Suggested Parameters for the Analysis of Wastewater from Healthcare Facilities

Introduction

This guidance note was prepared in response to requests from countries involved in the UNDP GEF project. It may be used as a guide in countries where regulations pertaining to wastewater from healthcare facilities do not exist.

Effluent Discharge Parameters

The table below gives a list of parameters that should be considered in the testing of wastewater from general hospitals. These parameters are based on an EU directive,[1] an EPA study in 1991,[2] and on pollutants that may be reasonably expected to be found in hospital wastewater.

Parameter	Concentration	Reference	Test Method	Notes
pH	6 – 9 is a typical acceptable range*		pH meter or titration	
BOD5 at 20°C	25 mg/L O_2	EU Council Directive 91/271/EEC	See Table 1 of EU Council Directive 91/271/EEC	
COD	125 mg/L O_2	EU Council Directive 91/271/EEC	See Table 1 of EU Council Directive 91/271/EEC	
Total suspended solids	35 mg/L	EU Council Directive 91/271/EEC	See Table 1 of EU Council Directive 91/271/EEC	
Oils and grease (also called fats/oils/grease or FOG)	100 mg/L	From North Carolina Department of Environment	EPA Method 1664 (instead of the APHA Standard Method	Typical concentration limit applicable to hospitals

[1] EU Council Directive 91/271/EEC http://ec.europa.eu/environment/water/water-urbanwaste/directiv.html

[2] In a study by the US EPA of hospital wastewaters, the following pollutants were found to have the highest average concentrations: total dissolved solids, chemical oxygen demand (COD), phosphate, surfactants, formaldehyde, phenol, and fluoride. In addition, the most frequently detected pollutants in hospital wastewater were: COD, phenol, silver, lead, copper, and zinc. Other pollutants found were: total chromium, nickel, arsenic, cadmium, selenium, and mercury. Reference: "Supplemental Manual on the Development And Implementation of Local Discharge Limitations Under the Pretreatment Program: Residential and Commercial Toxic Pollutant Loadings and POTW Removal, US EPA, Office of Water Enforcement and Compliance, May 1, 1991 http://www.epa.gov/npdes/pubs/owm0013.pdf

		and Natural Resources[3]	which uses Freon)	
Phosphate or total phosphorus	6 – 15 mg/L is the range for several US cities	Major pollutant found in hospitals by EPA (see footnote 2)	APHA Standard Method: digestion followed by vanadomolybdophosphorus acid calorimetric method	Due to detergents used in hospitals
Surfactants	See examples*	Major pollutant found in hospitals by EPA (see footnote 2)	APHA Standard Method: separation by sublation followed by colorimetric method as MBAS and CTAS	Due to detergents used in hospitals
Phenols	See examples*	Major pollutant found in hospitals by EPA (see footnote 2)	APHA Standard Method: chloroform extraction followed by colorimetric method using 4-aminoantipyrine	Due to disinfectants, cleaners, and medicines
Formaldehyde	0.1 mg/L (based on the 96-hr LC50 environmental toxicity to bluegill)	Major pollutant found in hospitals by EPA (see footnote 2)	APHA Standard Method: liquid-liquid extraction gas chromatography using PFBHA agent	Due to disinfectants and lab waste
Fluoride	See examples*	Major pollutant found in hospitals by EPA (see footnote 2)	APHA Standard Method: distillation followed by fluoride ion-selective method or colorimetric method using zirconium-dye lake	
Arsenic, barium, cadmium, chromium (total), copper, iron, lead, nickel, selenium, silver, and zinc	See examples*	Major pollutant found in hospitals by EPA (see footnote 2)	Flame atomic absorption (AA) or inductively coupled plasma (ICP) spectroscopy; electrothermal AA or ICP for arsenic and selenium	AA and ICP are the most common general methods used, included in the APHA Standard Method
Mercury	See examples*	Major concern for GEF project, WHO and HCWM	Cold vapor atomic absorption spectroscopy	
Trihalomethanes and chlorinated organics	(0.08 for trihalomethanes**)	Major concern for GEF project since chlorinated organics can lead to dioxin formation in wastewater	APHA Standard Method: Liquid-liquid extraction gas chromatography or purge-and-trap gas chromatography	Due to chlorinated disinfectants (hypochlorite)
Haloacetic acid and trichlorophenols	(0.06 for haloacetic acid**)	Major concern for GEF project since trichlorophenols can lead to dioxin formation in wastewater	APHA Standard Method: micro liquid-liquid extraction gas chromatography	Due to chlorinated disinfectants (hypochlorite)

