Treated Municipal Wastewater Irrigation Guidelines

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1. Introduction

1.1 General

The purpose of this guideline is to assist the owners of wastewater treatment works and consultants considering or practicing irrigation as a method of treated wastewater reuse. Where treated wastewater disposal alternatives such as discharge to a watercourse or by evaporation is not feasible, in some instances irrigation may be a viable option and offers an opportunity to conserve water sources. Since treated wastewater contains nutrients such as nitrogen and phosphorus, effluent irrigation may provide an alternative to irrigation areas where surface water has a limited capacity to assimilate the nutrients.

1.2 Treated Wastewater Irrigation Uses

The use of suitably-treated wastewater for food crops, non-food crops and golf course irrigation is considered an acceptable and sometimes desirable practice, provided the operation is designed and operated to avoid public health and other environmental problems and is agriculturally beneficial.

While providing recycling of our valuable water resource, treated wastewaters are an inexpensive water source, contain useful plant nutrients such as nitrogen and phosphorus, and normally will increase crop yields and promote good grass growth on golf courses.

Treated wastewater irrigation is generally considered for one or more of the following:

- to avoid wastewater discharge across privately-owned lands or into intermittent watercourses;
- as an alternative to nutrient or phosphorus removal, where required;
- as an alternative to exceptionally high treatment requirements; and
- to provide a water supply for food crops, non-food crops and golf course irrigation.

1.3 Permit Requirements

A permit to construct, extend or alter any treated wastewater irrigation works must be obtained from the Water Security Agency (WSA) before starting construction of such works. A permit to operate works must be obtained from the WSA prior to commissioning and operation. Applications for a permit to construct and/or operate a sewage works are required to be made on prescribed forms obtained from the WSA.

The following additional information will be required to supplement the application:

- legal description of the land to be irrigated, together with plans showing topography, watercourses, general soils classification, nearby wells, residences, and other buildings;
- representative chemical and physical descriptions of the soil, based on at least A, B, and C horizons. The number of sites will be dependent on the size of the area to be irrigated and the uniformity of the soils;
- data on water table locations, together with any available information on underlying aquifers;
- representative analyses of treated wastewater, including inorganic chemical, bacteriological, nitrogen, phosphorus and organic constituents;
- the proposed use of treated wastewater including intended crops, irrigation system description, irrigation procedure and any special management/operation considerations;
- a copy of the land control and/or irrigation agreement, if applicable; and
- contingency plans, including details about storage facilities or alternate methods when treated wastewater irrigation was not possible at certain instances.

In addition to the above, certain treated wastewater irrigation projects maywill require a hydrogeological investigation based on irrigated volumes and long-term effects on soil and groundwater. Furthermore, soil certification and an assessment of long-term soil and groundwater effects will be required. The water table in the irrigation area must be sufficiently deep to prevent water table rise to the root of the plants. Use of land for wastewater irrigation overlying shallow aquifers utilized for water supplies must be avoided.

Saskatchewan's review of wastewater effluent irrigation works focuses mainly on the quality of wastewater used for irrigation and protection of public health and environment. The WSA does not review the projects with regard to crop production and impacts to soil chemistry for agriculture. Project proponents are strongly advised to contact agrologists to determine the long-term sustainability of soil productivity for agricultural purposes. All of the treated wastewater irrigation projects shall be screened to determine if an Environmental Impact Study is required.

2. Design Guidelines

2.1 General

The following guidelines are based on currently available technology, information and experience. Exceptions to the guidelines will be reviewed on the basis of special circumstances and supporting technical documentation.

2.2 Wastewater Treatment

If effluent irrigation is considered by the owners of wastewater treatment works as a method of treated wastewater reuse, the minimum treatment requirement as per Guidelines for Sewage Works Design (EPB 503) shall be as follows:

- Lagoons followed by a storage cell of holding at least 210-230 days of sewage flow.
- Secondary treatment with adequate storage facilities.

Disinfection may be required prior to irrigation based on the type of reuse. Pump suctions or other irrigation intake works in the storage cells should be located as far as possible from the influent line to prevent short circuiting of the effluent.

2.3 Soils and Topography

The chemical, physical and morphological characteristics of a soil must be compatible to irrigation with a particular wastewater. It is important to minimize soil degradation to ensure that lands irrigated with treated wastewater benefit from irrigation and will retain productivity. The soil should not receive harmful quantities of undesirable elements and substances.

The physical properties of soil texture and structure are important features when evaluating the use of treated wastewater for irrigation. Careful consideration should be given to permeability, since the suitability of soil for irrigation depends on the ability to conduct air and water. Permeability problems usually occur in top surface of the soil and are mainly related to a relatively high sodium or low calcium content in this zone. Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) should be used to evaluate the potential permeability problem.

The topography should be suitable, not only for the irrigation procedure, but also to minimize runoff from the irrigation site.

