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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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 16075-5 was prepared by Technical Committee ISO/TC 253, *Treated Wastewater Use for Irrigation Projects*, Subcommittee SC , .

This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

ISO 16075 consists of the following parts, under the general title *Guidelines for Treated Wastewater Use for Irrigation Projects*:

— *Part 1: General*

— *Part 2: The Basis of a Reuse Project for Irrigation*

— *Part 3: Development of the project*

— *Part 4: Components of a reuse project for irrigation*

— *Part 5: Monitoring*

ISO/CD 16075-5

Introduction

This international Guide considers the parameters of treated wastewater quality, including maximum concentration values of substances, in order to prevent or minimize damage to soil, flora and water sources (surface or groundwater) or health hazards.

The parameters are classified as:

— Health issues

— Nutrients

— Salinity factors

— Trace elements (heavy metals)

TBC – Karl

Guidelines for Treated Wastewater Use for Irrigation Projects — Part 5: Monitoring

1 Scope

This part of the international standard provides recommendations regarding:

— Monitoring the quality of treated wastewater for irrigation

— Monitoring irrigated plants

— Monitoring the soil with regard to salinity

— Monitoring natural water sources in neighboring environment

It puts emphasis on sampling methods and on the frequency. Regarding the methods of analysis the guide refers to standard methods or other bibliographical references.

2 Normative references

TBC – Yaron Ben Ari

3 Terms and definitions

3.1 General

3.1.1
barrier
any means that reduces or prevents the danger and/or contacts between the treated wastewater and the ingested produce, thus reducing the risk of human infection

3.1.2
environment
surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation

3.1.3
food crops
crops which are intended for direct human consumption, often further classified as to whether the food crop is to be cooked, processed or consumed raw

3.1.4
health and environmental aspect
element of an organization's activities, projects or products that can interact with the health or the environment

3.1.5
health and environmental impact
any change to the environment, whether adverse or beneficial, wholly or partly resulting from the health and environmental aspects of an organization or a project

3.1.6
health and environmental parameter
quantifiable attribute of a health and environmental aspect

3.1.7
health and environmentally conscious design (HECD)
systematic approach which takes into account health and environmental aspects in the design and development processes with the intention to reduce adverse health and environmental impacts

3.1.8
irrigation project
development, construction, selection of equipment, operation and monitoring of works to provide suitably treated wastewater for appropriate reliable irrigation

3.1.9
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to the final disposal

3.1.10
life cycle assessment (LCA)
compilation and evaluation of the inputs, outputs and the potential health and environmental impacts of a product system throughout its life cycle

3.1.11
non-food crops
crops not for human consumption such as: fodder, fiber, and seed crops, pasture land, commercial nurseries, and turf farms

3.1.12
organization
group of people and facilities with an arrangement of responsibilities, authorities and relationships

3.1.13
phreatic aquifer
water bearing layer in the ground that overlays an impermeable layer but above the aquifer are layers of soil that are permeable enough to permit the vertical passage of water

3.1.14
process
a set of interrelated or interacting activities which transform inputs into outputs

NOTE 1 inputs to a process are generally outputs of other processes.

NOTE 2 processes in an organization are generally planned and carried out under controlled conditions to add value.

3.1.15
product
any goods or services

NOTE This includes interconnected and/or interrelated goods or services.

3.1.16
soil
layer of unconsolidated material consisting of weathered material particles, dead and living organic matter, air space and the soil solution

3.1.17
soil solution
liquid phase of the soil and its solutes

3.1.18
stakeholder
individual, group or organization that has an interest in an organization or activity

NOTE usually a stakeholder can affect or is affected by the organization or the activity

3.2 Use of treated wastewater (TWW)

3.2.1 Agricultural use

3.2.1.1
restricted agricultural irrigation
irrigation of certain agricultural crops that have been permitted for irrigation, depending on the treated wastewater quality and the barriers which have been defined by the rules

3.2.1.2
unrestricted agricultural irrigation
irrigation of any agricultural crops with no restrictions whatsoever.

