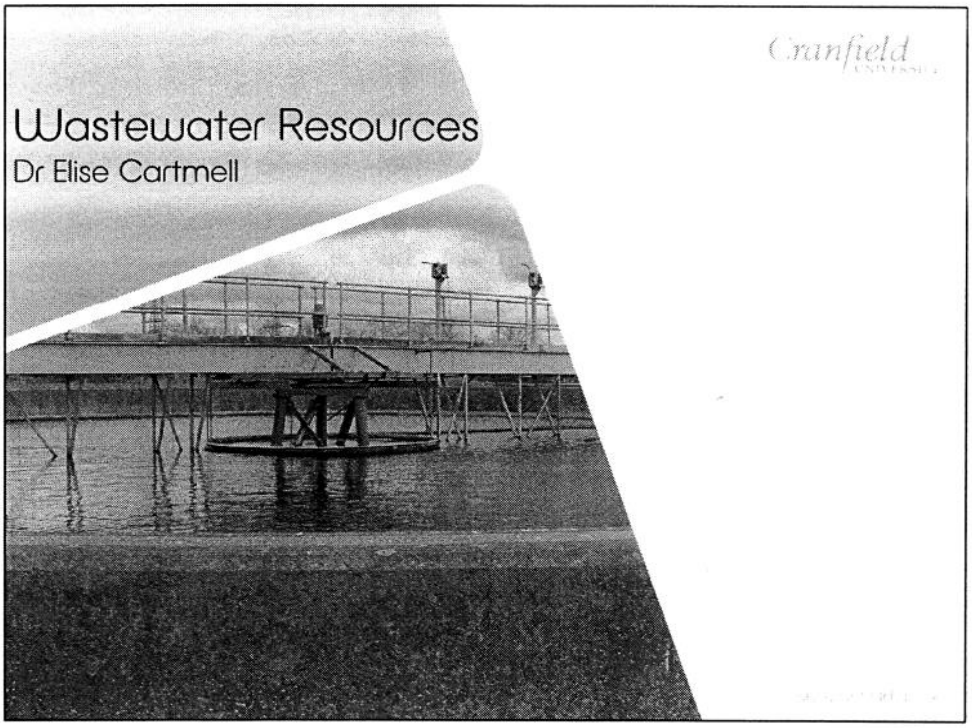

Cranfield
Wastewater Quality
Dr Elise Cartmell


Cranfield
Wastewater Resources
Dr Elise Cartmell

What will be covered in this lecture?

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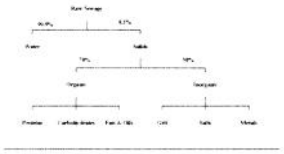
So what are the main constituents in sewage?



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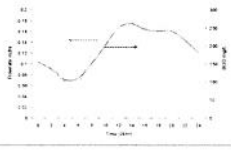
The flow pattern is typically diurnal



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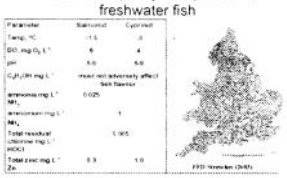
What water quality is expected for freshwater fish



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Aims and Objectives

- To be aware of the main constituents in municipal wastewater.
- To be aware of the regulatory drivers for wastewater treatment works

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So what are the main constituents in sewage?

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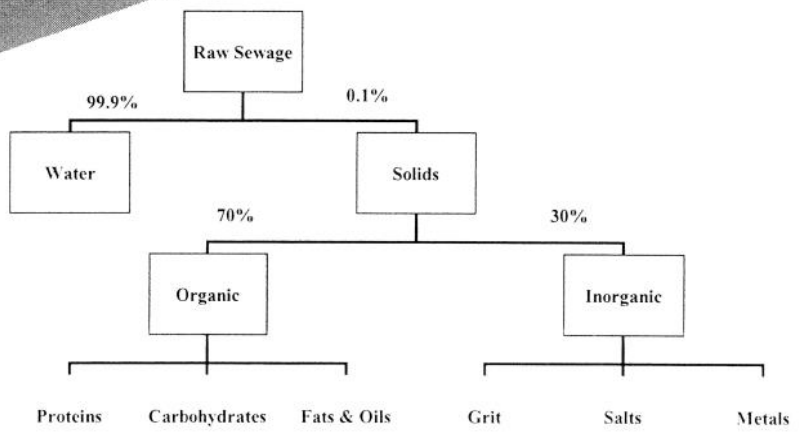

