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Guidelines for treatment and reuse of leachate from municipal solid waste (MSW) incineration plants

Lignes directrices pour le traitement et la réutilisation du lixiviat provenant des installations d'incinération des déchets ménagers

Reference number
ISO 24297:2022(E)

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 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

Commonly used methods for disposal of municipal solid waste (MSW) include landfilling, incineration and composting (Annex D), and each of these methods generates leachate. Leachate is a kind of wastewater containing highly concentrated organic contaminants that can pose a high risk to the environment. It is necessary for leachate to have proper treatment before being discharged or reused to avoid adverse impacts on the environment. Due to the differences in duration of waste stacking and fermenting, leachate from different MSW disposal methods varies significantly in the concentration and biodegradability of organic matter, which requires tailored treatment processes. Leachate generated from MSW incineration plants has a higher concentration of biodegradable organic pollutants, and thus degrades more easily than leachate from landfills and composting plants. Due to higher quality requirements for water reuse in MSW incineration plants, this document focuses on leachate treatment and reuse in MSW incineration plants.

In MSW incineration plants the MSW first enters the unloading platform and then goes to the MSW pit, where stacking and fermentation occurs. The stacking and fermenting process aims to reduce moisture content of the MSW before incineration. The MSW leachate has a strong odour and high concentrations of organic and inorganic compounds; it includes stacking and fermenting wastewater and unloading platform flushing water. Many kinds of wastewater, such as municipal wastewater, industrial wastewater and stormwater, are used as sources of reclaimed water to address worldwide water shortages caused by economic growth, increasing populations, climate change and other factors.

The quality and quantity of MSW leachate can vary based on climate, residents' living habits, composition of waste and waste collection and separation systems. Therefore, leachate treatment can be more challenging than other kinds of wastewater treatment. Due to the complex composition of leachate and the high concentrations of pollutants, a combined treatment process is usually necessary for leachate treatment to meet environmental requirements and intended reuse applications. The essential components of the leachate treatment and reuse system include pretreatment, biological treatment and advanced treatment.

In consideration of the problems in the treatment of MSW leachate and the absence of relevant International Standards, an integrated standard is needed to guide the treatment and reuse of MSW leachate.

This document aims to provide design and operation principles and advice for MSW leachate treatment and reuse in MSW incineration plants. It considers and addresses the critical issues and factors in the design and operation of treatment and reuse systems and is intended to assist engineers, authorities, decision-makers and stakeholders in providing a clear structure and feasible approach for safe and reliable treatment and reuse of MSW leachate.

Guidelines for treatment and reuse of leachate from municipal solid waste (MSW) incineration plants

1 Scope

This document provides guidelines for the treatment and reuse of MSW leachate.

It is applicable to personnel involved in the design, management, operation and supervision of the treatment and reuse of MSW leachate and environmental authorities engaged in regulation.

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
municipal solid waste
MSW
waste stream consisting of end-of-life-materials

[SOURCE: ISO 16559:2022, 3.135, modified — Notes to entry removed.]

3.2
MSW leachate
mixture of flushing water from the waste unloading platform and wastewater generated during the *stacking and fermenting* (3.3) process

3.3
stacking and fermenting
process to reduce moisture content of MSW and to degrade the organic materials in a MSW pit, during which leachate is generated

3.4
leachate treatment system
treatment units that receive and treat municipal solid waste leachate

Note 1 to entry: Leachate treatment systems include those for preliminary treatment, biological treatment, advanced treatment, disposal of sludge and concentrate and odour control.

3.5
aerobic biological treatment
biological treatment in the presence of oxygen

[SOURCE: ISO 11074:2015, 6.4.1]

3.6
anoxic biological treatment
biological treatment process in which nitrate and/or nitrite are reduced by microbes in the absence of, or with minimal, dissolved oxygen concentration with molecular nitrogen (N_2) ultimately produced

3.7
membrane bioreactor
MBR
integrated wastewater treatment process combining a suspended growth biological treatment and a membrane filtration system (UF/MF membrane) replacing conventional secondary clarifier

Note 1 to entry: The MF or UF membrane is submerged in the biological reactor (submerged MBR). Another configuration has pressurized membrane modules externally coupled to the bioreactor, with the biomass recirculated between the membrane modules and the bioreactor by pumping (side-stream MBR).