3.2.2 Urban use

3.2.2.1
gardens
public and private gardens, parks, road vegetation including lawns and turfed recreational areas

3.2.2.3
restricted urban use for irrigation
irrigation of areas in which public access during irrigation can be controlled, such as golf courses, cemeteries, and highway medians

3.2.2.4
unrestricted urban use for irrigation
irrigation of areas in which public access during irrigation is not restricted, such as gardens and playgrounds

3.2.3
environmental use
wastewater used to create artificial wetlands, enhance natural wetlands, and sustain or augment natural water bodies

3.3 Wastewater

3.3.1
excellent quality treated wastewater
treated wastewater which has undergone physical and biological treatment followed by filtration, through the soil or ultrafiltration or reverse osmosis membranes, and its microbiological quality is equivalent to the water quality required by the local Drinking Water Quality Regulations

3.3.2
extensive treated wastewater
wastewater which has been treated in plant that occupies a relatively large area of ground such as: earth embankment ponds, oxidation ponds, wetlands, etc.

3.3.3
extra high quality treated wastewater
treated wastewater which has undergone physical and biological treatment and disinfection, and its quality is: BOD ≤ 10 mg L^{-1}, TSS ≤ 10 mg L^{-1}, turbidity ≤ 2 NTU (at 80% of the monthly results for the three parameters) and fecal coliforms = 0/100 mL (as the monthly median) and not more than 14/100 ml in any test. The

disinfection should be equivalent to a chlorine dose value (CT) ≥ 30 mg L^{-1}*min (corresponding to a residual chlorine ≥ 1 mg L^{-1} measured after 30 min contact time).

NOTE In cases where disinfection other than by chlorine is carried out, such as UV or ozone treatment, there is a need for other reliable means of control on the effectiveness of the disinfection, instead of the level of residual chlorine

3.3.4
very high quality treated wastewater
treated wastewater which has undergone physical and biological treatment and disinfection, and its quality is: BOD ≤ 10 mg L^{-1}, TSS ≤ 10 mg L^{-1}, turbidity ≤ 5 NTU (at 80% of the monthly results for the three parameters) and fecal coliforms ≤ 10/100 mL (as the monthly average) and not more than 40/100 ml in any test. The disinfection should be equivalent to a chlorine dose value (CT) ≥ 30 mg L^{-1} *min (corresponding to a residual chlorine ≥ 1 mg L^{-1} measured after 30 min contact time).

NOTE In cases where disinfection other than by chlorine is carried out, such as UV or ozone treatment, there is a need for other reliable means of control on the effectiveness of the disinfection, instead of the level of residual chlorine

3.3.5
high quality treated wastewater
wastewater which has undergone physical and biological treatment, resulting in a monthly average quality of: BOD < 20 mg L-1 and TSS < 30 mg L-1 (both as monthly averages)

3.3.6
medium treated wastewater
wastewater which has undergone physical and biological treatment, resulting in a monthly average quality of: BOD < 60 mg L-1 and TSS < 90 mg L-1 (both as monthly averages)

3.3.7
low-quality quality treated wastewater
wastewater which has undergone physical and biological treatment, resulting in a monthly average quality of: BOD > 60 mg L-1 and TSS > 90 mg L-1 (both as monthly averages)

3.3.8
primary effluent
effluent from a primary treatment stage of a wastewater treatment plant

3.3.9
raw wastewater
urban wastewater which has not undergone any treatment

3.4 Irrigation systems

3.4.1
boom sprinkler
composed by two symmetrical pipes (boom), with sprinkler nozzles distributed in one of the pipes, being the sprinkler action complemented by a gun sprinkler placed at each end of both pipes; the nozzles work through a reaction effect (similar to a hydraulic tourniquet) which drives the boom rotation at a desired speed.