We can break down the solids into more useful descriptions

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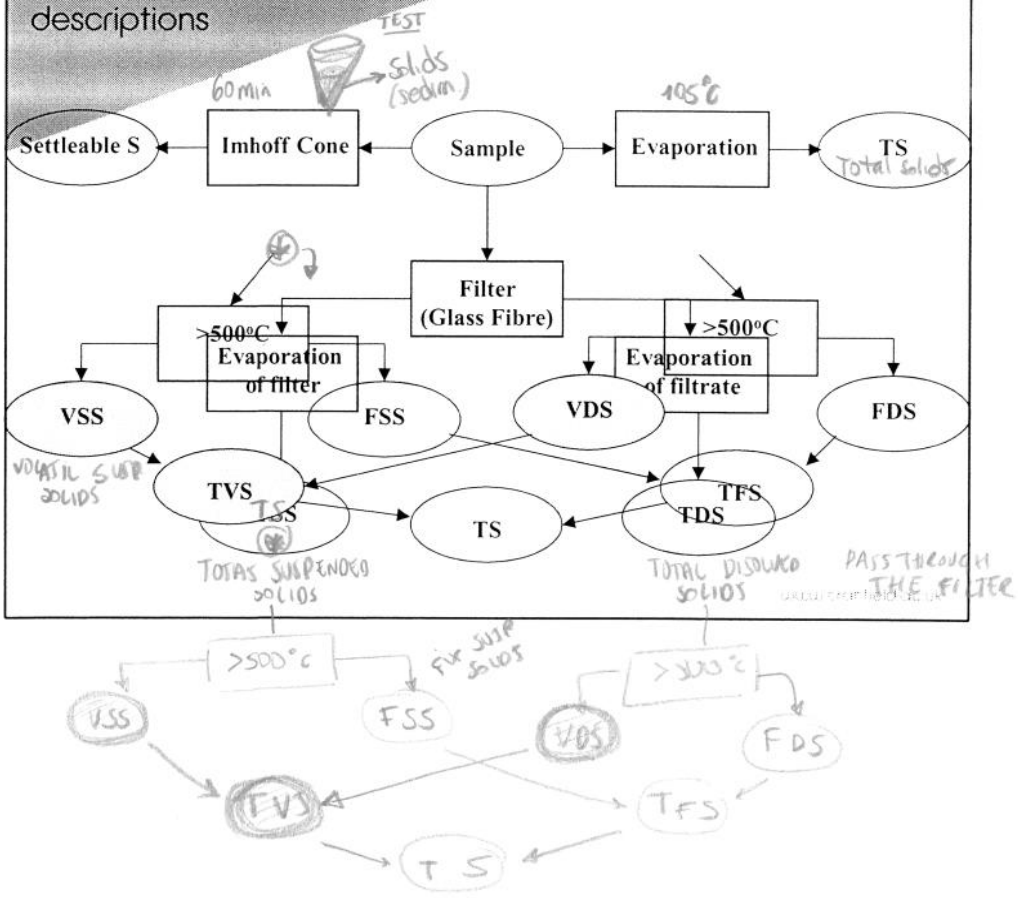

Size is very important!

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- Turbidity - measured in NTU
- Colour - qualitative, can tell you if sewage is septic
- Particle size

