NebGuide

Nebraska Extension

Research-Based Information That You Can Use

G2357

Treated Wastewater Reuse for Non-Direct Food Consumption Crops in Nebraska

Barriers and Benefits of Municipal Irrigation Lagoons

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This NebGuide discusses barriers and benefits of reusing treated wastewater from municipal lagoon systems for agricultural irrigation onto crops that are not directly consumed by humans. These systems have many benefits for small Nebraska communities. This NebGuide provides information and guidance for agricultural producers and cropland owners.

Introduction to Wastewater Reuse

The U.S. Environmental Protection Agency (EPA) defines water reuse as "the practice of reclaiming water from a variety of sources, treating it, and reusing it for beneficial purposes." Agricultural water reuse specifically is defined by the U.S. EPA as treated wastewater that is applied to cropland. Reusing treated wastewater for agricultural purposes in small, rural communities provides local benefits such as reduced wastewater treatment costs and lower operations and maintenance requirements. Wastewater treatment plants (WWTP) help protect and maintain public health. Although the main function of a WWTP is to treat wastewater, these systems can also recover valuable resources such as water, energy, nutrients, and biosolids. Many countries, especially developing and arid countries, have long been recovering and reusing wastewater for irrigation purposes. In the U.S., there are no regulations for wastewater reuse at the federal level, although guidelines have been developed and made available to states. Therefore, each individual state can implement regulations or guidelines for wastewater reuse, as desired. Furthermore, there is a need for more federal funding of reuse projects to continue encouraging wastewater reuse.

Irrigation Lagoons

Lagoon wastewater treatment systems are one of the most common technologies used for wastewater treatment worldwide. Lagoons treat wastewater naturally by using bacteria to metabolize organic matter. Lagoons are commonly used in small, rural communities of fewer than 3,000 people, where limited funding and resources are available for constructing and operating wastewater infrastructure. These smaller communities often struggle with maintaining qualified staff to operate WWTPs. Additionally, these systems tend to be implemented in areas where land is commonly and readily available, and where evaporation exceeds precipitation on an annual basis. Furthermore, small, rural communities often struggle with aging and inadequate WWTPs, and many of these systems will require improvements or replacements in the coming years to meet evolving treatment requirements and permit limits. It is important to clarify that municipal lagoon wastewater treatment systems, which are the focus of this guide, are regulated, designed, and operated differently than residential onsite wastewater treatment lagoons (i.e., decentralized systems that are not connected to a municipal system). Irrigating with water from a residential onsite wastewater treatment lagoon is currently not allowed in

Nebraska. Further information regarding residential onsite wastewater treatment lagoons is covered in the NebGuides Residential Onsite Wastewater Treatment: Lagoon Design and Construction, G1441 and Residential Onsite Wastewater Treatment: Lagoon Maintenance, G1423.

Irrigation lagoons are a specific type of complete retention lagoon wastewater treatment technology. Irrigation lagoons have the capability to apply treated wastewater, which is considered to be the final discharge of the wastewater treatment lagoon, onto cropland rather than discharging the treated wastewater to a nearby water body (i.e., controlled or continuous discharge lagoons) or indefinitely storing the treated wastewater until it evaporates (i.e., complete retention lagoons without irrigation capabilities). Irrigation lagoons, as referred to in this guide and in Nebraska, apply the treated wastewater onto crops that are not directly consumed by humans, such as feed crops, fiber crops, and industrial crops. There are two main ways that irrigation lagoons are used in Nebraska. First, cities or agricultural producers may use the treated wastewater alone to irrigate their cropland. This is most common when a city is irrigating nearby pasture or grassland. Second, agricultural producers may use a hybrid irrigation system, where the treated wastewater is applied to the cropland, but additional irrigation sources (e.g., groundwater wells) are available for supplemental irrigation purposes. This hybrid irrigation system is more common in Nebraska, as the treated wastewater alone generally does not meet all of the agronomic needs, which depends on factors such as seasonal variability.

Generally, when faced with the challenge of meeting updated treatment requirements, small, rural communities with existing wastewater treatment systems have two options: convert to a more advanced mechanical system or expand an existing lagoon system. However, irrigation lagoons can provide a third alternative that can be cheaper to construct and operate, have lower operational and labor requirements, and have less environmental impact, compared to mechanical systems and expanded lagoons. Landowners wishing to apply treated domestic wastewater onto their cropland may refer to the Nebraska Department of Environment and Energy's (NDEE) Guidance for Land Application Discharges of Treated Domestic Wastewater for detailed requirements and guidelines.

