



Ogden Water

# An Introduction to Waste Water Treatment

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# An Introduction to Waste Water Treatment

## Consent to Discharge

- Clean water is a critical component for virtually all food manufacturers and processors.
- Unless all water taken in forms part of the product, e.g. blends, formulations etc. it follows that waste water will be generated.
- To discharge liquid effluent or waste water to a sewer, a company needs to obtain a trade effluent discharge consent from the local water company.
- Depending on the location, water will be discharged to the relevant body, e.g. United Utilities, Yorkshire Water, Severn Trent etc.

No consent → No discharge → NO PRODUCTION



# An Introduction to Waste Water Treatment Consent to Discharge

- The local water authority (LWA) is required by law to accept a company's effluent as long as it conforms to certain standards.
- In England and Wales the water companies provide these services according to the Water Industry Act 1991 (as amended).
- The LWA will apply standards or restrictions to the flow, strength and character of your discharge, which form part of the trade effluent consent.
- These are primarily intended to ensure the safety of downstream workers, to preserve the sewers and other infrastructures, to allow the LWA's sewage works to process the effluent successfully, and to achieve compliance in its final discharge to a watercourse.



# An Introduction to Waste Water Treatment Trade Effluent Consent Parameters

- A trade effluent discharge consent could dictate some or all of the following conditions:
- maximum **daily flow** (m<sup>3</sup>/day) and maximum **hourly flow** (m<sup>3</sup>/hour)
- permitted **pH range**, e.g. pH 6 - 9
- maximum **chemical oxygen demand (COD)** value, expressed in milligrams of oxygen requirement per litre (mg/l)
- maximum concentration of **suspended solids (SS)** in mg/l
- Maximum level of **Separable Fats, Oils and Greases (SFOGs)** in mg/l
- Others include: **ammonia, phosphate, heavy metals etc.**
- The limits will depend upon the scale of the discharge relative to the size of your local sewage works, and the amount of spare treatment capacity that is available there.



# An Introduction to Waste Water Treatment Trade Effluent Consent Excursions



United Utilities North West  
Davyhulme WwTW  
Rivers Lane  
Umston

## Water Industry Act 1991 – Breach of Trade Effluent Consent

I enclose a summary table of analytical results for samples of trade effluent taken from your premises in the last 12 months. You will see that the trade effluent discharged was in breach of consent on 3 occasions in respect of the following parameters:-

### Separable Oil and Grease

Breaches of consent can have a significant impact on the receiving sewerage system, treatment processes and the environment and United Utilities Water PLC is under a statutory duty to use its regulatory powers to minimise this impact. Thus, as you are aware, the breach of any condition in a Consent to Discharge is contrary to Section 121 of the Water Industry Act 1991. I would point out that such an offence, on summary conviction, is liable to a maximum fine not exceeding £5,000.

You are reminded that it is your duty to take all necessary steps to ensure that the trade effluent discharged from your premises complies at all times with the conditions in your trade effluent consent.

Without prejudice to any additional action United Utilities Water PLC may take in respect of the consent failures, I require you to advise me in writing and within 21 days, of the action you intend to take to ensure that your trade effluent discharge will comply with all the conditions of consent and in particular, the condition in respect of Separable Oil and Grease. I will be contacting you shortly to arrange a meeting to discuss remedial action, and have enclosed the format of the action plan you are invited to submit within 10 days of the meeting. Any plan you supply and the timescales involved in its implementation will be taken into account by United Utilities Water PLC in deciding how to proceed further.



# An Introduction to Waste Water Treatment Trade Effluent Consent Excursions



## Trade Effluent System Determinand Report

From: 24-Nov-2006 To: 20-Nov-2007

Determinand Code	OGPS	Determinand Desc	Separable Oil & Grease			
Trader Reference	Company	Sample Date	Lab Reference	Value	Unit	Pass/Fail ?
694T_LS26A024		30/10/2007	42548380	15.00	mg/l	
		18/10/2007	42548379	106.00	mg/l	** Failed **
		10/09/2007	42548377	490.00	mg/l	** Failed **
		04/09/2007	42548376	190.00	mg/l	** Failed **
		21/08/2007	42548374	48.00	mg/l	
		24/07/2007	42548371	16.00	mg/l	
		10/07/2007	42548372	16.00	mg/l	
		15/06/2007	42548370	32.00	mg/l	
		05/06/2007	42548369	80.00	mg/l	
		24/05/2007	42548368	16.00	mg/l	
		24/04/2007	42548367	32.00	mg/l	
		19/04/2007	42548365	16.00	mg/l	
		16/03/2007	42509125	32.00	mg/l	
		05/03/2007	42509124	16.00	mg/l	
		15/02/2007	42509122	27.00	mg/l	
		25/01/2007	42509121	30.00	mg/l	
		15/01/2007	42534312	22.00	mg/l	
		30/11/2006	42509117	22.00	mg/l	

