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POPLAR FOR WASTEWATER AND BIOSOLIDS MANAGEMENT:
AN ENVIRONMENTAL APPLICATION OF THE BIOCYCLE FARM

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POPLAR FOR WASTEWATER AND BIOSOLIDS MANAGEMENT: AN ENVIRONMENTAL APPLICATION OF THE BIOCYCLE FARM

By,

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Introduction

Poplar trees are a highly effective wastewater management tool for biosolids application used by the Metropolitan Wastewater Management Commission (MWMC) in Eugene/Springfield, Oregon (Figure 1). The MWMC distributes the bulk of its nutrient-rich biosolids to local grass-seed farmers but needed a beneficial way to manage excess biosolids.

Based on published agronomic rates in the Willamette Valley, OR (see discussion below), the MWMC determined that rapidly-growing hybrid poplar trees have approximately twice the nitrogen uptake capacity per acre as grass crops—which means that the MWMC's 400 acres of poplar groves (called the Biocycle Farm) is equivalent to 800 acres of grass-seed fields for biosolids management. This uptake capacity also gives the MWMC flexibility in operating its program to meet local farm fertilizer demands while ensuring beneficial use of 100 percent of its annual biosolids production. Additionally, the water uptake capacity of poplar trees means the farm doubles as a land base for irrigation using recycled water. Recycled water use may become an important tool to reduce the MWMC's weekly discharge to the Willamette River during times of the year when reducing sources of heat to the river is needed to protect aquatic species.

The MWMC is an intergovernmental partnership of the City of Eugene, the City of Springfield, and Lane County, OR that directs the regional wastewater program for the Eugene/Springfield, OR metropolitan area. The MWMC's Biocycle Farm operates under a biosolids management plan (MWMC 2006) approved by the Oregon Department of Environmental Quality (DEQ) as part of the MWMC's National Pollutant Discharge Elimination System (NPDES) permit under the requirements of the federal Clean Water Act. Because the poplar trees have a high nutrient-uptake capacity and continue to take up soil nitrogen well after the biosolids are applied, the MWMC could theoretically apply all of its annual biosolids production of 3,500 dry tons to the trees in a given year. However, the MWMC typically applies only 20% of its biosolids to the Biocycle Farm to maintain the soil capacity for nitrogen loading and to balance the local demand for biosolids to fertilize nearby grass-seed farms.

Figure 1. The MWMC's Biocycle Farm tree units showing four blocks of trees comprising two of the Biocycle Farm's management units. (Photo: SkyShots; Portland, OR.)

By growing the poplar trees, the MWMC avoids risks borne by other wastewater processors, such as over-accumulating biosolids in storage lagoons or

the expense of trucking biosolids to a landfill or far-away farms for application to crops.

What *Are* Biosolids?

Biosolids are what the wastewater industry terms the "ready-for-field-use" processed and nutrient-rich organic solids component of municipal wastewater. These nutrients include nitrogen, phosphorous, and organic materials that build soils. Just think compost! It is the fertilizer we create from decayed organic material. In fact, many biosolids operations produce commercial-grade compost available to the public. While organic solids make up less than 1% of what comes through municipal wastewater, they are the first component singled out for treatment. After initial settling in primary clarifiers, the sludge is then broken down in high-heat digesters by biological processes. From there, it is further processed to become a farm-ready fertilizer product. For more information about the proper management and benefits of biosolids, see the Environmental Protection Agency's Biosolids webpage.

Benefits of the Biocycle Farm

The Biocycle Farm is managed for the following primary objectives developed by a citizen's advisory committee:

- Ensure the MWMC maintains 100% beneficial reuse of biosolids (e.g., avoid landfill disposal)
- Produce safe and beneficial products for the environment (e.g., organic soil amendments and sustainable wood products)
- Provide revenue to offset farm operating costs (from the sale of wood products at harvest)

In achieving these objectives, the MWMC has avoided landfill disposal of biosolids, has marketed the wood products from harvest of poplar rotations, and continues to seek new opportunities and products for biosolids and poplar materials as markets emerge.

