

STANDARDS FOR WASTEWATER RE-USE

1. JORDAN

Relevant legislation includes:

1.1 INSTRUCTIONS FOR THE DISCHARGE OF NON-DOMESTIC WASTEWATER INTO THE SEWAGE

These instructions detail the characteristics of the wastewater resulting from the use of water in any non-domestic activity, whether treated or not, including industrial, agricultural, commercial, service and municipal activities which contain additional contaminants, laboratories and studios , Fuel stations, laundries, lubrication stations, slaughterhouses, butcheries, poultry farms and cows, olive and sesame presses, workshops, professional workshops, water desalination plants, hotels, malls, restrooms, restaurants and more.

According to these instructions, the characteristics of any wastewater or substances that discharged into the sewerage system shall not exceed the upper limits in the next Table.

No	Characteristic	Symbol	unit	Maximum allowable limit
1	pH	pH	-	5.5-9.5
2	Temperature	C ⁰	C ⁰	65
3	Total Suspended Solids	TSS	mg/l	700
4	Total Dissolved Solids	TDS	mg/l	2000
5	Ammonia	NH4	mg/l	120
6	Phosphorus	PO4	mg/l	30
7	Total Nitrogen	TN	mg/l	100

No	Property	sign	unit	Maximum allowable limit
1	Fat, Oil & Grease	FOG	mg/l	100
2	Chemical detergents	MBAS	mg/l	40
3	Hydrogen Sulfides	H2S	mg/l	10
4	Phenols	-	mg/l	5
5	Chemical Oxygen Demand	COD	mg/l	1500

No	Property	sign	unit	Maximum allowable limit
1	Cyanide**	CN	mg/l	0.1
2	Chrome*	Cr	mg/l	3
3	Copper*	Cu	mg/l	3
4	Nickel*	Ni	mg/l	4
5	Cadmium*	Cd	mg/l	0.5
6	Arsenic	As	mg/l	1
7	Barium	Ba	mg/l	5
8	Lead*	Pb	mg/l	0.6
9	Manganese	Mn	mg/l	5
10	Silver *	Ag	mg/l	1
11	Boron	B	mg/l	3
12	Mercury*	Hg	mg/l	0.1
13	Iron	Fe	mg/l	30
14	Zink	Zn	mg/l	10
15	Cobalt*	Co	mg/l	1
16	Selenium*	Se	mg/l	0.5
17	Aluminum	Al	mg/l	3

*Provided that the total of these elements shall not exceed 10 mg/l and the Authority shall have the right to amend the above limits according to the needs

** Any liquid or substance containing cyanide or its compounds at a concentration that can result in 1 mg/l of hydrocyanic acid in the form of HCN

1.2 JORDANIAN STANDARD FOR RECLAIMED DOMESTIC WASTEWATER

Standard JS893/2006 was published in 2006, it is a modified version from the JS893/1995. It contains the reuse standards for irrigation, ground water recharge as well as discharge to water bodies and Wadies.

For the part of using treated wastewater for irrigation, the standard differentiate between 3 classes:

- Class A: for cooked vegetables, parks, playgrounds and roadsides within city limits
- Class B: for fruit trees, roadsides outside city limits and land-scape
- Class C: for field crops, industrial crops and forest trees.

Table would be good

1.3 JORDANIAN STANDARD FOR RECLAIMED INDUSTRIAL WASTEWATER NO. 202/2007

This Standard specifies the requirements and restrictions on the discharge of reclaimed industrial wastewater from industrial facilities or treatment plants to streams, wadies or water bodies, or reuse for irrigation purposes.

For the part of using treated wastewater for irrigation, the standard differentiates between 3 classes:

- Class A: for cooked vegetables, parks, playgrounds and roadsides within city limits
- Class B: for fruit trees, roadsides outside city limits and land-scape
- Class C: for field crops, industrial crops and forest trees.

Parameter	Unit	i. Cooked vegetables, parks, playgrounds sides of roads within city limits	ii. Fruit trees, sides of roads outside city limits, and landscape	iii. Field crops, industrial crops and forest trees	Cut Flowers	Wadi Discharge
Category A						
Biological Oxygen Demand (BOD)	mg/L	30	200	300	15	60
Chemical Oxygen Demand (COD)	mg/L	100	500	500	50	150
Dissolved Oxygen (DO)	mg/L	>2	-	-	>2	>2
Total Suspended Solids (TSS)	mg/L	50	200	300	15	60
pH	pH unit	6-9	6-9	6-9	6-9	6-9
Turbidity	NTU	10	N/A	N/A	5	15
Nitrate	mg/L	30	45	70	45	80
Ammonium	mg/L	-	-	-	-	5
TN	mg-N/L	45	70	100	70	70
E.coli	/100mL	100	1000	-	<1.1	1000
Helminthes	egg/L	≤1	≤1	≤1	<1	<0.1
Fat Oil and Grease (FOG)	mg/L	8	8	8	2	8
Category B						
Phenol	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002
Total Dissolved Solids (TDS)	mg/L	2000	2000	2000	2000	2000
Methyl Blue Active Substances (detergents) (MBAS)	mg/L	100	100	100	100	25
Total Phosphate	mg/L	30	30	30	30	15
Chloride	mg/L	400	400	400	400	350
Sulphate	mg/L	500	500	500	500	300
Bicarbonate	mg/L	400	400	400	400	400
Sodium	mg/L	230	230	230	230	-

Magnesium	mg/L	100	100	100	100	-
Calcium	mg/L	230	230	230	230	-
Aluminium	mg/L	5	5	5	5	2
Arsenic	mg/L	0.1	0.1	0.1	0.1	0.05
Beryllium	mg/L	0.1	0.1	0.1	0.1	0.1
Cooper	mg/L	0.2	0.2	0.2	0.2	1.5
Fluoride	mg/L	2	2	2	2	2
Iron	mg/L	5	5	5	5	5
Lithium	mg/L	0.075	0.075 (2.5 for citrus trees)	0.075	0.075	2.5
Manganese	mg/L	0.20	0.2	0.2	0.2	0.2
Molybdenum	mg/L	0.01	0.01	0.01	0.01	0.01
Nickel	mg/L	0.2	0.2	0.2	0.2	0.2
Lead	mg/L	0.2	0.2	0.2	0.2	0.2
Selenium	mg/L	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	5	5	5	5	5
Boron	mg/L	1	1	1	1	1
Chromium	mg/L	0.1	0.1	0.1	0.1	0.1
Mercury	mg/L	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	0.1	0.1	0.1	0.1	0.1
Cobalt	mg/L	0.05	0.05	0.05	0.05	0.05
Cyanide	mg/L	0.1	0.1	0.1	0.1	0.05
Sodium Absorption Ratio (SAR)	-	9	9	9	9	9
Color	cobalt unit	-	-	-	-	15
Temp change	°C	-	-	-	-	6

Notes: °C indicates degrees Celsius;
mg/L indicates milligrams per liter;
mg-N/L indicates milligrams nitrogen per liter;
NTU indicates Nephelometric Turbidity Unit;
/100mL indicates per 100 milliliters;
/L indicates per liter.