[3] "Considerations for Management of the Discharge of FOG to Sanitary Sewer Systems," Appendix F, NC Department of Environment and Natural Resources, North Carolina, USA, June 2002.

Ammonia	See examples*	Ammonia in the wastewater is expected	APHA Standard Method: ammonia-selective electrode or titration	If testing ammonia, it may not be necessary to test for nitrates
Nitrate	See examples*	Nitrates expected due to ammonia and other nitrogen compounds	APHA Standard Method: nitrate electrode or cadmium reduction	See note regarding ammonia
Fecal coliform	See note below***	Expected in hospital wastewater**	APHA Standard Method: incubation using EC or A-1 broth	If testing fecal coliform, it would not be necessary to test for total coliform
Total coliform	See note below***	Expected in hospital wastewater**	APHA Standard Method: dilution followed by multiple-tube fermentation	If testing total coliform, it would not be necessary to test for fecal coliform
Selected micropollutants (optional): absorbable organic halides, analgesics, antibiotics, anticonvulsants, antihistamines, antihypertensives, beta-blockers, cytostatics, hormones, iodized contrast media, platinum, and radionuclides	none	See footnote 4	High performance liquid chromatography or gas chromatography-mass spectrometry	Micropollutants are of increasing concern in hospital wastewater

* For examples of concentration limits, see examples below for the EU, two cities in the US and Canada, the Philippines, and various countries in Latin America.

** These values are for informational purposes only and may not apply to wastewater since they are based on the maximum contaminant levels (MCLs) for *drinking* water in the US as regulated by the US EPA.

*** If the wastewater goes directly to a river or coastal waters without treatment, the coliform count should be tested. Also, if the wastewater goes directly to a river or coastal waters without treatment, other microorganisms of interest should be tested: pathogenic *E. coli*, enterococci, *Clostridium perfringens*, and *aeromonas* are the typical indicator species tested in wastewater.

SAMPLING AND FREQUENCY OF TESTING

Flow-proportional or time-based 24-hour samples should be collected at the same well-defined point in the outlet. Flow-proportional or time-based sampling is generally done using an automatic sampler linked to a flowmeter or timer. International standards for laboratory practices to minimize degradation of samples between collection and analysis should be followed. These include following recommended sample containers, preservation techniques, and maximum holding times.

The frequency of testing is generally based on population equivalent (p.e.), also called the unit per capita loading. The p.e. refers to the ratio of the organic biodegradable load produced during a 24-hour period by the facility in relation to the individual organic biodegradable load in household sewage produced by one person in the same period of time. For calculations, one unit is generally assumed to be equal to 54 g of BOD per 24 hours or a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per 24-hour day. The BOD5 values for a wide range of hospitals correspond to about 3 p.e. per patient.[4] Thus, the sewage treatment plant for a 700-bed hospital would be equivalent to a very small urban wastewater treatment plant (2000 to 9999 p.e.). For this size, EU Council Directive 91/271/EEC requires 12 samples for the first year and four samples in subsequent years if the effluent complies with all the provisions. If one of the four samples fails, 12 samples have to be taken the following year. Some regulatory authorities may allow a deviation of individual parameters not exceeding 100% or may require that the annual average conform to the parametric value.

