerosols; a wind-tossed desert aerosol; and the Navy aerosol model. The manmade aerosols consist of dust produced from high-explosive munition; white phosphorus, fog oil; and hexachloroethane smokes. Many of the models are functions of relative humidity, wind speed, and other parameters. The database includes information at wavelengths for 0.35 to 40.0 micrometers dependent on the...

Waterfowl Mortality in Eagle River Flats, Alaska: The Role of the Munitions Residues

Authors: Charles H. Racine; Marianne E. Walsh; Charles M. Collins; Darryl J. Calkins; Bill D. Roebuck; COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

May 1992 46 pages

River Flats not used by waterfowl and white phosphorus in sediments from the bottom of shallow ponds where... observed to die or found dead in the salt marsh were collected, and we found white phosphorus in the gizzards of all 11 carcasses... River Flats. Adult mallards dosed in the laboratory with white phosphorus showed identical behavioral symptoms... Eagle River Flats. All evidence indicates that white phosphorus, as a particulate in the sediments, is responsible for the death... of the shallow salt marsh ponds are anaerobic, the white phosphorus particles will persist in the sediments indefinitely...

Waterfowl Mortality in Eagle River Flats, Alaska: The Role of Munitions Residues

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Enhanced Natural Remediation of White-Phosphorus-Contaminated Wetlands through Controlled Pond Draining

Authors: Michael R. Walsh; Marianne E. Walsh; Charles M. Collins; COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

Dec 1999 30 pages

Detonation of projectiles containing white phosphorus, a smoke-producing munition, contaminated Eagle River Flats (ERF),... marsh located on Fort Richardson, Alaska. Ingestion of the highly toxic white phosphorus residues by dabbling ducks and swans resulted in significant waterfowl mortality, leading to the suspension of Army training with white phosphorus in wetlands and designation of Eagle River Flats as a Superfund site. The permanent ponds at ERF are ideal for long-term storage of the millimeter-size particles of white phosphorus ejected from detonated mortar and howitzer shells, with...

A NEW SMOKE SCREENING CHEMICAL FOR USE IN AERIAL SMOKE TANKS

Authors: William H. McLain; Robert W. Evans; DENVER RESEARCH INST CO MECHANICS DIV

Oct 2000 2 pages

... indicated that liquid agents possessing an obscuring power greater than FS can be developed using selected mixtures, solutions, and compounds of phosphorus. A solution of 33 weight % methylene iodide in white phosphorus had a TOP of about 2800. A eutectic mixture of phosphorus sesquisulfide and white phosphorus had a TOP of about 2800. The major difficulty of the agents tested was their pyrophoricity, which resulted in handling difficulties. Considerable reduction in the rate of oxidation was accomplished...

Preliminary Assessment of Sedimentation and Erosion in Eagle River Flats, South-Central Alaska

Authors: Daniel E. Lawson; Bruce E. Brockett; COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

Dec 1993 24 pages

... impact range by the U.S. Army since 1945, must be understood to evaluate potential treatments of a high duck mortality resulting from ingestion of white phosphorus (WP) particles. The WP originates from smoke-producing devices detonated here. A preliminary assessment of erosion and sedimentation during May to... ranged from 8 to 16 mm. Recession rates of eroding gully headwalls were highly variable, ranging from negligible to over 3.9 m. White phosphorus particles may be suspended transport through gullies during ebb. Further studies are...

Toxicity Testing of Soil Samples from J-Field, Aberdeen Proving Ground, MD

Authors: Carlton T. Phillips; Ronald T. Checkal; EDGECWOOD RESEARCH DEVELOPMENT AND ENGINEERING CENTER ABERDEEN PROVING GROUND MD

Dec 1995 57 pages

Soil samples from the toxic burning pits, an area adjacent to the toxic burning pits, white phosphorus pits, and riot control pits were tested for their toxicity to lettuce and earthworms as part of an ecological risk assessment of J-Field. To adequately... ; moderately toxic at two sites (JBPPB and JBPMC); and highly toxic at one site (JHDP). An additional site (JPMB) was not fully evaluated. Results from the white phosphorus pits were nontoxic for three sites (JWPP1E, JWPPB, and JWPP2C) and moderately toxic at one site (JWPPA). One site (JBPT1W) from the...

Dredging in an Active Artillery Impact Area, Eagle River Flats, Alaska

Authors: Michael R. Walsh; Edwin J. Chamberlain; Karen S. Henry; Donald E. Garfield; Ed Sorenson; COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH

Sep 1996 52 pages

Ongoing investigations into the waterfowl die-offs and the persistence of the causal agent, white phosphorus, in Eagle River Flats, an estuarine salt marsh and military impact area, indicate that any remediation strategy will have to include... are constantly flooded, such as the deeper ponded areas, do not allow natural drying of the soil.

and subsequent sublimation of the residual white phosphorus (WP) particles. Some of these permanently flooded areas are interconnected over large areas and would be impractical to address through pond ...