2. WHO-GUIDELINES

Guidelines for the safe use of wastewater, excreta and greywater (WHO, 2006), available at:

http://www.who.int/water_sanitation_health/publications/gsuweg4/en/

Table A1.1 Water quality for irrigation

Parameter	Units	Degree of restriction on use			
		None	Slight to moderate	Severe	
Salinity EC _w ^a	dS/m	<0.7	0.7–3.0	>3.0	
TDS	mg/l	<450	450–2000	>2000	
TSS	mg/l	<50	50–100	>100	
SAR ^b	0–3	meq/l	>0.7 EC _w	0.7–0.2 EC _w	<0.2 EC _w
SAR	3–6	meq/l	>1.2 EC _w	1.2–0.3 EC _w	<0.3 EC _w
SAR	6–12	meq/l	>1.9 EC _w	1.9–0.5 EC _w	<0.5 EC _w
SAR	12–20	meq/l	>2.9 EC _w	2.9–1.3 EC _w	<1.3 EC _w
SAR	20–40	meq/l	>5.0 EC _w	5.0–2.9 EC _w	<2.9 EC _w
Sodium (Na ⁺)	Sprinkler irrigation	meq/l	<3	>3	
Sodium (Na ⁺)	Surface irrigation	meq/l	<3	3–9	>9
Chloride (Cl ⁻)	Sprinkler irrigation	meq/l	<3	>3	
Chloride (Cl ⁻)	Surface irrigation	meq/l	<4	4–10	>10
Chlorine (Cl ₂)	Total residual	mg/l	<1	1–5	>5
Bicarbonate (HCO ₃ ⁻)		mg/l	<90	90–500	>500
Boron (B)		mg/l	<0.7	0.7–3.0	>3.0
Hydrogen sulfide (H ₂ S)		mg/l	<0.5	0.5–2.0	>2.0
Iron (Fe)	Drip irrigation	mg/l	<0.1	0.1–1.5	>1.5
Manganese (Mn)	Drip irrigation	mg/l	<0.1	0.1–1.5	>1.5
Total nitrogen (TN)		mg/l	<5	5–30	>30
pH			Normal range 6.5–8		

Trace elements (see Table A1.2)

TDS, total dissolved solids; TSS, total suspended solids

Sources: Ayers & Westcot (1985); Pescod (1992); Asano & Levine (1998).

^a EC_w means electrical conductivity in deciSiemens per metre at 25 °C.^b SAR means sodium adsorption ratio ([meq/l]^{1/2}); see section A1.5.**Table A1.2 Threshold levels of trace elements for crop production**

Element	Recommended maximum concentration ^a (mg/l)	Remarks	
Al	Aluminium	5.0	Can cause non-productivity in acid soils (pH <5.5), but more alkaline soils at pH >7.0 will precipitate the ion and eliminate any toxicity.
As	Arsenic	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Be	Beryllium	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cd	Cadmium	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co	Cobalt	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr	Chromium	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Cu ^b	Copper	0.20	Toxic to a number of plants at 0.1–1.0 mg/l in nutrient solutions.
F	Fluoride	1.0	Inactivated by neutral and alkaline soils.
Fe ^b	Iron	5.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.

Element		Recommended maximum concentration ^a (mg/l)	Remarks
Li	Lithium	2.5	Tolerated by most crops up to 5 mg/l; mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron.
Mn ^b	Manganese	0.20	Toxic to a number of crops at a few-tenths to a few mg/l, but usually only in acid soils.
Mo	Molybdenum	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Ni	Nickel	0.20	Toxic to a number of plants at 0.5–1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Pb	Lead	5.0	Can inhibit plant cell growth at very high concentrations.
Se	Selenium	0.02	Toxic to plants at concentrations as low as 0.025 mg/l, and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. Essential element to animals, but in very low concentrations.
V	Vanadium	0.10	Toxic to many plants at relatively low concentrations.
Zn ^b	Zinc	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH >6.0 and in fine textured or organic soils.

Source: Adapted from Ayers & Westcot (1985); Pescod (1992).

^a The maximum concentration is based on a water application rate that is consistent with good irrigation practices (5000–10 000 m³/ha per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10 000 m³/ha per year. The values given are for water used on a continuous basis at one site.

^b Synergistic action of Cu and Zn and antagonistic action of Fe and Mn have been reported in certain plants species' absorption and tolerance of metals after wastewater irrigation. If the irrigation water contains high concentrations of Cu and Zn, Cu concentrations in the tissue may increase greatly. In plants irrigated with water containing a high concentration of Mn, Mn uptake in the plants may increase, and, consequently, the concentration of Fe in the plant tissue may be reduced considerably. Generally, metal concentrations in plant tissue increase with concentrations in the irrigation water. Concentrations in the roots are usually higher than in the leaves (Drakatos, Kalavrouziotis & Drakatos, 2000; Drakatos et al., 2002; Kalavrouziotis & Drakatos, 2002).

3. AUSTRALIA

Australian Guidelines for Water Recycling (2008), available at:

<https://www.nhmrc.gov.au/guidelines-publications/eh56>

Table 4.4 lists maximum concentrations of chemicals that have been detected in secondary treated sewage. The table was compiled from a range of Australian and international data sets, but should not be regarded as exhaustive. In addition, Table 4.4 includes health-related guideline values. As described in Appendix A, these values have been:

- derived from published guidelines and standards, giving preference to guideline values published in the *Australian Drinking Water Guidelines* (NHMRC–NRMMC 2004)
- developed from available health, toxicological and structural information.

Table 4.4 Chemicals detected in secondary treated sewage, maximum concentrations and guideline values

Chemical	Maximum concentration ^a	Guideline value ^a	Chemical	Maximum concentration ^b	Guideline value ^b
Inorganic chemicals					
Aluminium	2.2	0.2 ^c (aesth)	Iodide	0.048	0.1 ^c
Ammonia	39	0.5 ^c (aesth)	Iron	1.3	0.3 ^c (aesth)
Antimony	0.006	0.003 ^c	Lead	0.06	0.01 ^c
Arsenic	0.015	0.007 ^c	Manganese	0.47	0.5 ^c
Barium	0.1	0.7 ^c	Mercury	0.007	0.001 ^c
Boron	0.9	4 ^c	Molybdenum	0.03	0.05 ^c
Bromide	0.28	7 ^c	Nickel	0.6	0.02 ^c
Bromine	0.57	7 ^c	Nitrate (NO ₃)	19.7	50 ^c
Cadmium	0.004	0.002 ^c	Nitrite (NO ₂)	0.04	3 ^c
Chromium	0.11	0.05 ^c	Selenium	0.003	0.01 ^c
Copper	0.4	2 ^c	Silver	0.0028	0.1 ^c
Cyanide		0.08 ^c	Sulfate (SO ₄)	1870	500 ^c
Fluoride	1.4	1.5 ^c	Zinc	0.25	3 ^c
Disinfection byproducts					
2,4,6-Trichlorophenol (2,4,6-T)	0.00005	0.02 ^c	Chloroform	0.107	0.2 ^d
2,4-Dichlorophenol	0.0003	0.2 ^c	Dibromochloromethane	0.022	0.1 ^d
2,6-Dichlorophenol	0.000026	0.01 ^c	Dichloroacetic acid	0.0005	0.1 ^c
Bromoacetic acid	0.0004	0.00035 ^j	Dichloroacetonitrile	0.00072	0.002 ^d
Bromochloroacetonitrile	0.00025	0.0007 ^j	N-nitrosodiethylamine (NDEA)	3 ng/L	10 ng/L ^f
Bromodichloromethane	0.12	0.006 ^d	N-nitrosodimethylamine (NDMA)	550 ng/L	10 ng/L ^f
Bromoform	0.081	0.1 ^f	Trichloroacetic acid	0.004	0.1 ^c
Pesticides					
<i>Acetylcholinesterase inhibitors</i>					
Azinphos-methyl	0.0021	0.003 ^c	Dimethoate	0.0019	0.05 ^c
Bromophos-ethyl	0.0001	0.01 ^c	Ethion	0.0018	0.003 ^c
Carbendazim	0.0003	0.1 ^c	Ethoprophos (Mocap)	0.002	0.001 ^c
Chlorpyrifos	0.0007	0.01 ^c	Fenthion (fenthion-methyl)	0.0024	0.0005 ^d
Chlorpyrifos-methyl	0.0017	0.01 ^j	Malathion	0.0021	0.0 ^d
Demeton-S	0.003	0.00015 ^g	Parathion (ethyl parathion)	0.0022	0.01 ^c
Diazinon	0.0032	0.003 ^c	Parathion-methyl (methyl parathion)	0.0028	0.1 ^c
Dichlorvos	0.0024	0.001 ^c			
<i>Organochlorines</i>					
4,4'-DDT (44DDT; p,p'-DDT)	0.02	0.02 ^c	Endosulfan sulfate	0.00025	0.03 ^c
4,4'-DDE (44DDE; p,p'-DDE)	0.00015	0.02 ^c	Lindane	0.0001	0.02 ^c
Chlordane (gamma-Chlordane)	0.001	0.001 ^c	Pentachlorophenol (PCP)	0.0002	0.01 ^c
<i>General pesticides</i>					
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.0046	0.03 ^c	4-Nitrophenol	0.0023	0.03 ^g
Demeton-S	0.003	0.00015 ^g	Parathion (ethyl parathion)	0.0022	0.01 ^c
Diazinon	0.0032	0.003 ^c	Parathion-methyl (methyl parathion)	0.0028	0.1 ^c
Dichlorvos	0.0024	0.001 ^c			
<i>Organochlorines</i>					
4,4'-DDT (44DDT; p,p'-DDT)	0.02	0.02 ^c	Endosulfan sulfate	0.00025	0.03 ^c
4,4'-DDE (44DDE; p,p'-DDE)	0.00015	0.02 ^c	Lindane	0.0001	0.02 ^c
Chlordane (gamma-Chlordane)	0.001	0.001 ^c	Pentachlorophenol (PCP)	0.0002	0.01 ^c
<i>General pesticides</i>					
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.0046	0.03 ^c	4-Nitrophenol	0.0023	0.03 ^g
Alachlor (Lasso)	0.0002	0.002 ^d	2-Phenylphenol	0.0026	1 ^j
Atrazine	0.00088	0.04 ^c	Simazine	0.001	0.02 ^c

