AGROFORESTRY NOTES
AF Note — 17 April 2000

Wastewater Management Using Hybrid Poplar

Introduction

Hybrid poplars are rapidly growing trees that are well suited to use agricultural, industrial, and community wastewater. They are being used as an alternative to expensive wastewater treatment systems, and methods which apply wastewater to annual crops or pasture. The trees serve a dual purpose as a nutrient sink for wastewater use and as a means to produce a short-rotation harvested wood product which helps offset the cost of installation and maintenance.

Planning tree wastewater use systems requires both agroforestry and engineering expertise. Omission of either in the planning process can lead to disappointing results and reduced benefits. This *Agroforestry Note* outlines and discusses the major planning and engineering considerations for a short rotation woody crop (SRWC) wastewater application system.

Planning Considerations

Dual-Purpose Aspect. The dual objective of this technology for wastewater management and wood production will affect site selection, stand spacing, utility function, and marketing/utilization of wood products. Trees may be grown for chips for pulp or oriented strand board, solid wood products (veneer, paneling, molding, etc.), or as biomass for fuel. Product goals will influence initial stand spacing and future management regimes (i.e. pruning, thinning). Harvesting in short rotations (6 to 15 years) will keep the stand from deteriorating and take advantage of the rapid growth of young trees for wastewater uptake.

Interdisciplinary Team and Commitment. An interdisciplinary team knowledgeable in forestry/plant science, soil science, environmental and irrigation engineering, farming, and wood product utilization can provide critical input for the planning, design, and management of the project. This will require a series of meetings to discuss the project and to develop an appropriate plan of work. It is essential to determine the local commitment for the project in terms of coordination, technical design assistance, installation, maintenance, wood product marketing, permits, and public information.

Permits. Meetings with the appropriate agencies (i.e. U.S. Environmental Protection Agency (EPA), State Department of Environmental Quality (DEQ), USDA Natural Resources Conservation Service (NRCS), etc.) should occur early in the planning effort. Most municipal wastewater reuse systems require a permit. Examples include the National Pollutant Discharge Elimination System (NPDES) permit for industrial and municiple waste, and Concentrated Animal Feeding Operations (CAFO), or a Water Pollution Control Facility (WPCF) permit. Some states have additional state issued animal waste permits for agriculture. Facility plans, engineering reports, and management plans are just some of the possible support documents required during development.

Wastewater Design Components

Effluent Quantity and Quality. A clear understanding of the quantity and quality of the effluent to be managed is needed and will dictate the amount of land to be planted. Quantity is often established by the operations permit for the wastewater treatment plant and will vary depending on the water supply, waste inputs, treatment process, and type of storage/retention facility. These permit conditions may limit effluent discharge to a receiving stream during a specific time period and require a minimum level of treatment. The table to the right provides a general list of effluent quality parameters to consider. *In most cases, wastewater effluent from municipal systems has proven to be an ideal source of irrigation water for SRWC plantations.*

Key Parameters of Effluent Quality

Parameter (mg/L)

Biological Oxygen Demand
Suspended Solids
Dissolved Solids
Nitrogen
  Total Nitrogen
  Ammonia
  Nitrate-nitrite
Phosphorus
  Potassium
Chlorides
Sodium
Heavy metals

Irrigation Requirement and Nutrient Loading Rates. Water requirements and nutrient uptake capacity of the trees determines the land area requirements. Water needs for various crops can be found in the NRCS *Guide to Individual State Guidelines on Crop Water Use and Net Irrigation Requirement,* through agricultural extension agents, experiment stations, and/or state universities. The nutrient uptake capacity (fertilizer requirements) for tree crops can also be found through regional extension guides. In addition, general guidelines can be found in the EPA *Guidelines for Water Reuse and Process Design Manual for Land Treatment of Municipal Wastewater.* Several demonstration sites, as well as industrial scale hybrid poplar tree plantations, have been developed in the Pacific Northwest to reuse wastewater effluent and biosolids and have helped to better define the crop water use, irrigation requirement, and nutrient uptake capacity.

