Mining Reclamation

Evaluation and Comparison of Effective Microorganisms for Use in a Lead and Zinc Mine Land Reclamation Project in Jasper County, Missouri, USA.

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ABSTRACT:

This reclamation research is part of a demonstration project funded by an EPA grant to address "Former or Abandoned Lead/Zinc Mines" in Missouri. The reclamation project is taking place within the Oronogo/Duenweg Mining Belt Superfund site in Jasper County, Missouri. The site encompasses 33 square miles. Approximately 2,000 acres of the site are covered by un-vegetated mine/mill waste. Primarily chat and lesser amounts of tailings cover the test area. Metal concentrations range from 400 to 1,700ppm Lead, and 1,800 to 8,000ppm Zinc. The area has little vegetation, very low diversity index and heavy metals are regularly leached into ground water and carried away from the site.

The remediation strategy uses organic matter (OM) applications to the land to improve the soil conditions. Organic matter can improve several soil quality characteristics such as cation exchange capacity, water-holding capacity, nutrient holding capacity, and reduce surface temperatures of mine wastes.

Experimental plots have been established to test four different organic matter applications with Effective Microorganisms (EM) to assess the efficacy of EM's remediation abilities. EM's ability to eliminate odor and rapidly decompose raw turkey litter makes it immediately attractive to the Missouri Department of Natural Resources. However, EM application is expected to have other remediation benefits. EM is expected to enhance the OM amendments' impact on the soil, in particular. Parameters being measured are the rate of establishment of native grasses, diversity index, pH, Cation Exchange Capacity, organic matter content, water holding capacity, and changes in the toxicity, mobility, and solubility of metals.

Keywords: EM, mine tailings, lead, land reclamation, remediation

Introduction

Elevated lead concentrations in soils from abandoned Lead and Zinc mining and smelting areas have been identified as a human health threat and/or an ecological threat. An increased incidence of elevated blood-lead has been documented in children near contaminated areas of Jasper County in a study conducted by the Missouri Department of Health for the U.S. Agency for Toxic Substances and Disease Registry. Fourteen % of children under seven years old in and around mining areas had blood-lead above 10mg/dL as compared to zero % in a nearby control area. Further study revealed that occurrence of high blood-lead in children increased to 25% within one-quarter mile of a former high-capacity primary lead smelter1.

Additionally, contamination from mill waste has impacted over 7,000 acres of land in this area. Approximately 3,000 acres are barren or sparsely vegetated as a result of past mining activities. Metal concentrations in soils can create toxic conditions adverse to vegetation, and metals can accumulate in plants causing health risks to secondary consumers.

Problems with waste from confined livestock feeding operations are also a major issue in this area of the United States. Failure to control odor and overabundance of poorly treated livestock waste pollute both air and water in surrounding communities. For example, federal justice officials in Kansas City have recently launched a criminal investigation of the Sedalia Tyson plant, one of Missouri's largest poultry processing facilities2.

The potential for using livestock waste as a substrate for environmental remediation in Southern Missouri represents an integrated approach, creating positive results in two areas of environmental concern simultaneously. This integrated approach uses 'waste' biosolids from overburdened confined livestock production facilities to provide organic substrate for effective microorganisms that can remediate the mining waste and promote long-term vegetation on the site.

The remediation strategy uses organic matter (OM) applications to the land to improve the soil conditions. The primary role of Effective Microorganisms (EM) is to enhance these OM applications by managing the microbial populations to reduce or eliminate

odors and decompose raw organic matter quickly. EM, however, is also expected to have several other benefits related to soil quality and therefore increase the OM's remediative capacity.

Materials and Methods

During summer and fall of 1998 and 1999, different plots at the abandoned mine site received specific organic matter treatments. Turkey house litter (THL), spent mushroom compost (SMC), topsoil, and Class A sludge biosolids were some of the organic matter applications used on the site; the organic matter application distinguishes one plot from another on the site. Most plots are at least one acre. The organic matter amendments are believed to be essential to the successful reclamation of barren, lead/zinc mine wastes by improving soil conditions1. Organic matter can improve several soil quality characteristics such as cation exchange capacity, water-holding capacity, nutrient holding capacity, and reduce surface temperatures of mine wastes1. In addition, organic matter additions can also reduce the toxicity of heavy metals, through adsorption with complex organic molecules and Pb-phosphorous reactions1.

In 1998, EM-1 dilution was applied to the turkey house litter (consisting of turkey waste, carcasses, and oak chips) 1-acre plot. Three applications were made in 1998; once per month in July, August, and September. One application consisted of two layers of EM-1 dilution, and two layers of THL on the southeastern * acre of the one-acre THL plot.

Each application used five gallons EM-1 and five gallons molasses diluted with 600 gallons of water (approx. a 1:1:120 ratio). The EM-1 dilution was applied in a layer fashion to the plot. First, one layer of THL (approximately 25 tons/acre) was applied to the entire acre. Then one layer of approximately 2.5 gallons EM-1 and 2.5 gallons molasses diluted with water to 300 gallons was applied to the * acre.

