

OUTLINE OF THE JGC ON-SITE STABILIZATION PROCESS

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ABSTRACT

The JGC On-Site Stabilization Process (OSSP) was conceived as a response to the need for more effective stabilization methods for heavy metal and mercury contaminated soils. Several laboratory bench-scale tests were performed on artificially contaminated soils which indicated the system's feasibility. The tests showed excellent stabilization of heavy metals, and moderately good results for mercury. Additional research is being performed to demonstrate improved stabilization of mercury. As an added benefit, the process was found to significantly reduce the leachability of some PCB-like hazardous organics.

The OSSP concept is to stabilize, by both chemical and physical means, soils contaminated by heavy metals, mercury, and transuranic isotopes (TRU). The process makes use of a proprietary polymerized fixing agent to render the contaminants insoluble. A small amount of water must be added to the soil prior to adding this fixing agent to assure that the agent can be brought into contact with all of the contamination. The insoluble reaction products will be adsorbed into the soil, which is then encapsulated using either bentonite or Portland cement. This step physically isolates the contaminants within a cementitious matrix, and chemically buffers the resulting end product against large changes in external environmental pH.

INTRODUCTION

The JGC On-Site Stabilization Process (OSSP) is designed to meet the need for more effective stabilization methods for heavy metal and mercury contaminated soils. Laboratory bench-scale tests were performed on artificially contaminated soils to determine the system's feasibility. The tests showed excellent stabilization of heavy metals, and moderately good results for mercury. As an added benefit, the process was found to significantly reduce the leachability of some PCB-like hazardous organics.

OSSP stabilizes soils contaminated by heavy metals, mercury, and transuranic isotopes (TRU) by both chemical and physical means. The process uses a proprietary polymerized fixing agent to render the contaminants insoluble. A small amount of water is added to the soil prior to adding this fixing agent to assure that the agent can be brought into contact with all of the contamination. The insoluble reaction products are adsorbed into the soil, which is then encapsulated using either bentonite or Portland cement. This step physically isolates the contaminants within a cementitious matrix, and chemically buffers the resulting end product against large changes in external environmental pH.

JGC's On-Site Stabilization Process (OSSP) is not the first method proposed for treating contaminated soils on-location, but it is very different from other methods previously developed. EPA's SITE program has encouraged the development of a wide range of technologies to remediate soils on-site and return them to their original location. Currently available on-site remediation technologies include thermal decomposition of organics (i.e., incineration, pyrolyzing plasma), bioremediation of organics, freeze concentration of liquid waste, chemical fixation of heavy metals, cementitious stabilization, in-situ vitrification, vacuum ex-

traction of volatile organic compounds (VOC's), steam and air stripping, and UV oxidation.

The fundamental chemistry of the process has a somewhat longer history than the proposed stabilization method. The proprietary fixing agents used in this process were developed between 7 and 10 years ago in Japan to treat industrial waste effluents containing heavy metal and mercury without generating the large sludge volumes resulting from conventional methods. The low to medium polymerized fixing agents developed in that effort were found to be much more effective in removing the targeted ions from solution, and produced a significantly lower volume of sludge. The high cost of sludge disposal in Japan provided the market stimulus for converting to the new agents. Current users of the chemicals include municipal waste incineration plants, electroplating facilities, integrated circuit manufacturers, etc. The chemicals are used at municipal incinerators in two ways: to treat flue gas scrubbing water, and to treat heavy-metal-contaminated ash. This ash treatment is specifically for reducing the leach rate of heavy metals from the final disposal site.

Thermal decomposition methods can be used to treat soils contaminated with organics and heavy metals, but these processes are expensive and require disposal of the secondary waste ash as a hazardous or mixed waste when heavy metals, mercury, or radionuclides are present. This process is extremely expensive when very low concentrations of contamination are present.

Bioremediation is not appropriate for heavy metals, mercury, or radionuclides because it is not possible for such methods to isolate these materials from the biosphere. Vacuum extraction similarly will not remediate inorganic contamination. Freeze concentration cannot be used on soils,

since the process cannot practically be applied to solid wastes.

