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Guidelines for health risk assessment and management for non-potable water reuse

Lignes directrices pour l'appréciation et la gestion du risque pour la santé relative à la réutilisation de l'eau pour des usages non potables

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Contents

Page

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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 282, *Water Reuse*, Subcommittee SC 3, *Risk and performance evaluation of water reuse systems*.

Introduction

The reaffirmation of the importance of water along with food security and energy was a significant outcome in the actions and the follow-up framework passed at the United Nations Conference on Sustainable Development (Rio+20). Water is an indispensable resource for sustainable development including the eradication of poverty and hunger, public hygiene, food security, water power, agriculture, and development of farming and remote communities. In the management of water resources, essential actions include: the prevention of water contamination by households, industries, and agriculture; more efficient water usage and the treatment and reuse of wastewater as a water resource, particularly in growing urban areas.

Today, with many regions of the world facing potable water shortages, wastewater reuse can provide an alternative water source that is suitable for satisfying the majority of water demands, with the notable exception of drinking and cooking which require higher water quality. On the other hand, increased water reuse practices are raising concerns regarding potential health implications across the world. This has led to an increasing need to specify water quality parameters that are appropriate to specific water applications and uses, as well as the development of methods to assess and manage health risks from both regulator and user sides. Unless these needs are addressed, opportunities for sustainable development in the form of appropriate use of reclaimed water will be lost.

Direct or indirect contact with reclaimed water may have health implications for individuals, regardless of whether they are the intended users of the reclaimed water or not. Contact with reclaimed water can occur during the collection and treatment of wastewater, treated water storage and distribution, the use of reclaimed water, or after use. Health risks may also be present during the operations and/or maintenance work of the facilities and processes. These health implications can be moderate in some cases and serious in others, and continue for a short, moderate, or long period of time.

This document can be useful for the application of management system standards, such as ISO 9001 and risk management standards, such as ISO 31000.

Guidelines for health risk assessment and management for non-potable water reuse

1 Scope

This document aims to serve as technical guidelines for the assessment and management of the health risks associated with pathogens contained in reclaimed water, which are expected to be caused by the use of reclaimed water, and/or by the production, storage, and transportation of reclaimed water.

This document is applicable to the use of reclaimed water made from any source water (i.e. raw sanitary sewage; treated municipal wastewater; industrial wastewater; stormwater potentially influenced by sewage) and for non-potable water reuse.

NOTE The approach described in this document can be applied to chemical contaminant, if applicable.

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:—[1], *Water reuse — Terminology*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the 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:

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

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

3.1 Terms and definitions

3.1.1
disability-adjusted life years
population metric of life years lost to disease due to both morbidity and mortality

[SOURCE: WHO (2016) Quantitative Microbial Risk Assessment: Application for Water Safety Management]

3.1.2
dose-response assessment
determination of the relationship between the magnitude of exposure (dose) to a chemical, biological or physical agent and the severity and/or frequency of associated adverse health effects (response)

[SOURCE: WHO (2016) Quantitative Microbial Risk Assessment: Application for Water Safety Management]

1) Under preparation. (Stage at the time of publication ISO/DIS 20670:2017.)

3.1.3
hazardous event
event in which people are exposed to a hazard within the system

Note 1 to entry: It may be an incident or a situation that introduces or releases the hazard to the environment in which humans are living or working; amplifies the concentration of a hazard; or fails to remove a hazard from the human environment.

[SOURCE: WHO (2016) Quantitative Microbial Risk Assessment: Application for Water Safety Management]

3.1.4
non-potable water reuse
water reuse except reuse requiring drinking water quality according to local jurisdiction

3.1.5
pathogen
microorganism (e.g. bacteria and viruses) and parasite (e.g. protozoa and helminths) that can affect human health and cause disease

3.1.6
performance control point
activity, procedure or process where control of performance can be applied, and that is essential for preventing hazards that represent high risks or reducing them to acceptable levels

Note 1 to entry: See Australian Guidelines for Water Recycling [NRMMC, EPHC, AHMC (2006)].