Chemical	Maximum concentration ^{ab}	Guideline value ^a	Chemical	Maximum concentration ^{ab}	Guideline value ^a
[(Carboxymethyl)imino bis(ethylenetriolo)] tetra acetic acid	0.0085	0.005 ^d	Thiophanate	0.012	0.005 ^e
Cypermethrin	0.00008	0.0005 ^d	Trifluralin	0.0006	0.05 ^e
N,N-diethyltoluamide (NN-diethyl-3-methylbenzamide (DEET))	0.00078	2.5 ^b	α-BHC (alpha-BHC)	0.00008	0.02 ^d
Diuron	0.00029	0.03 ^c	β-BHC (beta-BHC)	0.00033	0.02 ^d
Metolachlor	0.00037	0.3 ^c			
Fragrances					
2,4,6-Trinitro-1,3-dimethyl-5-tert-butylbenzene (musk xylene)	36 ng/L	350 µg/L ^b	Musk ketone	410 ng/L	350 µg/L ^b
4-Acetyl-6-t-butyl-1,1-dimethylindan	8 ng/L	7 µg/L ^d	Musk tibetene	0.04 ng/L	0.35 µg/L ^d
6-Acetyl-1,1,2,4,4,7-hexamethyltetraline	88 ng/L	4 µg/L ^d	Pentamethyl-4,6-dimethylindane	8.3 ng/L	0.35 µg/L ^d
Galaxolide	150 ng/L	1.8 ^b			
Pharmaceuticals and metabolites					
<i>Antibiotics</i>					
Amoxicillin	0.02 µg/L	1.5 µg/L ^l	Monensin	0.08 µg/L	35 µg/L ^l
Anhydroerythromycin A	0.92 µg/L	17.5 µg/L ^l	Naladixic acid	0.22 µg/L	1,000 µg/L ^k
Amoxicillin	0.02 µg/L	1.5 µg/L ^l	Monensin	0.08 µg/L	35 µg/L ^l
Anhydroerythromycin A	0.92 µg/L	17.5 µg/L ^l	Naladixic acid	0.22 µg/L	1,000 µg/L ^k
Azithromycin	0.072 µg/L	3.9 µg/L ^l	Norflaxin	0.2 µg/L	400 µg/L ^k
Cefaclor	1.2 µg/L	250 µg/L ^k	Penicillin G	0.03 µg/L	1.5 µg/L ^l
Cephalexin	0.09 µg/L	35 µg/L ^l	Penicillin V	0.21 µg/L	1.5 µg/L ^l
Chloramphenicol	0.56 µg/L	175 µg/L ^k	Roxithromycin	0.68 µg/L	150 µg/L ^k
Chlorotetracycline	0.28 µg/L	105 µg/L ^l	Sulfamethoxazole	1.9 µg/L	35 µg/L ^l
Ciproflaxin	0.4 µg/L	250 µg/L ^k	Sulfamethoxine	0.06 µg/L	35 µg/L ^l
Clarithromycin	0.24 µg/L	250 µg/L ^k	Sulfamethazine	0.68 µg/L	35 µg/L ^l
Clindamycin	0.120 µg/L	300 µg/L ^k	Sulfamethizole	0.13 µg/L	35 µg/L ^l
Demeclocycline	1.1 µg/L	300 µg/L ^k	Terramycin (oxytetracycline)	0.66 µg/L	105 µg/L ^l
Doxycycline	0.03 µg/L	10.5 µg/L ^l	Tetracycline (TCLN)	0.11 µg/L	105 µg/L ^l
Enrofloxacin	0.015 µg/L	22 µg/L ^l	Trimethoprim	0.35 µg/L	70 µg/L ^l
Erythromycin	1.7 µg/L	17.5 µg/L ^l	Tylosin	1.1 µg/L	1050 µg/L ^l
<i>Non-steroidal anti-inflammatory</i>					
Aspirin (Acetylsalicylic acid)	2.1 µg/L	29 µg/L ^l	Indomethacin	0.6 µg/L	25 µg/L ^k
Diclofenac	0.81 µg/L	1.8 µg/L ^l	Ketoprofen	0.38 µg/L	3.5 µg/L ^l
Dipyrone (vet)	7.5 µg/L	525 µg/L ^l	Naproxen	0.57 µg/L	220 µg/L ^k
Fenoprofen	0.76 µg/L	450 µg/L ^k	Tolfenamic acid (vet)	1.6 µg/L	17.5 µg/L ^l
Ibuprofen	28 µg/L	400 µg/L ^k			
Ciproflaxin	0.4 µg/L	250 µg/L ^k	Sulfamethoxine	0.06 µg/L	35 µg/L ^l
Clarithromycin	0.24 µg/L	250 µg/L ^k	Sulfamethazine	0.68 µg/L	35 µg/L ^l
Clindamycin	0.120 µg/L	300 µg/L ^k	Sulfamethizole	0.13 µg/L	35 µg/L ^l
Demeclocycline	1.1 µg/L	300 µg/L ^k	Terramycin (oxytetracycline)	0.66 µg/L	105 µg/L ^l
Doxycycline	0.03 µg/L	10.5 µg/L ^l	Tetracycline (TCLN)	0.11 µg/L	105 µg/L ^l
Enrofloxacin	0.015 µg/L	22 µg/L ^l	Trimethoprim	0.35 µg/L	70 µg/L ^l
Erythromycin	1.7 µg/L	17.5 µg/L ^l	Tylosin	1.1 µg/L	1050 µg/L ^l
<i>Non-steroidal anti-inflammatory</i>					
Aspirin (Acetylsalicylic acid)	2.1 µg/L	29 µg/L ^l	Indomethacin	0.6 µg/L	25 µg/L ^k
Diclofenac	0.81 µg/L	1.8 µg/L ^l	Ketoprofen	0.38 µg/L	3.5 µg/L ^l
Dipyrone (vet)	7.5 µg/L	525 µg/L ^l	Naproxen	0.57 µg/L	220 µg/L ^k
Fenoprofen	0.76 µg/L	450 µg/L ^k	Tolfenamic acid (vet)	1.6 µg/L	17.5 µg/L ^l
Ibuprofen	28 µg/L	400 µg/L ^k			
<i>β-adrenergic blockers</i>					
Betaxolol	0.19 µg/L	10 µg/L ^k	Nadolol	0.06 µg/L	20 µg/L ^k
Bisoprolol	0.37 µg/L	0.63 µg/L ^k	Propranolol	0.29 µg/L	40 µg/L ^k
Carazolol	0.12 µg/L	0.35 µg/L ^l	Timolol	0.07 µg/L	10 µg/L ^k