[SOURCE: ISO 20468-5:2021, 3.1.12]

3.8
filtrate
liquid by-product from a filter press or other sludge dewatering devices

4 Abbreviated terms

A/O	anoxic or aerobic biological treatment
BOD_5	five-day biochemical oxygen demand
CAPEX	capital expenditure
COD_{Cr}	chemical oxygen demand
DO	dissolved oxygen
DTRO	disc-tube reverse osmosis
HRT	hydraulic retention time
IC	internal circulation anaerobic reactor
MBR	membrane bioreactor
MF	microfiltration
MLSS	mixed liquor suspended solids
MVR	mechanical vapour recompression
NF	nanofiltration
NH_4^+-N	ammonium nitrogen as N
OLR	organic loading rate
OPEX	operating expenditure

ORP	oxidation-reduction potential
RO	reverse osmosis
SBR	sequencing batch reactor
SCE	submerged combustion evaporation
SDI	silt density index
SS	suspended solids
STRO	spiral-tube reverse osmosis
TDS	total dissolved solids
TN	total nitrogen
TP	total phosphorus
UASB	upflow anaerobic sludge blanket reactor
UBF	upflow anaerobic sludge bed-filter reactor
UF	ultrafiltration
VFA	volatile fatty acids

5 General principles

5.1 General

The principles of safety, reliability, stability and economic viability and sustainability should be incorporated in the design of the treatment and reuse system for the MSW leachate. The quality of treated leachate should meet requirements for water reuse applications, be appropriate and safe for end users and protect human health and the environment from the adverse impacts of pathogens, toxic chemical contaminants and nutrients contained in the leachate.

5.2 Safety

The MSW leachate can contain highly concentrated salts, refractory organics, ammonium nitrogen, pathogens and heavy metals, which can impact human health, the environment and equipment. For example, highly concentrated salts can cause soil salinization, scaling and corrosion of equipment. Organics and ammonium nitrogen can pollute water. Heavy metals and pathogens can impact human health. It is important to take into consideration the quality of treated leachate in terms of physical, chemical and microbiological indicators to ensure safe reuse.

Mature and reliable technologies should be applied to attaining required effluent and reuse quality, as well as minimizing adverse environmental impacts. Validated and verified new technologies, processes, materials and equipment can also be adopted to improve treatment efficiency and effectiveness, optimize operation and management, save energy and reduce capital expenditure (CAPEX) and operating expenditure (OPEX). In addition, the quantity and quality of the leachate, the objectives of treatment, the intended purpose for water reuse, technological performance of the treatment facilities, location of the treatment facilities and land availability should be considered in the selection of technology and design of the process.

5.3 Reliability

The characteristics of the MSW leachate should be considered to ensure that the treatment and reuse system can perform its prescribed function without failure and the effluent quality can meet the demand of intended reuse purposes. The following aspects should be considered to ensure the reliability of the treatment and reuse system:

a) the peak leachate quality and quantity;

b) the demand for water reuse applications;

c) redundancy of systems and/or equipment;

d) effectiveness and efficiency of treatment technologies and processes;

e) monitoring programme, including operational monitoring, water quality monitoring, alarm systems and response plans for critical aspects to detect the performance of treatment processes and effluent quality;

f) operations, control and proactive maintenance.

5.4 Stability

When designing the treatment system, the operational stability and effluent quality stability should be assessed to ensure that the requirements of intended reuse applications are met. In view of the complexities of the leachate quality, a combined process approach and online monitoring system should be adopted to reduce the risks of effluent non-compliance. Redundant systems can also be considered, which involves the addition of measures beyond the minimum needs to ensure performance targets are consistently achieved.