2.4 Siting

The following buffer zones shall be observed for systems with effluent treated to secondary quality as described in Guidelines for Sewage Works Design:

- a buffer zone of 30 metres shall be maintained between irrigated land and adjacent properties unless written permission is obtained from adjacent property owner(s) to lessen this distance.
- a buffer zone of 60 metres shall be provided between irrigated land and seasonal/drainage courses, major public roads and railway lines.
- a buffer zone of 100 metres shall be provided between irrigated lands and either a lake, stream, river, dugouts, water course, water well, and water reservoir and isolated human habitation.
- a buffer zone of 300 metres shall be provided between irrigated land and occupied dwellings and water wells. built-up habitated areas.

Buffer zones may be adjusted based on permit conditions such as disinfection and easements. A buffer zone is the distance between the irrigation design wetted perimeter and a landscape feature such as a property line or highway or lake. The irrigation design wetted perimeter is based on irrigation with no wind. Applicable buffer distances required by road, highway, railway and other authorities must be considered. The WSA recommends that appropriate signage be used at the wastewater effluent irrigation site to protect the public health and environment.

2.5 Land Control

Ownership of lands to be irrigated should be obtained in the case of all new effluent irrigation projects to be constructed after April 1, 2004. It is highly recommended that that the owners of wastewater systems employing effluent irrigation in operation or beyond a pre-design stage as of April 1, 2004 seek ownership of any lands to be irrigated. In the case of existing effluent irrigation works where land ownership cannot be obtained, an easement agreement between the proponent of the wastewater facility and landowners with a minimum term of 10 years is the preferred. Provision should be made in the agreement for general liability, liability for any future soil related problems, operating procedures/restrictions, monitoring and other responsibilities as deemed appropriate by the circumstances of the project.

2.6 Irrigation Water Quality Criteria

The quality of treated wastewater is of prime importance in successful implementation of municipal wastewater irrigation projects. This in turn depends upon the quality of finished water supply, the nature of the wastes added during water use, and the degree of treatment the wastewater received.

The constituents that can degrade water quality for irrigation include salts, nutrients and contaminants. Four categories of potential irrigation problems associated with water quality are: 1) salinity, 2) infiltration/permeability, 3) specific ion toxicity, and 4) miscellaneous problems.

The owners of wastewater treatment works in the province who consider/practice effluent irrigation as a method of treated wastewater reuse must consider evaluation of following parameters:

Electrical Conductivity (EC) – is the most important parameter in determining the suitability of water for irrigation use. Irrigation using treated municipal wastewater adds salt concentration to the soils and a problem occurs if added salt accumulates to a concentration that is harmful to the crop or landscape. Salinity of treated municipal wastewater that is used for irrigation is determined by EC, which is used as a surrogate measure of Total Dissolved Solids (TDS) concentration in water. Due to osmotic effects, the salt concentration interferes with extraction of water by the plants thereby affecting the plant growth. The electrical conductivity for water is expressed as mmho/cm or decisiemens per meter (dS/m) (1 mmho/cm = 1 dS/m). Salt concentration is also reported as TDS in mg/L. Table 1 shows the guideline for EC and TDS values in waters used for irrigation.

Sodium Adsorption Ratio (SAR) – is a calculated value and an indicator of sodium hazard of water. High concentrations of sodium in soils affect its physical condition and soil structure resulting in formation of crusts, water-logging, reduced soil aeration, reduced infiltration rate, and reduced soil permeability; excessive concentrations of sodium in soils may also be toxic to certain types of crops. SAR is calculated from the following equation:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$ where Na, Ca and Mg are in meq/L

and

$$SAR = \frac{Na}{\sqrt{Ca + Mg}}$$ where Na, Ca, and Mg are in mmoles/L.

The guideline for SAR values in waters for irrigation use is shown in Table 1.

Table 1. Irrigation Water Quality Guideline[1]

Parameter restricting use	None	Slight to moderate	Severe
EC	<0.7	0.7 - 3	>3
TDS	<450	450-2000	>2000
SAR	<3	3 - 9	>9

[1] Source: Westcot and Ayers (1985)

Boron - Toxicity due to specific ions such as boron occurs when the ion is taken up by the plant and accumulates in the plant in amounts that result in damage or reduced yields. Discharges from industrial plants and household detergents are the common source for boron in wastewater; other ions of most concern in wastewater are sodium and chloride. Acceptable levels of boron and chloride are listed in WSA's document on Surface Water Quality Objectives (MB 110, 1997) under Table 4.5.

Other Parameters – Parameters such as Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Phosphorus (Total P), and Total Nitrogen (Total N) are to be analyzed to determine the quality of wastewater prior to irrigation use and the values should meet the guideline specified in Table 4.1 of 'Guidelines for Sewage Works Design' (EPB 203).

