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Guidelines for treated wastewater use for irrigation projects —

Part 1: The basis of a reuse project for irrigation

Lignes directrices pour l'utilisation des eaux usées traitées dans les projets d'irrigation —
Partie 1: Les bases d'un projet de réutilisation pour l'irrigation

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 282 *Water reuse*, Subcommittee SC 01, *Treated wastewater use for irrigation*.

This second edition cancels and replaces the first edition (ISO 16075-1:2015), which has been technically revised. The main changes compared to the previous edition are as follows:

— updating the subject of public and private gardens irrigation by treated wastewater (TWW);

— added Annex A (New)- Examples of means to improve TWW quality.

A list of all parts in the ISO 16075 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The increasing water scarcity and water pollution control efforts in many countries have made treated municipal and industrial wastewater a suitable option for augmenting the existing water supply, especially when compared to alternatives such as desalination or the development of new water sources involving dams and reservoirs. Water reuse makes it possible to close the water cycle at a point closer to cities by producing "new water" from municipal wastewater and reducing wastewater discharge to the environment.

Treated wastewater (TWW) (also referred to as reclaimed water or recycled water) can be used for various non-potable purposes. The dominant applications for the use of treated wastewater include agricultural irrigation, landscape irrigation, industrial reuse, and groundwater recharge. More recent and rapidly growing applications are for various urban uses, recreational and environmental uses, and indirect and direct potable reuse.

An important new concept in water reuse is the "fit-for-purpose" approach, which entails the production of reclaimed water quality that meets the needs of the intended end-users. In the situation of reclaimed water for irrigation, the reclaimed water quality can induce an adaptation to the type of plant grown. Thus, the intended water reuse applications are to govern the degree of wastewater treatment required and, inversely, the reliability of water reclamation processes and operation.

Agricultural irrigation was, is, and will likely remain the largest reused water consumer with recognized benefits and contribution to food security. Urban water recycling, landscape irrigation in particular, is characterized by fast development and will play a crucial role for the sustainability of cities in the future, including energy footprint reduction, human well-being, and environmental restoration.

The suitability of treated wastewater for a given type of reuse depends on the compatibility between the wastewater availability (volume) and water irrigation demand throughout the year, as well as on the water quality and the specific use requirements. Water reuse for irrigation can convey some risks for health and environment, depending on the water quality, the irrigation water application method, the soil characteristics, the climate conditions, and the agronomic practices. Consequently, the public health and potential agronomic and environmental adverse impacts are to be considered as priority elements in the successful development of water reuse projects for irrigation. To prevent such potential adverse impacts, the development and application of guidelines for the use of treated wastewater is essential.

The main water quality factors that determine the suitability of treated wastewater for irrigation are pathogen content, salinity, sodicity, specific ion toxicity, concentration of heavy metals, other chemical elements and nutrients. Local health authorities are responsible for establishing water quality threshold values depending on authorized uses and they are also responsible for defining practices to ensure health and environmental protection taking into account local specificities.

From an agronomic point of view, the main limitation in using treated wastewater for irrigation arises from its quality. Treated wastewater, unlike water supplied for domestic and industrial purposes, contains higher concentrations of inorganic suspended and dissolved materials (total soluble salts, sodium, chloride, boron, heavy metals), which can damage the soil and the irrigated crops. Dissolved salts are not removed by conventional wastewater treatment technologies and appropriate good management, agronomic and irrigation practices are intended to be used to avoid or minimize potential negative impacts.

The presence of nutrients (nitrogen, phosphorus, and potassium) can become an advantage due to possible saving in fertilizers. However, the amount of nutrients provided by treated wastewater along the irrigation period is not necessarily synchronized with crop requirements and the availability of nutrients depends on the chemical forms.

This guideline provides guidance for healthy, hydrological, environmental and good operation, monitoring, and maintenance of water reuse projects for unrestricted and restricted irrigation of agricultural crops, gardens, and landscape areas using treated wastewater. The quality of supplied treated wastewater has to reflect the possible uses according to crop sensitivity (health-wise and

agronomy-wise), water sources (the hydrologic sensitivity of the project area), the soil, and climate conditions.

This guideline refers to factors involved in water reuse projects for irrigation regardless of size, location, and complexity. It is applicable to intended uses of treated wastewater in a given project, even if such uses will change during the project's lifetime; as a result of changes in the project itself or in the applicable legislation.

The key factors in assuring the health, environmental and safety of water reuse projects in irrigation are the following:

— adequate monitoring of TWW quality to ensure the system functions as planned and designed;

— design and maintenance instructions of the irrigation systems to ensure their proper long-term operation;

— compatibility between the TWW quality, the distribution method, and the intended soil and crops to ensure a viable use of the soil and undamaged crop growth;

— compatibility between the TWW quality and its use to prevent or minimize possible contamination of groundwater or surface water sources.