3.4.2
center-pivot
rotates continuously, each revolution lasts 12 to 96 h

3.4.3
continuous linear move laterals
moving in a straight path, applying small and frequent irrigation in very large areas

3.4.4
continuous move laterals
consists of a long lateral (several hundred meters) equipped with sprinklers or sprayers, which is moving continuously at a controlled low speed, and generally electrically driven. There are two main systems: center-pivot and continuous linear move laterals

3.4.5
drip (or trickle) irrigation systems
this system is characterized by water point sources (drippers or trickles), generally equally spaced along the laterals, operating at low inlet pressure heads and small discharges (2-10 L h^{-1}). The laterals and drippers can be placed above the soil surface – surface drip irrigation – or under the soil surface – sub-surface drip irrigation

3.4.6
gravity flow irrigation systems
network under atmospheric pressure used to water plants **TBC - Bruno Molle**

3.4.7
gun sprinklers
very large rotating sprinklers with high discharges (40 – 120 m^3 h^{-1}) at high operating pressure (4–8 bar)

3.4.8
micro-irrigation systems
small amounts of water are applied near the roots of plants, as drops, tiny-streams or mini-spray. Surface and sub-surface drip irrigation and micro-spray irrigation are the main types of this system **TBC - Bruno Molle**

3.4.9
micro-spray irrigation systems
this system is characterized by water point sources similar to sprinkler´s miniatures (micro-sprinklers), which are placed along the laterals, with a flow rate between 30 and 150 L h^{-1} at pressure heads of 15-25 m, and the corresponding wetted area between 2 and 6 m

3.4.10
mobile sprinkling machine
sprinkling unit which is automatically moved on the soil surface during the water application

3.4.11
perforating pipe system
consists of perforated irrigation pipes, operating at low pressure

3.4.12
permanent system
a complete network located in a fixed position

3.4.13
portable system
a network and\or its elements that can be removed

3.4.14
pressurized irrigation systems
piped network under pressure, used to water plants **TBC - Bruno Molle**

3.4.15
rotating sprinklers
consist of a perforated hollow arm mounted on a pivot. Its rotation is driven by the dynamic reaction of the water discharging

3.4.16
self-moved system
unit where a lateral is mounted on wheels and is moved as a whole; rotating sprinklers/sprayers are placed on the lateral

3.4.17
self-propelled gun traveller
gun sprinkler that is moved continuously by hydraulic forces

3.4.18
semi-permanent system
similar to the semi-portable system, but with portable laterals and permanent pumping plant, main lines and sub-mains

3.4.19
semi-portable system
similar to the portable system, except that the water source and the pumping plant are fixed

3.4.20
solid-set system
temporary fixed network, where the laterals are positioned in the field during all the irrigation season

3.4.21
sprinkler irrigation systems
water is sprayed into the air, and falls on the soil surface, like rainfall **TBC - Bruno Molle**

3.4.22
stationary sprinkler systems
network of fixed sprinklers

3.4.23
open irrigation systems
open channelled network used to water plants, where water is applied directly to the soil surface from a channel **TBC - Bruno Molle**

3.5 Wastewater system related components

3.5.1
storage reservoirs
wastewater is produced throughout the year. The use of treated wastewater in most cases takes place only during part of the year and at varying quantities according to crop demand. Therefore, it is generally required to build storage reservoirs for the temporarily-unused treated wastewater, to enable its exploitation during irrigation periods and in periods where consumption exceeds its production

3.5.2
treated wastewater disinfection facilities
certain uses require adequate disinfection

3.5.3
treated wastewater filtration facilities
in some cases it is required to filter the treated wastewater for health, environmental or technical reasons of the irrigations systems. Therefore, the filtration systems often form a part of the treated wastewater use system

3.5.4
treated wastewater pumping stations and transport systems
system of pipelines and pumps transporting the treated wastewater from the WWTP to storage reservoirs and to the use site

3.5.5
wastewater collection system
main and secondary drains and sewers (most of which are gravity driven and some pressurized) and pumping stations, collecting wastewater from the local households and factories and transporting it to the wastewater treatment plant (WWTP)

3.5.6
wastewater treatment plant (WWTP)
system of facilities designed to treat wastewater by a combination of physical unit (mechanical) and chemical and biological processes, for the purpose of reducing the concentration of organic and inorganic contaminants in the wastewater. There are different levels of wastewater treatment, according to the desired quality of treated wastewater (TWW) and the level of contamination

4 Monitoring of the quality of treated wastewater for irrigation

4.1 Wastewater Sampling

4.1.1 Sampling procedure

4.1.1.1 Sampling from the irrigation system

The purpose of such sampling is to determine the sanitary conditions, nutrient and salts content in the Treated Wastewater (TWW) for irrigation.

