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Water reuse in urban areas — Guidelines for decentralized/onsite water reuse system — Design principles of a decentralized/onsite system

Réutilisation de l'eau en milieu urbain — Lignes directrices concernant les systèmes décentralisés/sur site de réutilisation de l'eau — Principes de conception d'un système décentralisé/sur site

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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 2, *Water reuse in urban areas*.

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

With economic development, climate change, rapid urbanization and increases in population, water has become a strategic resource especially in arid and semi-arid regions. Water shortages are considered as one of the most serious threats to the sustainable development of society. To address these shortages, reclaimed water is increasingly being used to satisfy water demands that do not require potable water quality. This strategy has proven useful in increasing the reliability of long-term water supplies in many water-scarce areas. The applications of reclaimed water depending on the volumes of reclaimed water available include restricted or unrestricted irrigation, industrial uses, toilet and urinal flushing, firefighting and fire suppression, street cleaning, environmental and recreational uses (ornamental water features, water bodies' replenishment, etc.) and car washing.

While centralized water reuse facilities have been widely implemented under different ownership and management structures, there is also a need to develop decentralized/onsite water reuse systems in cost-effective and resource-efficient ways, which can improve flexibility and convenience. Depending on the size and scope of the system, private and community owned systems can increase the flexibility of the system to the needs of the owner(s). Decentralized/onsite water reuse systems have the advantage that they can be installed for a short-term when needed and have a lower cost than centralized systems due to sewers systems large investments. Moreover, they allow the local reuse of water and therefore increase water productivity. Compared to centralized systems, decentralized/onsite systems still involve local wastewater collection and treatment. They are considered to be much smaller with fewer people connected (single, several or tens or hundreds of households) and less costly, especially when greywater components have been separated from the blackwater for reuse. If the systems are properly situated, designed, operated and managed, they can provide substantial environmental and social benefits (e.g. reduction of freshwater consumption and wastewater generation) as well. The concentrated blackwater can be treated using several treatments (e.g. septic tanks, cesspools, soil drain fields, chemicals, bio-digesters, composting toilets and blackwater recycling systems). Decentralized/onsite water reuse systems can also be integrated into the broader centralized systems in terms of clustered or contracting schemes for decentralized technology with centralized operation.

The design of a decentralized/onsite water reuse system requires a thorough understanding taking into account of scale, system components, end use requirements and other issues. This guideline can be useful for the application of design principles as well as feasible and cost-effective approaches for safe and reliable fit-for-purpose water reuse.

Water reuse in urban areas — Guidelines for decentralized/onsite water reuse system — Design principles of a decentralized/onsite system

1 Scope

This document provides guidelines for the planning, design principles and considerations of a decentralized/onsite water reuse system and water reuse applications in urban areas.

This document is applicable to practitioners and authorities who intend to implement principles and decisions on decentralized water reuse in a safe, reliable and sustainable manner.

This document addresses decentralized/onsite water reuse systems in their entirety and is applicable to any water reclamation system component (e.g. source water collection, treatment, storage, distribution, operation and maintenance and monitoring).

This document provides:

— standard terms and definitions;

— description of system components and possible models of a decentralized/onsite water reuse system;

— design principles of a decentralized/onsite water reuse system;

— common assessment criteria and related examples of water quality indicators, all without setting any target values or thresholds;

— specific aspects for consideration and emergency response.

Design parameters and regulatory values of a decentralized/onsite water reuse system are out of the scope of this document.

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*

3 Terms and definitions

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:

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

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

3.1
cluster system
private system
decentralized water reuse system used to treat and reuse wastewater from a collection of dwellings or facilities located adjacent to each other with typically a few owners

[SOURCE: Asano et al., 2007; CIDWT, 2009]

3.2
community system
decentralized water reuse system used to treat and reuse wastewater from a community with dwelling units and/or high-rise buildings

Note 1 to entry: A water-tight collection system is used for transport of pre-treated effluent or raw wastewater.

[SOURCE: Asano et al., 2007; CIDWT, 2009]

3.3
onsite water reuse system
treatment unit that receives, treats and provides reclaimed water at the immediate site of wastewater generation

[SOURCE: Asano et al., 2007]

4 Planning of a decentralized/onsite water reuse system

4.1 General

Good planning and management of a decentralized/onsite water reuse system are important. The planning and management of a decentralized/onsite water reuse system should consider the following aspects:

— internal planning (e.g. planning principles, targets, scope, project timeline and conceptual design);

— site selection and inspection, including population density, land availability and topography;

— wastewater quantity and quality and reuse potentials;

— scale and layout of the system and coordination and involvement in broader land use planning;

— operational and management conditions;

— operation and maintenance of residuals (e.g. sludge, screenings, trash, etc.);

— recognition and addressing of technological, economic, environmental, social and regulatory issues.

