INTERNATIONAL STANDARD

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Second edition

Guidelines for treated wastewater use for irrigation projects —

Part 4: Monitoring

Lignes directrices pour l'utilisation des eaux usées traitées en irrigation —

Partie 4: Surveillance

PROOF/ÉPREUVE

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 1, *Treated wastewater reuse for irrigation*.

This second edition cancels and replaces the first edition (ISO 16075-4:2016), which has been technically revised.

The main changes compared to the previous edition are as follows:

— xxx xxxxxxx xxx xxxx;

— xxx xxxxxxx xxx xxxx;

— xxx xxxxxxx xxx xxxx.

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 economic means of augmenting the existing water supply, especially when compared to expensive 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. The reuse of treated wastewater could be also a beneficial solution to improve water body’s quality, such as for example avoiding wastewater treatment plants discharge upstream sensitive areas (shellfish aquaculture area, swimming area).

An important new concept in water reuse is the “fit-to-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 of the type of plant grown. Thus, the intended water reuse applications should govern the degree of wastewater treatment required, and inversely, the reliability of wastewater reclamation processes and operation.

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 TWW 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.

Agricultural irrigation was, is and will likely remain the largest TWW consumer with recognized benefits and contribution to food security. Urban water recycling, in particular landscape irrigation, 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 TWW 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, public health and potential agronomic and environmental adverse impacts need 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 international guidelines for the reuse of TWW is essential.

The main water quality factors that determine the suitability of TWW for irrigation are pathogen content, salinity, sodicity, specific ion toxicity, 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 in account local specificities.

From an agronomic point of view, the main limitation in using TWW 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 irrigated crops. As dissolved salts are not removed by conventional wastewater treatment technologies and appropriate good management, agronomic and irrigation practices should 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 TWW along the irrigation period is not necessarily synchronized with crop requirements, and the availability of nutrients depends on the chemical forms.

This document 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

TWW should 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 document refers to factors involved in water reuse projects for irrigation regardless of size, location and complexity. It is applicable to intended uses of TWW 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:

— 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 4: Monitoring

1 Scope

This document provides recommendations regarding:

— monitoring the quality of treated wastewater (TWW) for irrigation;

— monitoring irrigated plants;

— monitoring the soil with regard to salinity;

— monitoring natural water sources in neighbouring environments;

— monitoring the quality of water in storage reservoirs.

It puts emphasis on sampling methods and their frequency. Regarding the methods of analysis, this document refers to standard methods or, where not available, to other bibliographical references.

NOTE In cases where a monitoring plan already exists, these recommendations can be integrated into this plan. This is notably the case when a broader approach of risk management is implemented, such as the water safety plans (serving as a model for sanitation safety plans) developed by WHO[16].

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, *Water reuse — Vocabulary*

ISO 16075-1, *Guidelines for treated wastewater use for irrigation projects — Part 1: The basis of a reuse project for irrigation*

3 Terms definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20670 and ISO 16075-1 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/

3.2 Abbreviated terms

BOD	biochemical oxygen demand
CFU	colony forming units
COD	chemical oxygen demand
DO	dissolved oxygen
HDPE	high-density polyethylene
PP	polypropylene
QA	quality assurance
QC	quality control
SAR	sodium adsorption ratio
SS	suspended solids
TKN	total Kjeldahl nitrogen
TP	total phosphorus
TSS	total suspended solids
TWW	treated wastewater
VOC	volatile organic compounds
WW	wastewater
WWTP	wastewater treatment plant

4 Monitoring of the quality of TWW for irrigation

4.1 General

The development and implementation of an appropriate monitoring strategy is a crucial step for the health and environmental safety of water reuse projects. This compliance monitoring is performed usually at the outlet of the wastewater treatment plant.