3.2 Abbreviated terms

BOD biochemical oxygen demand

DALY disability-adjusted life years

MLSS mixed liquor suspended solids

PCP performance control point

QA quality assurance

QC quality control

TSS total suspended solids

UV ultraviolet irradiation

YLD years lived with disability

YLL years of life lost

4 Concepts of health risk assessment and management for non-potable water reuse

4.1 Risk assessment and management framework

There is a possibility that reclaimed water contains hazards that can potentially affect human health. The goal of the risk assessment and management process is to estimate and reduce the risk of adverse outcomes to a level acceptable to society and the local community. A health risk assessment is undertaken to establish standards or performance goals which are used as a basis for the design of the treatment steps. In addition, health risk management is also implemented to ensure that water of a safe

quality is provided to end-users. A generic framework of health risk assessment and management for non-potable water reuse is shown in Figure 1.

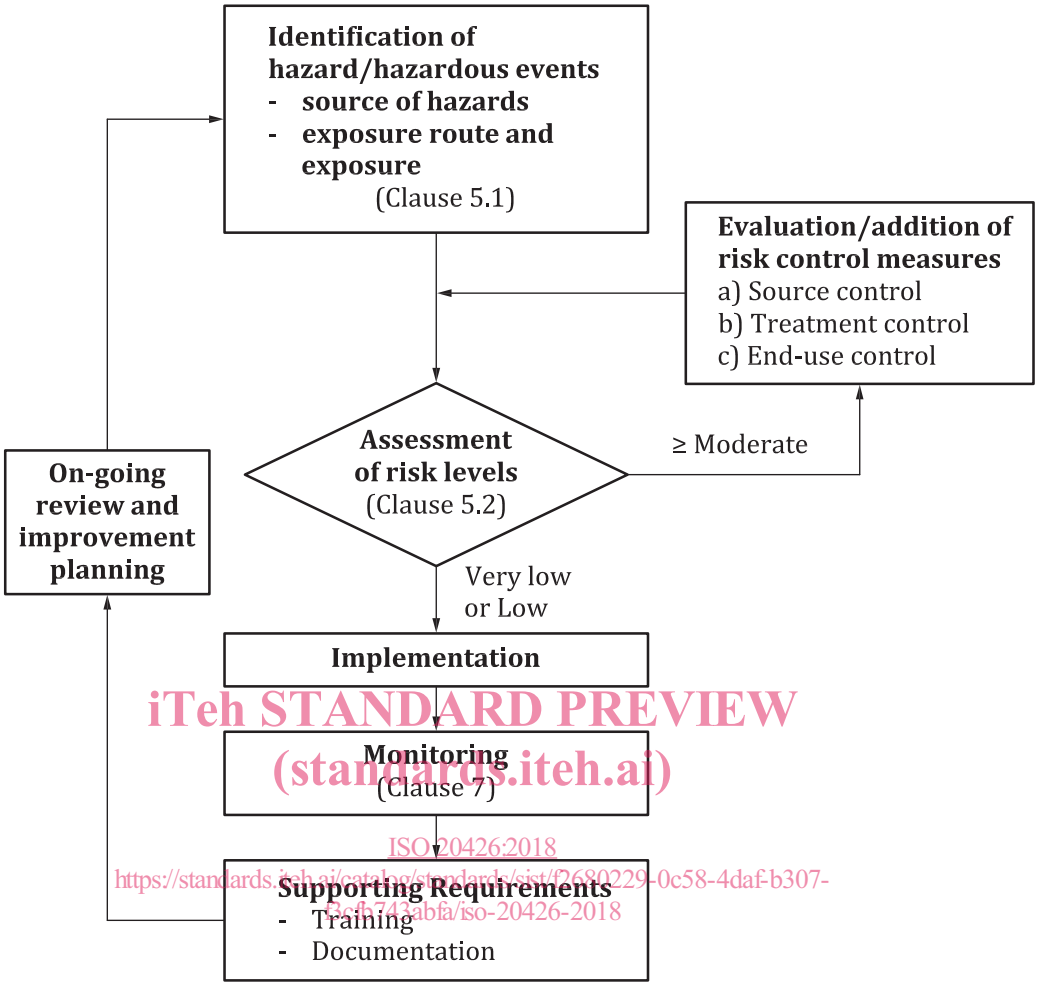

Figure 1 — Framework of health risk assessment and management for non-potable water reuse

4.2 Scope of end-uses of reclaimed water

This document can cover any kind of source water such as domestic/urban/industrial wastewater. In the case where industrial facilities are located within the catchment of a wastewater treatment plant, the risk for high contaminant loadings (e.g. chemicals, pathogens) from industries to the municipal wastewater should be taken into consideration. The main water reuse categories covered in the document are shown in Table 1.

Table 1 — Categories of non-potable reuse applications (adapted from Reference [22])

Category		Potential application	Issues/constraints
Agricultural uses		— Food crop, eaten raw, processed or cooked — Pastures for milk and/or meat production — Fodder and industrial crops — Ornamental plant nurseries	— Health risk related to food products and direct contact with reclaimed water — Water quality impacts on soils, crops, and groundwater — Runoff and aerosol control — Farmers acceptance and marketing of crops — Buffer zone requirements if applicable
Urban uses	Landscape irrigation uses	— Golf courses and landscape — Public parks, private gardens — Roadway medians, roadside plantings, greenbelts, cemeteries	— Health concerns related to direct contact with reclaimed water — Water quality impacts on ornamental plants — Runoff and aerosol control