Among the many stabilization technologies currently available, in-situ vitrification for mixed waste contamination produces the most stable product, but at a very high cost and a slow processing rate make it inconvenient and costly, thereby negating the benefits of on-site stabilization. Other stabilization methods typically add a silicate fixing agent, or merely add a cementitious binder to stabilize the contamination.

The OSSP fixing agent is unique in that it utilizes a sulfide radical to form a complex with the target ion. The agent's affinity for target metal ions is actually greater than EDTA, enabling it to be used to remediate soils where EDTA chelate agents are the carrier for the target heavy metal, mercury, or TRU ion. It also appears to more strongly bond to the target ion than silicate fixing agents, resulting in improved leach rate performance when compared with systems employing those agents.

The concept could contribute to a very low cost solution for the problem of soils contaminated with TRU. Other concepts involve high costs (vitrification) or poor performance (grout in place), but this concept could provide exceptional stabilization at substantially reduced costs, even if combined with engineered barrier systems.

CONCEPT DESCRIPTION

The fixing agent, unlike any other such reagent currently used or under study as a candidate for use in soil remediation or stabilization, is a polymerized sulfide. While the structure of this material is proprietary, its sulfide character distinguishes it from other stabilization agents currently in use. Further, the structure of the agent can be modified to adapt to various types of contamination, so that a wide range of contamination at a single site may be stabilized by mixing these variants together.

The agent requires that the soil be excavated and mixed with water to make a thick slurry. After the reaction is completed, bentonite or Portland cement is added to the slurry. The primary function of the bentonite or Portland cement is to encapsulate the precipitated and adsorbed contaminants to further reduce their leachability. Secondly, the additive reacts with the excess water in the slurry, drying it so that it can be returned to its original location.

A diagram of the process as presently conceived is shown in Fig. 1. First, the soil is excavated at the site and pulverized to reduce the average size of the soil particles. Water and fixing agent is added, and the resulting slurry is thoroughly mixed, to assure that all contaminate ions may contact the fixing agent. After the reaction is complete, bentonite or Portland cement is added to the slurry, while mixing continues. When all soil particles are completely coated with the bentonite or Portland cement, the product

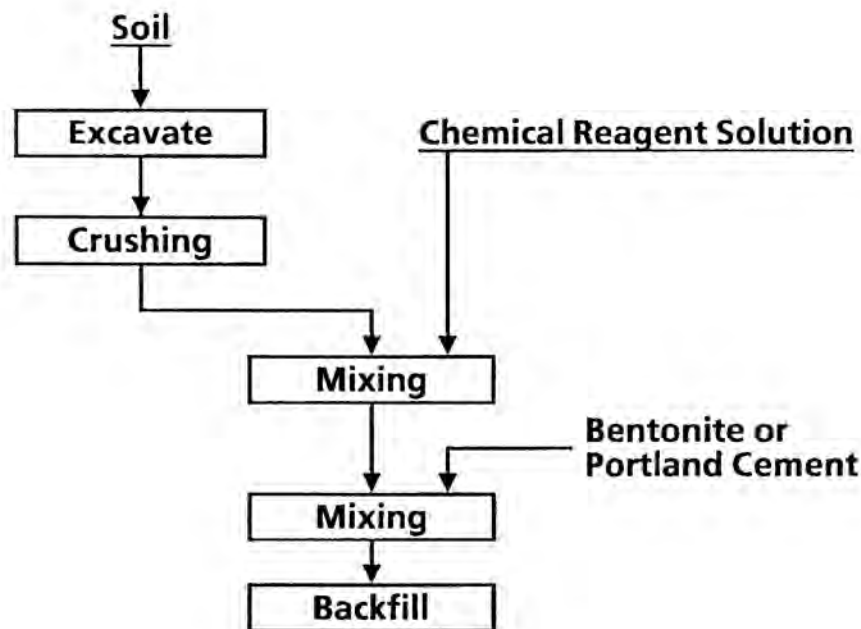


Fig. 1. OSSP Process Flow Diagram.

may be returned to its original location. Preliminary studies show a minimal volume increase (5%) with the system.