Monitoring can be undertaken for a range of purposes, and for each specific objective, different parameters may be selected. For example, water quality monitoring can be implemented for the following purposes:

a) human health protection: monitoring programmes include selected microbial indicators at concentrations that depend on health risk (risk of direct contact, risk related to the type of crops, etc.), as well as few other parameters, which indicate the reliability of operation of the wastewater treatment (e.g. turbidity, suspended solids, BOD, residual chlorine, etc.);

b) prevention of adverse effect on crops: monitored parameters (named also agronomic parameters) include nutrients, soluble salts, sodium, trace elements, etc.);

c) prevention of adverse effects on environment (natural water sources and soil);

d) prevention of clogging of irrigation system, e.g. drip and sprinkler irrigation.

The selection of sampling points to control water quality and treatment performance, named “performance control points”, should depend on the type of application and the level of health and environmental risks.

The key water quality control point should be located at the outlet of the wastewater reclamation plant. Sampling at the plant outlet should follow ISO 5667-4.[2] Treated wastewater should be monitored either through grab sampling or composite sampling (see below), depending on the monitored parameters.

Composite samples (as a rule for 24 h using refrigerated equipment) are very important for relevant monitoring of physico-chemical parameters as they represent the average quality of TWW. Microbiological parameters, dissolved oxygen, pH and temperature should be monitored in grab samples in situ, if possible during diurnal peak flow.

Similarly, the sampling frequency of other parameters related to prevention of adverse effects on crops, soils and environment should be adapted to risk associated with sensitive crops and/or sensitive environment (e.g. shallow aquifers used for potable water supply), and/or specific irrigation equipment. The decision about the sampling (composite or grab) for these parameters should also take into account the daily variations in raw wastewater.

4.2 Sampling procedure

4.2.1 General

Depending on the type of the monitored parameters, there exist some basic sampling rules described in standard methods and International Standards for water analysis or some specific analytical procedures defined by certified laboratories.

Sampling of TWW for irrigation should follow the list below:

— The sampling should be done by skilled employee.

— The type of samples can be either grab or composite samples to be used for water quality monitoring depending on the final objectives,

— All samples should be well labelled, indicating the type of water, site location, date, time and other pertinent data,

— Sampling frequency should be defined by water reuse granted permit,

— For better planning and management of the irrigation scheme, seasonal samples should be taken depending on seasons in the concerned region, in order to obtain representative data on the variation in water quality, in particular nitrogen and salinity,

— The baseline monitoring for human health protection should be undertaken by sampling at the outlet of the treatment facility (see ISO 16075-2:2020, Table 1 [1]).

To check the reliability of operation of treatment processes, additional sampling points may be added when necessary, particularly in the case of non-compliance.

— For verification of potential contamination or regrowth in storage reservoirs and/or distribution network, additional control points for sampling can be established as a function of the final use, site location and irrigation method, to verify potential contamination or regrowth in storage reservoirs and/or in the distribution network.

— Bottle type should be determined according to the parameters tested. It should be taken into account that some types of glass bottles yield boron to the samples and to prevent it high-density polyethylene (HDPE) or polypropylene (PP) bottles with double caps or self-sealing caps may be used.

  As the sample quantity depends on the type of analysis to be performed, for the analysis of the basic water characteristics and the main anions and cations, 1 l of sample can be sufficient.

— Sampling and handling should be done safely with suitable precaution to avoid disease transmission by means of plastic gloves or using other protection.

Quality control samples should be collected as part of any routine sampling programme. Sampling and handling of raw wastewater and treated wastewater should follow Table 1.