This document is not intended to prevent the creation of more specific standards or guides which are better adapted to specific regions, countries, areas, or organizations. If such documents are published, it is recommended to reference this document to ensure uniformity throughout the treated wastewater use community.

Guidelines for treated wastewater use for irrigation projects —

Part 1:
The basis of a reuse project for irrigation

1 Scope

This document contains guidelines for the development and the execution of projects intending to use treated wastewater (TWW) for irrigation and considers the parameters of climate and soil.

The purpose of this document is to provide guidance on all elements of a project using TWW for unrestricted and restricted irrigation, including design, materials, construction, and performance, when used for the following:

— irrigation of agricultural crops;

— irrigation of public and private gardens and landscape areas, including parks, sport fields, golf courses, cemeteries, etc.

These guidelines are intended to provide assistance for the benefit of users of TWW for irrigation. The guidelines relate to the widespread and common ranges of water quality rather than exceptional or unique ones and are intended for the use of professionals, such as irrigation companies (designers and operators), agricultural extension officers or advisors, water companies (designers and operators), local authorities and water utilities. The use of these guidelines by users might require additional specifications.

None of the parts of this document are intended to be used for certification purposes.

These guidelines suggest the parameters of TWW quality. These parameters include the following:

— agronomic parameters: nutrients (nitrogen, phosphorus and potassium), salinity factors (total salt content, chloride, boron, and sodium concentration) and heavy metals' concentration;

— pathogen presence.

Each of these parameters can have possible impacts on the crops, soil, and public health. The guidelines discuss the possibility of preventing the contaminants' addition during wastewater production and the ability to remove them during the course of treatment.

Contaminants of emerging concern (such as pharmaceuticals and personal care product residuals) are outside the scope of this document since up to day, there is no evidence of adverse effects on human health or environment via irrigation with TWW or via the consumption of crops irrigated with TWW.

The project should be designed in accordance with the sanitary quality of the TWW in order to avoid disease transmission by the pathogens in the water.

The use of these guidelines is encouraged to ensure consistency within any organization engaged in the use of treated wastewater.

These guidelines provide the basis for a healthy, hydrological, environmental and agronomic conscious design, operation, monitoring, and maintenance of an irrigation system using treated wastewater.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20670:2018, *Water reuse — Vocabulary*

3 Terms, definitions, and abbreviated terms

For the purposes of this document, the following terms and definitions given in ISO 20670 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Term and definitions

3.1.1
additional disinfection
disinfection of TWW in a water reuse project intended to raise the quality of the TWW just before irrigation in addition or not to previous disinfection in WWTP and/or a *reservoir* (3.1.26)

Note 1 to entry: See ISO 20670:2018, 3.21 for the definition of "disinfection".

Note 2 to entry: See ISO 20670:2018, 3.84 for the definition of "water reuse".

3.1.2
boom sprinkler
mobile sprinkling machine (3.1.17) composed of two symmetrical pipes (booms) with *sprinkler* (3.1.37) nozzles distributed in one of the pipes where the sprinkler action is complemented by a gun sprinkler placed at each end of both pipes

Note 1 to entry: The nozzles work through a reaction effect (similar to a hydraulic tourniquet) which drives the boom rotation at a desired speed.

3.1.3
category A: very high quality TWW
raw wastewater (3.1.25) which has undergone physical and biological treatment, filtration and disinfection and it average quality is: BOD: ≤5 mg/l (Max. 10 mg/l); TSS: ≤5 mg/l (Max. 10 mg/l); Turbidity: ≤3 NTU (Max. 6 NTU); Termo-tolerant coliforms (95 %ile): ≤10 no./100 ml (Max. 100 no./100 ml)

Note 1 to entry: See ISO 20670:2018, 3.27 for the definition of "filtration".

Note 2 to entry: See ISO 20670:2018, 3.21 for the definition of "disinfection".

Note 3 to entry: See ISO 16075-2 Table 1 for more TWW quality information values.

3.1.4
category B: high quality TWW
raw wastewater (3.1.25) which has undergone physical and biological treatment, filtration and disinfection, and it's average quality is: BOD: ≤10 mg/l (Max. 20 mg/l); TSS: ≤10 mg/l (Max. 25 mg/l); Termo-tolerant coliforms (95 %ile): ≤200 no./100 ml (Max. 1 000 no./100 ml)

Note 1 to entry: See ISO 20670:2018, 3.27 for the definition of "filtration".

Note 2 to entry: See ISO 20670:2018, 3.21 for the definition of "disinfection".

Note 3 to entry: See ISO 16075-2 Table 1 for more TWW quality information values.