Water Delivery System. The water delivery system generally includes pumps and pipelines needed to convey the wastewater from the treatment facility to the irrigation system at the SRWC plantation. The sizing and design criteria vary according to: 1) quantity of reuse water and required delivery pressure, 2) peak daily irrigation rate, and 3) distance and elevation between the wastewater treatment facility and the irrigation system.

The material selection for pump, pipeline, and filtration components must involve the consideration of the corrosivity of the effluent and the anticipated sediment load. California and Nevada's *Guidelines for Distribution of Nonpotable Water* provides specific guidelines on pipelines. Filtration after the pump station should be considered to protect the irrigation system from clogging. The mesh size of the filter depends on the type of irrigation application system used. Micro-spray sprinklers should have a minimum of a 50-mesh filtration system and drip lines should have a minimum of 150 mesh. Sand media filtration may be required for drip systems when the effluent has a heavy load of suspended organic particles.

Irrigation System. Several planning considerations are needed to identify the proper irrigation system components and layout: 1) tree spacing, 2) infiltration rate of the soil, 3) goals surrounding uniformity of water application, 4) water quality of the effluent and filtration desires, and 5) overall operations and management of the plantation. The two most common irrigation systems used in SRWC plantations are micro-spray sprinklers and drip emitters. Both of these systems generally employ an above ground lateral line that delivers water to the sprinklers or drip emitters spaced down the rows. Any buried flexible piping should be considered with caution due to the potential for crimping by tree roots. Drip systems require one lateral line per tree row, however the spacing between the rows for the micro-spray sprinkler system depends on the tree spacing and application uniformity desired. For example, a plantation with a 10 foot X 10 foot tree spacing may have a lateral line every other tree row. The spacing within a tree row depends on the tree spacing down the row, flow rate of the emitters or micro-spray sprinklers, and the desired application rate. Other types of irrigation application systems such as impact sprinklers, ditches, and/or gated pipe have also been successfully used.

Operation and Maintenance. Operation and maintenance considerations include: 1) sprinkler and/or emitter performance, 2) filtration cycle times, 3) pump flows and pressures, 4) tracking of total application rates and effluent quality, 5) soil moisture conditions, 6) soil pore water quality, and 7) groundwater quality. A routine schedule should be followed for flushing the system, cleaning and maintaining the filtration system, and repairing and/or replacing the micro-spray sprinklers or drip emitters.

Plant Design Components

Soils/Site Conditions at Proposed Project Location. Ideally, the site should be level with good drainage and a neutral pH (6 to 7). Loamy soils are best. Soil depth should be at least three feet, with four to six feet preferred. Good root development is needed for effective wastewater uptake and to reduce the potential for wind throw damage. Clayey, poorly drained soils or soils with a high pH (8+) or salts are not recommended for tree/wastewater projects. Extra caution should be taken with very sandy or gravely soils due to the potential for excessive leaching. It is also important to identify adjacent surface waters and communities that could be affected.

Hybrid Poplar Suitability. The technology for hybrid poplar varieties is rapidly advancing, so it is important to acquire the most current information on suitable varieties. This information may be available from locations such as university extension offices, hybrid poplar nurseries, USDA Forest Service Research Stations, private timber companies, private forestry consultants, and conservation district offices. Knowledge of the soil attributes, wastewater content, and common local pests and diseases is essential to variety selection. Matching varieties for the product desired as well as their utility function will benefit the overall economic outlook of the project.

Design – Initial Stand Spacing. Initial stand spacing is determined by a combination of factors like wood product desired, irrigation system, and weed control methods. Biomass plantings for fuel production will have close spacing (e.g. 3 foot X 5 foot) vs. plantings for chips for paper or strand board with moderate spacing (e.g. 8 foot X 10 foot). Wider spacing, such as 12 foot X 12 foot or wider, may be desired for producing a solid wood product like veneer, however, it may add to the number of years of weed control needed and may reduce the amount of wastewater uptake in the early growth phase of the planting. Weed control methods will influence spacing depending on the types of equipment used for mowing and/or tillage operations, and herbicide applications. The wastewater irrigation system may also influence stand spacing.