EXAMPLES OF WASTEWATER DISCHARGE LIMITS FROM DIFFERENT COUNTRIES AND REGIONS

Wastewater discharge limits in EU Council Directive 91/271/EEC (refer to the Directive for more details):

Requirements for discharges from urban waste water treatment plants subject to Articles 4 and 5 of the Directive. The values for concentration or for the percentage of reduction shall apply.

Parameters	Concentration	Minimum percentage of reduction (1)	Reference method of measurement
Biochemical oxygen demand (BOD5 at 20 °C) without nitrification (2)	25 mg/l O_2	70-90 40 under Article 4 (2)	Homogenized, unfiltered, undecanted sample. Determination of dissolved oxygen before and after five-day incubation at 20 °C ± 1 °C, in complete darkness. Addition of a nitrification inhibitor
Chemical oxygen demand (COD)	125 mg/l O_2	75	Homogenized, unfiltered, undecanted sample Potassium dichromate
Total suspended solids	35 mg/l 35 under Article 4 (2) (more than 10 000 p.e.) 60 under	90 (3) 90 under Article 4 (2) (more than 10 000 p.e.) 70 under	- Filtering of a representative sample through a 0,45 ìm filter membrane. Drying at 105 °C and weighing - Centrifuging of a representative sample (for at least five mins with mean acceleration of 2 800 to

[4] "Hospital effluents as a source of emerging pollutants: An overview of micropollutants and sustainable treatment options," P. Verlicchi et al., *Journal of Hydrology, 389*, 416–428 (2010).

	Article 4 (2) (2 000-10 000 p.e.)	Article 4 (2) (2 000-10 000 p.e.)	3 200 g), drying at 105 °C and weighing

(1) Reduction in relation to the load of the influent.
(2) The parameter can be replaced by another parameter: total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD5 and the substitute parameter.
(3) This requirement is optional.
Analyses concerning discharges from lagooning shall be carried out on filtered samples; however, the concentration of total suspended solids in unfiltered water samples shall not exceed 150 mg/l.

Requirements for discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication as identified in Annex II.A (a). One or both parameters may be applied depending on the local situation. The values for concentration or for the percentage of reduction shall apply.

Parameters	Concentration	Minimum percentage of reduction (1)	Reference method of measurement
Total phosphorus	2 mg/l P (10 000 - 100 000 p. e.)	80	Molecular absorption spectrophotometry
Total nitrogen (2)	15 mg/l N (10 000 - 100 000 p. e.)	70-80	Molecular absorption spectrophotometry

(1) Reduction in relation to the load of the influent.
(2) Total nitrogen means: the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate (NO_3)-nitrogen and nitrite (NO_2)-nitrogen.

Wastewater discharge limits in two cities in the US and Canada:

NOTE: All the discharge limits for cities in the US and Canada are available from: http://www.pmairegs.org/sewer/

Parameter	Units (daily)	San Francisco, California, USA	Toronto, Canada
Arsenic	Value (mg/L)	4.0	1
BOD5	Value (mg/L)		300
Cadmium	Value (mg/L)	0.5	0.7
Chromium (Total)	Value (mg/L)	5.0	4
Copper	Value (mg/L)	4.0	2
Fats and Oil	Value (mg/L)	300	150
Fluoride	Value (mg/L)		10

Lead	Value (mg/L)	1.5	1
Mercury	Value (mg/L)	0.05	0.01
Nickel	Value (mg/L)	2.0	2
pH		6 – 9.5	
Phenolic Compounds	Value (mg/L)	23	
Phosphorus	Value (mg/L)		10
Silver	Value (mg/L)	0.6	
Suspended solids (total)	Value (mg/L)		350
Zinc	Value (mg/L)	7.0	2

Wastewater discharge limits in the Philippines:

for facilities discharging less than 30 m^3 per day, depending on what type of inland body of water the wastewater is discharged into

