



Wastewater and Sludge Reuse Guidelines for Lebanon

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National Reuse Guidelines

- Baalbeck Iaat wastewater treatment plant was funded by a World Bank loan.
- As part of the loan, an agreement FAO-CDR signed July 2009 to implement a capacity building project with overall goal of:

enhancing re-use of treated effluent and sludge in Lebanon, taking into account the different stakeholders, through capacity building and awareness building as well as through the development of national guidelines

Project Outputs

- Soil conditions and types of crops that can be cultivated and irrigated with treated effluent in the Baalbeck area are assessed
- Guidelines for the reuse of treated effluent and sludge are developed
- Capacity of national technical personnel on the re-use of treated effluent and sludge is built
- Awareness campaign for all stakeholders concerned with the re-use of treated effluent and sludge is conducted.

Re-use Potential in Lebanon

1. Wastewater:

Aquastat, FAO, 2007

- 310 millions m³/year of wastewater are produced
- 2 millions m³/year of untreated wastewater are used for informal irrigation

2. Sludge:

- Depending on the type of treatment (Average 65 g/person)

Process Followed during the Development of the Guidelines for Sludge & Wastewater Reuse





Wastewater Reuse Guideline

Driving forces to increase reuse of treated wastewater

- Increasing Water Scarcity
- Degradation of fresh water resources resulting from improper disposal of wastewater
- Growing recognition of wastewater as a water and a nutrient source
- The millennium development goals (MDG) for ensuring environmental sustainability
- In Lebanon water use for agriculture irrigation accounts 60% of total water use.

Reuse of treated wastewater in agriculture

Objective: Maximize the protection of human health and the beneficial use of important resources

protection of public health: 'multiple barriers' approach

- ◇ waste water treatment
 - ◇ crop restriction
 - ◇ irrigation technique
 - ◇ human exposure control
 - ◇ vaccination (curative)
- } Must be managed by Guidelines or standards

	E. Coli Or Faecal Coli /100ml	Nematode eggs/l	TSS	Crops eaten uncooked is allowed	Code of practice
<u>California</u>	2,2	-	Turbidity		Yes
WHO	1000 (1989)	<1	-	Yes	Yes
Cyprus	5 (15)	Absence	10-45	No	Yes
France	1000	<1	-	Yes	Yes
Italy	10	-	10		Yes
Israel	10	-	10	Yes	Yes
Jordan	100	≤1	50-150	No	Yes
Morocco	1000	Absence	100-2000	Yes	No
Palestine	1000	<1	30-60	No	Yes
Syria	1000	<1	50-150	No	Yes
Tunisia	-	<1	30	No	Yes
Kuwait	20	<1	15	No	Yes
Oman	200	<1	15-30	Yes	
Saudi Arabia	2,2	<1	10	No	Yes
Spain	10	<1		Yes	Yes
Greece	10	<0,1	10-35	No	No
Turkey	2-1000	-	20-60	No	Yes

Raw wastewater (in) and treated water (out) at Baalbek WWTP

Date of analysis	TSS (mg/l)		BOD (mg/l)		Faecal Coliformes (In 100ml)
	In	Out	In	Out	Out
2009-08-24	394	80	243	46	166
2009-09-01	355	72	157	28	186
2009-09-09	302	36	168	22	156
2009-09-16	312	22	92	29	147
2009-09-24	386	24	138	20	192
2009-09-29	287	24	122	23	184
2009-10-05	210	33	108	21	172
Min	210	22	92	20	147
Max	394	80	243	46	192
Mean	321	42	147	27	172

<60

<200

Proposed Guidelines for Lebanon

Parameter	Category of treated wastewater		
	I Irrigation of vegetable eaten raw is <u>not</u> allowed	II	III
BOD ₅	25	100	100
COD	125	250	250
TSS	60	200	200
pH	6 – 9	6 – 9	6 – 9
Cl ₂ residual	0.5-2	0.5	0.5
N-NO ₃	30	30	30
Faecal Coliforms (in 100ml)	<200	<1000	None required
Helminth ova (in 1 litre)	<1	<1	<1

Water categories

- **Category I : (Irrigation of vegetable eaten raw is not allowed)**

1. Fruit trees and crops that are eaten cooked
2. Parks, public gardens, lawns, golf courses and other areas with direct public exposure
3. In case of stabilisation ponds, the TSS limit value is 200 mg/l.

Water treatment expected to meet the criteria: Secondary treatment + filtration + disinfection

- **Category II**

1. Fruit trees
2. Lawns, wooded areas, and other areas with limited public access, road sides outside urban areas
3. Landscape impoundments: ponds, water bodies and ornamental streams, where public contact with water is not allowed.

Water treatment expected to meet the criteria: Secondary treatment + filtration + disinfection or Secondary treatment + either storage or well-designed series of maturation ponds or infiltration percolation

- **Category III**

1. Irrigation of cereals and oleaginous seeds, fiber, & seed crops
2. Crops for canning industry, industrial crops
3. Fruit trees (except sprinkler-irrigated)
4. Plant nurseries, ornamental nurseries, wooded areas, green areas with no access to the public

Water treatment expected to meet the criteria: Secondary treatment + a few days' storage or Oxidation pond systems.