Trace elements from wastewater include arsenic, cadmium, chromium, cobalt, nickel, lead, selenium, etc. With repeated applications of wastewater effluent for irrigation use, trace elements tend to accumulate in the soil surface and become part of the soil matrix. They could also accumulate in crops to a level that is detrimental to the health of humans, domestic animals, and wildlife that consume the crops. The levels of trace elements in wastewater for effluent irrigation use are prescribed in Table 4.5 of 'Surface Water Quality Objectives' (MB 110, 1997) and the values described in the Canadian Environmental Quality Guidelines for Irrigation Water (CCME, 1999)[3]. The most stringent of these values will be applied.

The principal microorganisms in wastewater that are of concern for their effects on human health are bacteria, viruses, and parasites. The health concern is in proportion to the degree of human contact with the water, the quality of treated wastewater, and the reliability of the treatment processes. Wastewater effluent irrigation can potentially transport microorganisms to groundwater. Properly operated state-of-the-art municipal wastewater treatment plants can reduce microbial concentrations by many orders of magnitude. Bacteria that are used as indicators of wastewater contamination (fecal coliform) have been found in soil water at a depth of 1.37 meters below fields irrigated with treated but undisinfected wastewater effluent[2]. Standards and guidelines for water use for irrigation are primarily aimed at protecting the public health and based on control of microorganisms present in wastewater.

The microbial quality of treated municipal wastewater that is used for irrigation in Saskatchewan shall meet the requirements specified in Table 2 or as shown in permits.

2.7 Monitoring

- Groundwater and soil monitoring will be required for wastewater irrigation projects the extent of which will depend upon size and groundwater resources.
- Based on type of reuse, fecal coliform level in treated wastewater shall be monitored as per Table 2.
- EC and SAR of treated wastewater for irrigation use to be determined annually, and monitoring of chemical parameters required once every two years including sodium, boron, copper, calcium, magnesium, iron, manganese and chloride.
- Soil samples should be collected and analyzed for salts,and nutrients and trace elements at least once every two years and for trace elements at least once every four years.
- Records related to crops grown, yield, irrigation volumes and periods, and wastewater application rates shall be maintained and be available to the department on request.

- Monitoring wells will be required depending on the results of soil and water hydrogeological investigations. Installation and sampling of monitoring wells shall be performed in accordance with 'Protocols for the Installation and Sampling of Monitor Wells' (WQ 117, 1989) and 'Guidelines for Groundwater Monitor Wells at Wastewater Disposal Sites' (WQ 100, 1987) that are currently in use and as revised from time to time.

2.8 Sustainability Report

Provide a sustainability report to the department every eight years or as stipulated in the Permit to Operate. The report will include presentation and assessment of monitoring results for the last eight years, a review of crop records and soil and water monitoring results to determine agricultural sustainability of the works, presentation of any complaints received by the owner and presentation of any known off-site impacts. Effluent irrigation systems determined not to be agriculturally sustainable or displaying off-site impacts may have Permit to Operate conditions altered by the WSA.

Table 2. Guideline for Microbial Quality of Treated Municipal Wastewater for Irrigation

Irrigation water – type of reuse	Irrigation Water Quality and Treatment requirements	Monitoring requirements	Other
Agricultural reuse - Non-Food crops	*Fodder, fiber, seed crops, and sod farm:* • Treatment requirements as per section 2.2 • Fecal coliform or *E. coli* < 1000/100 mL *Pasture for milking animals:* • Treatment requirements as per section 2.2 • Disinfection required • Fecal coliform or *E. coli* 23/100 mL (median)	*Fodder, fiber, seed crops and sod farm:* • Fecal coliform or *E. coli* - 1/month *Pasture for milking animals:* • Fecal coliform or *E. coli* - ½ weeks	• Grazing period – Dairy cattle – at least 30 days after last irrigation • Grazing period – other Livestock – at least 7 days after last irrigation
Agricultural reuse - Food crops	• Treatment requirements as per section 2.2 • Disinfection required • Fecal coliform or *E. coli* 2.2/100 mL (median) • Fecal coliform or *E. coli* 23/100 mL (single sample)	• Fecal coliform or *E. coli* - 1/week	• Irrigation water use is not allowed for root crops or crops where edible portion contacts ground • Irrigation water use is not allowed for crops that may be eaten raw.
Golf course	• Treatment requirements as per section 2.2 • Disinfection required • Fecal coliform or *E. coli* 200/100 mL (median) • Fecal coliform or *E. coli* 400/100 mL (2 consecutive samples)	• Fecal coliform or *E. coli* - 1/month	

References

1. Westcot, D.W., and Ayers, R.S. (1985). "Irrigation water quality criteria." in "*Irrigation with reclaimed municipal wastewater – A guidance manual*", (Ed. G.S. Pettygrove, and T. Asano), Lewis Pulishers, Inc., Chelsea.
2. National Research Council (NRC). (1996). "Use of reclaimed water and sludge in food crop production." National Academy Press, Washington, DC.
3. Canadian Council of Ministers of the Environment (CCME), (1999). "Canadian Environmental Quality Guidelines for Irrigation Water." CCME Documents, Winnipeg, MB.