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Greenhouse and Field Response of Southern Pine Seedlings to Pulp Mill Residues Applied as Soil Amendments

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Abstract: Pulp and paper mills produce organic wastewater treatment residuals, inorganic process residues, and ash that have potential value as soil amendments in southern pine plantations. Chemical characteristics of 18 organic and 10 inorganic residues from 11 southern US pulp and paper mills were determined, and loblolly pine seedling growth response to their use as soil amendments was evaluated in two greenhouse studies. Fourteen of these 28 residues were then used in field studies in which they were incorporated into soil during establishment of pine plantations at three different sites. Under greenhouse conditions, seedling growth was increased by soil incorporation of most of the secondary wastewater treatment residuals at rates equivalent to 22.4 or 134.4 Mg · ha^{-1}. In contrast to these greenhouse studies, under field conditions seedling growth was either unaffected or reduced when secondary wastewater treatment residuals were incorporated into soil at these same rates at plantation establishment. Seedling growth in soil amended with primary wastewater treatment residuals was generally no greater and in some cases significantly less than in the untreated control in both greenhouse and field studies. However, some evidence for growth improvement was observed when these residuals were added to sandy soils of a flatwoods site. We observed little short-term growth benefit from incorporation of inorganic causticizing residues or ash in either the greenhouse study or in field studies of pine plantation establishment. Recycling pulp mill wastewater treatment residuals and process residues to forestland may be a viable recycling/reuse alternative, but growth responses will vary among materials and soil types and are relatively small. Secondary wastewater treatment residuals have the greatest potential to improve growth, but current silvicultural operations would need to be adapted to effectively use these materials. FOR. SCI. 58(6):618–632.

Keywords: ash, causticizing residues, dregs, grits, lime mud, yard waste, waste recycling, wastewater treatment residuals

EACH YEAR, THE PULP AND PAPER INDUSTRY generates more than 13.6 Tg (15 million dry tons) of organic and inorganic wastes in US mills (Thacker 2005). Although the waste stream from each mill is unique, waste streams can be grouped in the following manner: 1) primary wastewater treatment plant residuals, 2) secondary wastewater treatment plant residuals, 3) inorganic causticizing process residues (lime mud, grits, and dregs), and 4) ash. The source of these materials and their physical and chemical characteristics have been summarized in several reviews (Camberato et al. 1997, National Council for Air and Steam Improvement [NCASI] 1999a, Morris et al. 2000, Thacker 2005). Traditionally, most of these waste materials have been disposed of in landfills (NCASI 1984, 1992), but there has been a trend toward increased reuse and recycling. Nevertheless, recent data from the American Forest and Paper Association (Thacker 2005) indicates that 73% of wastewater treatment residuals are landfilled, lagooned, or burned and only 15% are used in land application programs. More than 65% of ash is landfilled or lagooned and less than 10% is used in land application programs. The last comprehensive study of inorganic process residue management was completed in 1995 (NCASI 1999b). It shows that between 70 and 91% of these residues were landfilled or lagooned and between 3 and 9% were used for land application (NCASI 1999b, Thacker 2005).

When land-applied at appropriate rates, many of the waste streams produced by pulp and paper mills can serve as a soil amendment with potential to improve tree growth. Some organic wastewater residuals, in particular, have been shown to be good soil amendments. Henry (1986) studied the effects of pulp and paper mill wastewater treatment residuals applied alone or in combination with municipal biosolids on growth of Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), noble fir (*Abies amabilis* [Dougl.] Forbes), white pine (*Pinus strobus* L.), and cottonwood seedlings (*Populus trichocarpa* Torr). Response was variable, but seedling growth was generally increased after application of

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This article uses metric units; the applicable conversion factors are: millimeters (mm): 1 mm = 0.039 in.; centimeters (cm): 1 cm = 0.39 in.; meters (m): 1 m = 3.3 ft.; hectares (ha): 1 ha = 2.47 ac.; kilograms (kg): 1 kg = 2.2 lb., megagrams (Mg): 1 Mg = 2,204.6 lb.