The stability of treated leachate quality should also be considered by assessing parameters, such as pH, alkalinity, temperature, hardness, anions such as sulfate and chloride and cations such as calcium and magnesium.

5.5 Economic sustainability

Economic evaluations should consider both CAPEX and OPEX. CAPEX includes acquiring property, plants, buildings, technology or equipment. OPEX includes operation, maintenance and repair. An economic and technological comparison between different technologies should be conducted, taking into account, for example, quality and quantity of the leachate, demand of water reuse applications and energy cost, before designing a proper leachate treatment system.

5.6 Environment

The reuse of treated leachate should consider the environmental impacts of contaminants in leachate. Water sampling should be at the main outlet of the reclaimed water system.

Preventive measures should be implemented to avoid adverse impacts caused by residual sludge, odour, concentrate and noise generated during the operation of the leachate treatment and reuse system on the ambient ecosystem (soil, air quality, noise levels and surface and groundwater).

6 Quantity and quality of the MSW leachate

6.1 Quantity

MSW leachate is generated principally by flushing the unloading platform and waste stacking and fermenting, as shown in Figure 1. The determination of the quantity of leachate produced is of critical concern for the design and operation of the treatment and reuse system. In general, the quantity of the leachate generated from waste stacking and fermenting can be estimated based on the available data from local MSW incineration plants or those in other similar regions. In the absence of reference information, the quantity of the leachate can be estimated according to the MSW moisture content and duration of waste stacking and fermenting. The quantity of flushing water can be estimated based on the water consumption in a single flushing and the frequency of flushing. Cases of leachate quantity data are given in Annex B.

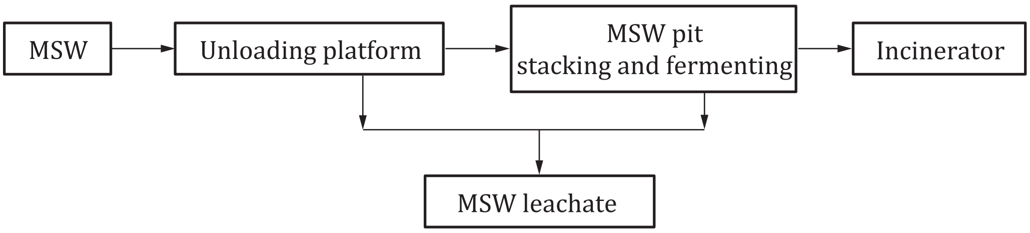

Figure 1 — Flow chart of a typical MSW incineration plant

6.2 Quality

The MSW leachate varies in composition depending on the type of waste, and it can contain high concentrations of organic matters, ammonium nitrogen and salts. Concentration of COD_{Cr} can reach tens of thousands of milligrams per litre. Concentration of ammonium nitrogen and salts can also reach several thousand milligrams per litre. The high concentrations of contaminants bring challenges to the treatment process and if not treated properly can pose a potential risk to the environment. The quality characteristics of the leachate affect the design and operation of the treatment process. The readily biodegradable organic matter contained in MSW leachate makes biological processes practicable for treatment. However, the high concentrations of ammonium nitrogen and high salinity in the MSW leachate should be noted, as they can inhibit the microbial activity and thus affect the effectiveness and efficiency of the biological treatment process or overwhelm the biological treatment.

The typical ranges of quality characteristics of the MSW leachate are given in Table 1. When data on the leachate quality are unavailable, the value ranges given in Table 1 can serve as a reference for MSW incineration power plants.