There are currently several other heavy metal stabilization methods that have been investigated. These fall into three basic categories:

1. Cementious matrix-- The contaminate is contained within a matrix of hydrated Portland cement or pozzolanic material.
2. Addition of simple compounds to produce simple insoluble compounds; e.g., the addition of lime to form insoluble hydroxide compounds.
3. The addition of silicate compounds to form complex silicates with the metal ions.

However, JGC's OSSP involves a sulfide polymer in addition to cementious immobilization, resulting in superior leaching performance than any of the methods described above, while producing significantly less volume increase. The important features of the system include:

- After treatment, soils exhibit very low leach rates for mercury and heavy metals, as well as for other contaminants.
- Uranium and TRU contamination can be effectively stabilized.
- Excessive volume increases are eliminated.

In addition, the system can easily be adapted to a mobile system, providing economical treatment at diverse locations

without excessive set-up costs. A sketch of a mobile treatment plant is provided in Fig. 2.

JGC expects that the process will:

- Allow more effective stabilization and leach resistance for heavy metals.
- Provide the first effective method of on-site stabilization of low levels of mercury contamination.
- Reduce the cost of remediating sites contaminated with mercury.
- Allow the stabilization of soils contaminated with a combination of hazardous metals, uranium, and TRU.

JGC is optimistic that this process could substantially improve the effectiveness and cost of remediation of these DOE sites. In addition, it is likely that many EPA-designated Superfund sites could benefit from the successful implementation of the concept.

DEVELOPMENT STATUS

The JGC On-Site Stabilization Process was conceived last year as a response to the need for more effective stabilization methods for heavy metal and mercury contaminated soils. Several laboratory bench-scale tests were performed on artificially contaminated soils to determine the system's feasibility. The tests showed excellent stabilization of heavy metals, and moderately good results for mercury. Further research is expected to result in significantly improved per-

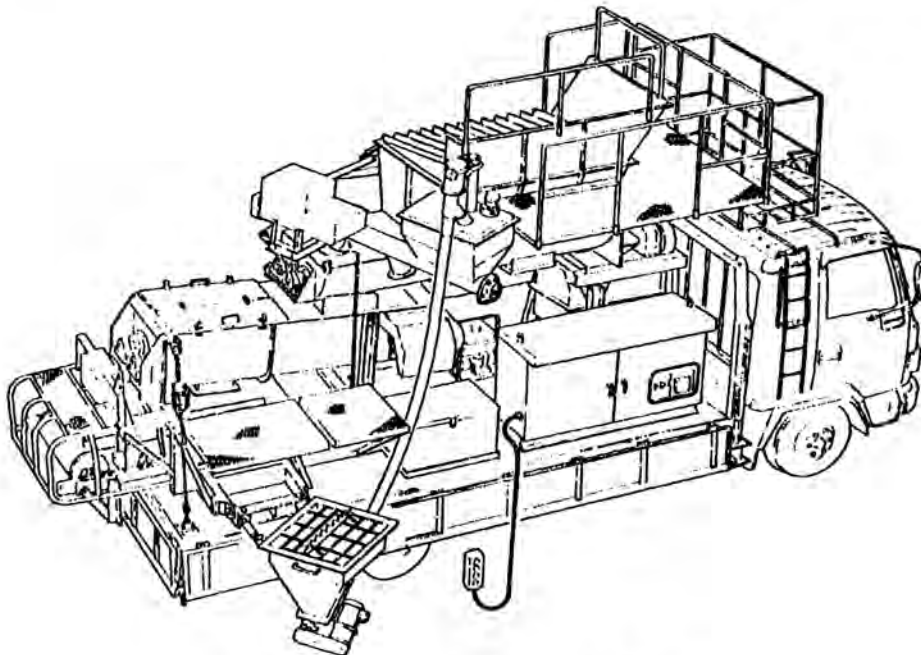


Fig. 2. OSSP Mobile Stabilization Plant

formance for mercury, as well as establish leachability performance for arsenic.