Understanding the Underutilization

Wastewater reuse systems for irrigation are not common in the U.S. due to limited guidance and regulations, public acceptance, and system knowledge. Small, rural communities are often limited in terms of funding and resources available to help identify wastewater treatment best practices. Additionally, engineers working with communities typically do not have the time or funding to analyze case studies and educate every curious stakeholder about projects.

Another major implementation challenge for small, rural communities is obtaining agricultural producer and landowner cooperation. Although eminent domain (i.e., the power of the government to take private property) is an option available to communities looking to implement irrigation lagoons, many communities consider this a last resort to avoid community disruption. This NebGuide provides information that addresses common questions and concerns about irrigation lagoons to help agricultural producers and landowners feel more comfortable with the system and become more engaged in the initial decision-making process.

Reasons for Implementation

Irrigation lagoons are implemented in small, rural communities for various reasons and typically involve, to some extent, multiple stakeholders in the decision-making process as shown in Figure 1. The main reasons for implementing an irrigation lagoon system are to convert from a mechanical system or to avoid or limit the expansion of an existing lagoon system to move away from National Pollutant Discharge Eliminate System (NPDES) permit requirements. Converting a mechanical WWTP to a lagoon system can be a result of old infrastructure and equipment, labor and operational costs, challenges with discharge compliance, shrinking populations, inflow and infiltration, and funding eligibility. Communities may consider expanding an existing lagoon if their population is growing. However, avoiding the expansion of an existing lagoon by adding irrigation capabilities can reduce land requirements and construction impacts.

Many impacts can be avoided by implementing irrigation lagoons, including operator time and labor requirements, as well as discharge permit requirements. In Nebraska, there is no need to obtain a NPDES permit for an irrigation lagoon, as it is considered to be non-discharge and Authorized by Rule (Nebraska Administrative Code Title 119 Chapter 12). There is also a reduced land footprint for irrigation lagoons compared to some other lagoon systems, which results in lower construction and materials costs, and thus lower environmental impacts of construction. Table 1 summarizes the reasons for implementation and avoided impacts associated with irrigation lagoons.

