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Integrated thermophilic and mesophilic activated sludge process for treating waste metalworking fluids

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Outline

- ❖ Background
- ❖ Configuration of the combined process
- ❖ Results
- ❖ Conclusion
- ❖ Further Work/ Considerations

Waste Metalworking fluids

- ❖ 400,000 tonnes/ year of spent MWFs in the UK only
- ❖ Disposal cost between £8 million and £16 million/ year
- ❖ A variety of recalcitrant compounds

Metalworking Fluids-properties

❑ Complex Emulsified System

- ✓ Emulsifiers
- ✓ Biocides
- ✓ Lubricating agents
- ✓ Pressure additives
- ✓ Anti-foam agents
- ✓ Corrosion inhibitors
- ✓ Metal passivators

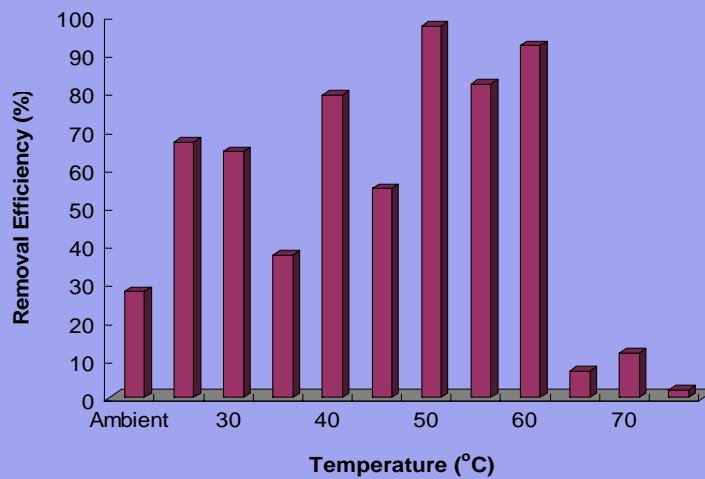
❑ Indigenous Microbial Communities

❑ High Toxicity

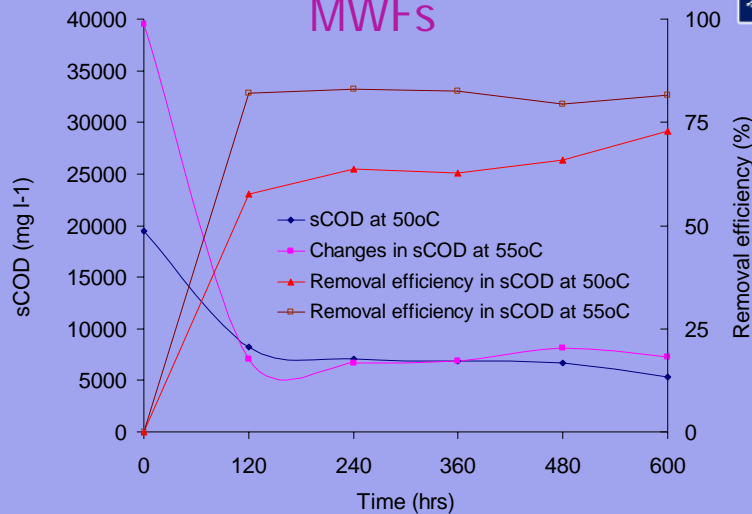
Thermophilic Aerobic Treatment

- ❑ **Faster biodegradation**
- ❑ Greater overall process efficiencies
- ❑ Low rates of residual biosolids production
- ❑ **Elimination of pathogens in the effluent**
- ❑ Free ammonia release etc
- ❑ **High-strength wastewater**