As an added benefit, the process was found to significantly reduce the leachability of some PCB-like hazardous organics, notably 1,2,4- trichlorobenzene. No tests were performed on PCB's, however, due to Japanese legal restrictions on their availability. The effect of the proposed concept on organic contaminants has not, however, been extensively researched. It is believed that the proposed concept's ability to stabilize organic materials comes from the physical capture of the organics within the bentonite or port-land cement matrix, rather than from the action of the fixing agent.

Results of EP toxicity tests and TCLP tests on artificially contaminated soils are reported in Tables I and II. The tables report contaminate concentrations in leachate from soils in each of three conditions:

- Untreated
- After addition of the fixing agent
- After completion of the process, including the addition of the encapsulation agent.

Photographs of the soil in each of the conditions tested are presented in Fig. 3.

The extensive experience with the chemical reagents used in the proposed concept, as well as the initial soil treatment experiments performed in JGC's own laboratory, support the ultimate feasibility of the total concept. However, basic research is required to demonstrate and improve the performance of the concept to a wide range of contaminants.

The OSSP concept, because it operates on wet soil, can be adapted to use on soils that have been washed with water based extractants. As stated above, the fixing agent can remove contamination from EDTA chelate solutions, and therefore, the OSSP concept is an ideal match for combining with EDTA soil washing. Because the OSSP process includes an additive to bind water remaining in soil after washing, improved leach-rate performance can be expected when combined with soil washing. In fact, a process to combine these two technologies is being considered for inclusion in the EPA SITE Emerging Technologies program, for the remediation of lead-contaminated former battery reclamation sites. The severe contamination at such sites requires some form of decontamination, and stabilization of whatever contamination that cannot be removed.

TABLE I

Concentration in EP-Toxicity Test Leachate (PPM)

<u>Heavy Metal in Soil</u>	<u>Untreated Soil</u>	<u>After Fixing Agent Added</u>	<u>Final Product</u>	<u>EPA Limit</u>
Cadmium	4.77	1.32	0.63	1.0
Chromium	1.13	0.01	ND	5.0
Lead	0.03	ND	ND	5.0
Mercury	2.17	0.18	0.20	0.2

1. The concentration of each of the heavy metals prior to treatment was 250 ppm in the soil.

2. "ND" = Not Detected

TABLE II

Concentration in TCLP Test Leachate (PPM)

<u>Heavy Metal in Soil</u>	<u>Untreated Soil</u>	<u>After Fixing Agent Added</u>	<u>Final Product</u>	<u>EPA Limit (TCLP)</u>
Cadmium	4.55	0.48	0.04	1.0
Chromium	0.33	0.07	0.11	5.0
Lead	5.06	0.74	0.33	5.0
Lead (9100 PPM)	280	164	0.45	5.0