Chemical	Maximum concentration ^{a,b}	Guideline value ^c	Chemical	Maximum concentration ^{a,b}	Guideline value ^c
Metoprolol	2.2 µg/L	25 µg/L ^k			
<i>Estrogenic hormones</i>					
17α-estradiol	74 ng/L	175 ng/L ^l	Estril	51 ng/L	50 ng/L ^k
17α-ethinyl estradiol	270 ng/L	1.5 ng/L ^k	Estrone	110 ng/L	30 ng/L ^k
17β-estradiol	93 ng/L	175 ng/L ^l	Mestranol	410 ng/L	2.5 ng/L ^k
Equilenin	280 ng/L	30 ng/L ^k	Norethindrone	870 ng/L	250 ng/L ^k
Equilin	150 ng/L	30 ng/L ^k	Progesterone	200 ng/L	105 µg/L ^l
<i>Androgens</i>					
Androsterone	0.21 µg/L	14 µg/L ^k	Testosterone	0.21 µg/L	7 µg/L ^l
<i>General pharmaceuticals</i>					
Alprazolam	0.62 µg/L	0.25 µg/L ^k	Fluoxetine (Prozac)	0.142 µg/L	10 µg/L ^k
Antipyrine (phenazone)	0.41 µg/L	1,000 µg/L ^k	Gemfibrozil	1.5 µg/L	600 µg/L ^k
Atorvastatin	0.04 µg/L	5 µg/L ^k	Iohexol	1.6 µg/L	720 µg/L ^k
Bezafibrate	4.6 µg/L	300 µg/L ^k	Iopamidol	15 µg/L	400 µg/L ^k
Carbamazepine	27 µg/L	100 µg/L ^k	Iopromide	11 µg/L	750 µg/L ^k
Cimetidine	0.58 µg/L	200 µg/L ^k	Isophosphamide	2.9 µg/L	3.5 µg/L ^h
Clenbuterol	0.05 µg/L	15 µg/L ^l	Metformin (1,1-Dimethylbiguanide)	0.15 µg/L	250 µg/L ^k
Clofibric acid	1.6 µg/L	750 µg/L ^k	Paracetamol (acetaminophen)	4.3 µg/L	175 µg/L ^l
Clenbuterol	0.05 µg/L	15 µg/L ^l	Metformin (1,1-Dimethylbiguanide)	0.15 µg/L	250 µg/L ^k
Clofibric acid	1.6 µg/L	750 µg/L ^k	Paracetamol (acetaminophen)	4.3 µg/L	175 µg/L ^l
Codeine	9.1 µg/L	50 µg/L ^k	Salbutamol	0.035 µg/L	3 µg/L ^k
Cotinine	0.9 µg/L	10 µg/L ^k	Salicylic acid	60 µg/L	105 µg/L ^k
Cyclophosphamide	0.02 µg/L	3.5 µg/L ^h	Sulfasalazine	0.12 µg/L	500 µg/L ^k
Dehydronifedipine	0.03 µg/L	20 µg/L ^k	Temazepam	1.6 µg/L	5 µg/L ^k
Diltiazem	0.049 µg/L	60 µg/L ^k	Terbutaline	0.12 µg/L	4.5 µg/L ^k
Enalaprilat	0.046 µg/L	1.3 µg/L ^k	Valium (Diazepam)	2.92 µg/L	2.5 µg/L ^k
<i>Fire retardants</i>					
Fyrol FR 2 (tri(dichloroisopropyl)phosphate) ¹	0.0002	0.001 ^l	Tris(2-chloroethyl)phosphate (TCEP)	540 ng/L	1,000 ng/L ^l
<i>Dioxins and dioxin-like compounds</i>					
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB156)	0.008 ng/L TEF 0.0005	0.016 ng/L ^{mm}	2,7-Dichlorodibenzo-p-dioxin (DCDD)	1200 ng/L No TEF	0.016 ng/L ^{mm}
2,3,3',4,4',5'-pentachlorobiphenyl (PCB105)	0.027 ng/L TEF 0.0001	0.016 ng/L ^{mm}	3,4,5,3',4',5'-Hexachlorobiphenyl (PCB169)	0.002 ng/L TEF 0.01	0.016 ng/L ^{mm}
2,3',4,4',5'-Pentachlorobiphenyl (PCB118)	0.064 ng/L TEF 0.0001	0.016 ng/L ^{mm}	Octachlorodibenzo-p-dioxin (OCDD)	0.1 ng/L TEF 0.0001	0.016 ng/L ^{mm}
2,4,5,3',4',5'-Hexachlorobiphenyl (PCB167)	0.004 ng/L TEF 0.00001	0.016 ng/L ^{mm}	PCB77	0.006 ng/L TEF 0.0001	0.016 ng/L ^{mm}
<i>Miscellaneous organic chemicals — polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), phthalates, organotin, etc</i>					
1,1-Dichloroethene	0.03	0.03 ^f	Coprastanol	9.8 µg/L	0.7 µg/L ^l
1,7-Dimethylxanthine (Paraxanthine)	50 µg/L	0.7 µg/L ^l	Coumarin	1.3 µg/L	0.5 µg/L ^d
2,5-Dihydroxybenzoic acid	0.59 µg/L	7 µg/L ^l	Diatrizeate Sodium	230 ng/L	350 ng/L ^l
2,6-di-tert-butyl-1,4-benzoquinone (2,6-bis(1,1-dimethylethyl)-2,5-Cyclohexadiene-1,4-dione)	460 ng/L	14 ng/L ^g	Diatrizeic acid	1900 ng/L	350 ng/L ^l
2,6-di-tert-butylphenol (2,6-bis(1,1-dimethylethyl)phenol)	110 ng/L	2,000 ng/L ^l	Dibutyltin (DBT)	34 ng/L	2 µg/L ^f
4-Chlorophenol	16 ng/L	10 µg/L ^f	Di-n-butyl phthalate	891 ng/L	35 µg/L ^f
4-cumylphenol	0.98 µg/L	0.35 µg/L ^l	Methylene chloride (Dichloromethane)	0.011	0.004 ^f
4-Nonylphenol (4NP)	2.9 ug/L	500 µg/L ^h	4-Methylphenol (p-cresol)	0.54 µg/L	0.6 ^g
4-tert octylphenol	14 ng/L	50 µg/L ^h	Monobutyltin (MBT)	90 ng/L	700 ng/L ^l
5-methyl-1H-benzotriazole	2400 ng/L	7 ng/L ^g	Naphthalene	80 ng/L	70 µg/L ^f
Anthracene	110 ng/L	150 µg/L ^f	N-nitrosomorpholine (NMOR)	12 ng/L	1 ng/L ^l
Acetophenone	410 ng/L	400 µg/L ^f	Phenanthrene	0.53 µg/L	150 µg/L ^f
Benzo(a)pyrene	240 ng/L	10 ng/L ^f	Phenol	1.3 ug/L	150 µg/L ^f
Benzyl chloride	1.8 ng/L	200 ng/L ^l	Phthalic anhydride	1,000 ng/L	7 ^g
Bisphenol A	12 ug/L	200 µg/L ^f	Pyrene	840 ng/L	150 µg/L ^f
Bromochloromethane	66 µg/L	40 µg/L ^f	Stigmastanol	4 µg/L	1 ^k