	Non-potable urban uses	— In-building reuse, toilet flushing — Landscaping (see irrigation) — Air conditioning, fire protection — Commercial car/trucks washing — Sewer flushing — Driveway and tennis court wash-down — Snow melting — Heavy construction (dust control, concrete curing, fill compaction, and clean-up)	— Health risk related to direct contact with reclaimed water — Scaling, corrosion, fouling, and biological growth — Cross-connection with potable water supply
Recreation and environmental uses		— Recreational impoundments — Wetlands or biodiversity restoration — Snowmaking — Environmental enhancement (freshwater or seawater protection) — Fisheries — Artificial lakes and ponds	— Health risk related to accidental ingestion or direct contact with reclaimed water — Eutrophication (algae growth) due to nutrients — Toxicity to aquatic life
Industrial uses		— Cooling water — Boiler feed water — Process water — Heavy construction in industrial parks or areas	— Health risk related to cooling tower aerosols — Blowdown disposal — Scaling, corrosion, fouling, and biological growth

The detailed explanations of categories of non-potable reuse applications, which are included in Table 1, are as follows:

Agricultural uses: Agricultural uses include the use of reclaimed water to irrigate food crops, and/or non-food crops. Users of this document can refer to the following ISO documents.

— ISO 16075-1

— ISO 16075-2

— ISO 16075-3

— ISO 16075-4

Urban uses: Urban uses include the use of reclaimed water for non-potable applications in municipal settings including recreational field and golf course irrigation, landscape irrigation, fire protection and toilet-flushing. Users of this document can also refer to the following ISO documents.

— ISO 20760-1

— ISO 20760-2

— ISO 20761[2)]

Recreational and environmental uses: Recreational uses include the use of reclaimed water in an impoundment in which no limitations are imposed on body-contact water recreation activities. Environmental uses include the use of reclaimed water to create, enhance, sustain, or augment water bodies, including wetlands, aquatic habitats, or stream flow. Users of this document can also refer to the following ISO documents.

— ISO 20760-1

— ISO 20760-2

— ISO 20761

Industrial uses: Industrial uses include the use of reclaimed municipal wastewater for industrial process and related applications that do not require potable water including power generation, food processing, pulp and paper, oil and gas industries.

