PRESSURE CONTROL IN LAND APPLICATION OF MUNICIPAL WASTEWATER

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INTRODUCTION

The use of waste material for application to farmland as fertilizer has been in practice for centuries. In the past sewage farms were common in locations such as Europe and Australia, however as technology advanced the use of sewage farms became less prominent. The 20th century saw an increase in the use of wastewater for irrigation due to increased pressure on fresh water resources in both developing and industrialized countries. (Johnson 2002).

As population growth continues to put increasing pressure on natural water resources, the search for alternative sources of water has lead to increased use of municipal wastewater. For example, Florida has seen an increase of 26 percent in the number of treatment facilities processing waste water for reuse over a ten year period beginning in 1986. The following chart gives a breakdown regarding reuse application in Florida.

Application use	Percent Breakdown
Landscape Irrigation	40 percent
Groundwater recharge	20 percent
Agriculture Irrigation	18 percent
Industrial Application	15 percent
Wetland and other minor applications	7 percent

(York & Coleman 1999).

Increased attention on municipal wastewater as a resource for irrigation has led to additional focus on the impact that it has on the public health, environment, and the economic return on investment. One of the key elements to a successful project that can address these issues of concern includes a well designed system. The components of a well designed irrigation system can be broken down into the following four categories:

1. Control equipment
2. Water conveyance system
3. Water distribution system
4. Pumping system.

A deficiency in any one area can result in long term problems (Smajstrla, 1994).

PURPOSE

The purpose of this paper is to discuss the water distribution system, specifically sprinkler application and how it is affected by changes in pressure. Pressure changes in the system can result in variable application rates and poor uniformity, thus negatively affecting the overall performance, longevity and economic return on investment of the irrigation system (Smajstrla, Zazueta, Haman 1989).

PRESSURE IMPACT ON APPLICATION RATE

Causes of pressure variations in a system include examples such as changes in elevation, flow differences, (such as different size zones, corner system and or end gun activation on a center pivot), management practices and under-sized laterals. It is suggested that there should be no more than 20% variation in sprinkler operating pressure within a zone. The impact of changes in pressure is more dramatic for systems utilizing low pressure emitters versus higher operating pressure sprinklers. This can be demonstrated by the following equation:

Flow versus Pressure Relationship: % Flow change = % Pressure change / 2

For example, a solid set field with impact sprinklers irrigating municipal wastewater for hay production that is designed to operate sprinklers at 50 psi with a flow rate of 9.66 gpm on a spacing of 60 x 60 ft. yielding an application rate of .25 inches per hour over a defined area of 350 ft. x 350 ft. The infiltration rate of the soil has been determined to be .25 inches per hour. However, one of the laterals has developed a leak and is shut off for repair but the zone is still activated resulting in an increase in pressure of 20 percent which translates into 10 percent increase of sprinkler flow rate, thus raising the application rate to .29 inches per hour. This exceeds the soil infiltration rate resulting in potential runoff.

PRESSURE IMPACT ON UNIFORMITY

Another important definition is Distribution of Uniformity. This can be defined as how uniformly the water is being applied across the area of application (Burt 1995).

DU=Minimum amount applied /Average amount applied x 100

Uniformity can be affected by spacing of the sprinklers, flow and pressure. As discussed above changes in pressure impacting sprinkler flow rate result in variable application rates within the defined area. Irrigation systems should be designed at or below the minimum infiltration rate to avoid runoff (Scherer 1999). A system designed with uniformity as one criteria can help achieve this goal.

The following example looks at the impact of uniformity on the volume of municipal water required to irrigate an agricultural crop. Corn grown in Minnesota requires a typical range of 9 to 11 inches of seasonal net irrigation application, based on ten year average in addition to natural rainfall (Scherer 1999). The design parameters of this example include 100 acres using impact sprinklers on a center pivot with a system Distribution Uniformity of 70%, and a net irrigation requirement of 11 inches per year.

Plant requirement / Uniformity =Irrigation Requirement
Irrigation Requirement x 27,154 gallons x acres = Gallons of water for crop requirement

Plant Requirement	**Uniformity**	**Irrigation Requirement**	**Gallons per Acre Inch**	**Irrigated Acres**	**Gallons/ year**
11 inches	70%	15.7 inches	27,154	100	42,631,780
11 inches	85%	12.9 inches	27,154	100	35,140,470

(Thompson 2002)

The information listed in the chart above indicates that an 18 percent decrease in water use is achieved by increasing uniformity from 70 to 85 percent. This example demonstrates that higher uniformity results in less water required to irrigate the crop, lower pumping costs, reduced risk of leaching chemicals, and runoff in areas where over-watering may have occurred.

FLOW CONTROL NOZZLE VS. PRESSURE REGULATION

Systems with operating sprinkler pressures that see differences of 20 percent or greater than design pressure are candidates for regulation or flow control. The flow rate of the sprinkler is controlled by two components, the size of the orifice and the operating pressure of the sprinkler. Sprinkler flow rate can be controlled by the use of flow control nozzles or if the nozzle is fixed then pressure regulators can be used to control pressure.

Flow Control Nozzles operate using a flexible disk with an orifice that changes shape based on pressure. As pressure increases the disk orifice becomes smaller due to outward flexing of the disk (Kranz 1988). However, activation of the flow control device does not usually occur until upstream pressure exceeds a threshold pressure. Threshold pressure for 1-5 gpm ranges from 20 to 40 psi and 35 to 50 psi for flows greater than 6 gpm (Van der Gulik 1983). This can be a limiting factor for application of low pressure sprinklers, which operate below these ranges (Kranz 1988). There is also a change in droplet size as the orifice changes shape in response to pressure fluctuations which can result in the distortion of sprinkler profile, thus adversely affecting system uniformity.

In-line pressure regulators are designed to maintain a preset outlet pressure. Flow enters the regulator through the inlet side and travels past a fixed seat and through a hollow cylinder (throttling stem) that moves up and down in response to changes in back pressure. The opening between the fixed seat and the throttling stem can be described as a modulating valve that opens or closes in response to changes in inlet pressures, thus maintaining preset outlet pressure. The desired opening for a given outlet pressure is maintained by equalizing back pressure against an internal compression spring. Regulators are generally available in preset operating pressures in 5 psi increments up to 60 psi depending on flow requirements. Activation of the regulator requires an inlet pressure of 5 psi above the preset outlet pressure rating. For example a 30 psi regulator will need 35 psi inlet psi for regulation to occur. A pressure regulator is chosen based on flow rate and operating pressure requirements of the sprinkler.

CONCLUSION

Availability of land for application of municipal wastewater is often limited and may be slated for areas where site development is too expensive due to elevation changes. The use of pressure regulators for application of municipal wastewater is an important tool to address issues such as uneven application rates and poor uniformity. A well designed system with the right nozzle selection, pressure regulation and spacing will achieve application rates at or below infiltration rates resulting in an irrigation system that is environmentally safe, publicly supported and good a return on investment.

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