Butylated hydroxytoluene (2,6-Di-tert-Butyl-p-Cresol)	100 ng/L	1 ^a	Tributyl phosphate	190 ng/L	500 ng/L ^f
Butylated hydroxyanisole (3-tert-butyl-4-hydroxy anisole)	200 ng/L	1.8 ^a	Tributyltin (TBT)	21 ng/L	1,000 ng/L ^f
Caffeine	44 µg/L	0.35 µg/L ^f	Tri(n-butyl cellosolve) phosphate (ethanol,2-butoxy-phosphate)	6700 ng/L	50 µg/L ^h
Chlorophene	710 ng/L	350 ng/L ^f	Triclosan	0.4 µg/L	0.35 µg/L ^f
Cholesterol	10 µg/L	7 µg/L ^f	Triphenyl phosphate	220 ng/L	1,000 ng/L ^f
Radiological					
Alpha particles	0.7 Bq/L	0.5 Bq/L ^f	Beta particles and photon emitters	1.2 Bq/L	0.5 Bq/L ^f
Gross gamma	0.1 Bq/L	0.5 Bq/L ^f			
Chelating agents					
Ethylenediaminetetraacetic acid (EDTA)	0.210	0.25 ^f	Propylenedinitrotetraacetic acid (PDTA)	0.027	0.0007 ^f
Nitrilotriacetic acid (NTA)	0.012	0.2 ^f			

aesth = aesthetic guideline — no health guideline value

a Values expressed as mg/L unless otherwise indicated

b Maximum concentrations were obtained from unpublished Australian data and from Fent (1996), Castillo et al (1997),

Daughton and Ternes (1999), Kolpin et al (2002), Costanzo and Watkinson (2007), Fatta et al (2007), Gomez et al (2007)

c NHMRC-NRMMC (2004)

d EC 98/83/EC

e US EPA (2007)

f WHO (2006a) (for non-threshold chemicals corrected to apply carcinogenicity risk of 10⁻⁶)

g Published tolerable daily intake or equivalent, Table A1

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h Published NOEL or equivalent, Table A2

i Published guideline for a non-threshold chemical, Table A3

j Calculated value, Table A6

k Calculated from therapeutic doses, Table A8b

l Calculated from ADI, Table A8a

m Compounds with dioxin-like activity should provide a total of <16 pg toxic equivalent per litre taking into account

toxicity equivalence factors (NHMRC 2002), Table A1

n Total PCBs should be below a guideline value of 0.14 µg/L derived from an ADI of 0.02 µg/kg/day (US EPA 1996) and

o Compounds with potentially genotoxic activity, calculated guideline value, Table A4.

4. U.S.A.

United States Environmental protection Agency (USEPA): Guidelines for Water Reuse, available at:

<https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-1530.pdf>

Table 3-4 Guidelines for interpretation of water quality for irrigation¹

Potential Irrigation Problem	Units	Degree of Restriction on Irrigation		
		None	Slight to Moderate	Severe
Salinity (affects crop water availability)²				
EC _w	dS/m	< 0.7	0.7 – 3.0	> 3.0
TDS	mg/L	< 450	450 – 2000	> 2000
Infiltration (affects infiltration rate of water into the soil; evaluate using EC_w and SAR together)³				
SAR	0 – 3	> 0.7	0.7 – 0.2	< 0.2
	3 – 6	> 1.2	1.2 – 0.3	< 0.3
	6 – 12	> 1.9	1.9 – 0.5	< 0.5
	12 – 20	> 2.9	2.9 – 1.3	< 1.3
	20 – 40	> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity (affects sensitive crops)				
Sodium (Na)⁴				
surface irrigation	SAR	< 3	3 – 9	> 9
sprinkler irrigation	meq/l	< 3	> 3	
Chloride (Cl)⁴				
surface irrigation	meq/l	< 4	4 – 10	> 10
sprinkler irrigation	meq/l	< 3	> 3	
Boron (B)				
	mg/L	< 0.7	0.7 – 3.0	> 3.0
Miscellaneous Effects (affects susceptible crops)				
Nitrate (NO ₃ -N)	mg/L	< 5	5 – 30	> 30
Bicarbonate (HCO ₃)	meq/L	< 1.5	1.5 – 8.5	> 8.5
pH		Normal Range 6.5 – 8.4		

¹ Adapted from FAO (1985)

² EC_w means electrical conductivity, a measure of the water salinity, reported in deciSiemens per meter at 25°C (dS/m) or in millimhos per centimeter (mmho/cm); both are equivalent.

³ SAR is the sodium adsorption ratio; at a given SAR, infiltration rate increases as water salinity increases.

⁴ For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; most annual crops are not sensitive. With overhead sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops.

Table 3-5 Recommended water quality criteria for irrigation

Constituent	Maximum Concentrations for Irrigation (mg/L)	Remarks
Aluminum	5.0	Can cause nonproductiveness in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity
Arsenic	0.10	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice
Beryllium	0.10	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans
Boron	0.75	Essential to plant growth; sufficient quantities in reclaimed water to correct soil deficiencies. Optimum yields obtained at few-tenths mg/L; toxic to sensitive plants (e.g., citrus) at 1 mg/L. Most grasses are tolerant at 2.0 - 10 mg/L
Cadmium	0.01	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L; conservative limits are recommended
Chromium	0.1	Not generally recognized as an essential element; due to lack of toxicity data, conservative limits are recommended
Cobalt	0.05	Toxic to tomatoes at 0.1 mg/L; tends to be inactivated by neutral and alkaline soils
Copper	0.2	Toxic to a number of plants at 0.1 to 1.0 mg/L
Fluoride	1.0	Inactivated by neutral and alkaline soils
Iron	5.0	Not toxic in aerated soils, but can contribute to soil acidification and loss of phosphorus and molybdenum
Lead	5.0	Can inhibit plant cell growth at very high concentrations
Lithium	2.5	Tolerated by most crops up to 5 mg/L; mobile in soil. Toxic to citrus at low doses—recommended limit is 0.075 mg/L
Manganese	0.2	Toxic to a number of crops at few-tenths to few mg/L in acidic soils
Molybdenum	0.01	Nontoxic to plants; can be toxic to livestock if forage is grown in soils with high molybdenum
Nickel	0.2	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH
Selenium	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of selenium
Tin, Tungsten, and Titanium	-	Excluded by plants; specific tolerance levels unknown
Vanadium	0.1	Toxic to many plants at relatively low concentrations
Zinc	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils

Table 3-6 Examples of global water quality standards for non-food crop irrigation

Microbial Standards or Guidelines by State, Country, Region	Total Coliform per 100 mL	Fecal Coliform or E. coli per 100 mL
Puglia (S. Italia)	≤ 10	
California, Italy	≤ 23	
Australia		≤ 10
Germany	≤ 100	≤ 10
Washington State	≤ 240	
Florida, Utah, Texas, EPA (Guidelines)		≤ 200
Arizona, New Mexico, Australia, Victoria, Mexico		≤ 1,000
Austria		≤ 2,000
Sicily	≤ 3,000	≤ 1,000
Cyprus		≤ 3,000
WHO, Greece, Spain		≤ 10,000

3.2.5 Reclaimed Water for Livestock Watering

Generally in the United States, reclaimed water is not utilized for direct consumption by livestock; however, *de facto* reuse often occurs. In this case, **Table 3-7** is provided as a guide to acceptable water quality for livestock consumption. It should be noted that the information in **Table 3-7** was developed from FAO 29 Water Quality in Agriculture, with more recent updates from Raisbeck et al. (2011) for molybdenum, sodium, and sulfate (FAO, 1985). These values are based on amounts of constituents normally found in surface and groundwater and are not necessarily the limits of animal tolerance. Additional sources of these substances may need to be considered along with drinking water, such as additional animal intake of these substances through feedstuffs. If concerns persist about safety for livestock, the local land-grant university should be consulted for additional information.

developed to protect swimmers from illnesses from exposure to pathogens in recreational waters, as described in Section 6.3.1. EPA has also recently proposed new draft recreational water quality criteria in response to research findings in the fields of molecular biology, virology, and analytical chemistry (EPA, 2011).