The capacity of the owner or operator to manage the system should be factored into the decision-making process leading to the planning and selection of a system or set of systems appropriate for the local household or community. An initial screening using criterion for safety, reliability, stability, operability and economics is a critical element of good planning. The dynamics of the reuse system that can be taken into consideration include system density, hydraulic and pollutant loadings, proximity to water bodies, soil and hydrogeological conditions and the potential impacts of water quality/quantity on groundwater and surface waters. For system reliability, it is important to conduct a risk management approach that consider the consequences of system failures or malfunctions in terms of public health and environmental impacts (see Table 1). In cases of high risk or non-conformance due to failures (e.g. power or treatment processes), procedures or options can be established/built to consider use of traditional networks, such as constructing holding or surge tanks, constructing connections to other nearby decentralized systems or other site-specific options.

Site investigation and assessment are important to ensure that the system is integrated into existing and proposed urban planning which includes future development, proposed road, water or sewer line extensions, zoning classifications, etc.

Table 1 — Considerations for risk management of a decentralized/onsite water reuse system

Potential issues	Contributing factors	Key risks
Treatment and reuse system and disposal area	— Soil; Topography — Planning (lot size) — Environmental sensitivity — Flooding — Operation and maintenance — Loading rates — Water extraction (boreholes, wells, springs)	Release of contaminants due to failure of the decentralized/onsite water reuse system
Surrounding soil	— Soil type and horizon depth — Physical characteristics — Chemical characteristics — Water table depth	Inability to renovate effluent and prevent contaminants from reaching groundwater and/or surface water
Public health	— Surface exposure — Water resources — Aerosols — Pests (e.g. mosquitoes)	A considerable health risk due to exposure to contaminants and pathogens from water/ surrounding environment
Environment	— Surface runoff — Groundwater discharge — Flooding — Water table	Release of contaminants into the receiving environment (ground/ surface waters) causing environmental harm (such as eutrophication) and odour and noise considerations
NOTE Adapted from Carroll, et al. (2006)[17].		

4.2 Possible models of the system

4.2.1 General

Decentralized/onsite water reuse systems come in a wide variety of options and scales. An important aspect in considering the use of decentralized/onsite systems is the appropriate scale of implementation to ensure proper operation and management. Onsite systems generally refer to allotment scale systems, including onsite family/household-based systems and onsite building scale systems (e.g. urban communities, industries, or other facilities). Decentralized systems can encompass a wider range of scales such as a cluster system, a community system, a seasonal operation system, etc.

Traditionally, the main application of a decentralized/onsite water reuse system is for servicing areas that are difficult to service with centralized water reuse systems due to technical or economic considerations. There are increasing opportunities to apply decentralized systems beyond the small town and rural communities by a mixture of different scales. Compared to centralized systems, the planning of decentralized/onsite water reuse systems require a thorough understanding of temporal and spatial demand variability for the end use requirements to determine an optimal design scale.

4.2.2 Onsite water reuse system

Onsite systems typically treat wastewater close to the source, and are generally applied to serve small to medium scale development. Figures 1 and 2 show typical examples of an onsite family/household-based water reuse system and a building scale water reuse system respectively. Back flow preventers should be considered as required by many jurisdictions when potable water and reclaimed water are supplied to the same equipment (e.g. toilets, washing machines, irrigation, etc.) for safety of individual and public systems. The maintenance and operational costs of onsite systems can be relatively high which usually relies on additional motivation, such as limited available supply of water (drought or arid lands) or high costs for disposal or positive environmental attitudes of individuals and households, etc.

Onsite systems for seasonally operated facilities such as seasonal hotels or campsites should be capable of adapting to changing conditions and deal with a high variability of organic load.