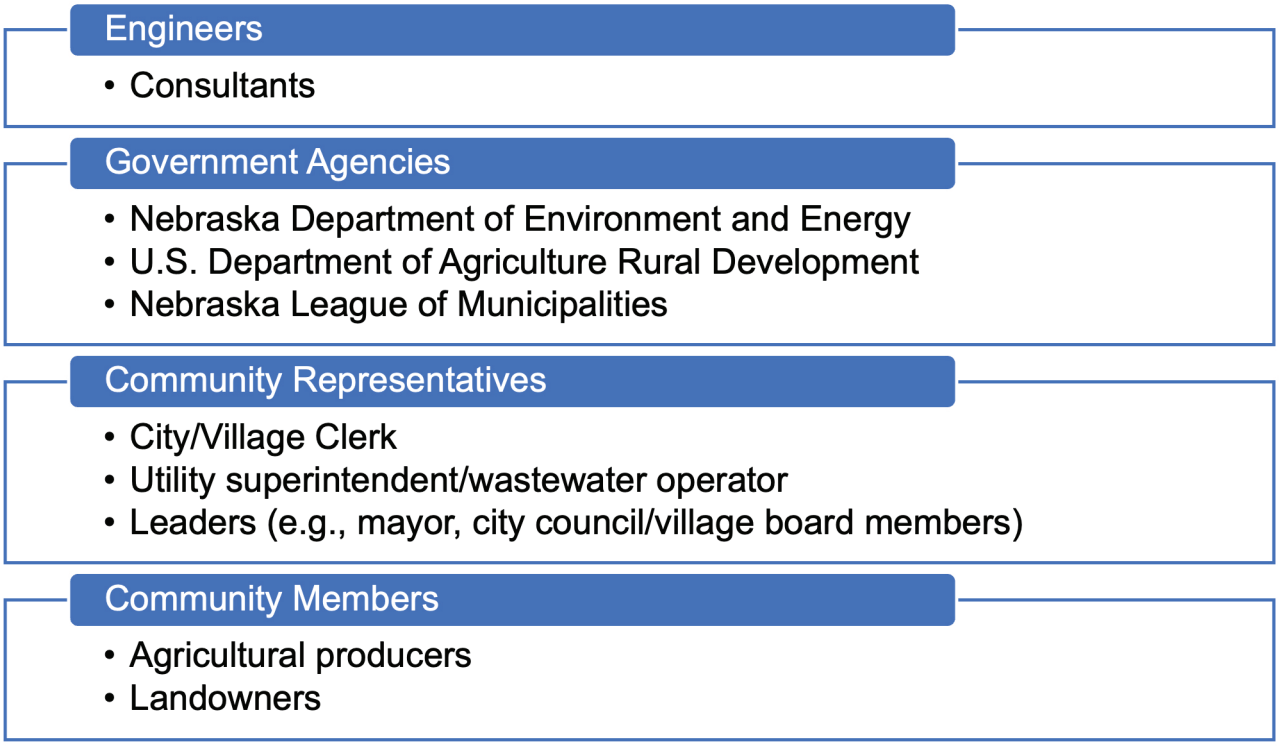

Fig. 1. Major stakeholders involved with irrigation lagoons as observed in Nebraska

Table 1: Reasons for implementation and avoided impacts of irrigation lagoons

Reasons for implementation	Convert from mechanical system
	Old infrastructure
	High operational costs
	Evolving permitting requirements
	Shrinking populations
	Inflow & infiltration
	Funding constraints
	Avoid expanding an existing lagoon
	Growing populations
Avoided impacts	Operator time and labor
	Reduced requirements compared to a mechanical plant
	Discharge permits
	Land footprint
	Reduced land area requirements for lagoon
	Lower economic and environmental impacts of construction

Barriers to Implementation

There are many barriers that can hinder irrigation lagoon success in small communities. The most common barriers to implementation include variability of the climate, availability of land nearby, and willingness of potential landowners and tenant agricultural producers. Climate (or seasonal) variability is a significant and common barrier among communities considering irrigation lagoons because it is difficult to meet the needs of both the city and the agricultural producer simultaneously. Agricultural producers prefer to receive water during dry times when their crops need water, whereas cities must dispose of water from the lagoons during wet times to avoid overflow. However, during dry years when the demand for irrigation is highest, the availability of treated wastewater may be lower due to high evaporation rates and limited inflow. Therefore, irrigation lagoons are a good alternative under the right climatic conditions.

Economic costs can also be a major implementation barrier. The economic costs of purchasing cropland to irrigate onto and installing piping, a pump, and a pivot to pump water to the cropland can become substantial when having to pump long distances. However, if ideally located, irrigation lagoons have been found to have reduced treatment costs compared to mechanical systems because they do not have to meet the rigorous discharge treatment requirements that mechanical systems must. Additionally, if the irrigation lagoon is located near the receiving cropland, lower energy usage is required to operate the system, leading to reduced energy costs and environmental impacts associated with energy usage.

Additional implementation barriers include public perception, odor concerns, groundwater contamination,

and a town's potential optimism for growth. The public is generally most concerned with odors when converting from a mechanical system to a lagoon system, but these concerns tend to subside once the lagoon becomes operational. The public may also be concerned about the potential for groundwater contamination due to seepage. However, geography and soil types are major considerations in the design and planning stages of irrigation lagoons to ensure groundwater is protected. Lastly, communities may feel that implementing an irrigation lagoon limits their ability to grow in population. Regarding public perception, acceptance of wastewater reuse increases if non-food crops are irrigated, and in areas with high crop demands and low water supplies.

Engineers have expressed concerns with potential water rights challenges. For example, a mechanical WWTP discharges effluent into nearby water bodies. If a community converts their mechanical WWTP to an irrigation lagoon, there will no longer be a discharge. However, the amount of effluent being added to the water body from a small mechanical WWTP is often a small component of the stream flow. It is recommended that communities in water-scarce regions consider potential water rights challenges. In dry regions, a number of water rights feuds may actually be resolved, as surface water and groundwater irrigation withdrawals can be replaced or supplemented with treated wastewater.

There is also a lack of knowledge regarding these systems, which has led to underutilization in Nebraska and the U.S. compared to the rest of the world. This is partially due to the exclusion of landowners and agricultural producers in the decision-making process for irrigation lagoons, which limits their knowledge and acceptance of such systems due to safety concerns and fear of risk. Agricultural producers and landowners should be included in the initial decision making, along with the city officials, engineers, the public, and wastewater operators. To help with inclusion, this guide aims to ensure that landowners and agricultural producers have a reliable way to gather information about these systems so that they may feel comfortable having a more active role in public meetings and decision-making.

