# Georemediation™: An Innovative Sediment Decontamination/Beneficial Use Technology

Ajay Kathuria[1], Anita O'Connor[2], and Jeffery Newton[3]

Abstract: Georemediation™ is an innovative advanced chemical treatment technology patented and developed by Aleph Group of Ithaca, New York, and engineered exclusively by BEM Systems, Inc. (BEM) of Chatham, New Jersey. Georemediation™ decontaminates soil, sediments, and other wastes (e.g. sludges, oil-drilling wastes) by mineralizing all types of organic contaminants or converting them into inert and environmentally benign compounds such as calcium carbonate and water. Georemediation™ immobilizes inorganic contaminants through pozzolanic reactions and incorporation into newly formed and insoluble crystalline structures. The proprietary Georemediation™ reagent contains a mixture of dispersants, clay pillaring agents, oxidative reagents, metal salt catalysts, and pozzolans. Georemediation™ has been successfully tested for the decontamination of soil, sediments, and other wastes (e.g. sludges, oil drilling wastes) with contaminants such as TPHC, PAH, PCBs, heavy metals, and dioxins. Georemediation™ treatment process is simple and economically favorable, when compared with other decontamination technologies. The Georemediation™ process employs off-the-shelf equipment and produces no excess contaminated water and/or air emissions. The resulting end-product is environmentally benign, looks and behaves like soil, and can be used as structural or non-structural fill material for use in transportation and infrastructure construction, brownfields redevelopment, and landfill cover applications.

Several sediment decontamination and beneficial use technologies and processes are currently under evaluation and development by the State of New Jersey, Office of New Jersey Maritime Resources (NJMR). This multi-staged effort by NJMR is part of its long-term strategy for effective and environmentally sound management of dredged material from the NY/NJ Harbor. Over 5 million cubic yards of sediments are projected to be dredged annually for the maintenance and deepening of the navigable channels of the NY/NJ Harbor. Although most of the dredged material does not meet the stringent environmental criteria required for ocean disposal, much of the material is chemically suitable for immediate upland disposal. However, each year over a million cubic yards of dredged material will have elevated contaminant concentrations that will require decontamination prior to its beneficial use. Some of the other decontamination/beneficial use technologies currently being pilot-tested by NJMR include: Sediment Washing/Manufactured Soil; Rotary Kiln/Light Weight Aggregate; and Thermal/Cement-lock. Vendors that are successful at showing physical and chemical effectiveness and economic viability at the pilot level, will be awarded a demonstration project for the treatment of up to 120,000 cubic yards of dredged material, leading up to full-scale implementation. The overall objective of the NJMR study is to develop one or more technologies capable of decontamination and upland beneficial reuse of 0.5 to 1 million cubic yards of contaminated material dredged from the NY/NJ Harbor on an annual basis at a full-scale cost of under $29/cubic yard.

The Georemediation™ process, currently being pilot-tested by BEM, mineralizes all types of organic contaminants or converts them into inert and environmentally benign compounds such as carbon dioxide and water. The inorganic contaminants are incorporated into newly formed crystalline structures, which significantly reduce any potential for leaching, and in some cases

[1] Sr. Environmental Engineer, BEM Systems Inc., 100 Passaic Avenue, Chatham, NJ, Ph 908.598.2600, Fx 908.598.2622, akathuria@bemsys.com
[2] Environmental Engineer, BEM Systems Inc., 100 Passaic Avenue, Chatham, NJ, Ph 908.598.2600, Fx 908.598.2622, aoconnor@bemsys.com
[3] Technology Manager, Aleph Group, Inc., 118 North Sunset Drive, Ithaca, NY 14850, Ph (607) 277-1563, Fx (607) 277-1481, AlephNTN@aol.com

reduce the total metal concentrations detected through acid digestion tests (SW846 3050B/6010B). The pozzolans in the proprietary Georemediation™ reagent increase the number of available surface sites for oxidation reactions. The dispersant and clay pillaring agents act to separate the fine slag and sediment particles, further increasing the number of reaction sites. Organic contaminants present on these surfaces are degraded and mineralized by the oxidative reagents, with the metal salt reagents facilitating greater electron transfer. The mineralization of the organic contaminants is accelerated several orders of magnitude on these new surface sites, in comparison with similar natural geochemical processes. Inorganic compounds are converted into highly insoluble and immobile hydrated precipitates locked in crystalline structures in highly stable silicate-based minerals (Figure 1), generated during the Georemediation™ treatment.

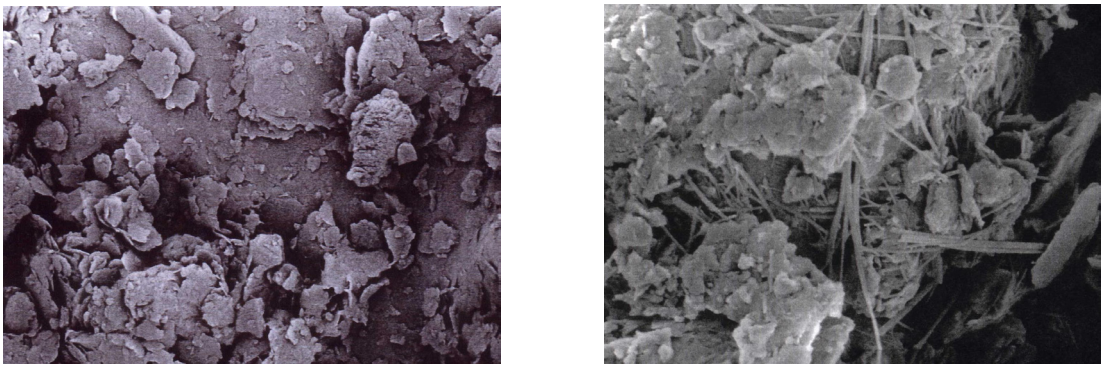

Figure 1: Environmental Scanning Electron Microscope (ESEM) images comparing the amorphous untreated sediment sample (left) with the crystalline Georemediation™ treated sediment sample (right)