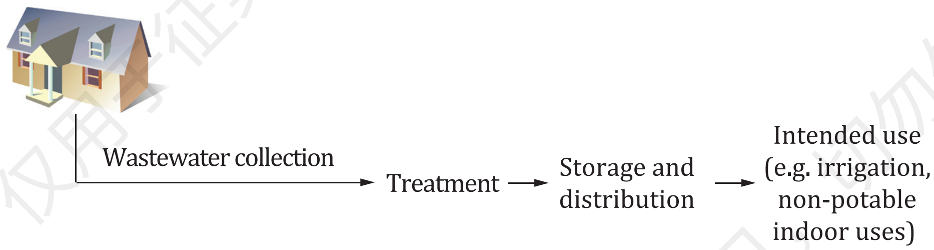
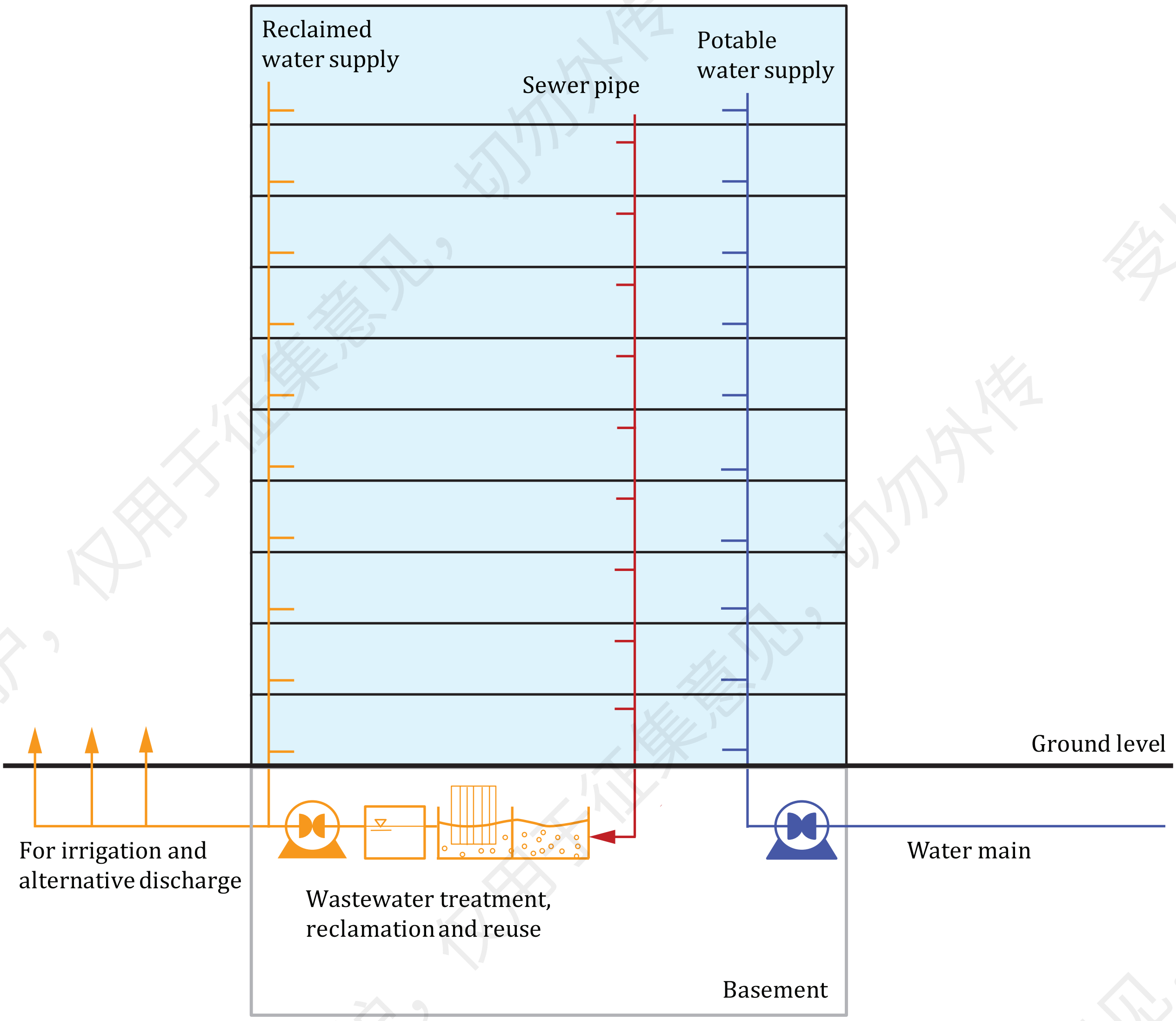


Figure 1 — Typical example of an onsite family/household-based water reuse system



NOTE Other collection and distribution systems could be used such as greywater.

Figure 2 — Typical example of an onsite building scale water reuse system

4.2.3 Cluster water reuse system

Cluster systems can be a combination of systems applied either at single onsite or communal scale systems or both. Cluster systems offer economies and maintainability of scale, as it is more efficient for a number of households to invest in and utilize a decentralized technology than for each household to own and operate its own system. Additional advantages are reducing the risk for system failure and facilitating repair. A typical example of cluster system is given in Figure 3.

