MuniRem Makes Contaminated Land And Water Safe For Use

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Long after they have served their explosive purpose, the munitions of war continue to damage lives and the environment. Their detonating capacities may be expended in battle or training, but the substances that made them volatile persist, contaminating the soil and ground water with carcinogens and other highly toxic substances.

It is a more complex problem than simple pollution. Many of these materials may also cause hard-to-extinguish fires or leach dangerous chemicals into lakes, streams and aquifers where they are subsequently incorporated into the food chain. Discarded and corroded munitions are found when foundations for new buildings are laid in certain areas. Moreover, munitions dumped at sea are now washing up on the shores of the Great Lakes and the Eastern Seaboard.

“When we hear ‘bombs and ammunition,’ we think of their destructive power in combat,” notes Valentine Nzengung, Ph.D., professor of geology at the University of Georgia (UGA) and president of Planteco Environmental Consultants LLC, based in Athens, Ga.

“Their explosive effect is gone quickly,” he says, “but their residues of nitrates, ammonia, perchlorates, mercury, chromium and other substances linger indefinitely. Munitions residues make soil sterile and unable to support vegetation, water unsafe to drink and streams unable to support healthy aquatic life. They place people at risk for ills like convulsions, central nervous problems, leukemias and other cancers.”

Typically, these problems have been dealt with by hauling away the contaminated soil and treating it as hazardous waste, or, sometimes, by incinerating the soil.

However, Nzengung has developed a different approach involving the use of MuniRem, an environmentally friendly compound that uses chemical processes to facilitate munitions remediation. This compound converts explosives contaminants into “nature-usable” components that are safe when humans are exposed to them. MuniRem is applied much like new seed is sown on cropland — it is broadcast, tilled in and watered.

“Once the chemical action starts,” Nzengung says, “nitrates are degraded and heavy metals are converted into nontoxic metal-sulfides, reducing soil contamination by more than 98 percent within 24 hours. These byproducts are easily metabolized by plants and bacteria and other organisms in the soil. Once treated, land has been planted with grasses and trees for several years, it’s safe for habitation.”

Remediation Missions

With a doctorate in environmental geochemistry, Nzengung has long had a strong focus on contaminant remediation. Nzengung founded Planteco in 2000 and now, with a dozen employees, the company has developed remediation approaches ranging from bacterial treatments that deal with oil sludge to bacterial mats and manmade wetlands that treat contaminated surface water.

Nzengung was studying perchlorate — a compound used in explosives and solid rocket propellants — with funding from the U.S. Air Force when the Department of Defense established the Military Munitions Response Program in the early 2000s to clean up former military sites with contamination problems. Contamination was a long-standing issue for military bases, but once the armed services began closing bases — often for conversion to civilian use — the need to deal with this contamination became more urgent.

Nzengung expanded his focus to general munitions. After initial work with soil samples in his UGA laboratory, he obtained funding from the Georgia Research Alliance through the Georgia BioBusiness Center (the university’s incubator) and, subsequently, the U.S. Army, to further develop and test the technology.

“Valentine holds a number of patents on environmental remediation techniques,” says Gennaro Gama, senior technology manager at the University of Georgia Research Foundation Inc. “He began working on munitions remediation — the technology that became MuniRem — with the belief that contaminated soils could be reclaimed rather than just hauled away.

“For one thing, it’s much less expensive. It opens the door to similar treatment of exhausted farmland — the remediation of nitrates in soil that has been over fertilized. And, most importantly, it makes our world safer for people to live in. It will address environmental contamination caused by wars past, present and future.”

Nzengung worked on the project for several years before bringing a completed prototype to the UGA Research Foundation in early 2007, Gama notes. The group filed the first of two patents in May 2007, licensing the technology exclusively to Planteco.

Confronting Contamination

Residue contamination occurs at every developmental stage and site of a bomb or artillery round's existence including the land surrounding munitions manufacturing plants, artillery firing ranges and aerial-bombing practice ranges. Although some contamination occurs in actual war zones, the residue levels are most concentrated at plants and practice ranges where the materials are used continuously.