Table 3-7 Guidelines for concentrations of substances in livestock drinking water¹

Constituent (Symbol)	Concentration (mg/L)
Aluminium (Al)	5.0
Arsenic (As)	0.2
Beryllium (Be) ²	0.1
Boron (B)	5.0
Cadmium (Cd)	0.05
Chromium (Cr)	1.0
Cobalt (Co)	1.0
Copper (Cu)	0.5
Fluoride (F)	2.0
Iron (Fe)	not needed
Lead (Pb) ³	0.1
Manganese (Mn) ⁴	0.05
Mercury (Hg)	0.01
Molybdenum (Mo)	0.3
Nitrate + Nitrite (NO ₃ -N + NO ₂ -N)	100
Nitrite (NO ₂ -N)	10.0
Selenium (Se)	0.05
Sodium (Na)	1000 ⁵
Sulfate (as SO ₄)	1000 ⁶
Vanadium (V)	0.10
Zinc (Zn)	24.0

- ¹ Adapted from FAO (1985) with updates for Mo, Na, and SO₄ from Raisbeck et al. (2011).
- ² Insufficient data for livestock; value for marine aquatic life is used.
- ³ Lead is accumulative, and problems may begin at a threshold value of 0.05 mg/L.
- ⁴ Insufficient data for livestock; value for human drinking water used.
- ⁵ Short-term exposure (days/weeks) can be up to 4000 mg/L, assuming normal feedstuff Na concentrations.
- ⁶ Short-term exposure (days/weeks) can be up to 1.8 mg/L, assuming normal feedstuff SO₄ concentrations.

Table 4-10 Agricultural reuse – non-food crops and processed food crops (where permitted)

Treatment (System Design) Requirements	Arizona		California Undisinfected Secondary	Florida	Hawaii R2 Water	Nevada ² Category E	New Jersey Type II RWBR	North Carolina Type 1	Texas Type II	Virginia Level 2	Washington Class C
	Class B	Class C									
Unit processes	Secondary treatment, disinfection	Secondary treatment, with or without disinfection	Oxidized	Secondary treatment, basic disinfection	Secondary-23; oxidized, disinfected	Secondary treatment ¹	Case-by-case	Filtration (or equivalent)	NS	Secondary treatment, disinfection	Oxidized, disinfected
UV dose, if UV disinfection used	NS	NS	NS	NS	NS	NS	75 mJ/cm ² at max day flow	NS	NS	NS	NWRI UV Guidelines
Chlorine disinfection requirements, if used	NS	NS	NS	TRC > 0.5 mg/L; 15 minutes contact time at peak hr flow ³	Chlorine residual > 5 mg/L; 15 minutes actual model contact time	NS	Chlorine residual > 1 mg/L; 15 minute contact time at peak hr flow	NS	NS	TRC CAT < 1 mg/L; 30 minutes contact time at avg flow or 20 minutes at peak flow	Chlorine residual > 1 mg/L; 30 minutes contact time
BOD ₅ (or CBOD ₅)	NS	NS	NS	CBOD ₅ : -20 mg/L (ann avg) -30 mg/L (mon avg) -45 mg/L (wk avg) -60 mg/L (max)	30 mg/L or 60 mg/L depending on design flow	30 mg/L (30-d avg)	NS	-10 mg/L (mon avg) -15 mg/L (daily max)	Without pond: 20 mg/L (or CBOD ₅ 15 mg/L) With pond: 30 mg/L	-30 mg/L (mon avg) -45 mg/L (max wk) or CBOD ₅ -25 mg/L (mon avg) -40 mg/L (max wk)	30 mg/L
TSS	NS	NS	NS	-20 mg/L (ann avg) -30 mg/L (mon avg) -45 mg/L (wk avg) -60 mg/L (max)	30 mg/L or 60 mg/L depending on design flow	30 mg/L (30-d avg)	30 mg/L	-5 mg/L (mon avg) -10 mg/L (daily max)	NS	-30 mg/L (mon avg) -45 mg/L (max wk)	30 mg/L
Turbidity	NS	NS	NS	NS	NS	NS	NS	10 NTU (max)	NS	NS	NS
Bacterial indicators	Fecal coliform: -200/100mL in last 4 of 7 samples -800/100mL (max)	Fecal coliform: -1000/100mL in last 4 of 7 samples -4000/100mL (max)	NS	Fecal coliform: -200/100mL (avg) -800/100mL (max)	Fecal coliform: -23/100mL (7-day med) -200/100mL (not more than one sample exceeds this value in 30 d)	NS	Fecal coliform: -200/100mL (mon geom) -400/100mL (wk geom)	Fecal coliform or E. coli: -14/100mL (mon mean) -25/100mL (daily max)	Fecal coliform or E. coli: -200/100mL (30-d geom) -800/100mL (max) Enterococci: -35/100mL (30-d geom) -89/100mL (max)	Fecal coliform: -200/100mL (mon geom) CAT < 800/100mL E. coli: -126/100mL (mon geom) CAT < 235/100mL Enterococci: -35/100mL (mon geom) CAT < 104/100mL	Total coliform: -23/100mL (7-d med) -240/100mL (max)
Other	If nitrogen > 10 mg/L, special requirements may be mandated to protect non-indicator	If nitrogen > 10 mg/L, special requirements may be mandated to protect non-indicator	-	-	-	-	(NH ₃ -N + NO ₂ -N) < 10 mg/L (max)	Ammonia as NH ₃ -N: -4 mg/L (mon avg) -6 mg/L (daily max)	-	-	-

5. INTERNATIONAL ORGANISATION FOR STANDARDIZATION (ISO)

Guidelines for treated wastewater use for irrigation projects, including agricultural irrigation (document not publically available, but presentation available here:

ISO 16075-2 (2015) Part 2/Table 1. Suggested **treated wastewater quality** according to chemical, physical and biological parameters

Cat	Type of treated wastewater	BOD		TSS		Turbidity		Thermo-tolerant coliforms		Intestinal Nematode		Potential uses without barriers	Potential corresponding treatment
		mg L ⁻¹		mg L ⁻¹		NTU		no./ 100 ml		Egg L ⁻¹			
		Ave	Max	Ave	Max	Ave	Max	95%ile	Max	Ave	Max		
A	Very high quality treated wastewater	≤ 5	10	≤ 5	10	≤ 2	5	≤ 10 or below the detection limit	100	-	-	Unrestricted urban irrigation and agricultural irrigation of food crops consumed raw	Secondary, contact filtration or membrane filtration and disinfection
B	High quality treated wastewater	≤ 10	20	≤ 10	25	-	-	≤ 200	1000	-	-	Restricted urban irrigation and agricultural irrigation of processed food crops.	Secondary, filtration and disinfection
C	Good quality treated wastewater	≤ 20	35	≤ 30	50	-	-	≤ 1000	10000	≤ 1	-	Agricultural irrigation of non-food crops.	Secondary and disinfection
D	Medium quality treated wastewater	≤ 60	100	≤ 90	140	-	-	-	-	≤ 1	5	Restricted irrigation of industrial and seeded crops	Secondary or High rate clarification with coagulation, flocculation
E	Extensively treated wastewater	≤ 20	35	-	-	-	-	-	-	≤ 1	5	Restricted irrigation of industrial and seeded crops	stabilization ponds and wetlands

ISO 16075-2 (2015) Part 2/Table 2. Suggested types and accredited number of barriers (*adapted from WHO 2006 and USEPA 2012*)