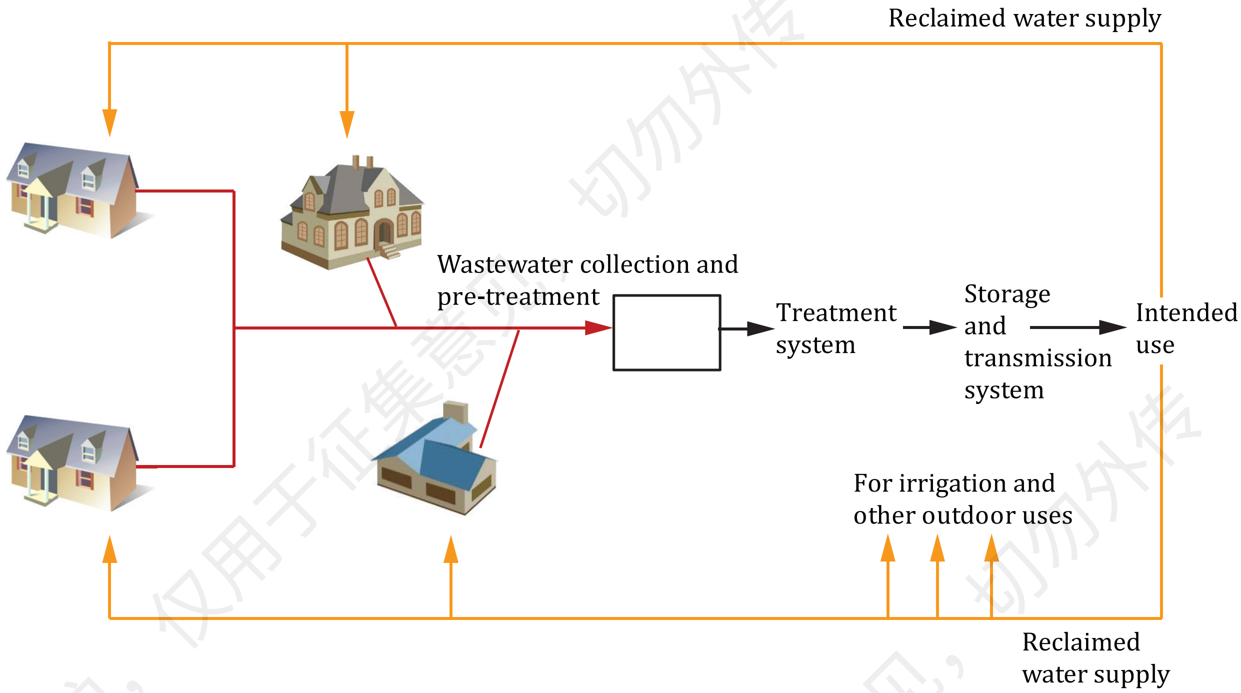


Figure 3 — Typical example of a cluster water reuse system

4.2.4 Community water reuse system

Community systems can be serviced using alternate collection systems in conjunction with treatment and reuse facilities. For example, wastewater solids may be retained in an onsite primary treatment tank and then be concentrated and/or hauled to a central site for treatment. The liquid portion of the wastewater is discharged to the collection systems and treated downstream near the point of reuse. Other advantages of community systems compared to onsite water reuse systems are economy of scale, the use of more sophisticated treatment processes, and the capacity to have dedicated operations and maintenance personnel. A typical example of community system is given in Figure 4.