Here is an example of different strength sewages looking at solids

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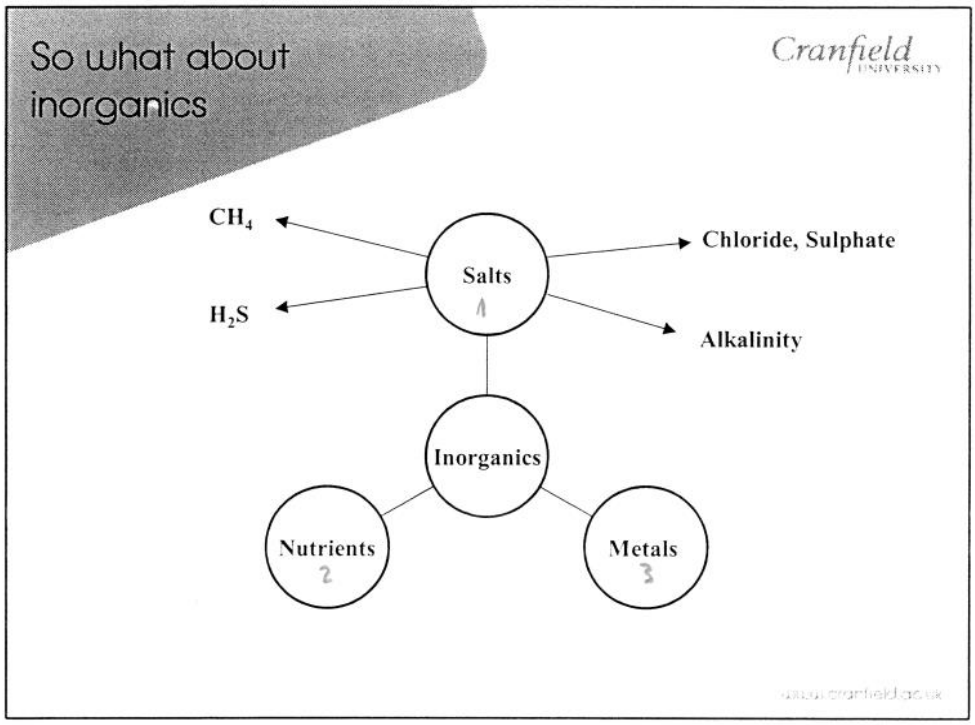
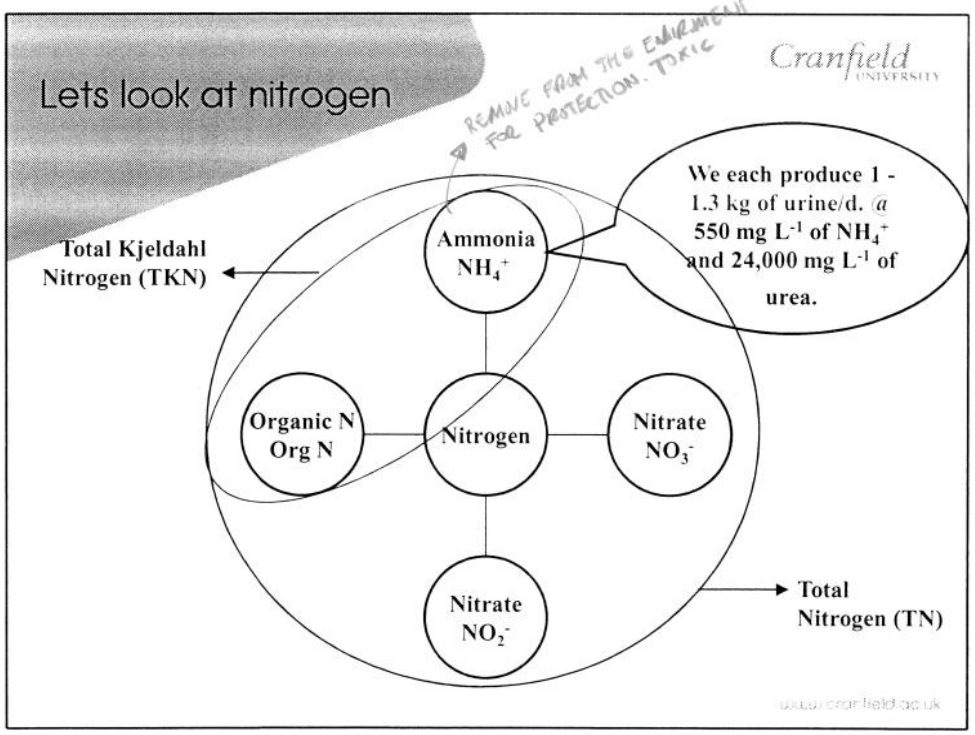
	Units	Low	Medium	High
TS	mg L^{-1}	390	720	1230
TDS	mg L^{-1}	270	500	860
FDS	mg L^{-1}	160	300	520
VDS	mg L^{-1}	110	200	340
SS	mg L^{-1}	120	210	400
FSS	mg L^{-1}	25	50	85
VSS	mg L^{-1}	95	160	315
Settleable	mg L^{-1}	5	10	20