<b>Average</b>	<b>67.06</b>
<b>Maximum</b>	<b>490.00</b>
<b>Minimum</b>	<b>16.00</b>

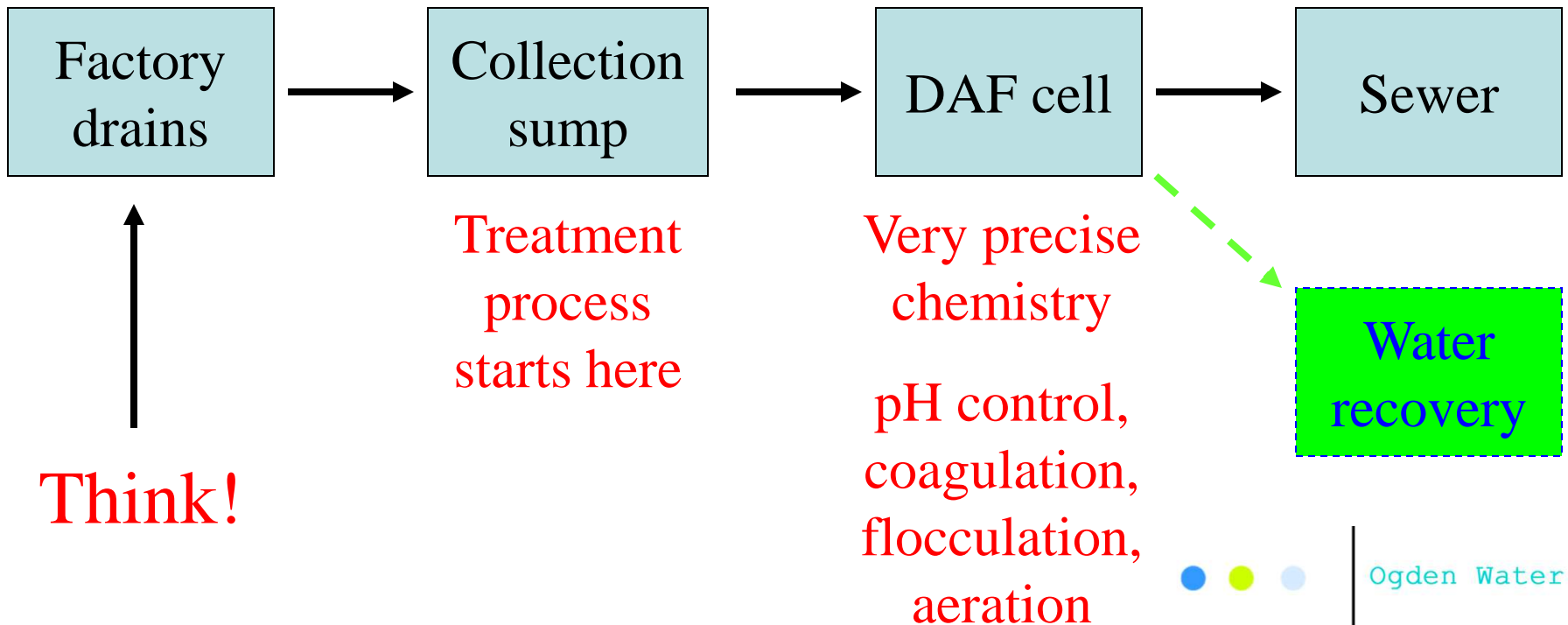
Total No of Samples: 18  
Total No of Failures: 3