3.1.5
category C: good quality TWW
raw wastewater (3.1.25) which has undergone physical and biological treatment and it average quality is: BOD: ≤20 mg/l (Max. 35 mg/l); TSS: ≤30 mg/l (Max. 50 mg/l); Termo-tolerant coliforms (95 %ile): ≤1 000 no./100 ml (Max. 10 000 no./100 ml); Intestinal Nematodes ≤1 Egg/l

Note 1 to entry: See ISO 16075-2 Table 1 for more TWW quality information values.

3.1.6
category D: medium quality TWW
raw wastewater (3.1.25) which has undergone physical and biological treatment and it average quality is: BOD: ≤60 mg/l (Max. 100 mg/l); TSS: ≤90 mg/l (Max. 140 mg/l); Intestinal Nematodes ≤1 Egg/l (Max. 5 Egg/l)

Note 1 to entry: See ISO 16075-2 Table 1 for more TWW quality information values.

3.1.7
category E: extensively TWW
raw wastewater (3.1.25) which has undergone natural biological treatment process with long (minimum 10 d to 15 d) retention time and its average quality is: BOD: ≤20 mg/l (Max. 35 mg/l); Intestinal Nematodes ≤1 Egg/l (Max. 5 Egg/l)

Note 1 to entry: See ISO 16075-2 Table 1 for more TWW quality information values.

3.1.8
center-pivot and moving lateral irrigation machine
automated irrigation machine consisting of a number of self-propelled towers supporting a pipeline rotating around a pivot point and through which water supplied at the pivot point flows radially outward for distribution by sprayers or *sprinklers* (3.1.37) located along the pipeline

3.1.9
emitter
emitting pipe
dripper
device fitted to an irrigation lateral and intended to discharge water in the form of drops or continuous flow at flow rates not exceeding 15 l/h except during flushing

3.1.10
environmental parameter
quantifiable attribute of an environmental aspect

Note 1 to entry: See ISO 20670:2018, 3.24 for the definition of "environmental aspect".

3.1.11
gravity flow irrigation system
irrigation system where water is applied directly to the *soil* (3.1.32) surface and is not under pressure

Note 1 to entry: See ISO 20670:2018, 3.43 for the definition of "irrigation system".

3.1.12
in-line emitter
emitter (3.1.9) intended for installation between two lengths of pipe in an irrigation lateral

3.1.13
irrigation gun
large discharge device being either a part circle or full circle *sprinkler* (3.1.37)

3.1.14
irrigation sprayer
device which discharges water in the form of fine jets or in a fan shape without rotational movement of its parts

3.1.15
micro-irrigation system
system capable of delivering water drops, tiny-streams, or mini spray to the plants

Note 1 to entry: Surface and sub-surface drip irrigation and *micro-spray irrigation* (3.1.16) are the main types of this system.

3.1.16
micro-spray irrigation system
system characterized by water point sources similar to *sprinkler* (3.1.37) miniatures (micro-sprinklers), which are placed along the laterals, with a flow rate between 30 l/h and 150 l/h at pressure heads of 15 m to 25 m and the corresponding wetted area between 2 m and 6 m

3.1.17
mobile sprinkling machine
sprinkling unit which is automatically moved across the *soil* (3.1.32) surface during the water application

3.1.18
on-line emitter
emitter (3.1.9) intended for installation in the wall of an irrigation lateral, either directly or indirectly by means such as tubing

3.1.19
perforated pipe system
emitting pipe *(emitter)* (3.1.9) continuous pipe, hose or tubing, including collapsible hose, with perforations, intended to discharge water in the form of drops or continuous flow at emission rates not exceeding 15 l/h for each emitting unit

3.1.20
permanent system
stationary fixed-grid irrigation system (*sprinklers* (3.1.37)) for which sprinkler set positions are rigidly fixed by semi-permanent or permanently installed irrigation laterals

EXAMPLE Portable solid-set irrigation system, buried irrigation system.

3.1.21
portable system
system for which all or part of the elements can be moved

3.1.22
pressurized irrigation system
piped network system under pressure

3.1.23
process
set of interrelated or interacting activities which transform inputs into outputs

Note 1 to entry: Inputs to a process are generally outputs of other processes.

Note 2 to entry: Processes in an organization are generally planned and carried out under controlled conditions to add value.

3.1.24
product
any goods or services

Note 1 to entry: This includes interconnected and/or interrelated goods or services.

3.1.25
raw wastewater
wastewater which has not undergone any treatment

Note 1 to entry: See ISO 20670:2018, 3.80 for the definition of "wastewater".