$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

$\begin{cases} pH > 7 \rightarrow NH_3 \\ pH < 7 \rightarrow NH_4^+ \end{cases}$

We also have to consider phosphorus and metals

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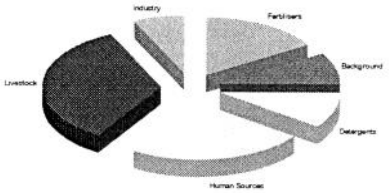
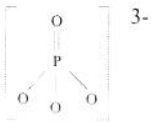
- Phosphorus - from household products & sewage
  ↳ ↑Phosp → ↑Algae (eutrophic.)
- Total phosphorus made up of Inorganic and organic phosphorus compounds





STPP

P-O-C

- Metals - wide range of metal present in sewage
  - Toxic metals such as - Ni, Cr, Pb, Cd, Hg, Se...
  - Metals from added chemicals – Fe, Mg, Na, Al...
  - Metals from ground water – As, Ca, Mg..

Here is an example of different strength sewages looking at nutrients

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	Units	Low	Medium	High
Total Nitrogen	mg L^{-1}	20	40	70
Organic	mg L^{-1}	8	15	25
Free ammonia	mg L^{-1}	12	25	45
Nitrites	mg L^{-1}	0	0	0
Nitrates	mg L^{-1}	0	0	0
Total Phosphorus	mg L^{-1}	4	7	12
Organic	mg L^{-1}	1	2	4
Inorganic	mg L^{-1}	3	5	8

There is also a range of organic material in sewage

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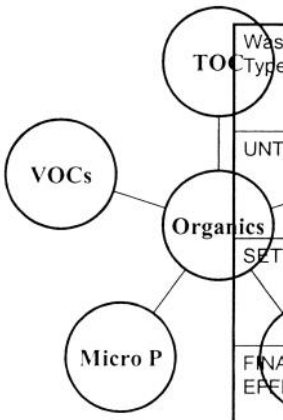
BIOCHEM. OX. DEMAND ↑ CHEMICAL OX. DEMAND ↑



Wastewater Type	BOD/COD	BOD/TOC
UNTREATED	0.3 - 0.8	1.2 – 2.0
SETTLED	0.4 – 0.6	0.8 – 1.2
FINAL EFFLUENT	0.1 – 0.3	0.2 – 0.5

We commonly use BOD & COD to tell us about strength

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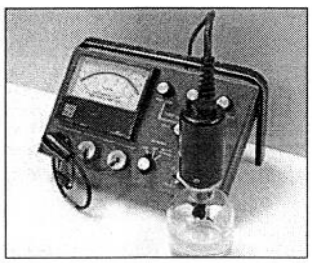

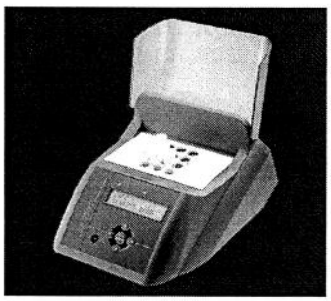

BOD → Give an idea of the treatment requirements

Here is an example of different strength sewage looking at organics

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	Units	Low	Medium	High
BOD_5	mg L^{-1}	110	190	350
COD	mg L^{-1}	250	430	800
TSS	mg L^{-1}	80	140	260
Oil and Grease	mg L^{-1}	50	90	100
VOCs	μg L^{-1}	<100	100-400	>400
Total Coliforms	No./100 mL	10^6 - 10^8	10^7 – 10^9	10^7 - 10^{10}
No./100 mL	No./100 mL	10^3 - 10^5	10^4 – 10^6	10^5 - 10^8

