CIE4485 Wastewater Treatment

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14. Agricultural use of treated effluents











Consumption (m ³ /pers./year)	NL 491 10	USA 1688	Haiti 5	Qatar	Tanz.	Yemen	Jordan
Consumption (m ³ /pers./year)	491 10	1688	5	476			
Domestic (%)	10			470	35	162	155
Domestic (70)		12	24	23	9	7	22
Industry (%)	59	46	8	3	2	1	3
Agriculture (%)	31	42	68	74	89	92	75
Total consumption (km ³ /year)	8	469	0.4	0.3	1.2	2.9	1.0
Renewable (km ³ /year)	90	2478	14	0.1	89	4.1	0.9
Threate	ening W	/ater Sh	nortage i	n Arid C	limate A	rea	
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Pathogenic	organisms in wastew	vater:
	Organism	Numbers in Wastewater (per litre)
Actual concentration	Bacteria: Fecal coliforms Campylobacter jejuni Salmonella spp. Shigella spp.	10 ⁷ - 10 ¹⁰ 10 - 10 ⁴ 1 - 10 ⁵ 10 - 10 ⁴
depends on: - Type of sanitation - Water consumption - Endemic diseases	Vibrio cholerae Helminths: Ascaris lumbricoides Ancylostoma / Necator	$\frac{10^{2} - 10^{5}}{1 - 10^{3}}$ $1 - 10^{3}$
	Trichuris trichiura Protozoa: Cryptosporidium parvum Entamoeba histolytica Giardia intestinalis	$\frac{1 - 10^2}{1 - 10^4}$ $\frac{1 - 10^2}{10^2 - 10^5}$
	Viruses: Enteric viruses Rotavirus	10 ⁵ - 10 ⁶ 10 ² - 10 ⁵
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WHO guid	elines, 2	2006 update:	
Based on to	olerable rotaviru	is infection of 10 ⁻² /person/year	
	Worm eggs (per I)	Fecal Coli (per 100 ml)	
A. Unrestricted consumed uncooked	≤ 1*	≤ 1000 (≤ 10⁴ if no root crops grown)	
B. Restricted Fodder and industrial crops	≤ 1*	 ≤ 10⁵ (with human exposure) ≤ 10⁶ (mechanised agr.) ≤ 10⁴ (Children < 15 years) 	
C. Localised Drip irrigation without exposure to workers/public	-	-	
	(*reduced to	0.1 when children < 15 exposed)	
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Treatment options fo	or pathogen re	emoval:
Treatment for pathogen remova	al (log units):	
	Helminth eggs	Bacteria
Primary sedimentation Anaerobic high-rate (UASB) Activated sludge [*] Trickling filter High rate trickling filter (DHS) Chlorination / Ozonation Waste stabilisation ponds Membranes	$ \begin{array}{c} 0 - 1 \\ 1 - 2 \\ 0 - 2 \\ 0 - 2 \\ 1 - 2 \\ 2 - 3 \\ 1 - 3 \\ 3 \end{array} $	$ \begin{array}{r} 0 - 2 \\ 0 - 2 \\ 0 - 2 \\ 0 - 2 \\ 2 - 4 \\ 3 - 6 \\ 3 - 5 \\ 5 - 6 \end{array} $
* Including settling pond		
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Removal et	fficiency (%)			
	Enteric viruses	Salmonella	Giardia	Cryptosporid um
Raw sewage	10 ⁵ -10 ⁶	5000-80000	9000-200000	1-4000
Primary tr.	50-98.3%	95.8-99.8%	27-64%	0.7%
Secondary tr.	53-99.9%	98.7-99.996%	45-96.7%	
Tertiary tr.	99.983- 99.9999998%	99.99- 99.9999999995%	98.5-99.99995%	2.7%

	R	RWZI Kralingseveer			RWZI Amsterdam Westpoort Huishoudelijk		
geometric mean	untreated sewage water	effluent from RWZI	purification efficiency	untreated sewage water	effluent from RWZI	Purification efficiency	
microorganisms (n	umber/l)						
Cryptosporidium	540	17	1.5 log (96.8%)	4650	250	1.3 log (94.7%	
Giardia	1220	13	2.0 log (99.0%)	21300	250	1.9 log (98.8%	
SSRC	6.2 x 10 ⁵	$1.7 \text{ x } 10^4$	1.6 log (97.2%)	7.9 x 10 ⁵	3.8×10^4	1.3 log (95.1%	
SCP	6.0 x 10 ⁵	$1.5 \ge 10^4$	1.6 log (97.4%)	5.4 x 10 ⁵	2.1×10^4	1.4 log (96.2%	
THCOL	9.4 x 10 ⁷	1.1 x 10 ⁶	1.9 log (98.8%)	1.6 x 10 ⁸	6.9 x 10 ⁵	2.4 log (99.6%	
FSTREP	3.6 x 10 ⁶	$5.7 \ge 10^4$	1.8 log (98.4%)	$1.6 \ge 10^7$	$1.1 \ge 10^5$	2.1 log (99.3%	
FRNAPH	2.2×10^{6}	5.7 x 10 ³	2.6 log (99.7%)	4.3 x 10 ⁶	$3.1 \ge 10^4$	2.1 log (99.3%	
enterovirus	34	0.27	2.1 log (99.2%)	190	0.53	2.6 log (99.7%	
reovirus	69	2.7	1.4 log (96.1%)	370	8.4	1.6 log (97.7%	
general parameters	(mg/l)						
BZV	87	3.1	96%	310	2.3	99%	
CZV	270	37	86%	570	33	94%	
suspended matter	96	< 10	> 90%	230	14	94%	
chloride	140	120	14%	190	210	0%	