Since the farm was established, other benefits of growing poplar have been suggested. Some, such as carbon credit benefits, are not applicable for the Biocycle Farm but could be assets to other growers. Because the Biocycle Farm is deemed an existing wastewater operation asset, it is not eligible for carbon banking credits. Furthermore, the carbon sequestration value of the Biocycle Farm is considered limited, due to the relatively short carbon-cycle lifespan of the short-rotation trees and non-sequestered nature of the end products made from the poplar, such as cardboard (Good Company 2014).

There are still carbon benefits, and, depending on the age of standing trees, the 400 acres of poplars can store over 25,000 metric tons of carbon dioxide equivalents (MT CO_2e), which will remain as long as the trees are regrown after each harvest cycle. The practice of applying biosolids as fertilizer also has known carbon storage benefits. Therefore, cities can reduce their overall carbon footprint through poplar plantings and increase the storage capacity as additional acres are planted. Poplar use in durable end products, such as building materials, will enhance the carbon sequestration value over the long term (MWMC 2015).

The Biocycle Farm is zoned for exclusive farm use under Oregon's land use rules and is further classified as farmed wetland under USDA rules. Therefore, the MWMC manages the poplar as an agricultural crop. To qualify as an agricultural crop instead of a forest product under Oregon rules, the trees are grown for up to 12 years. The farm has three different management units planted at different age intervals. The more recently planted units show apparent improvement in general vigor (such as resistance to leaf rusts) and growth rates, which is likely due to selecting for top-performing poplar varieties and the establishment of more routine biosolids and irrigation application practices. The MWMC's initial harvest (in 2013–2015) was comprised of 9-, 10-, and 11-year-old trees. The average yield across these age classes was 30 bone dry tons (BDT) of wood chips per acre at a market prices of over $100/BDT—generating revenues of over $3,000 per acre. Additionally, parts of the tree not suitable for chips were processed into the wood mulch known in the industry as "hog fuel" and sold to local markets as a fuel or fiber source. The average total yield of chips and hog fuel was 50 BDT/acre. Between chip and hog fuel markets, the MWMC's poplar were manufactured into products

as diverse as newspaper, cardboard, paper bags, charcoal briquettes, and electricity (biomass energy).

Biosolids and Recycled Water Uses

The Biocycle Farm provides a double benefit for wastewater management by optimizing the use of both biosolids and recycled water. Besides being fertilized with biosolids, the poplars are irrigated with recycled water—another beneficial reclaimed wastewater product.

A Better Nitrogen Management Tool

While nitrogen, a plant nutrient, is a key fertilizer ingredient and a major component of biosolids, excess nitrogen is a water pollutant that can contribute to algal blooms in lakes and toxic nitrate levels in drinking water. Regulatory limits and agricultural guidelines for nitrogen management help protect against water pollution. The high nitrogen uptake capacity of poplar can reduce excess nutrients in the environment.

To manage nitrogen levels, nitrogen is calculated in units of plant available nitrogen (PAN). Managing for PAN applications, farm operators can understand how much fertilizer is needed, regardless of whether the application is liquid or dry cake biosolids, or a commercial inorganic fertilizer product. The MWMC applies up to a conservative PAN rate of 220 lb/acre/yr. The estimated nitrogen capacity of mature poplars grown in the Willamette Valley (OR) is 260 lb/acre/yr (CH2M Hill 2001). The MWMC biosolids contain 23.2 lb PAN/ton; at the conservative application rate of 220 lb PAN/acre/year, that equates to 9.5 ton/acre at the agronomic rate, equal to 3,800 tons. This capacity is well over the MWMC's annual biosolids production of up to 3,500 dry tons. The MWMC tests annually for residual nitrogen. Typically, the MWMC finds 25–35 lb/acre of carryover soil nitrate that is deducted from the maximum agronomic loading rate.