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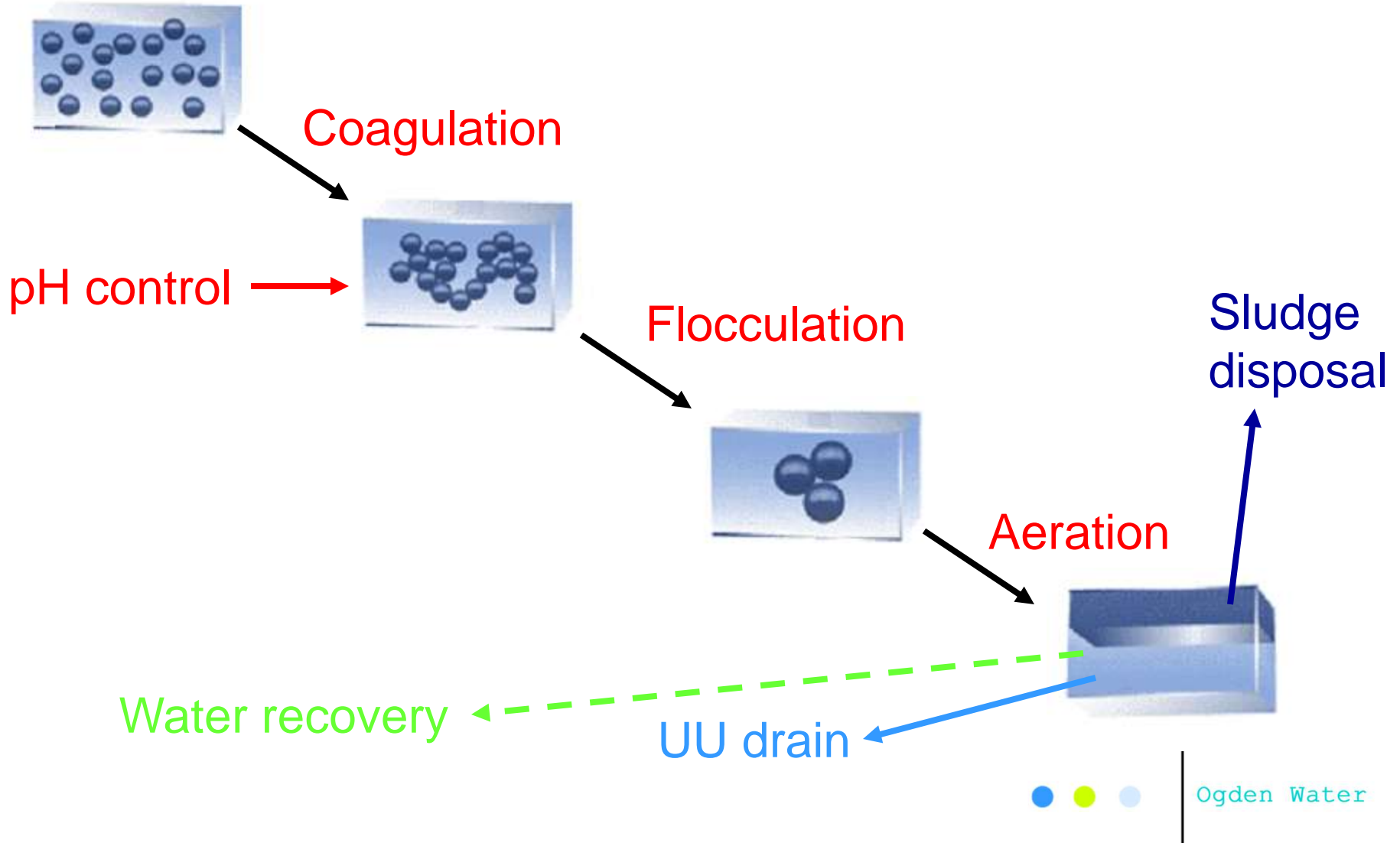
## Trade Effluent Consent - Preventing Excursions

- Before considering how we can prevent excursions above the trade effluent consent levels, we need to understand what happens to factory waste:



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## What happens in the 'effluent plant'?