Table 1 — Characteristics of the leachate quality[9]–[17]

Parameter	Units	Values
COD_{Cr}	mg/l	20 000 to 75 000
BOD_5	mg/l	10 000 to 50 000
NH_4^+-N	mg/l	500 to 2 500
TP	mg/l	50 to 150
TN	mg/l	1 500 to 3 000
SS	mg/l	1 000 to 15 000
pH	—	5 to 7
SO_4^{2-}	mg/l	50 to 3 000
S^{2-}	mg/l	0 to 50
TDS	mg/l	10 000 to 25 000
Cl^-	mg/l	500 to 5 000
Na	mg/l	1 000 to 4 000
Mg	mg/l	300 to 1 500
Ca	mg/l	500 to 6 000
Fe	mg/l	0 to 1 000
Mn	mg/l	0 to 50

Table 1 *(continued)*

Parameter	Units	Values
Zn	mg/l	0 to 50
Pb	mg/l	0 to 8
Ni	mg/l	0,05 to 5
As	µg/l	40 to 120
Pd	mg/l	0,05 to 0,2
Cr	mg/l	0,05 to 1,5

6.3 Influencing factors and considerations

The quantity and quality of the MSW leachate are affected by factors such as waste classification, waste collection and transportation system, composition of domestic waste, separation of organics and plastics, moisture content, duration of stacking and fermenting, seasonal changes, local climate and residents' living habits (Annex D). The varying waste classification systems from different areas can change the composition and moisture content of MSW and can impact the quantity and quality of leachate. In the rainy season or in rainy areas, the entry of rainwater during waste collection and transportation can increase the quantity of leachate and at the same time lower the concentration of the pollutants. Therefore, the factors mentioned should be fully considered when estimating the quantity and quality of the leachate.

In determining the quantity and quality of leachate, data comparisons with local MSW incineration plants and/or those in similar areas should also be considered in estimating ranges of the quality and quantity of the MSW leachate. To ensure that the MSW leachate can be treated in a timely manner, fluctuations of the quality and quantity of the leachate, and required operating time, should be considered in determining the capacity of the treatment system.

7 Treatment system design for the MSW leachate

7.1 Treatment process

MSW leachate has a high concentration of pollutants with complex constituents. Treatment process combinations with several different technologies are required to ensure the reliability and stability of the treatment system. The leachate treatment system (Figure 2) normally comprises preliminary treatment, biological treatment and advanced treatment. In some cases, the combined processes of preliminary treatment + advanced treatment or biological treatment + advanced treatment can also be adopted, depending on the quantity and quality of the leachate to be treated and the requirements for reclaimed water quality and use.

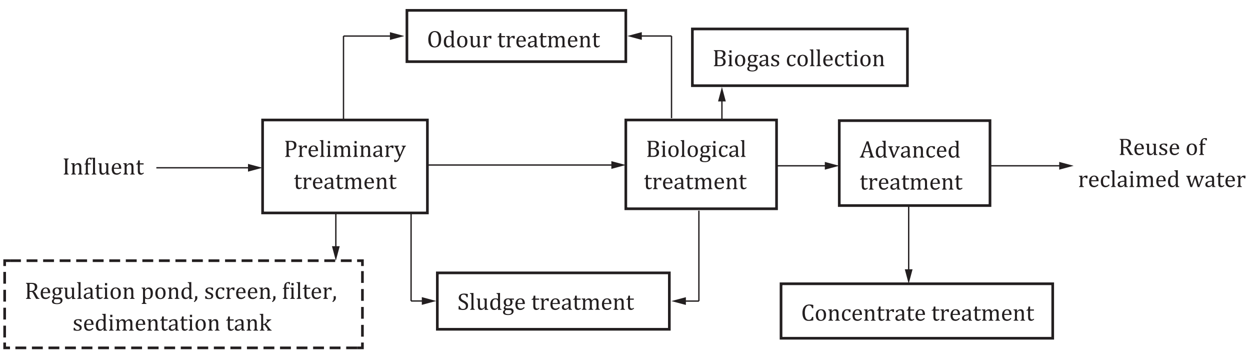

Figure 2 — Process flow chart of the leachate treatment system

To increase safety and address reliability concerns, if temporary interruptions are not allowed or alternative water resources are not available, equipment redundancy is required to ensure