The following steps describe the procedure:

1) turn on the irrigation until the system operates on full designed pressure and let the system irrigate until fresh treated wastewater has filled the pipes

2) collect a sample from a control filter or from an irrigation emitter (a sprinkler, micro-jet or a dripper)

NOTE Sampling the water should not be taken when fertigation (fertilization through irrigation) is taking place

3) sample the water into a clean 1lt. Bottle

4) write all necessary details on a sticker attached to the bottle (Name, address, date, location, etc.) and seal the lid

TBC *ISO Standards* – Yaron Ben Ari

4.1.1.2 Sampling from the reservoir

In order to evaluate the treatment degree and efficiency, a sample from the reservoir itself is required.

The following steps describe the procedure:

— It is recommended to take the sample as close as possible to the pumping point.

— Avoid sampling downwind.

— Tie an empty bottle to a weight and attach both to a pole.

— Lower the bottle so that the neck is within the top 100 mm and fill the bottle.

— Extract the bottle, seal it and indelibly label the bottle

TBC ISO Standards – Yaron Ben Ari

4.1.1.3 Composite sample

The purpose of such a sample is to characterize the TWW entering the reservoir. Fluctuations in sewage composition can occur (day of the week, hour of the day). Therefore, a simple arbitrary sample may not represent correctly the TWW composition. Therefore, it is recommended to use an automatic sampler to take samples over a period of a few days or weeks.

4.1.1.4 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 4ºC.

TBC ISO Standards – Yaron Ben Ari

4.1.2 Treated Wastewater Monitoring plan

The monitoring plan to characterize TWW used for irrigation is presented in Table 1. The table includes the parameters to be tested, and the sampling frequency of the TWW flowing to reservoirs, directly to irrigation or from reservoirs.

Table 1 — Monitoring plan for treated wastewater intended for agricultural irrigation

Parameter	Units	Sampling Method	Sampling frequency from WWTP (1)	Samplin g Method	Sampling frequency for TWW reuse system emitting over 10,000 m^3/day (2)	Sampling frequency for TWW reuse system emitting up to 10,000 m^3/day (2)
Electrical conductivity	dS/m	Composite[a]	Once a month	Grab	Once every 2 months	Once every 4 months
BOD[b]	mg L^{-1}	Composite	Once a week	Grab		
COD	mg L^{-1}	Composite	Once every 2 weeks	Grab		
TSS 105ºC	mg L^{-1}	Composite	Once a week	Grab		
Fecal coliform *	Unit per 100 ml	Grab[c]	Once a week	Grab	Once a year	Once a year
Residual chlorine *	mg L^{-1}	Composite	Once a week	Grab	Once a month	Once every 2 months
Ammonium nitrogen as N	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months
Total nitrogen	mg L^{-1}	Calculated	Once a month	Grab	Once every 2 months	Once every 4 months
TKN	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months

Nitrate as N	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months
Nitrite as N	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months
Total phosphorus	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months
Chlorides	mg L^{-1}	Composite	Once every 2 weeks	Grab	Once a month	Once every 2 months
Fluoride	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Sodium	mg L^{-1}	Composite	Once every 2 weeks	Grab	Once a month	Once every 2 months
Dissolved oxygen	mg L^{-1}	Grab	Once every 2 weeks	Grab	Once a month	Once every 2 months
pH	mg L^{-1}	Grab	Once every 2 weeks	Grab	Once a month	Once every 2 months
Mineral oil	mg L^{-1}	Grab	Twice a year	Grab	Once a year	Once a year
MBAS	mg L^{-1}	Grab	Twice a year	Grab	Once a year	Once a year
SAR	$(mmol\ L^{-1})^{0.5}$	Calculated	Twice a year	Grab	Twice a year	Once a year
Boron	mg L^{-1}	Composite	Once a month	Grab	Once every 2 months	Once every 4 months
Calcium	mg L^{-1}	Composite	Twice a year	Grab	Twice a year	Once a year
Magnesium	mg L^{-1}	Composite	Twice a year	Grab	Twice a year	Once a year
Potassium	mg L^{-1}	Grab	Twice a year	Grab	Twice a year	Once a year
Hardness	mg L^{-1}	Grab	Twice a year	Grab	Twice a year	Once a year
Arsenic	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Barium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Mercury	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Chromium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Nickel	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Selenium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Lead	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Cadmium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Zinc	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year

