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ScienceDirect
Bioresource Technology 99 (2008) 7848–7858
BIORESOURCE TECHNOLOGY

Evaluation of pulverized trommel fines for use as a soil amendment

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Received 21 November 2005; received in revised form 10 January 2008; accepted 16 January 2008
Available online 18 April 2008

Abstract

Pulverized trommel fines collected from the City of Chicago's municipal solid waste were applied as a soil amendment over a 2-year period to evaluate: (1) their effects on soil quality by measuring soil elemental concentrations, pH, organic matter and cation exchange capacity; (2) their potential for pathogen transfer. A secondary objective was to examine crop growth, yield and productivity. Total and fecal coliform, Enterococci, *Escherichia coli*, Staphylococci and *Salmonella* were below minimum detection limits in trommel fines. Trommel fines contained 894.5 ± 171.4 mg/kg Pb, and when applied at a rate equivalent to 9.95 mt/ha dry wt, resulted in a soil Pb concentration increase of 18.80 mg/kg, thereby limiting lifetime trommel fine application to 15.9 years before reaching the 300 ppm IEPA (USEPA) regulatory limit. Trommel fines were subjected to a shake extraction procedure and resulting leachate Pb samples were 88.7% below the IEPA (USEPA) regulatory limit (5 mg/l). For the first year, corn yield was significantly higher on soil amended with trommel fines than soil amended with inorganic nitrogen fertilizer. During the second year, soybean yield was significantly lower on soil amended with trommel fines than on soil amended with inorganic fertilizer due to lower plant population. Results of this study suggest that trommel fines can be land applied as a soil amendment if best management practices are followed.
Published by Elsevier Ltd.

Keywords: Trommel fines; Municipal solid waste; Soil amendment; Crop productivity

1. Introduction

Over 463 million metric tons of municipal solid waste (MSW) are generated each year in the US and of that amount 64.1% is landfilled (Simmons et al., 2006). Chicago alone generates over one million tons of MSW annually (William Schubert, personal communication, 2002). To decrease the amount of MSW entering landfills, Waste Management, Inc. developed a process to separate trommel fines from the Chicago MSW. Trommel fines consist of grass, leaves, soil, pieces of glass, partially decomposed organics and other inerts with the physical appearance of soil (Schubert et al., 2000). In 2000, Waste Management, Inc. collected 100,000 t of trommel fines from Chicago's MSW. With this diversion comes a need to find a beneficial use for trommel fines. Direct land application as a soil amendment is one potential use. Other waste products such as biosolids, dead leaves, and woodchips have been used as a soil amendment with varying success (Flanagan et al., 1993; Pascual et al., 1997; Brown and Leonard, 2004). A paucity of knowledge exists regarding the use of MSW trommel fines as a soil amendment for agricultural purposes. The purpose of this study was to conduct an applied field study investigating the feasibility of utilizing trommel fines as a soil amendment in corn and soybean production. Specific objectives included: determining the short term effect of trommel fine application on soil health and quality by monitoring soil pH, organic matter, cation exchange capacity (CEC), and elemental concentrations before and after application; evaluating the potential for pathogen transfer by analyzing the concentration of selected pathogenic and pathogen indictor bacteria in trommel fines; and determining corn (*Zea mays*) and soybean (*Glycine max*) plant response to trommel fines for growth, yield and productivity parameters.

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0960-8524/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.biortech.2008.01.081

2. Methods

2.1. Experimental design

A 0.41 ha Illinois EPA approved field site was selected at a closed landfill in Illinois. The field site had not been in crop production for at least 32 years, and mainly consisted of weed vegetation. The field site has uniform soil (Huntsville loam; fine-silty, mixed, superactive, mesic Cumulic Hapludolls), with a 2–3% slope, optimal drainage and moderate to low fertility. Initial soil parameters were measured prior to trommel fine application, and annually to determine the influence of annual trommel fine application on soil element concentration, organic matter, pH and cation exchange capacity (CEC). At each sampling, four soil cores were taken from each plot to a depth of 18 cm and composited to represent each plot. Four treatments were evaluated to determine the effect of trommel fine application on crop growth and development: (1) the equivalent of 0 metric tons/ha (mt/ha) trommel fines (negative rate control); (2) 60.5 mt/ha of trommel fines (on dry weight basis) (1× application rate); (3) 121.0 mt/ha of trommel fines (on dry weight basis) (2× application rate); (4) 168.5 kg N/ha inorganic fertilizer nitrogen (positive control). Weed control was accomplished by manual removal, and the spot treatment of glyphosate herbicide as required. An experimental unit consisted of 9.1 m (twelve 76.2 cm crop rows) by 18.3 m in length. Each treatment was replicated three times, utilizing a randomized complete block design (RCB).