The treatment process initially involves mixing the proprietary powder reagent with water to create a slurry, using 1:1 water to reagent ratio. The slurry is then mixed with the contaminated material using simple "off-the-shelf" equipment such as pug mill. Typically, proprietary reagent is added at 10-15% by weight of the contaminated material. Georemediation™ uses the natural moisture content of the material for pozzolanic reactions, with no excess free liquids produced during decontamination process, even in the case of 50% solids dredged material. The homogenized material-reagent mixture is then allowed to cure in the open for a period of 15 to 30 days, after which the decontaminated material may be beneficially reused. The mixing and curing processes produce no wastewater and/or by-products, minimizing the need for any water discharge permits. The resulting decontaminated material looks and behaves like a soil material (Figure 2) suitable chemical characteristics for upland beneficial use and geotechnical characteristics for structural or non-structural fill applications.

Figure 2: Comparison of a heavily contaminated sediment sample (left) with > 7.5% TPHC by weight and Georemediation™ treated soil-like end-product (right) after 3-weeks of curing period

Initially, Georemediation™ was developed as a soil remediation technology. In 1996, Georemediation™ was successfully utilized, on a full-scale level, for the treatment of over 300,000 tons of lead (Pb) contaminated soil from Bronx Shooting Range in New York City. The untreated soil contained lead concentrations in excess of 68,000 mg/kg, with TCLP values in some of the hot spot samples of above 2,400 mg/l. After the addition of between 5% to 10% Georemediation™ reagent, the treated soil consistently gave an average TCLP value of less than 0.5 mg/l regulatory limit in one to three days of curing under full-scale conditions.

Subsequently, Georemediation™ was bench-scale tested on contaminated sediments from Hamilton Harbor, Ontario and Boston Harbor, Massachusetts, showing reductions of 80-94% in total PAHs, with starting concentrations in excess of 10,000 mg/kg. More recent studies with sediments from Venice lagoon in Italy showed over 75% reductions in total concentrations of heavy metal contaminants, as measure by acid digestion methods.

BEM, in association with Aleph Group, has conducted various bench- and pilot-scale tests on Georemediation™ technology with sediments contaminated with wide range of organic contaminants and heavy metals. From 1997 to 1999, BEM, in collaboration with New Jersey Institute of Technology (NJIT), conducted a bench-scale study on several contaminated sediment samples collected from NY/NJ Harbor, including sediments from dioxin contaminated Diamond-Shamrock Superfund site in Passaic River, New Jersey. More recently, as part of NJMR pilot study, BEM tested NY/NJ Harbor sediment sample primarily contaminated with low levels of dioxins (total Toxicity Equivalent Quotient [TEQ] = 202 ppt). The following table summarizes some of the analytical results of Georemediation™ treatment of the NY/NJ Harbor sediment samples at the end of a 3-week curing period:

| Contaminant(s) | Untreated Conc. (mg/kg) | Treated Conc. (mg/kg) | % Reduction |
|---|---|---|---|
| TPHCs | 75,600 | 18,450 | 76% |
| Dioxins (Passaic River) | | | |
| Total TEQ | 169 µg/kg (ppb) | 88 µg/kg (ppb) | 48% |
| 2,3,7,8-TCDD | 131 µg/kg (ppb) | 7.23 µg/kg (ppb) | 94% |
| Dioxins (NY/NJ Harbor) | | | |
| Total TEQ | 202 ng/kg (ppt) | 11.27 ng/kg (ppt) | 94% |
| 2,3,7,8-TCDD | 127 ng/kg (ppt) | 6.43 ng/kg (ppt) | 95% |

BEM has also performed limited geotechnical testing for the beneficial use evaluation of the dredged material treated with Georemediation™. Initial results indicate that the treated material may be used as subgrade fill for highway construction applications. Specifically, significant improvements were observed in the workability of the material with plasticity index of 7-10 (typical: <15). In addition, increased strength in the treated material was observed, with California Bearing Ratio (CBR) values >15-20, above the typical requirement of >10 for subgrade material. More extensive geotechnical tests are currently underway at the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University, New Jersey as part of BEM's pilot project under NJMR. The results of these tests will be available in July 2001, with the completion of the NJMR pilot project anticipated for Fall 2001.

At the completion of the pilot project under NJMR, BEM expects to demonstrate that Georemediation™ process can be successfully used to decontaminate and beneficially reuse 0.5 to 1 million cubic yards of typical contaminated material dredged from navigable channels (excluding "hot spots") of the NY/NJ Harbor on an annual basis under $29/cubic yard.