Iron	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Copper	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Manganese	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Aluminum	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Molybdenum	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Vanadium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Beryllium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Cobalt	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Lithium	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year
Cyanide	mg L^{-1}	Composite	Twice a year	Grab	Once a year	Once a year

* Only if it is necessary according to the quality of the TWW(1) - Only where the irrigation is directly derived from the WWTP(2) - Where the irrigation is from seasonal reservoir.

a Daily composite sampling – sampling, proportional to the treated wastewater flow rate, which is carried out by collecting samples at a frequency of at least once an hour for 24 consecutive hours, either each sample is stored in a separated cooled vessel and at the end of the 24 hours, the samples are added to a single cooled vessel, or the samples are all collected into a single cooled vessel.

b BOD can be determined in treated wastewater intended for irrigation also by using nitrification inhibitors.

c These parameters require composite sampling. However, if the discharge takes place from a reservoir after retention time of at least 5 days, and subject to any necessary approval of authorities, these parameters may be sampled by grab sampling. However, at direct discharges from the WWTP, these parameters should be sampled only by composite sampling.

The monitoring program should be adapted to the local conditions in each region. The program presented in the tables above serves as an example.

4.2 Test methods for Treated Wastewater for irrigation

Methods for testing treated wastewater for irrigation should be performed in accordance with National Standards.

Where no national standards exist, international ISO or regional standards may be used, or reference can be made to recognised test procedures[1].

5 Monitoring of the irrigated crops

There are two ways to monitor plots irrigated with TWW through the crop: visually to detect shortage or excess of elements or through analyzing and examining a part of the crop. The visual method may not be able to prevent salinity damage to the crops or avoid yield loss; the same applies to shortage in substances. The laboratory analysis is usually performed on a leaf sample, since the results are capable to examine toxic growth substances (chloride, boron, sodium) as well as nutritious substances (nitrogen, phosphorus, potassium and the like, including micro-substances). For perennial crops the results obtained in the current season enable to determine the fertilization program for the following season. One-year crops can be tested and inspected immediately, but this requires rapid organization and availability of the laboratory to produce the results quickly while they are pertinent to the crop.

Occasionally, a comparative analysis between damaged and healthy leaves can be conducted when there is a visual sign for leaf damage and it is difficult to verify the cause of the damage. In this manner, it is easy to detect the source of the damage. This method is used due to lack of criteria for normal concentration of substances in crops leaves.

The sampling method of leaves and the laboratory sampling techniques are not within the scope of this standard, therefore users should examine the appropriate method for each crop in the professional literature.

6 Monitoring of the soil with regard to salinity

6.1 Soil Sampling

Irrigating with treated wastewater may lead to greater salt application to the soil and the plants. In order to prevent damage and to adjust the irrigation management optimally, it is recommended to continuously or periodically carry out soil monitoring.

Regarding salinity management, see Informative Annex A.

The recommended threshold values for Chlorides and Total nitrogen for all irrigation waters are:

Chlorides: 150 mg L^{-1} or EC of 1 dS/m;

Total nitrogen: 25 mg L^{-1}

NOTE the amount of nitrogen in the treated wastewater should be determined with reference to the necessary crop fertilization.