> *The three main forms of munitions are unexploded ordnance; discarded military munitions; and munitions constituents from stockpiled munitions, former military facilities and manufacturing installations. Some of these are present in land that is now privately owned, while some is public land used for recreation or other purposes.*

At rifle ranges, the primary issue is lead contamination from bullets. But at artillery ranges the powder charge bags used in cannons to propel rounds exude mixed residues along the firing lines, and the target areas become residue-contaminated where the rounds detonate during impact. Many sites involve contaminated bodies of water — like artillery ranges on the Chesapeake Bay and Great Lakes, for example — complicating cleanup.

"Beyond the inevitable contamination associated with training," notes Catherine Knudsen, Planteco's vice president of federal programs, "the military commonly dealt with excess munitions for years by burying them in the ground or disposing of them in the sea. As these materials corrode, leakage from the stocks into groundwater is a major problem. And once they are there, these pollutants stay in the environment."

The most common types of highly explosive materials are the familiar TNT (trinitrotoluene), the more recent RDX (royal demolition explosive) and variations like HMX (high melting explosive). RDX is among the most frequently used type of ordnance today, but any munition is likely to consist of a formula combining different substances for desired characteristics. Their manufacture is a complex process of combining, altering, refining and synthesizing a myriad of often-volatile chemicals for desired characteristics — perchlorates, sulfuric and nitric acids, many variations of nitramine compounds, and toluene (the second T in TNT).

"MuniRem utilizes a sulfur-based compound to address explosives and metals," Nzengung says. "By attacking the nitro groups, our formula reduces them to nitrogen gas or to a low-oxidation state — nitrogen oxide. And it causes sulfide from the reaction of MuniRem to bond to heavy metals that may be present, like chromium and lead, to form a non-soluble metal sulfide — the way iron sulfide can be turned into pyrite, or fool's gold."

Other metals normally found as environmental contaminants in military areas include mercury, cadmium, arsenic and depleted uranium, all of which can be passivated by MuniRem and, if needed, extracted from the soil in subsequent processing steps.

On the Ground

Before any treatment is undertaken, the Planteco team takes soil samples for analysis to determine the types and concentrations of contaminations and soil characteristics such as the pH value — necessary information for creating the right mixture of MuniRem chemicals.

For soil remediation, MuniRem is usually applied in granular form, broadcast on the soil and tilled in. If the soil column is deep, an auger with a large-diameter tip may be used to embed it. Then the area is saturated with water to activate the compound.

“You can see the reaction,” Knudsen says. “If you have a high concentration, you can see the soil change color, becoming a dark brown. It becomes warm. If it reacts to certain explosives, it may turn pink.

“We return a day later and take more samples. Our experience is that almost all the chemical action is complete within 24 hours. But we take more samples two weeks later to confirm permanency.”

MuniRem, Knudsen notes, may also be sprayed in liquid form to treat the walls of a contaminated building or injected down a borehole to reach a contaminated groundwater aquifer.

Pilot tests at munitions plant sites in Ohio and Wisconsin — the Department of Defense prefers that specific sites not be identified — demonstrated MuniRem’s effectiveness. At a former plant in Ohio, just under an acre of contaminated land was treated successfully — basically overnight. In Wisconsin, the Planteco team quickly neutralized the explosive material from 10 artillery rounds, demonstrating the procedure for dealing with live munitions recovered intact, whether from in-ground burial or from underwater disposal. The recovered munition is split open with a water jet cutter (no sparks) by explosive ordnance specialists and the volatile materials inside placed in a chemical reactor to neutralize them.

The U.S. Army Corps of Engineers has awarded Planteco multiple contracts for demonstrating the MuniRem technology, and the company is poised to receive a series of remediation contracts from the Department of Defense and military munitions manufacturers.

“It’s very difficult to get a new product like this adopted by large, established contractors,” notes UGA’s Gama. “Progress is being made in demonstrating its capabilities and fostering its implementation.

“As it should be. MuniRem can play a great role in resolving threats to our environment and our health. It’s not just that it makes land safe for habitation by local residents. It’s a key for making groundwater aquifers safe for populations as a whole and for reclaiming the ecosystem.”

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