Award Period: **2016-2018**

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Project Title: Land Use, Landscape, Legacy Pollution, and Soil Health in Southwestern Poland

Amount spent: _____

Non-technical summary

Jay Norton traveled to Wrocław, Poland in September 2016 to collaborate with scientists at the Institute of Soil Science and Environmental Protection at the Wrocław University of Environmental and Life Sciences. Dr. Norton worked with Professor Cezary Kabała and Dr. Agnieszka Medyńska-Juraszek to evaluate effects of land use on interactions between soil organic matter cycling and heavy metals from a legacy of industrial pollution. The study site was outside Legnica, an ancient Polish city of about 100,000, which was occupied by Germany for many centuries. It was finally transferred to Poland after WWII and became the headquarters of the Soviet forces in Poland from 1945 to 1990. The huge Legnica-Głogów mining complex was developed in the 1950s. The copper smelter opened in 1953 and, until the early 1980s, was a source of heavy metals. Emissions reduced by the 1990s but left a large contaminated area downwind from the smelter. The most severely polluted areas were planted to fast-growing metal-tolerant poplars, but cultivation continued to the west. We used this contrast to define legacy effects of pollution and land use. Our findings indicate that heavy metal content in both forest and cultivated soils remains above background levels, but is much higher under the forests. Forest cover stabilized the site and prevented loss of heavy metal pollutants to food and feed, as well as with erosion to streams. We found that the most forest litter had accumulated closest to the smelter where it had higher amounts of readily decomposable organic material, but lower microbial biomass. This suggests that microbial activity in the most heavily contaminated area is suppressed, which leads to litter accumulation and transport of metals from soils to surface litter.

Land Use, Landscape, Legacy Pollution, and Soil Health in Southwestern Poland

Final Report for 2016 Global Perspectives Award to Jay Norton, Department of Ecosystem Science & Management, University of Wyoming

November 20, 2018

Introduction

The area surrounding the Legnica Copper Smelter in southwestern Poland is representative of legacy effects of pollution during mid-20th-century industrialization, and offers insights on how different land uses affect the long-term fate of contaminants after heavy pollution stops. In this case, the smelter began operation in 1953 and emitted large amounts of smoke and dust laden with heavy metals and other contaminants, notably copper, lead, and zinc, for over 30 years until improved technology reduced emissions. Prevailing southeasterly winds created a plume of heavily polluted soils and what's known as "industrial barrens" to the northeast of the smelter (Fig. 1).

Figure 1. Example of industrial barrens.

After heavy emissions stopped in the 1980s, tolerant, fast-growing poplar trees were planted in the most polluted area to stabilize the site and prevent agriculture from occurring there. The plantation stops abruptly on the west side, however, and borders cultivated fields on soils that were also heavily polluted. This creates a paired-site scenario where contaminated land was divided, with one side being cultivated since pollution stopped, and the other being stabilized by the poplar plantations (Fig. 2).

Figure 2: The study area and sample locations.

Collaborative Research

In fall of 2016, with support of the University of Wyoming Global Perspectives Program, I partnered with Professor Cezary Kabała of the Polish Institute of Soil Science and Environmental Protection to evaluate soil organic matter dynamics and heavy metal contents in the contrasting land uses. Our objectives were to determine impacts of the contrasting land management approaches on legacy effects of the heavy metal pollution, as well as to help develop organic matter analysis capabilities at Wrocław University and to establish collaborative relationships for future opportunities.

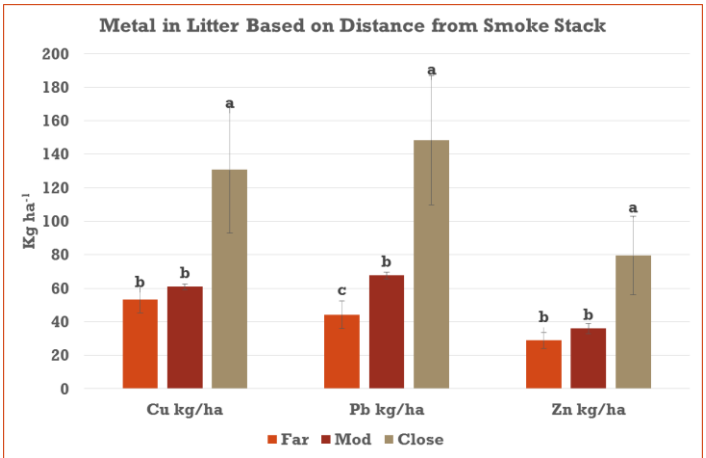
Study Approach

In October, 2016, we collected soil samples from three replicated points at three depths (0-5, 5-20, and 20-30 cm) on each side of the land use boundary at three locations (Close, moderate, and far from the smelter; see Fig 2.). In the poplar plantation, we collected forest litter from a 20 cm x 20 cm square above the point where each soil sample was collected. In the lab at Wrocław University, we analyzed the samples for labile and total organic carbon and nitrogen, including microbial biomass N, mineral N, dissolved organic N. I helped to develop a chloroform fumigation-extraction technique for microbial biomass in the lab there. We also analyzed soil bulk density, acidity, and texture along with content of copper, lead, and zinc in both soil and forest litter.

Prof Kabała collects samples in field of winter canola and beneath forest litter.

Results

Soil concentrations of metals were 5 to almost 200 times typical concentrations, with higher concentrations under the forest cover than the cultivated field, and were highest at the moderate distance. The forested location closest to the smelter had both most forest litter (almost twice as much as the other two locations) and the highest litter concentrations of all three metals, but the lowest soil concentrations. Soils in the closest location had the lowest amount of soil microbes, but the high amount of readily decomposable organic material, indicating that the accumulation of metal-rich layer may have resulted from inhibition of microbial-facilitated decomposition, and that metals are being translocated from the soil to the surface litter. Compared with the cultivated areas, the poplars effectively retained and cycled heavy metals on-site in ways that impact organic matter dynamics.



Heavy metals contained in forest-floor litter. Note that Kg/ha is approximately equal to pounds/acre.

I planned to bring Prof Kabała to Wyoming as part of the project, but he was promoted to director of the institute and his time became very limited.