The effect of changes in temperature on the biodegradation of waste MWFs



Further biodegradation of waste MWFs



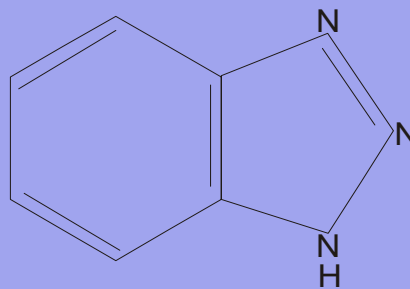
Recalcitrant compound: Benzotriazole

- **Applications**

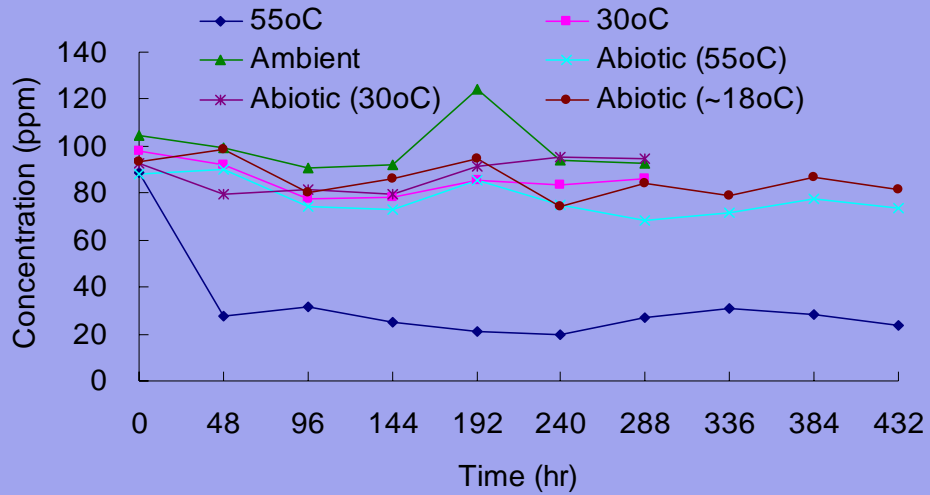
- Corrosion inhibitor
- Aircraft deicing fluids

- **Toxicity**

- Water flea (*Ceriodaphnia dubia*) 48h LC₅₀: 86-120mg/l
- Butylbenzotriazole
Microtox 15min EC₅₀: 0.71-1.1mg/l



Effect of temperature change on biodegradation of benzotriazole



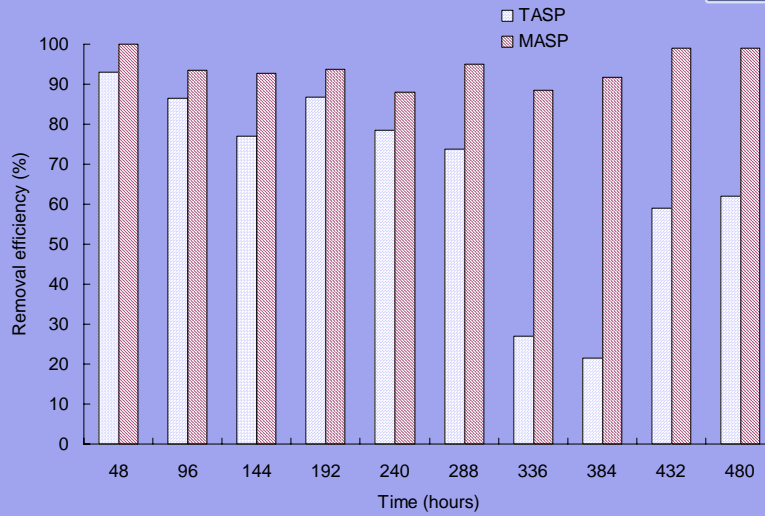
Configuration of the combined process



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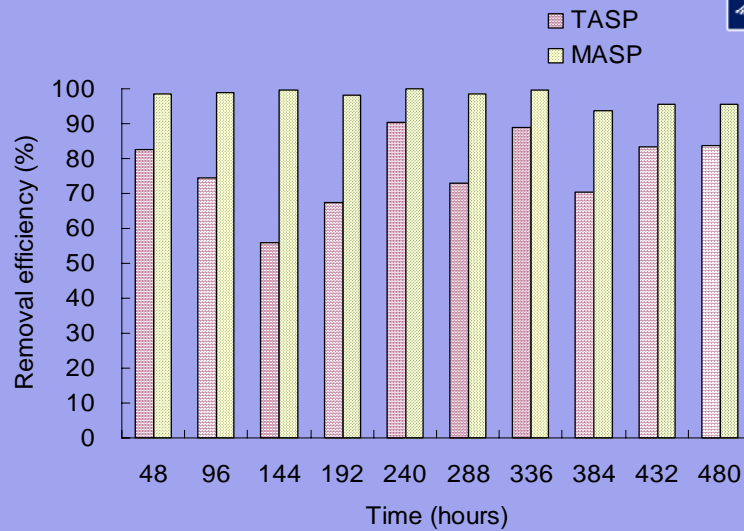
Reduction of soluble COD