Site Preparation, Planting, and Maintenance

Site Preparation. Existing vegetation is typically killed the year before planting and tilled to mellow over winter. If the soil is compacted and/or there are clay or plow pan layers present in the upper two feet of the soil profile, the site will need to be ripped or subsoiled to allow for root growth. Ripping is usually done along the tree row line and sometimes again perpendicular to the tree row line. In the spring, before planting, the site may be tilled. In some wet climates, trees should be planted in early spring when soil conditions are still too wet for tillage. “Flour” type conditions are created with too much tillage and present major problems for plant establishment and potential soil erosion. Cover crops or orchard grass mixtures are sometimes established between the tree rows but three feet should be left clear on either side of the trees.

Planting and Maintenance. Branch or stem cuttings 8 to12 inches in length and greater than 3/8 inch diameter are planted by inserting them into the soil until only one bud remains above ground. This will generally produce a single dominant stem. Avoid very fine or cloddy soil conditions at the planting site to insure good root development. Very fine or powdery soil conditions cause the soil to settle after irrigation, while cloddy conditions will create air pockets next to the stem. It is extremely important to plan for weed control. Pre-emergent and contact herbicide information can be obtained from extension offices, consultants, nurseries, etc. Usually, pre-emergence herbicides are applied within the tree rows just before or after planting and they are used until the trees have shaded out competing vegetation. Control of weeds between rows may be important for reducing habitat for rodents, such as mice/voles, that can girdle young tree stems. In irrigated plantings, such as wastewater applications, mowing or shallow tillage can accomplish this. Make sure the mowing cycle is diligent and weeds are not allowed to go to seed. Sprinkler lines need to be placed in the tree rows to avoid damage by mowing or tillage equipment for between-row weed control.

Management. Management consists of protection from animals, insects, diseases, and stand treatments to produce a harvestable product. Deer browse the terminal bud of stems in the first year causing loss of growth and excessive branch development. This reduces stem wood development and quality. Observations from plantation owners and nurseries suggest that deer tend to browse the outer rows of a planting.

For insect and disease control, the best defense is to plant the most tolerant varieties suitable for a region. Leaf rust, stem canker diseases, leaf beetles, aphids, stem borers, and grasshoppers can be important pests to monitor throughout the growth of the planting.

Stand treatments like thinning and pruning are essential for producing a high-value wood product. Initial stand spacing and growth rates will dictate thinning and pruning operations. Wide spacing will reduce the need for thinning, however, it may increase the need for pruning. To determine the harvesting cycle it is useful to target an average stand diameter; common averages are: biomass - four to five inches; chips - seven to eight inches; and sawlogs (lumer, veneer, moldings) - 12 to 16 inches. The length of time trees are grown can determine whether they fall under agricultural or forestry practice laws. State and local laws should be understood when determining harvest cycles.

For More Information

"Crop Water Use and Net Irrigation Requirements." USDA-NRCS. Individual state guidelines. Available at USDA-NRCS offices.

"Guidelines for Distribution of Nonpotable Water." 1983. American Water Works Association (AWWA) - California-Nevada Section.

"Guidelines for Water Reuse." 1992. US EPA 625/R-92/004. Prepared by US EPA and US AID by Camp Dresser and McKee.

"Process Design Manual: Land Treatment of Municipal Wastewater." 1981. US IEPA 625/1-81-013, US EPA.

Authors

Gary A. Kuhn, USDA National Agroforestry Center, c/o Washington State University, 668 N. Riverpoint Blvd., Box B, Spokane, Washington 99202-1662. Phone: 509-358-7946. E-mail: *kuhn@mail.wsu.edu*

Jeff Nuss, Greenwood Resources, Inc., One SW Columbia, Suite 1720, Portland, Oregon 97528. Phone: 503-274-0438. E-mail: *jnuss@GreenWood-Res.com*

USDA National Agroforestry Center

A partnership of Forest Service and NRCS Natural Resources Conservation Service

Contact: USDA National Agroforestry Center, 402.437.5178 ext. 4011, 1945 N. 38th St., Lincoln, Nebraska 68583-0822. *www.unl.edu/nac*

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