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## Step 1 - Coagulation

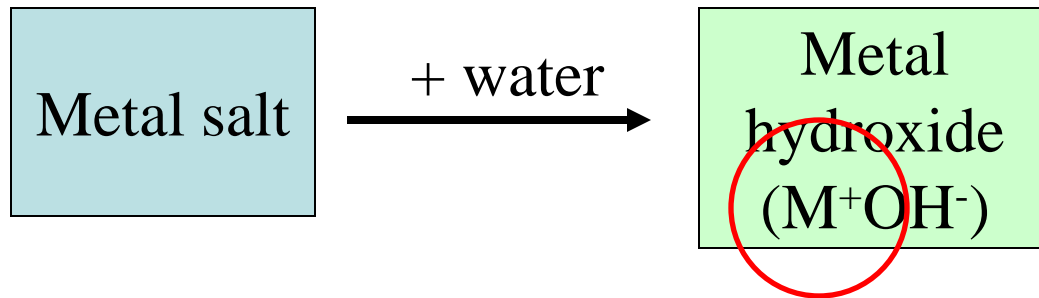
- Coagulation - the destabilisation of charges around particles in a liquid so that they may agglomerate together producing a larger particle.
- Most inorganic coagulants consist of a divalent or trivalent metal (commonly aluminium or iron) based salt.
- Both iron and aluminium salts have an optimum pH range within which they will produce the best results for the specific stream they are being used to treat. The pH commonly is slightly acidic and pH adjustment may be required to ensure optimum results. Once the metals are dosed a series of complex reactions are believed to take place.



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## Coagulation - mechanism

- A number of theories exist as to exactly how metal based salts destabilise the charge around colloids thereby initiating coagulation:



- It is believed that the metals, possessing **strong positive charges**, reduce the **negative charges** associated with the colloids triggering coagulation.
- This destabilising effect occurs within the first few seconds following the addition of the coagulant, hence, rapid and thorough mixing is required (the metal hydroxides may only exist for a matter of seconds before forming more complex and less effective compounds).



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## Coagulation - mechanism



Steric stabilization



Electrostatic stabilization

- Note - One of the key problems with metal salt dosing is the subsequent generation of large quantities of sludge that can be difficult and expensive to de-water further.

- **Action - assess organic coagulants**



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## Step 2 - Flocculation

- The formation of larger particles which may subsequently be removed by a solid-liquid separation system, e.g. DAF cell.
- There are two distinct types of natural flocculation:

**Orthokinetic** – Accelerated aggregation caused by deliberate agitation of the solution.

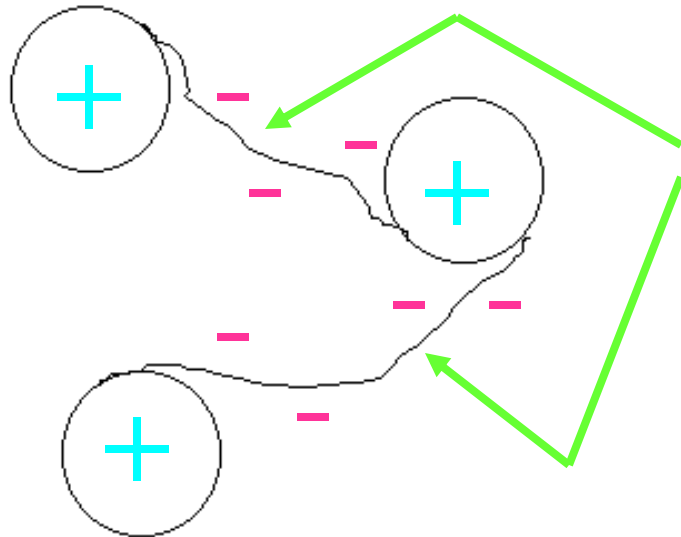
**Perikinetic** – The natural movement of particles in a liquid caused by Brownian motion.

- Both of the above are reversible - this is because flocculation is generally a loose association of particles, the 'flocs' can be re-dispersed relatively easily



# An Introduction to Waste Water Treatment Enhanced Artificial Flocculation

- To increase the rate of flocculation, we can add a flocculant. This results in **Bridging Flocculation**:



**Flocculants** are long chained molecules with charged segments making up part of the chain.

- Bridging flocculation occurs when there is a dilute solution of macromolecules in the disperse phase and these molecules attach themselves to particles at their ends, pulling the particles together.

