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# Consideration of Ecosystem Services Provided through Remediation Approaches at Large-Scale Mining Sites

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**Background/Objectives.** Expanding the considerations of remediation projects to include ecosystem services can garner more benefits from remediation. At large-scale mining sites, the conventional remediation approach often involves dig and haul and replacement with harvested topsoil from offsite. Typically, this approach does not account for the negative impact of topsoil removal to ecosystem services. The consideration of the value of healthy soil and its associated ecosystem services as part of remediation supports viable, sustainable approaches. Residual-based soil amendments, as an alternative approach to topsoil harvesting, utilizes materials such as biosolids and composts for soil restoration at remediation projects. Use of residual-based amendments has led to effective remediation of large-scale sites, with the added benefit of restoration of ecosystem function and services, sequestration of carbon, and avoidance of impact to offsite soil resources. As a case example, this presentation describes the comparison study at the Oronogo-Duenweg National Priorities List site in Jasper County, Missouri.

**Approach/Activities.** To assess the long-term efficacy of residual-based soil amendments to reduce metal availability in situ and to restore a self-sustaining plant cover, seven large-scale demonstration plots were established on mine wastes (tailings and overburden) at the Oronogo-Duenweg NPL site. Plots included one area amended with biosolids at 110 Mg $ha^{-1}$, two areas amended with biosolids at 336 Mg $ha^{-1}$, one area with topsoil from residential yards, one area amended with mushroom compost, and two control areas. Amendment application occurred from 1998 to 2001. Plant uptake of metals, bioaccumulation in earthworms, and metal concentrations in small mammal kidneys were analyzed at the plots in 2002. For long-term analysis of efficacy, in 2012, plant yields and percent cover, metal concentrations, soil properties, and ecosystem service impacts were assessed. The ecosystem service impacts were quantified using the USDA Conservation Reserve Program's (CRP) monetization values for securement of soil ($1.8 billion annually in 14 million hectares), an estimate of the rate of soil formation (0.008 cm $yr^{-1}$), and the change in $CO_2$ emissions for disposal of biosolids compared to land application of biosolids.

**Results/Lessons Learned.** The short-term analysis of the transfer of contaminants to plants, earthworms, and small mammals indicated similar concentrations of metals in organism tissues, across all amendment treatments. In 2012, the control plots had minimal to no plant growth, while all plots, except the low-rate biosolids plot, had similar plant yield (40-50 g $m^2$) and percent cover (60-100%). The high-rate biosolid treatments, when analyzed for soil properties, had more plant-available K than all other treatments, higher available P than control and topsoil treatment, higher total N than control, and largest increase of organic carbon concentration. Application of residual-based amendments to the site avoids the removal of topsoil estimated to cost $241,070 based on CRP payments over time to rebuild soil. Treatment with biosolids has an ecosystem services benefit of the sequestration of 156 Mg $CO_2$ $ha^{-1}$. The results confirm that residual-based soil amendments effectively substitute for harvested topsoil in large-scale mining site remediation and have the added benefit of positive impact on ecosystem services, suggesting that use of residual-based amendments is the preferable approach when applicable. Calculation of the ecosystem services implications of remediation provides a better understanding of the environmental impact of different options and reveals the benefit of equally effective, but more sustainable remediation approaches.

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