6.1.1 Timing of the soil sampling

The first sampling during the irrigation season should be at the beginning of the irrigation season. Afterwards, it is recommended to sample the soil every four to six weeks. Sampling frequency depends on water quality and soil type**.**

6.1.2 Sampling procedure

Drip irrigation – Soil samples should be taken along the drip lateral, at about 10 cm distance from the dripper, to depths of 0-30, 30-60 and 60-90 cm. The upper 3-5 cm. of the soil surface should be discarded. About 20 randomly sampled samples should be taken from a plot in order to have a representative and random composite sample. Each composite sample of a certain depth should be put in a separate bag.

Sprinkler and micro-jet irrigation – Soil samples should be taken at about 70-100 cm distance from the micro-jet and at about 100-120 cm distance from the mini sprinkler. The distance should be within the range of the discharge and water distribution of the emitter. The same depths and number of samples for a composite representative and random sample should be taken as specified for drip irrigation.

The following steps describe the procedure:

- Each composite sample of a certain depth should be well mixed.
- About 1 kg of the mixed sample should be put in a bag on which all details are recorded (Name, address, plot, crop, date of sampling, depth, etc.)
- The samples should be delivered as soon as possible to the laboratory

6.2 Soil test methods

Soil methods for analysis must be adapted to the characteristics of soils in each area. The main differences are based on pH and soil texture.

7 Monitoring of the neighbouring environment

7.1 General

Hydrological systems are complex by nature, mainly due to the high heterogeneity of soils and rocks. Therefore, there is a considerable risk that the hydraulic tests carried out in the field may not adequately represent the hydraulic conditions.

Where groundwater protection is concerned, a major risk is the existence of preferential flow routes, mainly through soil cracking, which have not been identified. For that reason, environmental monitoring is important to detect any contamination that develops.

This clause deals with the methods of monitoring of surface water systems and groundwater systems, rivers, lakes.

The Guideline does not address especially sensitive hydrological systems, i.e. cases where there is a surface body of water in great proximity to the areas irrigated by treated wastewater. Such cases may require a much denser sampling layout, both spatially and frequently.

7.2 Water Sampling in channels of surface runoff

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7.3 Water sampling in rivers and lakes

The surface water sampling stations will be established downstream of the upper hydrological system, at least one station per area of 10 km² irrigated by treated wastewater (and not less than one station for each area irrigated by treated wastewater located in a different drainage basin).

Water sampling should be carried out at least once every half a year (semi-annually), where in the first year of using the treated wastewater, sampling will be gathered at intervals of at least once a month.

Sampling will include all the parameters mentioned in the TWW sampling (see clause 7.2).

Values of measurements, which are 150 % or more above that permitted for irrigation will be considered an anomalous results. Such results require three additional measurements within three days.

An average value (for the four measurements) that exceeds 150 % of the specified threshold values requires immediate interruption of the irrigation with treated wastewater until the source of contamination is identified and a thorough hydrological examination has been conducted.

7.4 Groundwater monitoring stations

If there is groundwater beneath the area irrigated by treated wastewater, a network of piezometers should be set up in the irrigated area. This network should include at least one piezometer for an area of 10 km² (and in any case not less than three piezometers).

The piezometers should be located at a depth of at least 1 m more than the minimum groundwater level at that location, with the piezometer’s wall being perforated at least in the entire section between the location’s minimum and maximum groundwater levels.

Groundwater sampling should be carried out in all piezometers twice a year (semi-annually), where in the first year of operation sampling will take place once a month. The sampling should be carried out by pumping a volume of at least 10 times the water volume found in the piezometer (i.e. sampling will be active rather than passive).

The sampling should include all the components mentioned in determining the quality of treated wastewater for irrigation in the summary of criteria section 4). Values of measurements which are 150 % or more above the recommended threshold values for irrigation (see tables XX to XX) will be considered an anomalous result. Such result requires three additional measurements within three days. An average value (for the four measurements) that exceeds 150 % of the recommended threshold value requires immediate interruption of the irrigation with treated wastewater until the source of contamination is identified and a thorough hydrological examination is conducted.