	E. Coli Or Faecal Coli /100ml	Nematode eggs/l	TSS	Crops eaten uncooked is allowed	Code of practice
Lebanon	200	<1	60-200	No	Yes
<u>WHO</u> (1989)	1000	<1	-	Yes	Yes
Cyprus	5 (15)	Absence	10-45	No	Yes
France	1000	<1	-	Yes	Yes
Italy	10	-	10		Yes
Israel	10	-	10	Yes	Yes
Jordan	100	<=1	50-150	No	Yes
Morocco	1000	Absence	100-2000	Yes	No
Palestine	1000	<1	30-60	No	Yes
Syria	1000	<1	50-150	No	Yes
Tunisia	-	<1	30	No	Yes
Kuwait	20	<1	15	No	Yes
Oman	200	<1	15-30	Yes	
Saudi Arabia	2,2	<1	10	No	Yes
Spain	10	<1		Yes	Yes
Greece	10	<0,1	10-35	No	No
Turkey	2-1000	-	20-60	No	Yes

Why WHO-FAO guidelines: 1000 FC/100 ml is acceptable ?

- Is sufficient for the irrigation of all crops for the following reasons:
 - The U.V rays proceed to a certain inactivation of the pathogens,
 - Survey studies conducted by WHO and FAO have shown that 45% of the studied rivers showed concentrations > 1000 C.F. /100 ml).
 - WHO for bathing: < 1000 FC/100ml and EU < 2000 FC/100 ml

Why Lebanese guideline <200 FC/100ml is safe and sustainable

- More stringent than WHO-FAO guidelines
- The cost to obtain this concentration is not higher than the cost for environment protection
- The first result from Baalbek WWTP show that this concentration can be maintained during all the year

Chemical water quality

- The microbiological elements are possible to eliminate by biological treatment,
- wastewaters and conventional irrigation water contain **chemical elements that cannot be eliminated by a traditional secondary biologic treatment** (FAO Guidelines for conventional irrigation water gives concentration limits to consider)
- Often, the limits on concentrations of many chemicals in the irrigation water will be determined by crop requirements and not by health concerns (N, B, Na)
- Water quality is also a factor in selecting the type of irrigation method. For example, sprinkler irrigation with water that contains relatively high concentrations of sodium or chloride ions can cause leaf damage to sensitive crops.

Water quality for irrigation - FAO

Parameter	Guidelines	Units	Degree of restriction on use		
			None	Slight to moderate	Severe
Salinity EC		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 sulphide (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
Nitrogen (NO ₃ -N)		mg/l	<5	5-30	>30
pH			Normal range 6.5-8		

Threshold levels of trace elements for crop production - FAO Guidelines

Element		Recommended maximum concentration (mg/l)
Al	Aluminium	5.0
As	Arsenic	0.10
Be	Beryllium	0.10
Cd	Cadmium	0.01
Co	Cobalt	0.05
Cr	Chromium	0.10
Cu	Copper	0.20
F	Fluoride	1.0
Fe	Iron	5.0
Li	Lithium	2.5
Mn	Manganese	0.20
Mo	Molybdenum	0.01
Ni	Nickel	0.20
Pd	Lead	5.0
Se	Selenium	0.02
V	Vanadium	0.10
Zn	Zinc	2.0

Suggested frequency of sampling

Parameter	Number of samples
BOD ₅ Suspended Solids Total Phosphorous Total Nitrogen	For capacity 2000 - 49999 p.e. 12/year (1/month) For capacity > 50000 p.e. 24/year (2/month)
Inlet flow (m ³ /sec) Outlet flow (m ³ /sec)	Daily
Al, As, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Va, Zn, Hg	1/year (in the cases that the results show high concentration value, a second measurement is suggested within the year)
pH, temperature, color, TDS, nitrates, phosphates, conductivity	1/month
Na, Ca, Mg, K, sulphates, chlorides, B	2/year
E. Coli/100ml Feacal Coli/100ml Helminth eggs/l	24/year (wastewater treatment plants with p.e.> 50.0000)



Sludge Reuse Guidelines

Sludge Reuse in Agriculture

Advantages:

- Full nutrients recovery
- Cheap fertilizer
- Low disposal cost

Advantages:

- Pathogens may be spread
- Heavy metals and organic pollutants are applied too

Limits trace elements concentration in sludge

International guidelines

COUNTRIES	Cd	Cr	Cu	Hg	Ni	Pb	Zn
EU	20 - 40	1000 - 1750	1000 -1750	15 - 25	300 - 400	750 - 1200	2500 - 4000
France	20 - 40	1000 - 2000	1000 - 2000	10 - 20	200-400	800-1600	3000-6000
Germany	5 -10	900	800	8	200	900	200-2500
Belgium - W	10 - 20	500	600 - 1000	10 - 16	100-300	500-750	200-2500
Belgium – F	12	500	750	10	100	600	2500
Denmark	0.8 - 200	100	1000	0.8 - 200	30 - 2500	60-120	4000
Spain-Soil pH < 7	20	1000	1000	16	300	750	2500
Spain-Soil pH > 7	40	1500	1750	25	400	1200	4000
Greece	20 - 40	-	1000 - 1750	16 - 25	300 - 400	750 - 1200	2500 - 4000
Ireland	20	-	1000	16	300	750	2500
Italy	20	-	1000	10	300	750	2500
Luxembourg	20-40	1000 -1750	1000 - 1750	16 - 25	300 - 400	750 - 1200	2500 - 4000
The Netherlands	1.25	75	75	0.75	30	100	300
Suisse	5	500	600	5	80	500	2000
Syria Class A - E	3-32	100-600	100-1500	1-19	60-300	150-400	200-2800
Lebanon-Class A	5	250	375	4	125	150	700
Lebanon- Class B	20	500	1500	15	270	300	2500
Lebanon-- Class C	32	600	1500	19	300	400	2800

Trace elements classes for sludge Proposition for Lebanon

Metal Element ($\mu\text{g/g}$)	Class		
	A	B	C
Arsenic	20	20	30
Cadmium	5	20	32
Chromium	250	500	600
Copper	375	1500	1500
Lead	150	300	400
Mercury	4	15	19
Nickel	125	270	300
Selenium	8	50	90
Zinc	700	2500	2800

- Class A, unrestricted use,
- Class B and C restricted use,
- Class D, not suitable for use.

Sludge use on the basis of its class

<i>Class</i>	<i>Usage</i>	<i>Restriction level</i>
A	<ul style="list-style-type: none"> 1) Public activities sites 2) Parks and green areas 3) Agriculture (vegetables eatable raw are not allowed) 4) Forest 5) Reclamation land 6) Landfills 7) Surface soils within the premises of treatment plants 	Unrestricted Use
B	<ul style="list-style-type: none"> 3) Agriculture (vegetables eatable raw are not allowed) 4) Forest 5) Reclamation land 6) Landfills 7) Surface soils within the premises of treatment plants 	Restricted I
C	<ul style="list-style-type: none"> 4) Forest 5) Reclamation land 6) Landfills 7) Surface soils within the premises of treatment plants 	Restricted II
D	<ul style="list-style-type: none"> 6) Landfills 7) Surface soils within the premises of treatment plants 	Not suitable for use

Pathogenic organisms in the dry sludge

International Guidelines

	Faecal coliforms	Salmonella	Helminth eggs
US – Class A	<1000 MPN /gr. dry solids	<3 MPN / 4 gr. dry solids	<1 viable /4 gr. dry solids
US – Class B	<2.10 ⁶ MPN /gr. dry solids		
EU	No guidelines		
Tunisia	<2.10 ⁶ MPN /gr. dry solids	-	-
Syrian	<1000 MPN /gr. dry solids	<3 MPN / 4 gr. dry solids	<1 / 100ml at 5% dry solids
Jordan	<1000 MPN /gr. dry solids	<3 MPN / 4 gr. dry solids	<1 viable /5 gr. dry solids
Lebanon	<1000 MPN /gr. dry solids	<3 MPN / 4 gr. dry solids	<1 viable /5 gr. dry solids

Main limitations for Agricultural use

- Do not use biosolid products on lands where crops like raw edible vegetables and fruits are cultivated,
- Biosolid products can be used after 8 months of its date of production,
- Pasturing on treated lands with biosolid products should not be allowed before two months of its application,
- Use mechanical burial methods for biosolid products and do not use the manual traditional methods,
- Biosolids products should not be stored close to the drain, irrigation channels and water resources,

Main limitations for Agricultural use

- Limitation of the applied amount and restrictions for sludge rich in heavy-metals.
- Restricted access to farmland where biosolids have been applied for 30 days.
- Application limited to level areas (< 5 % slope) and no application close to water bodies.
- Soil depth to groundwater > 1m - setback distances to water supply wells (> 150 m) and surface water supply intake (> 750 m).

Sludge analyses

Agricultural use parameters

- pH (water);
- dry matter,
- organic matters,
- total N,
- NH₄-N
- P₂O₅
- K₂O
- MgO

Guidelines parameters

- Contents on heavy metals: cadmium, copper, nickel, lead, zinc, mercury, chromium.
- Faecal coliform, Salmonella and Helminths ova

Frequency of sludge analysis

Theoretical WWTP capacity PE	Minimum analysis per year	Time between 2 consecutives analysis	
		minimum	maximum
Capacity < 5.000 PE	1	6 months	1 year
5.000 < Capacity < 10.000 PE	2	4 months	6 months
10.000 < Capacity < 50.000 PE	3	3 months	4 months
50.000 < Capacity < 100.000 Pe	6	1 month	2 months
Capacity > 100.000 PE	12	15 days	1 month

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Thank you



Merci