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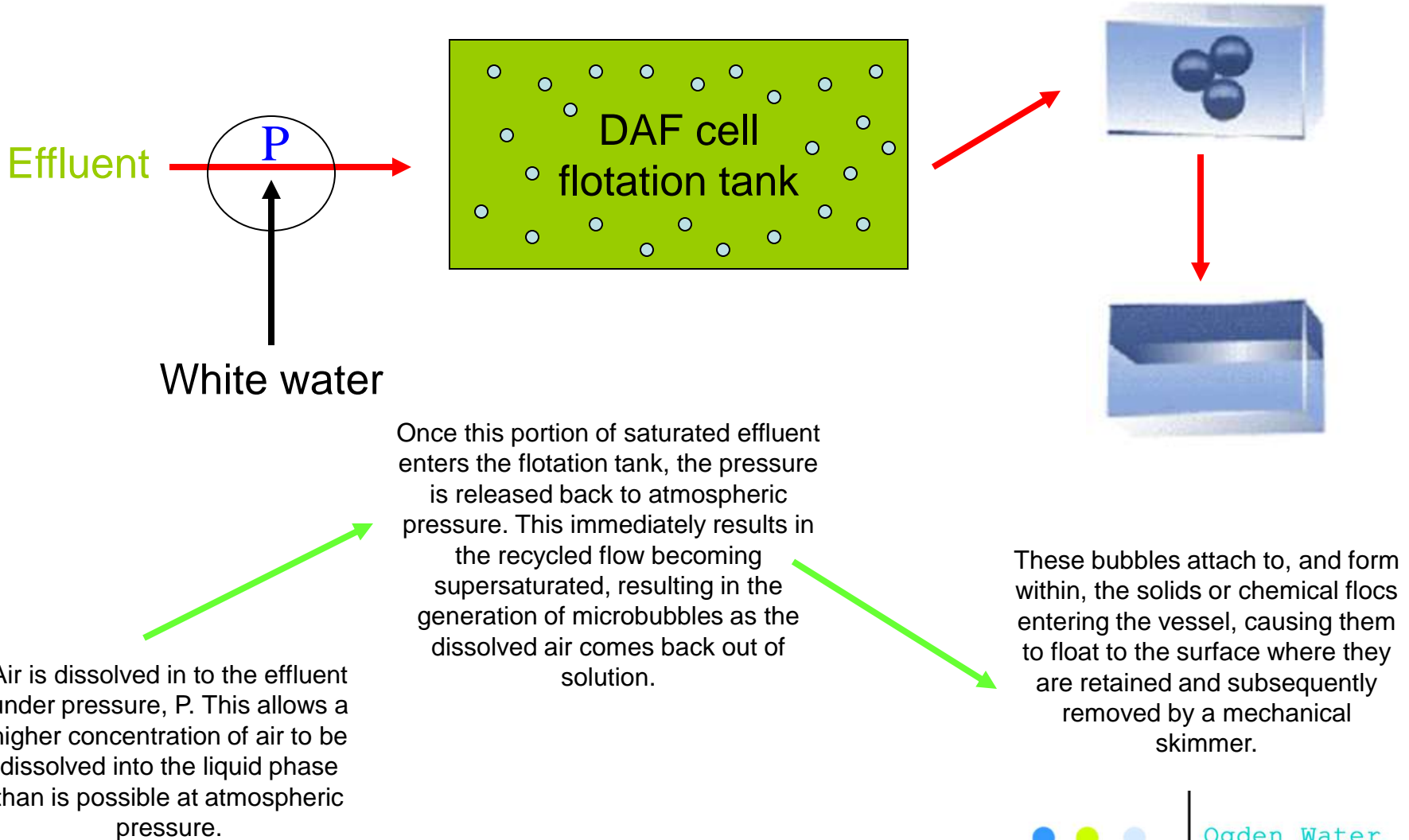
## DAF cell - how does it work?

- DAF systems are commonly applied to remove **suspended solids, fats, oils and greases** and associated **BOD** and **COD**.
- Advantages include:
  - High-rate process when compared with more traditional gravity-based settlement systems.
  - Low space requirements.
  - Thicker sludges can be produced.
  - Some degree of flexibility, subject to design and operating parameters.
- Basic operation - a purely physical process which operates on a reasonably simple design philosophy.
- Incoming effluent is pre-treated to ensure optimum conditions for coagulation and flocculation.



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## DAF cell - Basic operation



Air is dissolved in to the effluent under pressure, P. This allows a higher concentration of air to be dissolved into the liquid phase than is possible at atmospheric pressure.