		(Till, 2001)		
Membrane	Pore Size(mm)	Average Log Reduction	Bacterial Virus	Reference
MBRs: PE (1)	0.1	4.6	Coliphage QB	Chiemchaisri (1992)
PS (1) PS (1)	0.5 0.3	5 ND	TC TC	Gander (in press) Jefferson (1998)
Memtec (2)	0.2	ND	тс	Kolega (1991)
Memcor (2)	0.2	3.8	FC	Till (1998)
Renovexx (2)	0.5-1.5	3.3	FC	Till (1998)
Stork (3)	0.05-0.2	2.5	FC	Tin (1998)
Starcosa (3)	0.2	ND	TC	Till (1998)
DOW (3)	0.2	<7	TC	Till (1998)
(1) Activated sl(2) Primary sev(3) secondary sND - None Det	udge within M vage effluent; sewage efflue ected; TC - To	IBR; nt. otal Coliforms; F	C - Faecal C	oliforms





















Salinity level (EC and TDS)	Strategy
< 0.7 dS/m = < 500 mg/l	No problem for nearly all crops
0.7 – 3.0 dS/m = 500 – 2000 mg/l	Leaching is required; drip irrigation allows for most efficient leaching
> 3.0 dS/m = >2000 mg/l	High leaching requirements (up to 30%) may become restrictive <u>and thus salinity</u> tolerant crops are to be selected





Farm	Commodity	N-surplus (kg/ha)	P-surplus (kg/ha)	K-surplus (kg/ha)
A2	Alfalfa 1	6261	4100	3064
B1	Alfalfa 1	12906	5383	3450
B2	Apricot	70	37	49
C1	Tomato	721	477	1166
	Cucumber	0	461	1041
C2	Onion 1	456	89	411
	Potato 1	115	60	167
	Potato 2	146	64	192
	Iomato	920	209	/14
	Cucumber	782	271	960
03	Onion 1	1439	123	568
~	Cucumber	/11	322	1193
C4	Iomato	944	2/1	198
	Potato	340	93	231
Δft	er Boom and Dugg	ab (2000)		

Contri	bution of efflu	uent nutrients	to plant nutrie	ent demand (%
Farm	Commodity	N	Р	к
A2 B1 B2	Alfalfa 1 Alfalfa 1 Apricot	461 752 229	1858 3090 3446	439 313 329
C1	Tomato	27 86	85 73	126 205
C2	Onion 1 Potato 1 Tomato	204 95 396 208	364 322 459 342	208 83 416 604
СЗ	Onion 1 Cucumber Tomato	358 132 36	921 303 118	476 920 96
C4	Potato	38	159	27
By using t Jordanian	he available nut farmers could s	trients in treated save 650 – 2000	sewage: Euro per vegeta	ble per season !
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Source: ad	Nutrient removal by crops e: adapted from Feigin et al., 1991			
Crop	Yield (kg/ha)	Removal fr	om field in harve in kg/ha	ested product
		N	Р	к
Alfalfa	15.000	425	34	384
Barley	5.000	85	16 (grain) 8 (straw)	140
Cotton (seed)	6.000	140	21	300
Corn (silage)	5.000	100	5.2	89
Corn (grain)	10.000	361	30	42
Wheat (grain)	5.000	112	8	141
	Note: Ducky (ac	weed nutrien quaculture)	t harvest: 5-1 1-3	0 kg N/(ha.day kg P/(ha.day)
UDelft			Agricultural us	e of treated effluent













	Survival times in days (at 20-30°C)					
	In faeces, nightsoil and	In fresh water and sewage	In the soil	On crops		
Viruses	sludge					
Enteroviruses	<100 (<20)	<120 (<50)	<100 (<20)	<60 (<15)		
Bacteria						
Faecal Coliforms	<90 (<50)	<60 (<30)	<70 (<20)	<30 (<15)		
Salmonella spp.	<60 (<30)	<60 (<30)	<70 (<20)	<30 (<15)		
Shigella spp.	<30 (<10)	<30 (<10)	-	<10 (<5)		
Vibrio cholerae	<30 (<5)	<30 (<10)	<20 (<10)	<5 (<2)		
Protozoa						
Entamoeba histolytica cysts	<30 (<15)	<30 (<15)	<20 (<10)	<10 (<2)		
Helminths						
Ascaris lunbricoides eggs	Many Months	Many Months	Many Months	<60 (<30)		