During year 1, the experiment was planted into a single cross corn hybrid (Pioneer 33A14) and thinned after emergence to a uniform density equivalent to 69,188 plants/ha. To monitor corn plant development, three plants were sampled from each plot at silking (R1 crop stage) and at physiological maturity (R6 crop stage). Total above ground stover, and grain fresh weight and dry weight were determined. A subsample was taken from each plot to analyze for nutrient concentration and content nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sulfur (S), sodium (Na), copper (Cu), manganese (Mn), iron (Fe), zinc (Zn), and boron (B). Grain productivity was estimated at harvest maturity by combining the center eight rows of each plot and measuring grain weight, test weight and moisture. Because this was intended as an exploratory study, additional information could be gleaned by growing corn and soybean, rather than just corn.

Therefore, during year 2, soybean was drilled (20.32 cm rows) using the variety Pioneer 93B67. Due to extremely wet conditions the soybeans were planted late in the season (mid-June) for the geographic location. The population was dramatically increased to compensate for the reduction in vegetative growth. The plots were planted at a 4× rate in part to maximize plant nutrient and potential contaminate accumulation per plot. To monitor soybean plant development, 20 plants were sampled from each plot at beginning seed stage (R5 crop stage). Total above ground plant fresh weight and dry weights were determined, and a subsample was taken from each plot to analyze for nutrient concentration and content (N, P, K, Mg, Ca, S, Na, Cu, Mn, Fe, Zn, and B). Seed productivity was estimated at harvest maturity by combining the center 4.57 m of each plot and measuring seed weight, test weight and moisture.

2.2. Trommel fine application

A traditional tandem-axle manure spreader powered by a farm tractor was used to apply the trommel fines. For the year 1 growing season, trommel fines were applied to appropriate replicate plots using a volumetric method. Net weight and moisture content of the delivered trommel fines were obtained. This weight was used to calculate the rate of trommel fine application, assuming trommel fines would be applied to treatment replicates at a 1× and 2× rate. Accordingly, the equivalent of 60.5 mt:ha (1×) and 121.0 mt:ha (2×) (dry weight basis) were applied to the six appropriate replicate plots.

For the year 2 growing season, trommel fines were applied to appropriate replicate plots by the net weight method. The dry matter content of the trommel fines was determined, and each load of trommel fines applied was weighed and applied in equivalent weight amounts to the same replicate plots as the previous year such that the equivalent of 60.5 mt:ha and 121.0 mt:ha (dry weight basis) were applied to the six appropriate replicate plots. In both years, the trommel fines were applied in the spring before planting and incorporated into the soil to a depth of 15-cm via tillage with a field cultivator. Fertilizer N was applied at the same time as the trommel fine application. Solid urea granules (46%) were spread by hand (broadcast) and incorporated in a similar fashion to trommel fines. A N rate equivalent to 168.5 kg N/ha was applied each year, according to University of Illinois Agronomy Handbook recommendations for corn based on yield goal and previous cropping history.

2.3. Microorganism analyses

Soil, trommel fine, corn and soybean grain, and corn and soybean plant samples were analyzed for heterotrophic bacteria, total and fecal coliform, Staphylococci, Enterococci, *Salmonella*, and *Escherichia coli* (*E. coli*) concentrations using standard membrane-filtration and streak/spread plate culturing techniques using appropriate selective/differential media (APHA, 1995; Freir and Hartman, 1987; Kelley et al., 1995). Samples were stored at 4 °C prior to initiating bacterial analyses (APHA, 1995). Replicate subsamples of 10.0-g were weighed into sterile blender jars, 20.0-ml of 1.0% sterile buffered peptone–water surfactant was added and samples were blended for 30-s at approximately 15,000-rpm using an Oster® (Sunbeam Products, Inc., Boca Raton, Florida) blender (Kelley et al., 1994, 1995). A standard membrane-filtration culturing method was used to determine coliform concentration (Freir and