Estrogen
Settled Sewage

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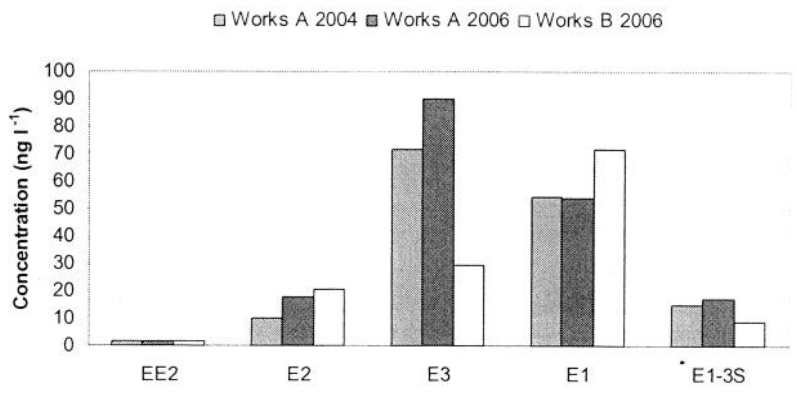

What else makes up sewage?

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	Units	Rainfall	Runoff	Grey water
BOD_5	mg L^{-1}	1-13	8-10	30-330
COD	mg L^{-1}	9-16	40-73	50-500
TSS	mg L^{-1}	<1	67-101	25-304
TKN	mg N L^{-1}		0.43-1.0	low
Nitrate	mg N L^{-1}	0.05 – 1	0.48-0.91	low
Phosphorus	mg P L^{-1}	0.02 – 0.15	0.67-1.66	low
Faecal Coliforms	No./100 mL		10^3-10^4	10^6-10^8

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Grey water recycling

Excluding toilet flushing

We also have to consider infiltration into sewers

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- Infiltration is defined as –
  - 'Water entering a collection system from a variety of points including service connections and from the ground through defective pipes, connections or manhole walls'
  - Ranges from 0.2 – 28 m^3/ha.d
  - In heavy rainfall can be as high as 500 m^3/ha.d

The flow pattern is typically diurnal

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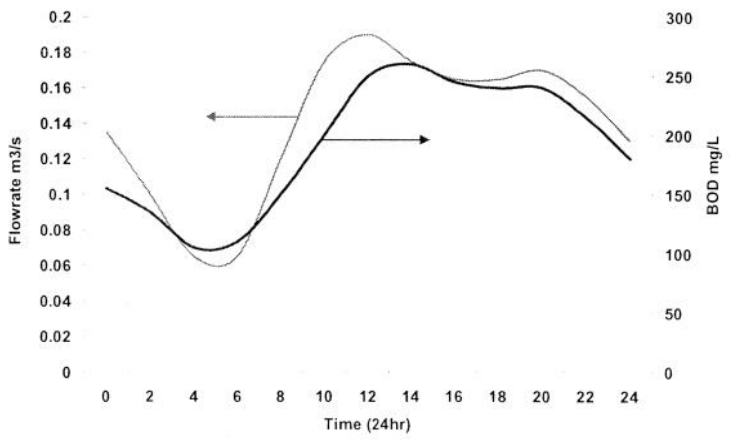
- Related to consumption patterns



Regulations

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What UK/EU regulations do we need to meet?

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- Urban Wastewater Treatment Directive (1991/271/EEC)
- Bathing Water Treatment Directive (2006/7/EC) replacing (76/160/EEC)
- Shellfish Directive (79/923/EEC)
- Freshwater Fish Directive (78/659/EEC)
- Water Framework Directive (2000/60/EC)
    - Priority Substances

UWWTD

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Parameter	Guideline	% Reduction
BOD_5	25 mg L^{-1}	70-90
COD	125 mg L^{-1}	75
TSS	35 mg L^{-1} (>10k p.e.) 60 mg L^{-1} (2k – 10k p.e.)	90 70
P	2 mg L^{-1} (10k – 100k p.e.) 1 mg L^{-1} (>100k p.e.)	80
N	15 mg N L^{-1} (10k – 100k p.e.) 10 mg N L^{-1} (>100k p.e.)	70-80