This was repeated one more time to complete one application. One complete application consisted of approximately 12.5 tons THL and 600 gallons of EM-1 dilution applied to the * acre plot.

Two more applications as described above occurred in the following two months until an annual total of 15 gallons of EM-1(diluted to 1800 gallons) and 37.5 tons/acre of THL was applied to the southeastern * acre of the THL plot.

Proposed Future Work

EM applications in 1998 were designed to allow for quick and easy implementation. However, there are many methods of culturing effective microorganisms for application and integration in various systems. Recommended applications to the site in 1999 include Extended EM Waste Treatment solution, EM fermented plant extract, EM5, and EM bokashi. The methods used to culture EM in these preparations utilize the beneficial microbial content of diverse ingredient materials such as molasses, fresh plant matter, and 'waste' biosolids. During the fermentation process which EM technology employs, the pathogenic microbes of parent materials are eliminated through a process of competitive exclusion, while the beneficial species remain intact and multiply. The use of various substrates in the suggested EM applications should result in a diverse population of beneficial microbes that are able to fill a variety of ecological niches. This should result in higher success and proliferation of beneficial species as well as competitive exclusion of pathogenic species in the soil. Additionally, EM-X Ceramic Powder can enhance microbial activity and immobilize metals due to porosity and high surface area where metals can be adsorbed, chelated and neutralized.

The primary application method for this site will be use of EM bokashi. EM Bokashi uses 'waste' organic matter (e.g. turkey house litter, spent mushroom compost, sawdust, biosolids, etc.) fermented with EM for approximately 2 weeks. These inoculated biosolids are applied directly to the site, thereby increasing the organic matter (OM) content of the soil. It is important to note that the quality of the OM is greatly improved by fermentation and inoculation by Effective Microorganisms.

Another difference in the application strategy for 1999 is to use less water to dilute the Extended EM Waste Treatment solution. The proposed EM to water dilution ratio will decrease from 1:120 to 1:10. This stronger ratio greatly reduces the logistical problems of applying EM to the site. It's also important to note that the proposed application of the more "activated" Extended EM Waste Treatment solution in 1999 will replace the EM-1 dilution of 1998. EM will be applied to four 0.25-acre plots on site. In order to easily compare treatments, the EM 0.25-acre plots were staked off within larger one-acre plots. This will facilitate quick assessments of vegetative regrowth results. See the attached map for the EM plots highlighted with dashed lines, staked off in July 1999. The type of Organic Matter applied distinguishes the larger one-acre plots within which EM will be applied. The four one-acre areas are numbered 2-5 on the map: 2) Mizzou Doo, Landscape Mix, 3) Topsoil, 4) Spent Mushroom Compost, and 5) Turkey House Litter. Application rates are given in the following table:

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EM-related quantitative analysis of the site thus far is limited to one series of soil tests. Most composite samples taken from the site have been 0-15 cm deep, and are comprised of three to five aliquots mixed together. Aliquots are typically collected within a 10-meter radius. Future sampling plans include use of an X-ray Fluorometer to get in situ metal concentrations in plant samples with 5% uncertainty. XRF used for soils, plant samples will be analyzed using inductively coupled plasma. There may also be some samples collected for further microbial analyses with the University of Missouri-Columbia. Other future goals include comparisons of various plots and treatments, and analysis of beneficial or adverse aspects of different treatments (e.g. metals solubility, toxicity, and mobility; rate of re-establishment of vegetative growth; water holding capacity; microbial diversity).

Results

Despite the unique nature of the ground composition, EM and organic matter applications are expected to have many benefits. One quantitative indicator that demonstrates EM's influence on this soil was discovered in the soils tests mentioned above. This microbial assay analyzed concentrations of fungi, and other bacteria. The only distinguishing characteristic of the EM soil versus the non-EM treated soil was a larger total population of fungi. This assay occurred in April 1999 when the last EM treatment was in September 1998.

One qualitative result from EM applications in 1998 is an increased amount of wildlife on the EM plot compared to the other plots, based on observations from the land caretaker.

Discussion and Conclusions

The primary objectives of EM application at the abandoned Lead/Zinc Mine in Jasper County, Missouri are:

1. To increase the long-term vegetation success and stability of the site

2. To decrease the uptake and toxicity of metals in humans, plants, and animals The reclamation site is unique.

While EM has been proven to greatly enhance native soils and crops, this site is not a typical soil. It lacks critical elements of healthy soil such as organic material and humus. However, based on evidence from past research, use of EM will augment the soil formation process when used in conjunction with past and current organic matter applications at the site. It will also increase the growth of plants while significantly reducing metals uptake by plants and the leaching of metals into the watershed.

While the youth of the project prohibits much quantitative data analysis at this stage, there has been an increase in total fungal count on the EM plot. Also, an increase in wildlife has been observed on the EM plot according to the land caretaker.

References

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