Type of barrier	Application	Pathogen reduction (log units)	Number of barriers
Irrigation of food crops			
Drip irrigation	Drip irrigation of low-growing crops such as 25 cm or more above from the ground	2	1
	Drip irrigation of crops such as 50 cm or more above from the ground	4	2
	Subsurface drip irrigation where water does not ascend by capillary action to the ground surface	6	3
Spray and sprinkler irrigation	Sprinkler and Micro sprinkler irrigation of low-growing crops such as 25 cm or more from the ground	2	1
	Sprinkler and Micro sprinkler irrigation of crops such as 50 cm or more from the ground	4	2
Additional disinfection in field	Low level disinfection	2	1
	High level disinfection	4	2
Sun resistant cover sheet	In drip irrigation, where the sheet separates the irrigation from the vegetables	2-4	1
Pathogen die-off	Die-off support through irrigation cessation or interruption before harvest	0.5-2 per day ⁽¹⁾	1-2 ⁽¹⁾
Produce washing before selling to the customers	Washing salad crops, vegetables, fruits with drinking water	1	1
Produce disinfection before selling to the customers	Washing salad crops, vegetables, fruits with a weak disinfectant solution and rinsing with drinking water	2	1
Produce peeling	Peeling of fruits and root crops	2	1
Produce cooking	Immersion in boiling water or under high temperature until the product is cooked	6-7	3

6. EU-LEVEL

Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge, available at: <http://ec.europa.eu/environment/water/reuse.htm>

Table 1 Classes of reclaimed water quality and allowed agricultural use and irrigation method

Minimum reclaimed water quality class	Crop category	Irrigation method
A	All food crops, including root crops consumed raw and food crops where the edible part is in direct contact with reclaimed water	All irrigation methods
B	Food crops consumed raw where the edible part is produced above ground and is not in direct contact with reclaimed water, processed food crops and non-food crops including crops to feed milk- or meat-producing animals	All irrigation methods
C		Drip irrigation* only
D	Industrial, energy, and seeded crops	All irrigation methods

(* Drip irrigation (also called trickle irrigation) is a micro-irrigation system capable of delivering water drops or tiny streams to the plants and involves dripping water onto the soil or directly under its surface at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers.

Table 2 Reclaimed water quality requirements for agricultural irrigation

Reclaimed water quality class	Indicative technology target	Quality requirements				Other
		<i>E. coli</i> (cfu/100 ml)	BOD ₅ (mg/l)	TSS (mg/l)	Turbidity (NTU)	
A	Secondary treatment, filtration, and disinfection	≤10 or below detection limit	≤10	≤10	≤5	<i>Legionella</i> spp.: <1,000 cfu/l where there is risk of aerosolization in greenhouses Intestinal nematodes (helminth eggs): ≤1 egg/l for irrigation of pastures or forage
B	Secondary treatment, and disinfection	≤100	According to Council Directive 91/271/EEC ¹ ((Annex I, Table 1)	According to Directive 91/271/EEC ((Annex I, Table 1)	-	
C	Secondary treatment, and disinfection	≤1,000			-	
D	Secondary treatment, and disinfection	≤10,000	-			

Minimum monitoring frequencies						
Reclaimed water quality	<i>E. coli</i>	BOD ₅	TSS	Turbidity	<i>Legionella</i>	Intestinal
class					spp. (when applicable)	nematodes (when applicable)
A	Once a week	Once a week	Once a week	Continuous	Once a week	Twice a month or frequency determined by the reclamation plant operator according to the number of eggs in waste water entering the reclamation plant
B	Once a week	According to Directive 91/271/EEC ((Annex I, Section D)	According to Directive 91/271/EEC ((Annex I, Section D)	-	Once a week	
C	Twice a month			-		
D	Twice a month	-				

7. SPAIN

Spanish regulations for water reuse [http://www.iwa-network.org/filemanager-
uploads/WQ_Compndium/Database/Selected_guidelines/042_2.pdf](http://www.iwa-network.org/filemanager/uploads/WQ_Compndium/Database/Selected_guidelines/042_2.pdf)

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES ¹	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
1. URBAN USES					
QUALITY 1.1: RESIDENTIAL ² a) Irrigation of private gardens ³ b) Supply to sanitary appliances ³	1 egg/10 L	0 (CFU ⁴ /100 mL)	10 mg/L	2 NTU ⁵	OTHER CONTAMINANTS ⁶ included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances ⁷ , use of reclaimed water must comply with environmental quality standards. ⁸
QUALITY 1.2: SERVICES a) Landscape irrigation of urban areas (parks, sports grounds and similar) ³ b) Street cleansing ³ c) Fire hydrants ³ d) Industrial washing of vehicles ⁹	1 egg/10 L	200 CFU/100 mL	20 mg/L	10 NTU	OTHER CONTAMINANTS ⁶ included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances ⁷ , use of reclaimed water must comply with environmental quality standards. ⁸ <i>Legionella spp.</i> 100 CFU/L (if there is a risk of aerosolization)

¹ At least the following genera must be included in all quality categories: *Ancylostoma*, *Trichuris* and *Ascaris*.

² Controls must be performed to ensure the correct maintenance of facilities.

³ Authorization will only be given if each section up to the point of use is a marked dual circuit.

⁴ Colony-forming units.

⁵ Nephelometric turbidity units.

⁶ See Appendix II of RD 849/1998, of 11 April.

⁷ See Appendix IV of RD 907/2007, of 6 July.

⁸ Environmental quality standard; see Article 245.5 a of RD 849/1998, of 11 April, amended by RD 608/2003, of 23 May

⁹ If there is a risk of water aerosolization, the conditions of use stipulated on a case-by-case basis by public health authorities must be followed; otherwise, such uses will not be authorized.

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
2. AGRICULTURAL USES¹					
QUALITY 2.1 ² a) Crop irrigation using a system whereby reclaimed water comes into direct contact with edible parts of crops to be eaten raw.	1 egg/10 L	100 CFU/100 mL Based on a 3-class sampling plan ³ with the following values: n = 10 m = 100 CFU/100 mL M = 1,000 CFU/100 mL c = 3	20 mg/L	10 NTU	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. <i>Legionella spp.</i> 1,000 CFU/L (if there is a risk of aerosolization) It is compulsory to conduct detection tests for presence-absence of pathogen (<i>Salmonella</i> , etc.) when results repeatedly show that c=3 for M=1,000.

¹ Reclaimed water characteristics that require additional information: Conductivity, 3.0 dS/m; Sodium Adsorption Ratio (SAR), 6 ; Boron, 0.5 mg/L; Arsenic, 0.1 mg/L; Beryllium, 0.1 mg/L; Cadmium, 0.01 mg/L; Cobalt, 0.05 mg/L; Chrome, 0.1 mg/L; Copper, 0.2 mg/L; Manganese, 0.2 mg/L; Molybdenum, 0.01 mg/L; Nickel, 0.2 mg/L; Selenium, 0.02 mg/L; Vanadium, 0.1 mg/L. The following formula should be used to calculate the SAR (a dimensionless value, indicated by transistors):

$$SAR = \frac{[Na]}{\sqrt{[Ca] + [Mg]}}$$

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
QUALITY 2.2 a) Irrigation of crops for human consumption using application methods that do not prevent direct contact of reclaimed with edible parts of the plants, which are not eaten raw but after an industrial treatment process. b) Irrigation of pasture land for milk- or meat-producing animals. c) Aquaculture.	1 egg/10 L	1,000 CFU/100 mL Based on a 3-class sampling plan ¹ with the following values: n = 10 m = 1,000 CFU/100 mL M = 10,000 CFU/100 mL c = 3	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. <i>Taenia saginata</i> and <i>Taenia solium</i> : 1 egg/L (when irrigating pasture land for milk- or meat-producing animals) It is compulsory to conduct detection tests for presence-absence of pathogen (<i>Salmonella</i> , etc.) when results repeatedly show c=3 for M=10,000.
QUALITY 2.3 a) Localized irrigation of tree crops whereby reclaimed water is not allowed to come into contact with fruit for human consumption. b) Irrigation of ornamental flowers, nurseries and greenhouses whereby reclaimed water does not come into contact with the crops. c) Irrigation of industrial non-food crops, nurseries, silo fodder, cereals and oilseeds.	1 egg/10 L	10,000 CFU/100 mL	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. <i>Legionella spp.</i> 100 CFU/L

¹ Where n = number of aliquot samples analyzed; m = (MAV) maximum acceptable value for the bacterial count; M = maximum permitted value for the bacterial count (MAV + Maximum Deviation Limit); c = maximum number of aliquot samples whose bacterial count falls between "m" and "M".