4.3 Risk management framework

Risk management framework and risk management planning are essential to implement safe water reuse schemes and to ensure compliance with reclaimed water quality standards. This framework typically includes four requirements [24].

a) Responsible use of reclaimed water: Engagement of agencies with expertise in water supply, wastewater management and protection of public health.

b) Regulatory and formal requirements: Identification of all relevant regulations, guidelines, and local requirements.

c) Partnerships and engagement of stakeholders: Identification of all agencies with responsibilities and all stakeholders influencing water reuse activities.

d) Reclaimed water policy: Development of a reclaimed water policy, permits and specific contracts with end users.

The risk management framework is used to develop a management plan that describes how the water reclamation system should be operated, monitored and managed. It is normally developed by a team comprising of representatives from various sectors with sufficient knowledge and expertise. These members typically include, but are not limited to, recycled water suppliers (e.g. technical staff), key decision makers, risk experts, regulatory agencies, local government and end-users. Other stakeholders such as the public are also invited to participate, as necessary.

2) Under preparation. (Stage at the time of publication ISO/FDIS 20761.)

5 Health risk assessment

5.1 Identification of hazard and hazardous events

5.1.1 Constituents in source water

Municipal wastewater can contain pathogens that can cause adverse impact on public health; consequently, human health hazards for non-potable water reuse applications are mostly related to these pathogens. Wastewater can also contains numerous chemical constituents, but experience with reuse applications to date indicates that chemicals present in reclaimed wastewater generally complies with drinking water quality requirements for most parameters, including heavy metals, organic chemicals, pesticides and disinfection by-products[24]. Therefore, although it is recognized that under certain circumstances, such as spill-events, and high industrial contributions to sewer, these constituents can pose a hazard, the subject is beyond the scope of this document. Pathogens that are typically identified in raw wastewater and are considered as key microbial hazards are shown in Annex A.

5.1.2 Hazardous events, exposure route and exposure at end-use

In addition to the identification of the key microbial hazards, the first step of risk assessment includes the identification of the most probable hazardous events, exposure routes and exposure, which depends on the type of end-use and the configuration of the water reuse scheme. The most common potential hazardous events associated with human health risks at the points of use of reclaimed water in non-potable water reuse projects are as follows[24]:

a) Potential non-compliance of reclaimed water quality due to failure of treatment or contamination of storage and distribution system;

b) Potential for deliberate or inadvertent misuse of reclaimed water (e.g. ingestion);

c) Accidental exposure to reclaimed water which arise from design or operational deficiencies (e.g. pipe bursts or leaks, inadequate irrigation timing);

d) Accidental exposure to reclaimed water caused by end-use system failures resulting from sabotage, natural disasters, or extreme weather conditions;

e) Cross-connection to higher quality water sources (e.g. drinking water) or to lower quality water sources; and

f) Inadequate education and information about permitted uses.

5.2 Assessment of risk levels

5.2.1 Qualitative risk assessment

Once all of the risks associated with a given water reuse scheme have been identified, the level of each risk needs to be comprehensively assessed to establish priorities for risk management [20] [24]. Qualitative risk assessment is based on a combined evaluation of the magnitude of consequences and the likelihood that those consequences can happen. For the non-potable reuse projects, the qualitative risk assessment is the most appropriate and economically feasible methodology.

Consequences: For each hazard identified, the consequences that result from exposure to the hazard need to be clarified. “Consequence” in health risk assessment indicates a potential adverse health impact of hazard exposure scenarios. Consequence analysis can be performed through qualitative evaluation with a descriptive representation of the likely outcome for each hazard/hazardous event. Consequences in terms of adverse public health impacts can be classified into five categories in terms of a qualitative descriptor (for example, a scale of ‘1 = insignificant’ – ‘5 = catastrophic’ for event consequences). See Table 2.