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## DAF cell - Basic operation

- There are limits to what can efficiently be removed by applying flotation technology. It would seem a logical step therefore to apply DAF systems to effluents where the solids present are of approximately neutral or perhaps even positive buoyancy so that the bubbles produced are working with gravity rather than against it.
- The Air:Solids (A:S) ratio may be reported as a volume:mass ratio and will be application specific.
- Typical values range between 0.005 – 0.06 ml/mg which, at 20°C and atmospheric pressure (say 1.0133 bar) is equivalent to 0.006 mg – 0.072 mg of air per mg of solids to be removed.



# An Introduction to Waste Water Treatment

## Trade Effluent Charges - The MOGDEN formula

- The LWA will provide a company with a discharge analysis each month to form the basis for deriving the trade effluent charge.
- The charge for treatment of your effluent is calculated using the MOGDEN FORMULA:



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## The MOGDEN Formula

$$C = R + [ (V + B_v) ] + B ( O_t / O_s ) + S ( S_t / S_s )$$

- $C$  = charge / p/m<sup>3</sup>
- $R$  = reception/ conveyance cost (“sewer maintenance”)
- $V$  = Primary treatment cost (“volumetric”)
- $B_v$  = charge related to bio treatment disposal
- $B$  = Oxidation treatment cost (“biological”)
- $O_t$  = COD trade effluent
- $O_s$  = COD crude sewage (“UU average”)
- $S$  = Sludge treatment cost
- $S_t$  = TSS trade effluent
- $S_s$  = TSS crude sewage (“UU average”)



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## The MOGDEN Formula Simplified

$$\text{Charge} = \text{UU treatment costs} + B ( O_t / O_s ) + S ( S_t / S_s )$$
$$= 33.9 + (40.2 O_t / 350) + (46.3 S_t / 230)$$

- $O_t$  = COD trade effluent
- $S_t$  = TSS trade effluent
- Note, not all the trade effluent consent parameters affect the MOGDEN formula, e.g. pH and SOGs. These are simply legally enforceable with the potential of fines and removal of the consent to discharge.



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## The MOGDEN Formula - Examples

$$\text{Charge} = 33.9 + (40.2 O_t / 350) + (46.3 S_t / 230)$$

- Target discharge level:
  - $O_t = \text{COD trade effluent} = 1,250 \text{ mg/l}$
  - $S_t = \text{TSS trade effluent} = 100 \text{ mg/l}$
  - Charge = £24,000 per annum
- Example consent level excursion:
  - $O_t = \text{COD trade effluent} = 27,000 \text{ mg/l}$
  - $S_t = \text{TSS trade effluent} = 30,400 \text{ mg/l}$
  - Charge = £692,000 per annum



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## Reducing the MOGDEN Formula - Volume

- The volume flow of your effluent is the most important factor in determining the bill.
- It follows that any water that is used carelessly in processes, bears not only a purchase charge, but also a trade effluent charge.
- It is therefore very important to take all steps to reduce your water consumption. A company should always map and analyse the flow of water and effluent through the factory. This allows consideration of opportunities for reducing water use.
- Water recycling - can water that flows to sewer be sufficiently clean for re-use?
- Environmental considerations



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## Reducing the MOGDEN Formula - COD/ SS

- The COD and suspended solids concentrations are significant components of the bill. A company **should take steps to ensure that no product or other material enters the effluent stream unnecessarily.**
- The DAF cell should be optimised to ensure maximum removal of COD and SS.
- A turbidimeter is to be utilised to indicate levels of SS, COD and SOGs being discharged.