Annex A
(informative)

Salinity Management and Drainage (Underground and runoff)

A.1 Salinity management

Several techniques may be used to manage salinity. Some conventional techniques may develop contamination problems, mainly through leaching processes. This contamination is higher in open irrigation systems, followed by sprinkle irrigation. Drip irrigation systems are those with lower contamination problems. However, when leaching is used, a high controlled care must be adopted concerning soil slopes, water table depth, soil permeability and water capillary rise. Conventional techniques to control the salination process can be characterized as follows:

1) Problem of root zone salination by soil leaching - two options can occur - when there is an impermeable layer, salts will be concentrated above this layer; on the other hand, when there is no impermeable layer, aquifers contamination can be observed.

2) Use of subsurface trickle irrigation - economy of water, and therefore less additional salts; however the problem of groundwater contamination due to natural rain or artificial leaching remains.

3) Enhanced fertilization increases plant tolerance to salinity, but plant sensitivity (the rate of yield reduction per unit of salinity) also increases. Several other fertilizers, such as potassium and calcium, will increase the plant's tolerance, but with lower effects than the nitrogen increases also; but the contamination will increase by other hazardous chemicals such as nitrate.

4) Use of salt tolerant species - this technique will be very useful to the plants, but it does not solve the problem of soil or groundwater contamination.

When using saline wastewater, the only way as to control the salination process and to maintain the sustainability of landscape and agricultural fields is to solve the salination problems by using environmentally safe and clean techniques, such as:

— Using salt (ions) phytoremediation techniques (salt removing high capacity species), to remove salts (ions), from the environment and to render them harmless

— Using drought tolerant crops species, because less water is applied and, therefore, less salt is infiltrated

— Reducing salt application by deficit irrigation

— Applying minimal levels of water to obtain a good visual appearance of the plant. These clean and environmental safe procedures to control salinity should be combined with the conventional techniques (generally more efficient), in order to improve the environmental, economic and social aspects of the salinity management

A.2 Drainage

TBC – Karl

TBC – Yaron Ben Ari – Possible ISO Standards that may be referenced and used in the PC253 Guidelines:

ISO 5667-1:2006, *Water quality -- Sampling -- Part 1: Guidance on the design of sampling programmes and sampling techniques*

ISO 5667-3:2003, *Water quality -- Sampling -- Part 3: Guidance on the preservation and handling of water samples*

ISO 5667-4:1987, *Water quality -- Sampling -- Part 4: Guidance on sampling from lakes, natural and man-made*

ISO 5667-6:2005, *Water quality -- Sampling -- Part 6: Guidance on sampling of rivers and streams*

ISO 5667-10:1992, *Water quality -- Sampling -- Part 10: Guidance on sampling of waste waters*

ISO 5667-11:2009, *Water quality -- Sampling -- Part 11: Guidance on sampling of groundwaters*

ISO 5667-14:1998, *Water quality -- Sampling -- Part 14: Guidance on quality assurance of environmental water sampling and handling*

ISO 5667-16:1998, *Water quality -- Sampling -- Part 16: Guidance on biotesting of samples*

ISO 5667-17:2008, *Water quality -- Sampling -- Part 17: Guidance on sampling of bulk suspended solids*

ISO 5667-20:2008, *Water quality -- Sampling -- Part 20: Guidance on the use of sampling data for decision making -- Compliance with thresholds and classification systems*

ISO 5667-22:2010, *Water quality -- Sampling -- Part 22: Guidance on the design and installation of groundwater monitoring points*

ISO 5667-23:2011, *Water quality -- Sampling -- Part 23: Guidance on passive sampling in surface waters*

ISO 9213:2004, *Measurement of total discharge in open channels - Electromagnetic method using a full-channel-width coil*

ISO 11074:2005, *Soil quality -- Vocabulary*

ISO/TS 13530:2009, *Water quality -- Guidance on analytical quality control for chemical and physicochemical water analysis*

ISO 15175:2004, *Soil quality -- Characterization of soil related to groundwater protection*

ISO 19458:2006, *Water quality -- Sampling for microbiological analysis*

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[4] Methods of Soil Analysis: Chemical Methods. Part 3. Soil Science of America Book Series. Second Edition. 1986. D.L. Sparks, editor