3.1.26
reservoir
system to store temporarily unused TWW depending on the balance between demand for water irrigation and the treatment plant discharge

Note 1 to entry: The following are different types of reservoirs that can be used to store temporarily unused TWW:

a) open reservoirs which are commonly used for short-term *storage* (3.1.39) with hydraulic residence times from one day to two weeks;

b) closed reservoirs for short-term storage to limit bacterial regrowth and external contamination common with hydraulic residence time of 0,5 day to a week;

c) surface reservoirs for long-term or seasonal storage of TWW, to accumulate water during periods of time when the treatment plant discharge is higher than irrigation demand and to satisfy irrigation requirements when the demand is higher than the treatment plant discharge. The hydraulic residence time changes according to seasons and specific needs;

d) aquifer storage and recovery for long-term storage which is commonly combined with *soil* (3.1.32) aquifer treatment (by means of infiltration basins). The residence time is also a variable that is affected by the TWW discharge and irrigation demand. This aquifer storage should not contribute to the aquifer recharge for potential potable water use.

3.1.27
rotating sprinkler
device which distributes water over a circular area or part of a circular area by its rotating motion around its vertical axis

3.1.28
self-moved system
unit where a lateral is mounted through the centre of a series of wheels and is moved as a whole

Note 1 to entry: *Rotating sprinklers* (3.1.27) sprayers are placed on the lateral (also called wheel move).

3.1.29
self-propelled gun traveller
gun *sprinkler* (3.1.37) on a cart or sled attached to the end of flexible pipe/hose

3.1.30
semi-permanent system
system similar to the *semi-portable system* (3.1.31) but with portable laterals and permanent pumping plant, main lines, and sub-mains

3.1.31
semi-portable system
system similar to the *portable system* (3.1.21) except that the water source and the pumping plant are fixed

3.1.32
soil
layer of unconsolidated material consisting of weathered material particles, dead and living organic matter, air space, and *soil solution* (3.1.33)

3.1.33
soil solution
liquid phase of the *soil* (3.1.32) and its solutes

3.1.34
solid-set system
temporary fixed network where the laterals are positioned in the field throughout the irrigation season

3.1.35
stationary sprinkler system
network of fixed *sprinkler* (3.1.37)

3.1.36
spray
release of water from *sprinkler* (3.1.37)

3.1.37
sprinkler
water distribution device of a variety of sizes and types, for example, impact sprinkler, fixed nozzle, sprayer, *irrigation gun* (3.1.13)

3.1.38
sprinkler irrigation system
irrigation system composed of *sprinklers* (3.1.37)

Note 1 to entry: See ISO 20670:2018, 3.43 for the definition of "irrigation system".

3.1.39
storage
retained temporary unused TWW for short or long term before its release for use in irrigation system

Note 1 to entry: See ISO 20670:2018, 3.43 for the definition of "irrigation system".

3.1.40
travelling irrigation machine
irrigation machine designed to irrigate a field sequentially, strip by strip, while moving across the field

3.2 Abbreviated terms

BOD	biochemical oxygen demand
COD	chemical oxygen demand
EC	electrical conductivity
ESP	exchangeable sodium percentage
FDS	fixed dissolved solids (mg/l)
LF	leaching fraction
LR	leaching requirement
NPW	non-potable water

NTU	nephelometric turbidity units
PET	potential evapotranspiration estimated by the Penman-method
SAR	sodium adsorption ratio
TDS	total dissolved solids
TWW	treated wastewater
UV	ultraviolet
WW	wastewater
WWTP	wastewater treatment plant

4 Improving the quality and the use of TWW

4.1 General

The chemical quality of wastewater depends on the chemical quality of the background water. Background water used at home, in the office, in commerce, and in industry is received from different sources (groundwater, rivers, lakes, and desalination of seawater or brackish water). Water soluble chemicals, which are often added to the background water during its use, are not removed by the conventional wastewater treatment.

To avoid adverse effect of TWW dissolved salts, quality on irrigated crops and soil, different strategies listed in 4.2 and 4.3 may be implemented (See Annex A, Table A.1).

4.2 Improving the quality of TWW for irrigation

TWW quality may be improved using the following methods:

a) supplying a higher quality of water (lower salt concentration) or desalinated water to municipal use;

b) reducing salt additions by treating diffuse sources such as salt-water intrusion in sewers, domestic additions through laundry detergents or dishwasher salts, and/or from point sources such as industrial factories using large volumes of water and emitting large quantities of salt from their manufacturing processes.

4.3 Applying good agronomic and irrigation practices

Good agronomic and irrigation practices may be applied with the following:

a) crop selection and management;

b) leaching and drainage;

c) management of soil structure;

d) adjusting fertilizer application or amendment;

e) adjusting the timing of water application and selecting appropriate irrigation technique.

Where desalinated water is a relevant background water source, attention should be given to the boron concentration in the desalinated water if special processes to remove it during desalination cannot be carried out. Attention should be given to the addition of calcium and magnesium in the post treatment step. In any case, the irrigated crops should be species adapted to the quantity and concentration of dissolved salts in the TWW.