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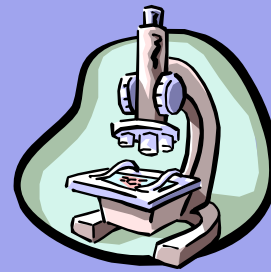
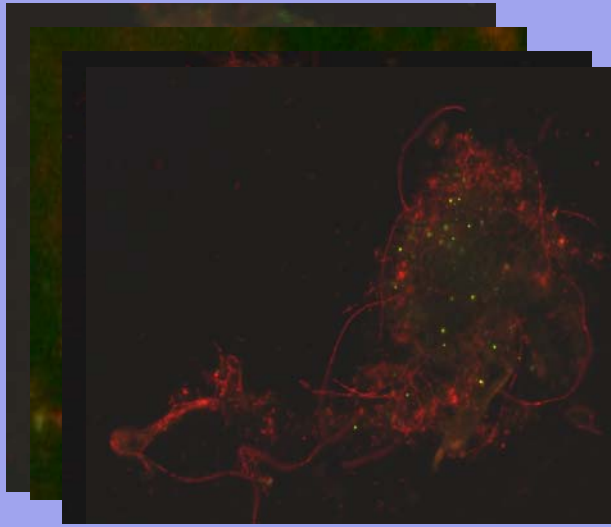


Reduction of benzotriazole



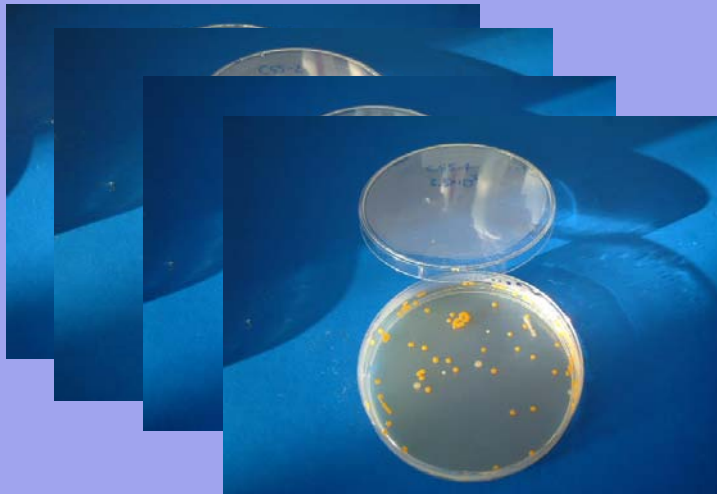
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Microbial viability