What water quality is expected for freshwater fish

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Parameter	Salmonid	Cyprinid
Temp, °C	≤1.5	≤3
DO, mg O_2 L^{-1}	6	4
pH	6-9	6-9
C_6H_5OH mg L^{-1}	must not adversely affect fish flavour	
ammonia mg L^{-1} NH_3	0.025	
ammonium mg L^{-1} NH_4	≤1	
Total residual chlorine mg L^{-1} HOCl	≤ 0.005	
Total zinc mg L^{-1} Zn	0.3	1.0

FFD Stretches (2003)

Freshwater Fish - Guidelines

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Parameter	Salmonid	Cyprinid
DO, mg O_2 L^{-1}	7	5
SS, mg L^{-1}	25	25
BOD_5	3	6
Nitrites mg NO_2 L^{-1}	0.01	0.03
ammonia mg NH_3 L^{-1}	0.005	0.005
ammonium mg NH_4 L^{-1}	0.04	0.2
Dissolved copper mg Cu L^{-1}	0.04	0.04

What water quality is expected in a bathing water

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Parameter	Guideline	Mandatory
Total Coliforms No./100 mL	800	10,000
Faecal Coliforms No./100 mL	100	2000
Faecal streptococci No./100 mL	100	-
Salmonella/litre	-	0
Enteroviruses PFU/litre	-	0

Bathing Water 2

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Parameter	Guideline	Mandatory
pH		6-9
Colour		No change
Mineral oil mg L^{-1}	≤0.3	No film visible
Surface active substances mg L^{-1}	≤0.3	No lasting foam
Phenols mg L^{-1}	≤0.005	No specific odour ≤0.005
Transparency	2	1 (0)
Dissolved O_2 (% sat.)	80-120	-
Tarry residues & floating material	Absence	-

What do we need to consider if discharging to a shellfish water

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Metals	Organohalogens	Others
Arsenic	DDT	Colour
Cadmium	Dieldrin	DO
Copper	Lindane	Faecal *coliforms*
Lead	Parathion	Hydrocarbons
Mercury		pH
Nickel		Salinity
Silver		Suspended solids
Zinc		Temperature

What's new – the priority substances directive Current UK chemicals Investigation Programme

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- This proposed Directive lays down environmental quality standards for priority substances and certain other pollutants.
- Includes range of organics and metals – examples include
  - Nonylphenol
    - Annual average of 0.3 $\mu g\ L^{-1}$ & MAC of 2.0 $\mu g\ L^{-1}$
  - Lead
    - Annual average of 7.2 $\mu g\ L^{-1}$
- http://ec.europa.eu/environment/water/water-dangersub/surface_water.htm

Aims and Objectives

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- To be aware of the main constituents in municipal wastewater.
- To be aware of the regulatory drivers for wastewater treatment works

Design a 80.000 population equivalent (PE) wastewater treatment works to treat a medium strength waste water to the Urban Wastewater Treatment Directive Standards

El fósforo solo hace falta si va a río, si estamos en costa no.

- Screening
- Grit removal } (heavy/large materials.
- Sedimentation
- Aerobic biological suspended growth → Degrades dissolved and suspended organic compounds in presence of oxygen
  Up to 15% removal of dissolved organic compounds,
  Influent BOD 100-10000 mg/l. Suspended solids increases from c. 100 to 2000 mg/l
- Sedimentation (settled sludge)

+ Anaerobic - Anoxic - Aerobic → phosphorous retaine

→ Sludge
- Thickening
- Dewatering
- Digestion

Popul. equiv. is a parameter used to describe the volume and load of a STW: refers to the amount of oxygen consumed by the waste water pollutants taking in consideration the waste water produced by one person

BOD wastewater: 0'220 g/l
Water usage per capita: 250 L/person·day

BOD load = BOD (g/L) · Capita usage (L/person·day)
BOD load = 55 g/person·day

PE = BOD (g/L) / BOD load (g/person·day) · flow (l/day)

The use of lime increase the PH and the final amount of sludges. Use not recommended.

GENERAL WASTEWATER TREATMENT FLOWSHEET