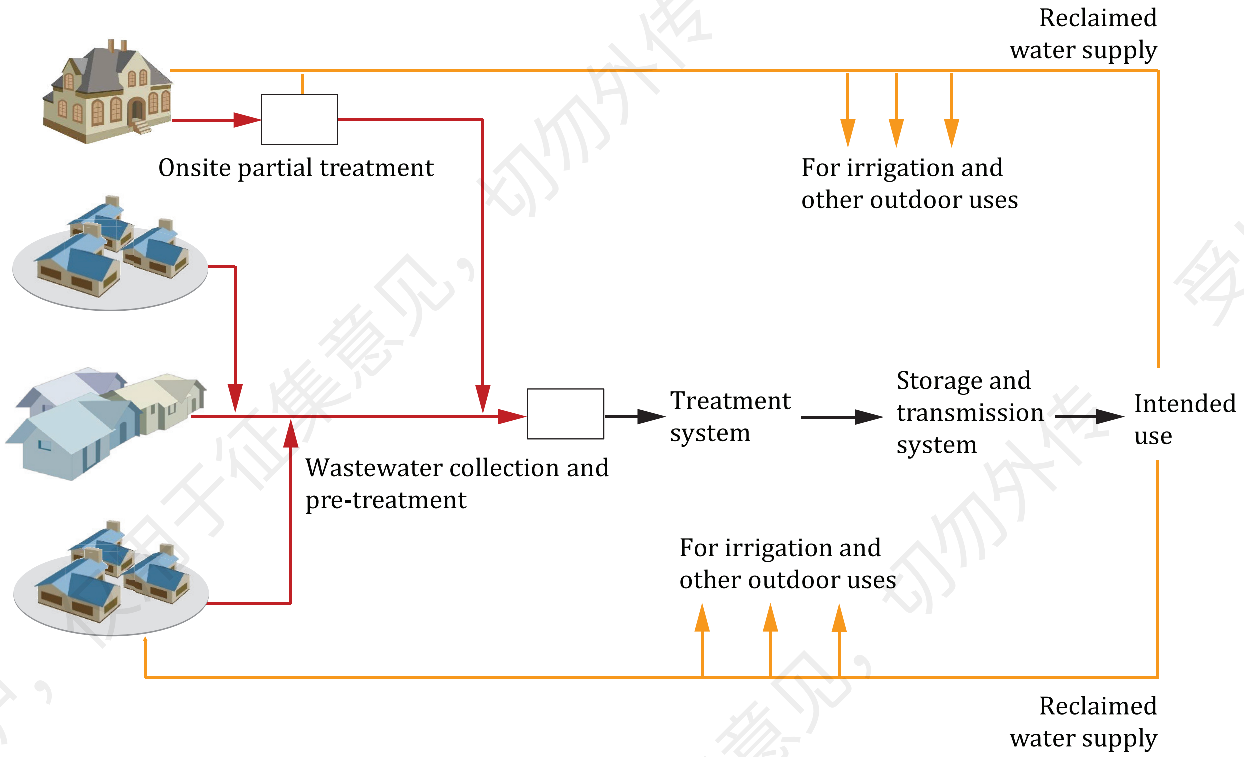


Figure 4 — Typical example of a community water reuse system

Compared to centralized systems, community system ensures lower collection and distribution cost and can offer flexible solutions to cope with the new demands wherever certain thresholds of demographic changes are exceeded. Centralized systems can have lower operating costs per volume of treated wastewater. Community systems can be more resilient because a failure in one system would only affect a small part of the region. However, the overall collection and treatment is case specific.

In addition, community systems can also be integrated with a centralized system where the management of several decentralized/onsite systems is undertaken by a single centralized entity. These systems can reduce demands on centralized infrastructure while enabling opportunities for localized water reuse. The same operator can manage a number of individual decentralized/onsite systems to increase convenience for the end user, lower operator costs and may improve operations and effluent quality. A typical example of this management concept is shown in Figure 5.

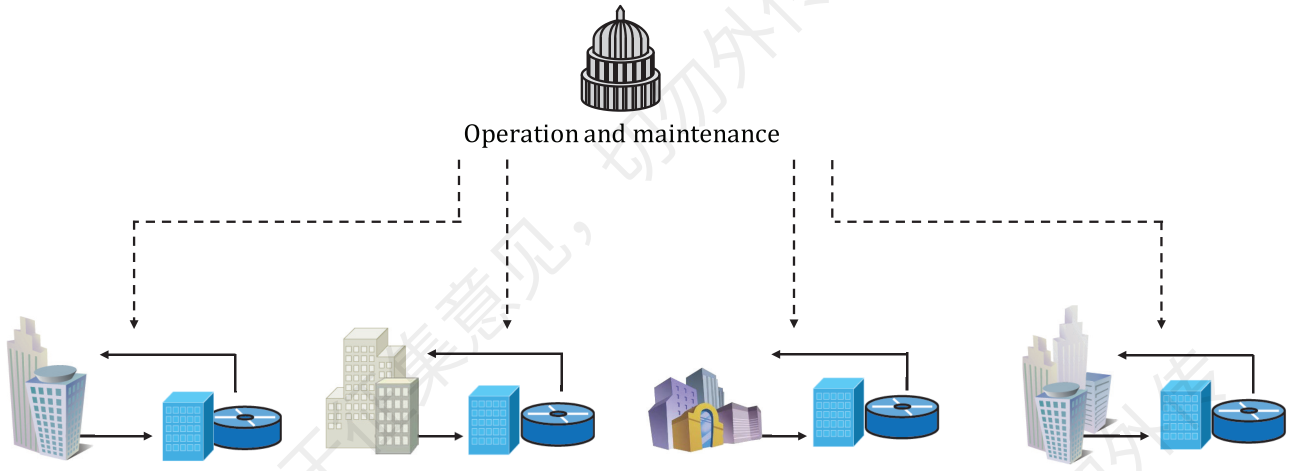


Figure 5 — Typical example of centralized management of several decentralized and/or onsite water reuse systems

5 Collection of source water for decentralized/onsite water reuse

5.1 Source water

The potential source water for decentralized/onsite water reuse can include wastewater, blackwater, greywater, rainwater, etc. In most circumstances, it is expected that domestic wastewater will be used as the source water in a decentralized/onsite water reuse system. Possible backup water resources should also be considered, such as a potable water tie-in.

The quality of source water should meet the safety considerations for human health and environmental safety of the reclaimed water, see ISO 20760-1. The quantity of reuse production should meet the demand requirements. The quality of a particular water source coupled with its end uses can determine what level of treatment is necessary.

5.2 Collection system

The collection system consists of networks with connections to the source water or septic tank effluent. Such networks are furnished with the necessary equipment (e.g. gates, weirs, pumps) to achieve the collection and transport function. Small scale and onsite systems may or may not include a sewer pipeline within the site, where the collection system may include trenches, pumping stations and the transport is usually done by carrier, see ISO 24511.

The hydraulic design of the pipe networks and connections should ensure that no backflow, or cross connections occur. The potable water distribution system should be protected from potential contamination from the reclaimed water piping as well as sewer, surface and rainwater drainage piping through the use of prevention devices, labelling, marking, etc.

Pipe material should be carefully selected since leakage from collection systems may result in groundwater or surface water contamination.

5.3 Greywater collection, treatment and reuse

Greywater excludes used water from toilets and urinals. The quality of greywater varies depending upon the behaviour of the residents as well as the volume of water and the chemicals used. Generally, it is less polluted and low in contaminating pathogens, nitrogen, suspended solids and turbidity compared with municipal and industrial wastewaters. Special attention should be paid if wastewater from kitchen sinks is also included as greywater source because of potential high concentration of organic loads, fats, oil and grease.