Table 1 — Recommendations for sample preparation and conservation

Parameter	Type of bottle	Addition of chemicals	Conservation	Comments
Anions and cations (chloride, sulfate), as well as general physico-chemical parameters (pH, suspended solids, conductivity, turbidity)	1 l HDPE or PP bottles with double caps or self-sealing caps, with or without air	No additive	Dark, 4 °C	Temperature, pH and dissolved oxygen should be measured on site.
Phosphorus and N Kjeldahl	1 l HDPE or PP bottles with double caps or self-sealing caps, with or without air	H_2SO_4 to pH = 2	Dark, 4 °C	
Boron	100 ml HDPE or PP bottles with double caps or self-sealing caps	HNO_3 to pH = 2	Dark, 4 °C	
COD	100 ml HDPE or PP bottles with double caps or self-sealing caps, no air	H_2SO_4 to pH = 2	Dark, 4 °C	No additive is needed if the samples are analysed within 48 h.
BOD	500 ml HDPE or PP bottles with double caps or self-sealing caps, no air	No additive	Dark, 4 °C	Na_2SO_3 should be used for dealing with samples with residual chlorine. Sample should be Preserved and added seed for chlorinated and dechlorinated wastewater samples.
Trace elements and heavy metals	250 ml HDPE or PP bottles with double caps or self-sealing caps, with or without air	HNO_3 to pH = 2	Dark, 4 °C	A special bottle [such as polytetrafluoroethylene (PTFE)] and additive are needed for the analysis of mercury (Hg).
Trace organics and pesticides	1 l dark glass bottle or PTFE bottle, no air rinsed with organic solvents	Ascorbic acid (1000 mg l^{-1}) if residual chlorine is present	Dark 4 °C	
Microbiological parameters (total and *faecal coliforms*, helminths, viruses, or other additional microbiological parameters)	1 l to 5 l sterile HDPE or PP bottles with double caps or self-sealing caps bottle, with air	No additive	Dark, 4 °C	Additive of sodium thiosulfate at a well-defined concentration is mandatory in presence of residual chlorine and recommended in all cases.

4.2.2 Sampling from an irrigation system

Water quality should be checked by the end user according to the following procedure:

a) Turn on the irrigation system until the system operates to full designed pressure and let the system irrigate until the pipes have flushed of all stagnant water from the previous irrigation event.

b) Collect a sample from a tap located at the entrance to the irrigation system or from an irrigation emitter (a sprinkler, micro-jet or a dripper).

c) The water sample should be collected in bottles as provided or recommended by the analytical laboratory or procedure and the parameters to be tested (see Table 1). For bacterial sampling, a sterile bottle should be used. Write all necessary details on a sticker attached to the bottle (name, address, date, location, etc.) and seal the lid.

d) Preserve samples according to standard laboratory practice and transport them to an analytical laboratory within the time period recommended for the analysis (see Table 1).

e) Water sampling should not be taken when fertigation (fertilization through irrigation) is taking place.

For more information about sampling from an irrigation system, see ISO 5667-10[3].

4.2.3 Sampling from a storage reservoir

To evaluate a potential evolution of treated wastewater quality during storage, a sample from the storage reservoir should be taken.

The best way to measure the quality of TWW that was stored in a reservoir is by sampling the TWW at appropriate sampling point situated at the exit of the reservoir's pumping station.

In periods of no irrigation from the reservoir, the sample should be taken directly from the storage reservoir, according to the following procedures:

a) It is recommended to take the sample as close as possible to the pumping point;

b) Avoid sampling downwind to prevent the collection of floating materials (plant or algae residues) transported by water waves to the downwind side of the storage reservoir;

c) Attach an empty bottle to the sampling pole;

d) Lower the bottle so that the neck is submerged in the storage reservoir to a depth of about 10 cm and fill the bottle;

e) Remove the bottle from the storage reservoir, seal it and label the bottle;

f) Preserve the sample if required or refer to Table 1 to determine if and what preservative is required. Store the sample and take them to the laboratory within the time period recommended by the analytical laboratory or procedure (see Table 1).

For more information about sampling from a storage reservoir, see ISO 5667-4[2].

4.2.4 Composite sample

To characterize TWW at the outlet of the treatment plant in order to take into account the fluctuations of WW quality, a composite sample should be taken.

Composite sampling should be taken within a 24 h duration.

A refrigerated automatic sampler should be used.

4.2.5 Sample handling

Samples should be kept in a thermally insulated container and delivered immediately to the laboratory. If the samples cannot be delivered immediately, they should be temporarily stored in a refrigerator at 4 °C.

For more information about sample handling, see ISO 5667-1[4].