In addition to helping identify implementation barriers, suggestions for overcoming these barriers are provided. These suggestions include explaining the details of these systems to the public during public meetings to help resolve concerns, researching the system and talking with agricultural producers currently using the system, and building and maintaining trust between stakeholders within a community. Table 2 summarizes the implementation barriers and concerns for irrigation lagoons.

Table 2: Implementation barriers for irrigation lagoons

Barriers	Climate/seasonal variability
	Dry years
	Agricultural producers have a high irrigation water demand
	Municipal wastewater lagoon has a low water supply
	Wet years
	Municipal wastewater lagoon has a high water supply
	Agricultural producers have a low irrigation water demand
	Nearby land availability
	Purchasing cropland can become expensive if there are few landowners willing to accept the system
	Piping and pumping costs increase as the distance between the lagoon and receiving cropland increases
	Nearby land reduces energy usage and costs
	Reduced energy usage results in less environmental and economic impact from energy use
	Willing landowners/agricultural producers
	Lack of system knowledge
	Limited access to streamlined information
	Limited involvement in decision making process
Concerns	Odors
	Groundwater contamination
	Optimism for town growth
	Public acceptance
	Non-food crops (acceptance increases if non-food crops are irrigated rather than food crops)
	Crop and water security (acceptance increases in areas with high crop demands and low water supply)
	Water rights
	Eliminate a discharge to a nearby water body

Lagoon and Irrigation System Ownership Structures

Ownership structures for each element of this system are important to both the community and the agricultural producer/landowner. The ownership and financial management structure of irrigation lagoons is similar across communities in Nebraska. Typically, the city pays for piping to the cropland, the center pivot (unless the agricultural producer owns one), center pivot maintenance, pumping, and soil and water monitoring. In some communities, agricultural producers paid for their own pumping electricity and center pivot maintenance. However, in general, the treated wastewater is essentially free water for the agricultural producer.

Cropland for the application of reused wastewater is generally obtained in one of three ways: 1) most commonly through a long-term agreement between a willing landowner and the city, 2) through a city purchase, or 3) very rarely through eminent domain. Long-term agreements are required by the NDEE funding agency. In these agreements, landowners and/or agricultural producers operate the pivot according to crop needs. In contrast, if the land is acquired by the city, then the city operates the system with the main objective being to keep from discharging to surface waters. Landowners are generally more hesitant to accept the water compared to the tenant agricultural producers. This is because agricultural producers generally accept that free water is a valuable commodity. In general,

Table 3: Common ownership structures of irrigation lagoons

Payment	City pays for:
	Piping to cropland
	Center pivot and maintenance (unless agricultural producer already owns one)
	Pumping electricity
	Soil and water monitoring
	Agricultural producer receives:
	Free water
Leasing or Acquiring Land	Long-term (duration of funding) lease of the property to the city
	Required by NDEE funding agency
	Landowner/agricultural producer operates pivot
	Landowner sells to city
	City operates pivot
	Eminent domain (rare)

agricultural producers are willing to irrigate with treated wastewater as long as it is economically beneficial. Funding opportunities may be available to communities interested in reuse. For example, the U.S. Department of Agriculture Rural Development provides funding to states and local government entities for the acquisition, construction, or improvement wastewater treatment systems, and the NDEE Clean Water State Revolving Fund provides funding to small communities for wastewater improvements, which can be combined with other federal and state funds.

Once the land is obtained, agreements related to system benefits between a landowner, city, and tenant agricultural producer, as applicable, are typically made, emphasizing the importance of building and maintaining trust within communities. Typically, long-term (duration of funding) lease agreements are made between the city and the landowner. Landowners and tenant agricultural producers oftentimes have a verbal and/or informal agreement. This is to avoid overpromising the unknown, such as nutrient benefits, water availability, and maintenance support. By creating informal/verbal agreements, landowners and tenant agricultural producers can realize the uncertainty and variability of these systems, so as to not create false hope. Table 3 summarizes the common ownership and financial management structures related to irrigation lagoons.