Treatment requirements are reduced for resource recovery when wastewater streams are separated as early as possible. The separation of greywater provides an alternative way of water reuse. Compared with domestic wastewater reuse, greywater reuse involves smaller hygienic concerns and requires less treatment effort. Since greywater systems are usually expensive to retrofit into an existing building, they should be included, if possible, during planning and construction stages.

Depending on the greywater quantity, quality and the intended uses, different treatment schemes may be applied such as physical, chemical and/or biological treatment. Common uses for greywater are toilet flushing and irrigation.

6 Treatment processes

6.1 General

Multiple criteria analysis should be considered for the selection of a treatment scheme (e.g. life cycle cost, health risks, environmental issues, social aspects, etc.).

Current decentralized/onsite wastewater treatment options vary widely in sophistication from simple septic tanks to multi-stage biological treatment systems or to advanced treatment technologies. The systems mainly consist of several or a combination of physical, chemical and biological processes such as precipitation, adsorption, aeration, filtration, biodegradation and disinfection.

Septic tanks are widely used as onsite wastewater treatment system. Due to limited treatment performance of septic tanks, additional treatment is usually required for reuse of septic tank effluent. Alternatively, many enhanced treatment units are able to treat the source water directly for fit-for-purpose water reuse.

Enhanced treatment units for decentralized/onsite water reuse can include:

a) natural treatment processes;

b) aerobic processes such as suspended growth, attached growth and combined suspended and attached growth;

c) anaerobic processes such as anaerobic pond and anaerobic upflow filters;

d) combined (aerobic/anaerobic/natural) processes such as anaerobic-aerobic, anaerobic-natural and anaerobic-aerobic-natural system;

e) additional polishing processes such as filtration (e.g. deep media or mechanical filtration);

f) disinfection (e.g. chlorination, ultraviolet radiation and ozonation);

g) advanced processes such as activated carbon adsorption and ion exchange, membrane filtration (e.g. microfiltration, ultrafiltration, nanofiltration and reverse osmosis) and advanced oxidation (e.g. electrochemical oxidation, photochemical catalytic oxidation and radiation).

Sludge handling systems (e.g. storage, thickening, dewatering, aerobic digestion and chemical stabilization) are also important issues and should be considered.

The selection of enhanced treatment units (e.g. secondary treatment, filtration and disinfection) depend on the reuse applications, site specific conditions, economic constraints and environmental impacts. Typical reuse applications include garden irrigation, pond supplementation, car washing, cooling, irrigation and potentially for household uses (e.g. toilet flushing). The applications are influenced by source water characteristics, treatment methods used, effluent quality and regulations.

The technologies used for decentralized/onsite water reuse systems should also be able to operate for extended periods of time with low maintenance needs, be fundamentally easy to operate, and be designed to accommodate the level of flow and constituent concentration fluctuations. Factors to be considered during design and selection of a decentralized/onsite treatment system are shown in Table 2.

Table 2 — Possible considerations for design and selection of a decentralized/onsite treatment system

Issue	Description
Aesthetics	— Odor control (e.g. gas tight lids, carbon filters at air release points and vents) — Appearance: above ground components (e.g. tank covers, air pumps, control panels) — Noise emissions (e.g. pumps, aerators)
Residential practices	— Proper disposal of materials — Daily volume per capita — Avoidance of slug dosing of hazardous chemicals (e.g. chlorine bleach)
Flowrate	— Acceptable variability in flow and constituent loading — Diurnal flow variability should be considered in design of all hydraulic components
Operation	Factors that should be changed by the operator in response to underperformance or non-conformance (e.g. aeration, circulation, pumping, chemical dosing and UV radiation intensity)
Maintenance	— Frequency (e.g. solids removal frequency, outlet filter cleaning, media packing replacement, cleaning emitters and spray nozzles) — Responsible party (e.g. system manufacturer, residents, municipals, third party, owner) — Costs and fees associated with maintenance — Annual inspection of the system
Equipment control and monitoring	— Capacity for remote and onsite monitoring (e.g. blowers, pump on/off cycles, pump run time, tank liquid levels, alarm condition, constituent concentrations, UV lamp status) — Capacity for remote and onsite control (e.g. pump settings, alarm reset)
Process performance control	— Overall performance and reliability checking (e.g. nutrient reduction, pathogens) — Power outages (e.g. short periods, > 24 h, extended periods) — Extended periods of no flow (e.g. during family vacation) — Startup procedures — Final water quality and conformance monitoring
Power supply	— Power supply availability, reliability and cost should be considered — Energy consumption of the system should be considered — Power may be used for aeration, blowers, pumping, disinfection, control systems, monitoring and telemetry equipment
Scalability and retrofitting	— Ability to expand or upgrade process to accommodate increased hydraulic or constituent loadings
Service life	— Warranties for process components — Life span for pumps, electrical components, tankage, packing media, etc.
NOTE Time, skill and training are necessary for operation and maintenance.	