1. The concentration of each of the heavy metals prior to treatment was 250 ppm in the soil, unless otherwise noted.

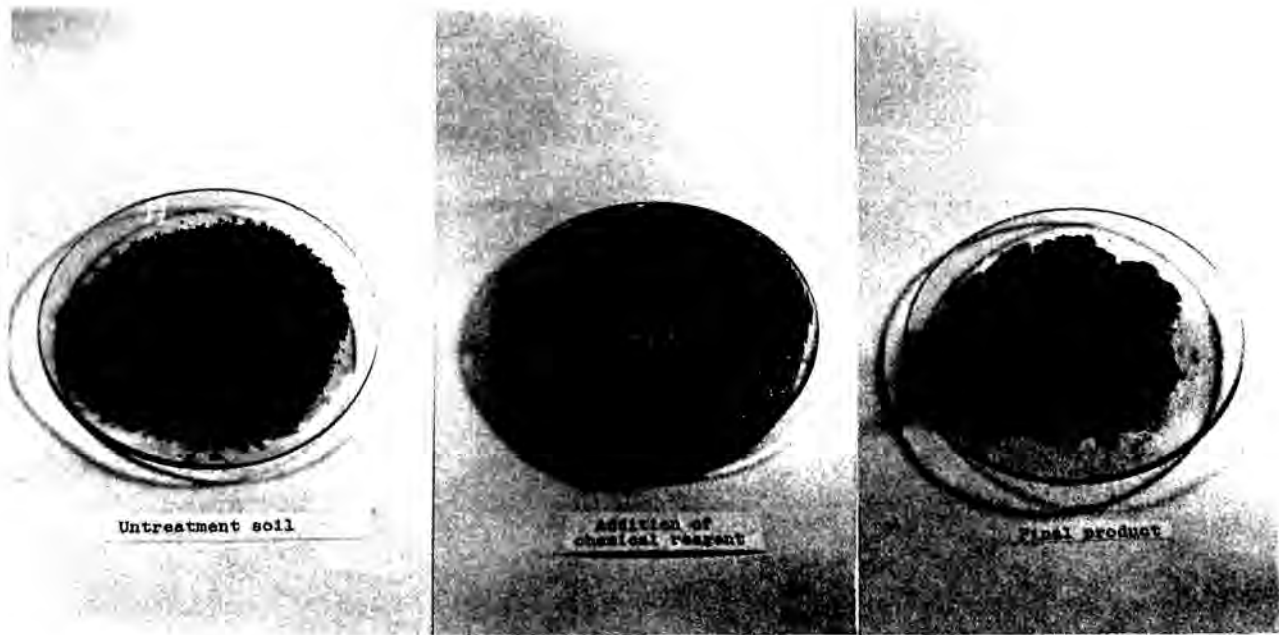


Fig. 3. Untreated Contaminated Soil After Addition of Fixing Agent Final Product

CONCEPT IMPLEMENTATION

The key concepts behind the On-Site Stabilization System are not complicated, and there are therefore only a few problems and obstacles to overcome prior to implementation of the technology to actual contaminated soils. The preliminary investigation into the technology feasibility demonstrated that stabilization of heavy metals and mercury were achievable. However, tests of modifications to the process to improve mercury stabilization, and to include a TRU fixing agent (in addition to or as an alternate to the previously investigated heavy metal and mercury fixing agent) have not yet been completed.

One of the major cost components of stabilization using the proposed concept is the bentonite or Portland cement binder used to encapsulate the metal-fixing agent complex. This important step in the process assures that the final product performs well throughout a wide range of pH environments. However, the actual amount of bentonite or Portland cement required is determined by the amount of water present in the soil slurry after treatment with the fixing agent. Currently, only a very small amount of cementitious binder is required for effective stabilization, but efforts to reduce this amount still further are under way.

Because the chemistry of both the soils and the contamination may vary significantly between the various candidate sites (e.g., Oak Ridge Y-12, West Valley, Hanford 200 area, INEL), an investigation of the process effectiveness on the most probable remediation site soils is appropriate. JGC

has proposed to test the OSSP process at INEL as part of the DOE's efforts to develop promising new technologies. However, as of press time, the decision to accept the proposal is pending.

Because the fixing agent can be used to precipitate contaminants out of EDTA waste streams, the concept is especially promising for the remediation of sites where EDTA waste stream contamination is the major source of TRU and heavy metal contamination. Conventional precipitation methods will not precipitate metal complexes of EDTA, because the pH adjustment required to separate the metal ion will not permit the formation of the precipitates. The proposed fixing agent, however, is capable of separating the contaminate ion from EDTA, and precipitating.

CONCLUSIONS

JGC's OSSP concept could prove very useful at a variety of contaminated sites both within the DOE complex and other private contaminated sites. The degree of stabilization evidenced in the laboratory-scale tests shows excellent results. However, the process will be much more credible as an effective means of remediating soils when currently planned actual site testing has been completed.

The OSSP's ability to be adapted for various different types of contamination, as well as its ability to work well when combined with other water-based soil washing processes, promise to make the OSSP process a very effective and useful tool for restoring contaminated sites.