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
3. INDUSTRIAL USES					
QUALITY 3.1 ¹ a) Process and cleaning water, except for use in the food industry. b) Other industrial uses.	No set limit	10,000 CFU/100 mL	35 mg/L	15 NTU	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. <i>Legionella spp.</i> : 100 CFU/L
c) Process and cleaning water for use in the food industry.	1 egg/10 L	1,000 CFU/100 mL Based on a 3-class sampling plan ² with the following values: n = 10 m = 1,000 CFU/100 mL M = 10,000 CFU/100 mL c = 3	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. <i>Legionella spp.</i> : 100 CFU/L It is compulsory to conduct detection tests for presence-absence of pathogen (<i>Salmonella</i> , etc.) when results repeatedly show that c=3 for M=10,000
QUALITY 3.2 a) Cooling towers and evaporative condensers.	1 egg/10 L	Absence CFU/100 mL	5 mg/L	1 NTU	<i>Legionella spp.</i> : Absence CFU/L Authorization is subject to: - Approval by public health authorities of a facility's specific control program, as provided for in Royal Decree 865/2003, of 4 July, on the health and hygienic criteria for the prevention and control of legionnaires' disease. - Use for industrial purposes only and in facilities that are not located in urban areas or near public or /commercial buildings.

¹ If there is a risk of water aerosolization, the conditions of use stipulated on a case-by-case basis by public health authorities must be followed; otherwise, such uses will not be authorized.

² Where n = number of aliquot samples analyzed; m = (MAV) maximum acceptable value for the bacterial count; M = maximum permitted value for the bacterial count (MAV + Maximum Deviation Limit); c = maximum number of aliquot samples whose bacterial count falls between "m" and "M".

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
4. RECREATIONAL USES					
QUALITY 4.1 ¹ a) Golf course irrigation.	1 egg/10 L	200 CFU/100 mL	20 mg/L	10 NTU	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. If irrigation water is directly applied to soil (drip irrigation, micro-sprinkler), criteria for Quality 2.3 shall apply. <i>Legionella spp.</i> : 100 CFU/L (if there is a risk of aerosolization)
QUALITY 4.2 a) Ornamental ponds and lakes in which public access to water is prohibited.	No set limit	10,000 CFU/100 mL	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. P _r : 2 mg P/L (in standing water)

¹ If there is a risk of water aerosolization, the conditions of use stipulated on a case-by-case basis by public health authorities must be followed; otherwise, such uses will not be authorized.

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	ESCHERICHIA COLI	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
5. ENVIRONMENTAL USES					
QUALITY 5.1 a) Aquifer recharge by localized percolation through the ground.	No set limit	1,000 CFU/100 mL	35 mg/L	No set limit	N ₂ ¹ : 10 mg N/L NO ₃ : 25 mg NO ₃ /L
QUALITY 5.2 a) Aquifer recharge by direct injection.	1 egg/10 L	0 CFU/100 mL	10 mg/L	2 NTU	Articles 257 to 259 of RD 849/1986.
QUALITY 5.3 a) Irrigation of woodland, green areas and other spaces not accessible to the public. b) Silviculture.	No set limit	No set limit	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards.
QUALITY 5.4 a) Other environmental uses (maintenance of wetlands, minimum stream flows and similar).	Minimum quality requirements will be set on a case-by-case basis.				

USE	QUALITY	INTESTINAL NEMATODES	ESCHERICHIA COLI	SS	TURBIDITY	NT AND PT	OTHER CONTAMINANTS	OTHER CRITERIA
1. URBAN USE	1.1 and 1.2	Every two weeks	Twice a week	Once a week	Twice a week	---	The water basin organization will assess the analytical frequency based on the effluent disposal permit and the water reclamation treatment.	Once a month
2. AGRICULTURAL USE	2.1	Every two weeks	Once a week	Once a week	Once a week	---		Once a month
	2.2	Every two weeks	Once a week	Once a week	---	---		Every two weeks
	2.3	Every two weeks	Once a week	Once a week	---	---		----
3. INDUSTRIAL USE	3.1	----	Once a week	Once a week	Once a week	---		Once a month
	3.2	Once a week	Three times a week	Once a day	Once a day	---		<i>Legionella spp.</i> 3 times a week
4. RECREATIONAL USE	4.1	Every two weeks	Twice a week	Once a week	Twice a week	---		----
	4.2	----	Once a week	Once a week	----	Once a month		----
5. ENVIRONMENTAL USE	5.1	----	Twice a week	Once a week	----	Once a week		----
	5.2	Once a week	Three times a week	Once a day	Once a day	Once a week		Once a week
	5.3	---	---	Once a week	---	----		----
	5.4							Frequency similar to that of the most similar use

8. PORTUGAL

Portuguese decree nº 236/98 states in its Annex XVI the chemical quality criteria for irrigation water as MRV (maximum recommended value), which were adopted in NP 4434 and are presented in Tables 1 and 2. Concerning microbiological quality of irrigation water the Decree nº 236/98 [7] indicates that the water should contain no more than 103 faecal coliforms /100 mL and less than 1 helmynth egg/L.

3.2 Quality criteria of treated urban wastewater for irrigation

The Portuguese decree n° 236/98 states in its Annex XVI the chemical quality criteria for irrigation water as MRV (maximum recommended value), which were adopted in NP 4434 and are presented in Tables 1 and 2. Concerning microbiological quality of irrigation water the Decree n° 236/98 [7] indicates that the water should contain no more than 103 faecal coliforms /100 mL and less than 1 helmyth egg/L.

Table 1 – Standards on salinity of irrigation water.

Parameter		Unit	MRL
Salinity	EC	dS/m 25° C mg/L	1
	TDS		640
R _{Na}		-	8
TSS		mg/L	60
pH		Sorensen	6.5 – 8.4

the plant, and reduce the risk of runoff and spray generation and transportation by the wind.

Table 2 – Standard on chemical quality of water for irrigation

Element or ion	MRV (mg/L)	MPV (mg/L)
Aluminium (Al)	5.0	20
Arsenic (As)	0.10	10
Barium (Ba)	1.0	*
Beryllium (Be)	0.5	1.0
Boron (B)	0.3	3.75
Cadmium (Cd)	0.01	0.05
Lead (Pb)	5.0	20
Chloride (Cl)	70	-
Cobalt (Co)	0.05	10
Copper (Cu)	0.20	5.0
Chromium (Cr)	0.10	20
Tin (Sn)	2.0	*
Iron (Fe)	5.0	*
Fluoride (F)	1.0	15
Lithium (Li)	2.5	5.8
Manganese (Mn)	0.20	10
Molybdenum (Mo)	0.005	0.05
Nickel (Ni)	0.5	2.0
Nitrate (NO ₃)	50	*
Selenium (Se)	0.02	0.05
Sulphate (SO ₄ ²⁻)	575	*
Vanadium (V)	0.10	1.0
Zinc (Zn)	2.0	10.0