Table 2 *(continued)*

Issue	Description
System owner	— System leased to building owner — System owned by building owner — Owner and user responsibilities
Tank construction	— Noncorrosive, lids watertight, lids lockable, aboveground materials UV resistant
Volume	Total volume of system and hydraulic retention time for emergency storage in case of power failure or clogging
Economic considerations	— Financing — Life cycle cost
Safety considerations	— Health safety — Environmental protection — Equipment
NOTE Time, skill and training are necessary for operation and maintenance.	

6.2 Natural treatment process

A natural treatment process combines plant and microbial communities to provide biological treatment. The common natural treatment systems utilized for decentralized/onsite water reuse are oxidation ponds, hydroponic systems and constructed wetlands. These processes are ecological treatment options with technical capacity to provide efficiency (including adequate bacterial elimination rates) and a high level of inertia when faced with large fluctuations in the flow and the effluent load to be treated, simplicity in sludge handling, minimum or nil energy cost that can be supported by utilization of renewable energy sources (solar and wind energy) and high environmental integration. Both climate and land availability for its implementation are important in the consideration of the use of these processes and should be considered in process selection and design.

An oxidation pond process normally contains a series of anaerobic, facultative and maturation ponds. Pre-treatment processes (e.g. coarse screening and grit removal) can be considered prior to oxidation process to remove coarse solids and other large particles. Important parameters to be considered for oxidation pond design include light penetration, temperature, wind, pond geometry, and oxygen concentration.

Hydroponic systems use plant racks suspended over aerated reactors and the plants can provide surface area for bacteria and other microorganisms to live on the roots and can remove nutrients to some extent. Hydroponic systems generally require primary screening and subsequent filtration (e.g. clarifier, disc filter or media filter) processes.

Constructed wetlands are considered as environment-friendly technology for onsite wastewater treatment or polishing of treated wastewater. Organic matter, organic pollutants, heavy metals and nutrients can be fixed and removed through filtration and adsorption by biofilms, clay particles as well as plant uptake. To ensure sufficient pollutant removal, constructed wetlands require a lower influent flow rate and long retention times compared with other intensive (high rate) aerobic treatment options. Depending on the type of constructed wetlands, the retention times may vary between 4 and 15 days for surface or free flow wetlands to 5 days for subsurface horizontal constructed wetland and hours for subsurface vertical constructed wetland. Important factors for constructed wetland design include:

a) specific surface area (which may vary between 2 and 10 m^2/population equivalent, depending on the type of wetland);

b) the choice of plant species;

c) substrates;

d) area of reed bed/macrophyte bed;

e) the nature, loading and distribution of the influent;

f) temperature.

6.3 Aerobic, anaerobic and combined processes

Aerobic processes, such as suspended growth, attached growth (e.g. trickling filters, rotating biological contactors and moving bed bioreactors), extended aeration and/or others, need electricity to increase the availability of oxygen to microorganisms to foster their accelerated growth. A pre-treatment step (e.g. septic tank, primary settling compartment and trash trap) can be considered to improve the performance of aerobic process. Cold climate may have adverse effects on the performance of aerobic processes. Insulation around the systems can be considered under cold weather conditions. To minimize sludge production, small scale or onsite systems can be operated at low hydraulic and organic loading rates.

Advantages of anaerobic process include low capital investment, a low energy requirement, operational simplicity, energy recovery in the form of biogas and low sludge production. It is usually applied to treat high strength wastewater. The effluent from the anaerobic process requires further treatment. For instance, anaerobic ponds followed by constructed wetlands are a convenient solution in warm tropical developing countries, however the potential for odour and algae blooms should be taken into account.

Multiple stage biological treatment processes (e.g. A/O, A/A/O, BARDENPHO, Johkasou and/or others) can be considered.

6.4 Disinfection

Disinfection is normally required to effectively protect public health. Electrochemical chlorination, ozone, sodium hypochlorite, calcium hypochlorite and UV radiation are commonly used for decentralized/onsite water reuse systems. Disinfection with chlorine gas and chlorine dioxide is typically not used for decentralized/onsite water reuse systems as these processes present hazards for small facilities associated with storage, handling, and application.

6.5 Advanced processes

The combination of a membrane process with a biological treatment process, such as membrane bioreactor (MBR) and membrane aerated biofilm reactor (MABR), can be considered as advanced technologies due to the process stability and the ability for bacterial removal. They have a small footprint, high loading rate capacities, and produce an effluent with superior quality and a high removal efficiency. They are also adaptive to ever stringent standard limits.

7 Storage and delivery system

Equalization tanks may be considered to accommodate peak loads and demands both prior to and following enhanced treatment units. Operational storage may also be considered for some systems depending on the intended use of the treated effluent. If reclaimed water quality deteriorates during storage, post-treatment (e.g. filtration and solid calcium hypochlorite tablet) could be considered.