Parameter	Units (daily)	Source of general water supply	Recreational water (swimming)	Recreational water (boating), fishing area or source of agricultural water supply	General navigation or source of industrial water supply
Ammonia as NH_3-N	Value (mg/L)	.5	.5	.9	13
Arsenic	Value (mg/L)	0.02	0.02	0.04	0.08
Barium	Value (mg/L)	1.5	1.5	6	8
BOD5	Value (mg/L)	20	30	80	200
Cadmium	Value (mg/L)	.006	.0060	.01	.02
COD	Value (mg/L)	60	60	175	350
Copper as dissolved Cu	Value (mg/L)	.004	.004	.004	.008
Fats and Oil	Value (mg/L)	2	10	35	85
Fecal coliform	MPN/100ml	4	300	400	800
Fluoride	Value (mg/L)	2	2	2	4
Iron	Value (mg/L)	5	5	13	60
Lead	Value (mg/L)	.02	.02	.1	.2
Mercury	Value (mg/L)	0.002	0.002	0.004	0.008
Nickel	Value (mg/L)	.1	.2	1	5

Nitrate as NO_3-N	Value (mg/L)	14	14	24	50
pH		6 - 9	6 - 9	6 - 9	5.5 – 9.5
Phenol and phenolics	Value (mg/L)	.01	.01	.9	9
Phosphate	Value (mg/L)	1	1	2	15
Surfactant (MBAS)	Value (mg/L)	2	3	25	50
Total coliform	MPN/100ml	3000	3000	15000	25000
Total suspended solids	Value (ml/L)	70	85	150	250
Zinc	Value (mg/L)	4	4	4	8

Wastewater discharge limits in Latin America:

Parameter	Units (daily)	Chile	Bolivia	Peru	Brazil	Ecuador	Argentina	Mexico	Colombia	Venezuela	Paraguay
Arsenic	Value (mg/L)	0.5	1	0.5	1.5	0.1	0.5	0.75	0.5	0.5	0.5
Barium	Value (mg/L)					5			5	0.1	
BOD5	Value (mg/L)	33 - 50	80	250		250	200	200	800	350	250
Cadmium	Value (mg/L)	0.5	0.3	0.2	1.5	0.02	0.1	0.75	0.1	0.2	0.2
Chlorine (active)	Value (mg/L)					0.5					
Chloroform	Value (mg/L)					0.1			1		
Chromium (Total)	Value (mg/L)	10		10					1	2	
COD	Value (mg/L)		250 - 300	500		500			1500	900	600
Copper	Value (mg/L)	3	1	3	1.5	1		15	3	1	1
Fats and Oil	Value (mg/L)	150	10-20	100	150	100	100	75	100	150	100
Fluoride	Value (mg/L)				10						
Iron	Value (mg/L)		1		15	25			10	25	5
Lead	Value (mg/L)	1	0.6	0.5	1.5	0.5	0.5	1.5	0.5	0.5	0.5
Mercury	Value (mg/L)	0.02	0.002	0.02	1.5	0.01	0.005	0.015	0.02	0.01	0.01
NH_3 - NH_4+	Value (mg/L)	80	4	80		40					
Nickel	Value (mg/L)	4		4	2	2		6	2	2	2
pH		5.5 - 9.0	6.9	6 - 8	6 - 10	5 - 9	5.5 - 10	5.5 - 10	5 - 9	6 - 9	5 - 9
Phenolic Compounds	Value (mg/L)		1		5	0.2	0.5		0.2	0.5	0.5

Phosphorus	Value (mg/L)	10 - 45		10		15		20		10	
Selenium	Value (mg/L)					0.5			0.5	0.2	
Settleable solids	ml/L 1 hour	20		8.5	20	20	0.5	7.5	10		1
Silver	Value (mg/L)				1.5	0.5			0.5	0.1	
Surfactant	mg/L	7					5		10	8	5
Suspended solids (total)	Value (mg/L)	300	60	300		220		200	600	400	
Temperature	°C	35	±5°C	35	40	40	45	< 40	< 40	40	40
Zinc	Value (mg/L)	5	3	5	5	10		9	5	10	5

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