Issues Related to Agricultural Practices and Cropland

Agriculture practices and cropland can be affected by irrigation lagoon implementation. Agricultural producers have noticed that treated wastewater has little nutrient value due to effective wastewater treatment processes. Thus, similar crop yields can generally be observed between cropland irrigated with treated wastewater and cropland irrigated with traditional irrigation water sources. However, if the cropland was previously dryland/rainfed, then increased crop yields can be expected from applying the treated wastewater, although the increase in yield relies heavily on the climate dependent supply and demand of treated wastewater. It should be noted that other regions in the world may find yield benefits when applying treated wastewater to their cropland. For example, agricultural producers in Italy, Spain, Tunisia, and Brazil all experienced higher crop yields when irrigating with treated wastewater.

Another common agricultural concern is long-term sodium build up in soils, which may lead to additional costs incurred from having to neutralize cropland with chemicals. Some studies have found that there are generally no long-term salinity or nutrient related consequences due to the low amount of both in the treated wastewater used for irrigation, whereas others have found that wastewater irrigation can lead to long-term salinization. To avoid long term consequences of salinity, engineers should ensure that irrigation lagoons are sized properly to limit evaporation and maximize salt-free rainfall capture, as freshwater blending can reduce salinity. Additionally, agricultural producers should consider alternative irrigation methods such as cyclical irrigation or blending interventions. Cyclical irrigation methods use treated wastewater in conjunction with freshwater sources. Blending interventions could be done if multiple willing landowners rotated between receiving treated wastewater and using traditional water sources for irrigation. Alternative crop selections that are more resistant to salinity consequences may also be of interest to agricultural producers. Lastly, it is crucial that agricultural producers monitor and analyze the soils and crops to adequately manage any salt build up from wastewater irrigation. Further information about water quality criteria for irrigation is covered in the NebGuide Water Quality Criteria for Irrigation, EC782.

Cropland value is an important consideration for landowners and tenant agricultural producers. Agricultural producers generally consider cropland where treated wastewater is applied, although irrigated, to be less valuable compared to a system with surface or groundwater rights. This is because the agricultural producers do not have the ability to control their irrigation water usage or have a continuous source of water with only the treated wastewater supply. Thus, many agricultural producers choose to supplement their existing irrigation source with the treated wastewater to account for seasonable variabilities.

Irrigated cropland is known to be more valuable economically compared to dryland cropland. The state of Nebraska generally views cropland irrigated with treated wastewater as irrigated cropland for assessment purposes, which increases the value of the land. However, there may be an opportunity for lower assessment values for land-

Table 4: Agricultural impacts of irrigation lagoons

Agricultural Impacts	Crop yields
	Low nutrient values in treated wastewater
	Yield can increase if converting from dryland/rainfed to irrigated (with treated wastewater) cropland
	Larger treated wastewater supply results in larger yield increase
	Salinity
	Limited long-term consequences
	Proper lagoon sizing
	Maximize rainfall capture
	Limit evaporation
	Encourage freshwater mixing
	Cyclical irrigation practices
	Combine treated wastewater and freshwater sources
	Blended irrigation practices
	Multiple landowners rotate between receiving treated wastewater and using traditional water sources
	Alternative crop selection
	Monitor and analyze soils, crops, and water
	Free water for agricultural producers
Land Value	Non-continuous water supply
	Difficult to align supply and demand of treated wastewater with seasonal variability
	Supplemental freshwater resources are generally needed
	Higher economic value compared to dryland cropland
	Opportunity to explore assessment values
	Non-continuous water supply
	Potential to classify as non-irrigated cropland

owners converting from dryland to semi-irrigated land (i.e., land that is irrigated solely with treated wastewater), as this may not be considered a continuous water source because supplemental irrigation is not used. In addition, semi-irrigated land does not receive the same agronomic benefit as fully irrigated cropland due to not having the full agronomic application of water. This information may be useful to landowners and tenant agricultural producers who wish to explore their current assessment values. Table 4 summarizes the agricultural impacts of irrigation lagoons.

Summary

This NebGuide provides streamlined information for those curious about irrigation lagoons. Although irrigation lagoons are known to have vast benefits in terms of environmental, economic, and social impacts, it is oftentimes difficult to implement these systems due to limited agricultural producer and landowner cooperation. A better understanding of the reasoning behind implementation, barriers to implementation, ownership and financial structures, and agricultural impacts can help alleviate some concerns.

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