Based on the Willamette Valley agronomic rates, the uptake capacity of nitrogen for poplar trees is 60% more than that of ryegrass, but, in practice, the rate is more than double that of ryegrass. The MWMC compared the annual agronomic PAN uptake of poplar and ryegrass under three different conditions as shown on Figure 2: (1) the maximum agricultural capacity of the plant in pounds of nitrogen per acre (equal to 260 lb PAN/acre for poplar and 160 lb/acre for grass), (2) the conservatively lower application rate (220 lb/acre poplar, 120 lb/acre grass) to ensure against over-application of nitrogen, and (3) that conservative rate adjusted to account for the unused nitrogen that remains available in the soil (approximately 30 lb/acre, resulting in a capacity of 190 lb/acre poplar, and 90 lb/acre grass). Following the lower application rate of the third condition, operators like the MWMC can significantly reduce the risk of excess nitrogen build up or leaching nitrate to groundwater. By using poplar, the MWMC can follow the more conservative application rate while still achieving a higher biosolids application capacity per acre than they could with a grass crop.

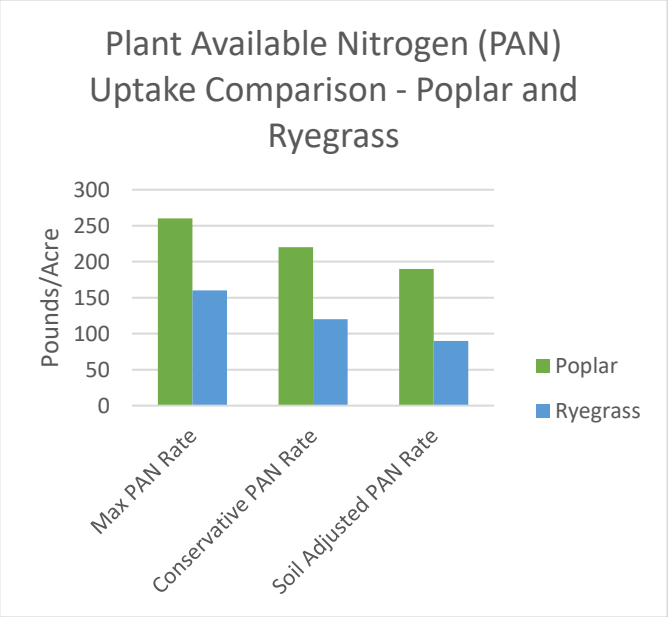

Figure 2. Agricultural nitrogen uptake capacity for poplar compared to ryegrass.

Recycled Water Use to Reduce River Temperature Impacts

To meet future river temperature reduction goals under Oregon's water quality standards, the MWMC may be required to reduce its overall thermal load contribution to the river during certain time periods. One effective way to do this is to reduce the total volume of effluent discharged back to the river, such as by diverting the treated water for irrigation use. By increasing irrigation of the Biocycle Farm with recycled water, the MWMC can reduce its effluent discharge to the Willamette River.

The MWMC historically applies 80 to 90 million gallons of recycled water per year to the trees, but the MWMC's 400 acres of poplar could use over 250 million gallons annually. The agronomic irrigation rate for Willamette Valley poplar greater than four years old is at least 24 acre-inches, assuming low rainfall annually (Greenwood Resources 2008). Based on 24 acre-inches over 400 acres, the total annual irrigation demand is 800 acre-feet (or 260 million gallons). This is roughly the equivalent of ten days of wastewater flow from the entire community!

Poplar trees can accommodate approximately 30% more irrigation than grass seasonally, and yet still have a greater overall biosolids application capacity than grass, whether it is irrigated (recycled water use benefit) or non-irrigated (no recycled water use benefit). This benefit has the potential to save the MWMC's ratepayers millions of dollars in future investment toward alternative thermal reduction strategies. Fully irrigating the Biocycle Farm trees could use over 2 million gallons per day in summer, diverting over 20 million kilocalories per day of thermal load. The MWMC has estimated that strategies for similar thermal reduction in mid-summer could cost upwards of $5,000,000 or more (MWMC 2014).