- **Action - install and commission turbidimeter**



# An Introduction to Waste Water Treatment Turbidity

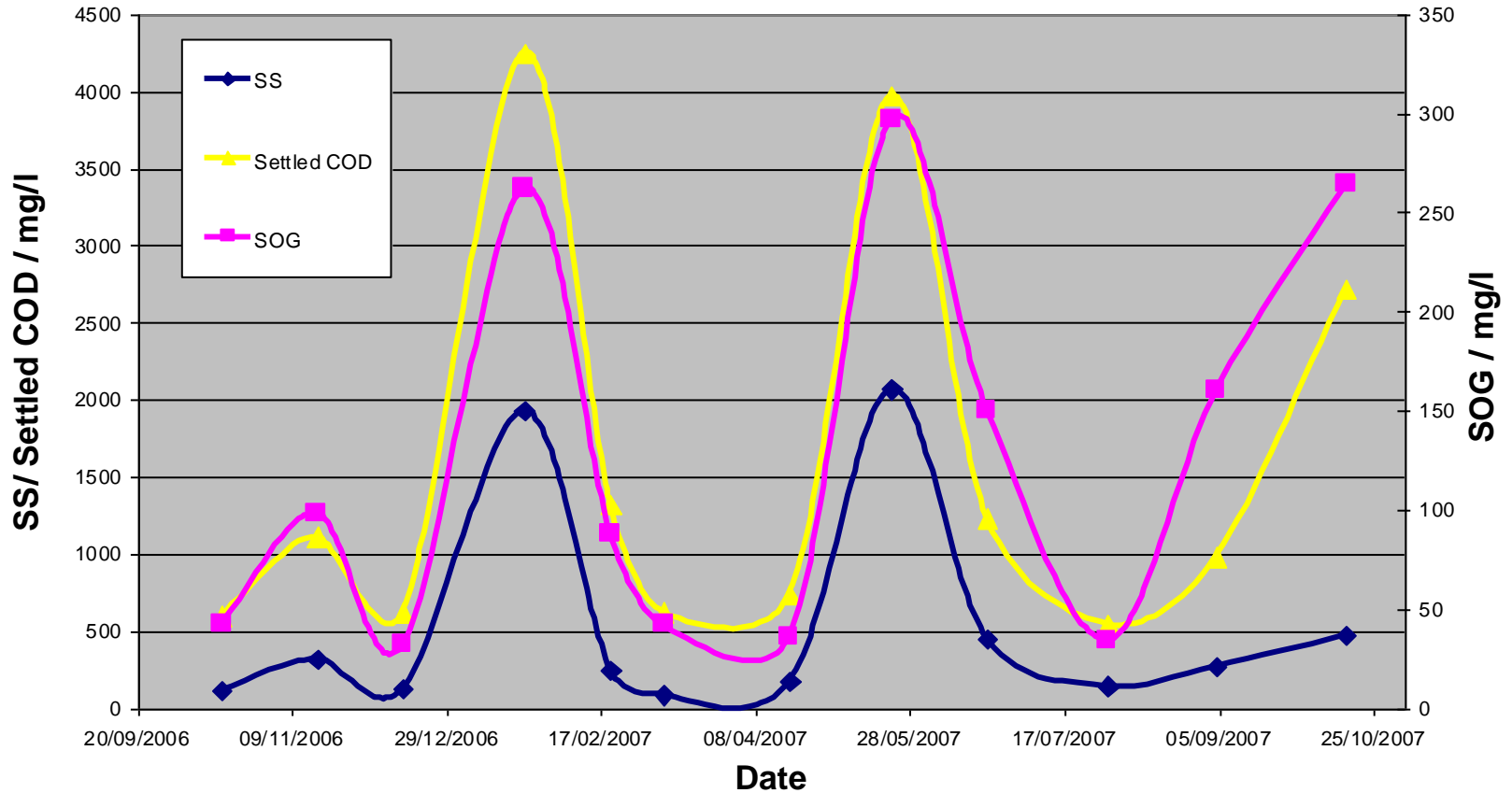
- “The cloudiness of a waste water caused by suspended solids” measured in NTUs (Nephelometric Turbidity Units).
- Nephelometry is the detection of reflected light caused by the scattering effect created by suspended solids (SS).
- E.g. 5, 50 and 500 NTUs:



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## Turbidity - Calibration Curves

Graph to show levels of Suspended Solids, Settled COD and SOGs against time



# An Introduction to Waste Water Treatment Summary

- The LWA provide a crucial service - the consent to discharge
- However, it can be an extremely expensive service if not appreciated and controlled accordingly
- The waste water plant is a complex chemical process - think how its' day to day running can be made more consistent, watch for spillages, large quantities of water been sent to drain etc
- Use the equipment available to its' full potential to improve the plant and to reduce costs

Think of the effluent plant as the final piece of the manufacturing jigsaw  
- without it, production would be extremely difficult and very  
expensive!