The delivery system may be designed to receive the treated effluent from enhanced treatment units and convey it securely to the end use applications. It is recommended that the delivery system is operated at pressures lower than the potable system. When a pump system is used for pressurized distribution, the pump chamber or feed tank should be fitted with a high water-level alarm. A sufficient storage volume should also be provided. Effluent overflow outlet should be provided in the pump chamber or feed tank in order to provide controlled overflow in cases of pump failure.

Effective measures (e.g. monitoring devices, check valves and backflow preventers) should be taken to prevent cross-connections and backflow from non-potable reclaimed water storage and distribution network into potable water supply systems through colour-coding, labelling, marking, etc.

8 Monitoring

Monitoring of decentralized/onsite water reuse systems is important to ensure that a safe quality of reclaimed water is provided to end users without causing adverse health impacts. Monitoring generally includes two major types of monitoring, namely water quality conformance monitoring and performance monitoring, refer to ISO 20426.

Conformance monitoring programs of decentralized/onsite water reuse systems are often part of the wastewater treatment system with which the reclaimed water providers/system owners should conform to. Water quality conformance monitoring is carried out to verify conformance with relevant requirements. Performance monitoring is undertaken for operational parameters to confirm that treatment processes are properly designed and operated. The degree of monitoring (i.e. conformance monitoring and/or performance monitoring) is related to the complexity of the system, and the risk of the end use, etc. For example, a less complex system may require not as frequent monitoring. Routine conformance or verification monitoring is a general requirement at least for complex or large systems (e.g. cluster or community water reuse system). Primary monitoring of effluent quality is subject to regulations. Regular conformance and performance monitoring can, in some cases, be as simple as visual assessment (e.g. for yellowing or browning of leaves, or flooding), with follow-up action if there are concerns. Such visual inspection may be an important part of verification for small scale or onsite systems. Decentralized systems should perform regular sampling and analysis.

Regular ongoing evaluation of reclaimed water quality results and audit of reclaimed water quality management are required to determine whether preventive strategies are effective and whether they are being implemented appropriately. This long-term evaluation allows performance to be measured against objectives and helps to identify opportunities for improvement. Auditing could involve active participation by reclaimed water consumers, particularly in relation to application of onsite control measures and in assessment of onsite impacts. For details concerning performance evaluation, see ISO 20468-1.

9 Risk management and emergency response plan

9.1 Risk management

Risk assessment and management approaches can be conducted to ensure conformance with reclaimed water quality standards. The framework may include the procedures to identify critical control points, potential risk situations and best management options for reducing risk levels to minimum or acceptable levels. It is recommended for system owners or operators to implement preventive measures and control to ensure the effectiveness and efficiency of the processes, anticipate potential problems and respond before problems become critical. Further information can be found in ISO 20426, ISO 20760-1 and ISO 20760-2.

9.2 Emergency response plan

Emergency response plans should be put in place to deal with and minimize the impacts of incidents or emergencies that might compromise reclaimed water quality, such as extreme weather conditions, natural disasters, process failure and illness outbreaks, etc. For instance, a minimum emergency capacity and separate emergency storage should be provided in the treatment and pumping system or in accordance with relevant requirements. A prevention and response plan to a cross-connection or backflow incident is also important to minimize contamination of high-quality water such as potable water. The following protocol can be considered:

— development of an emergency response plan and related procedures;

— emergency contacts;

— standard operating procedures, for example, documentation to the operators onsite regarding actions can be provided;

— troubleshooting guide to help diagnose the cause of problems and suggest solutions. The guide should include system instructions and operating conditions (e.g. pipe connections, electrical connections, commissioning and start-up procedures), advise on emergency actions and provide contact details of the maintenance contractor, equipment suppliers, and septic tank pumpout operators. The guide should be designed to be readily accessible, preferably close to the system;

— communication between all relevant agencies and/or local authorities, users, residents, to define potential incidents and emergencies;

— in case of a power failure, backup power supply should be activated or connected. The availability of functional operating backup power supply should be checked regularly according to manufacturer or relevant instructions;

— regular checking and updating of the emergency response plan;

— data storage. The responsible party should be advised on the details needed for an adequate record-keeping system (e.g. regular monitoring data, maintenance and repair logs) to provide evidence of control and conformity and assist in the assessment of recurring problems.

10 Public engagement and outreach

Public refers to the users of the decentralized/onsite water reuse systems. Public engagement and outreach should include:

— protecting and maintaining the decentralized/onsite water reuse systems from inappropriate discharges such as solid wastes, wet wipes, household and garden chemicals;

— educational material and guidance regarding health risks and proper use of reclaimed water.

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[3] ISO 20761, *Water reuse in urban areas — Guidelines for water reuse safety evaluation — Assessment parameters and methods*

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[7] ISO 16075-3, *Guidelines for treated wastewater use for irrigation projects — Part 3: Components of a reuse project for irrigation*

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