Poplar's Economic Benefits

Market Sales

Once poplar trees reach their harvest age, revenue from poplar products helps offset the costs of the Biocycle Farm. Historically, poplar chips and hog fuel have been used in a wide range of markets in western Oregon, but today the demand is not as large as before. Primary markets for chips include corrugated cardboard, paper for grocery bags ("Kraft paper"), and newsprint. Hog fuel is primarily sourced for charcoal and biomass energy production. Prices per dry ton of chips ranged from $90 to $130 from 2013 to 2015 and averaged $113 (Table 1). Hog fuel, on the other hand, fetched an average of $20/dry ton but was more consistently priced from year to year. Additionally, small batches of logs were peeled for veneer and used in plywood products at two separate mills. These test batches demonstrated good future market potential for poplar as a veneer source.

Table 1. Summary of chip market sales.

Harvest Year	Tree Age	Market	Price ($/dry ton)
2013	9 years	Corrugated cardboard	$90
2013	9 years	Kraft paper	$98
2014	10 years	Newsprint	$117
2015	11 years	Newsprint	$130

Harvest Benefits

In addition to receiving more favorable chip prices each successive year of the harvest, the total chip yield of the 222 tree-per-acre farm increased each year. The increase in production appears to be directly correlated with the additional growth on the trees in successive years, resulting in more biomass per acre and a greater recoverable chip portion of the tree with larger trees (reflected as percent chip biomass in Figure 3). The chip production chart illustrates the successive increase by year in total chip yield and chip percent of total biomass.

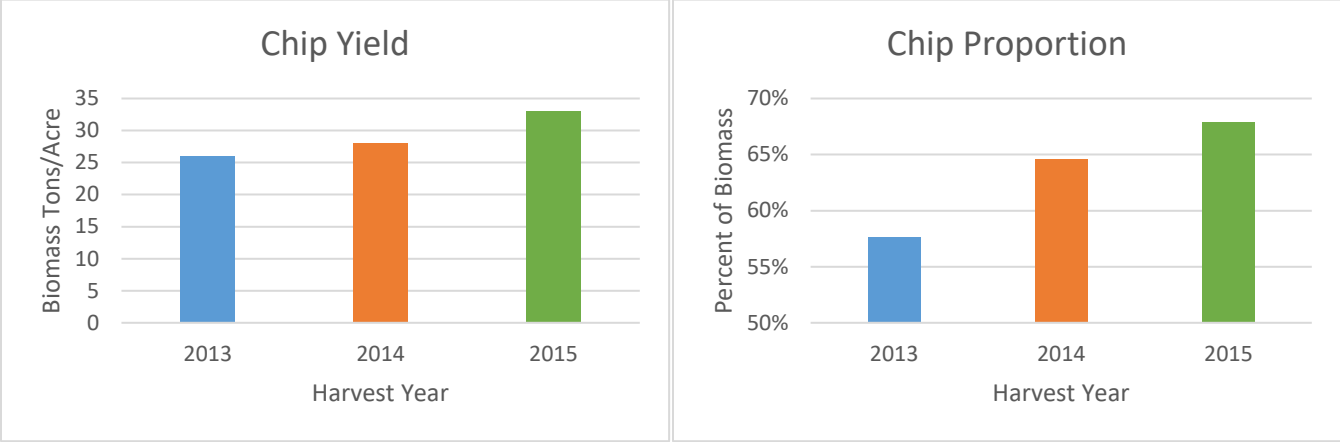

Figure 3. Increased biomass yield per acre per year of growth.

Next Steps

The Biocycle Farm's advantages for biosolids management demonstrate the value of poplar for this application. However, operating the Biocycle Farm requires significant dedication of land, operations staff, and planting and harvesting expenses. To optimize operations, the MWMC is looking forward to continued improvements in total poplar yield, harvest efficiency, and market opportunities. As the Biocycle Farm becomes an established operational asset, the MWMC is pursuing the following production enhancements:

- Determine optimum irrigation and biosolids fertilization to increase harvest yields while enhancing wastewater management benefits.
- Pursue sustainable-forestry certification to enhance market demand and value.
- Continue to collaborate directly with poplar buyers and researchers to develop sustainable and long-term markets.
- Collaborate with other growers to increase supply and availability of poplar regionally to enhance market opportunities.

For More Information

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