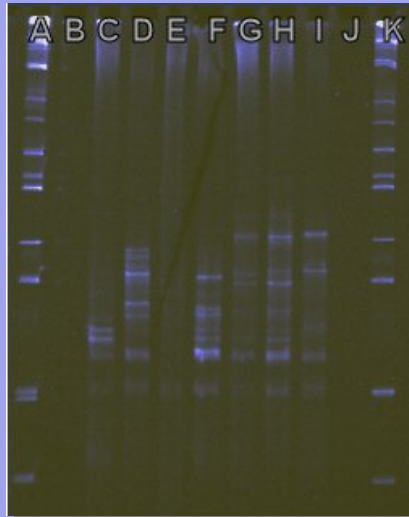


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Microbial communities



PCR-DGGE

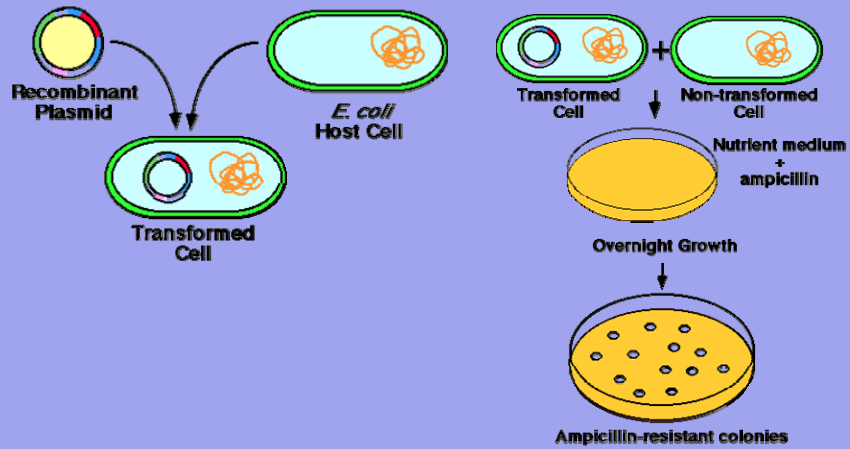


Lane A & K: DNA marker
 Lane B & J: Control
 Lane C: Waste MWF
 Lane D: TASP at T= 0
 Lane E: MASP at T= 0
 Lane F: TASP at T= 240
 Lane G: MASP at T= 240
 Lane H: TASP at T= 480
 Lane I: MASP at T= 480

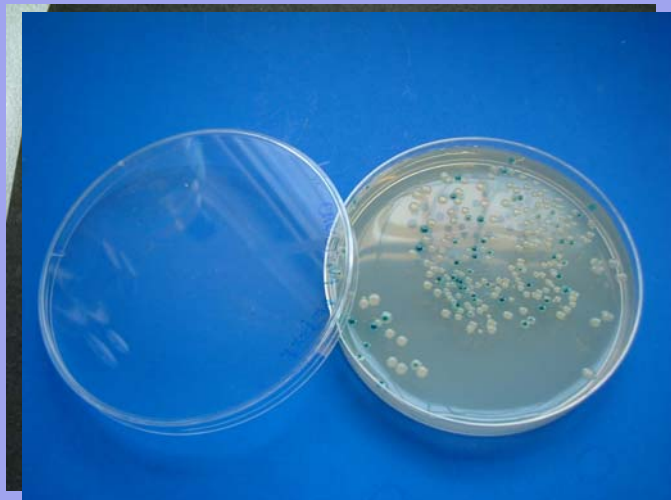
The Dice Index (Cs) for PCR-DGGE fingerprints of bacterial communities

Sample	Time (hr)	Dice Index (Cs)						
		0		240		432		
		MWF	TASP	MASP	TASP	MASP	TASP	MASP
0	MWF	1						
	TASP	0.32	1					
	MASP	0.40	0.22	1				
240	TASP	0.66	0.50	0.22	1			
	MASP	0.54	0.40	0.24	0.54	1		
480	TASP	0.62	0.46	0.20	0.58	0.88	1	
	MASP	0.40	0.52	0.28	0.28	0.46	0.40	1

Bacterial Identification



Bacterial Identification



Bacterial Identification

Clone number	Species	Present similarity
MASP ₀ -1	<i>Pseudomonas putida</i>	99
MASP ₀ -2	<i>Uncultured beta proteobacterium</i>	96
MASP ₂₄₀ -1	<i>Pseudomonas japonica</i>	98
MASP ₂₄₀ -2	<i>Petrobacter succinimandens*</i>	96
MASP ₄₈₀ -3	<i>Uncultured actinobacterium</i>	97
TASP ₀ -1	<i>Actinomycetales</i>	98
TASP ₂₄₀ -1	<i>Hydrogenophilus denitrificans**</i>	88
TASP ₄₈₀ -1	<i>Ralstonia sp.</i>	98
TASP ₄₈₀ -2	<i>Microbacterium sp.</i>	94
TASP ₄₈₀ -3	<i>Acinetobacter sp.</i>	98
TASP ₄₈₀ -4	<i>Nitrosococcus oceanii</i>	98

Conclusions

- ❖ Overall, the use of combined thermophilic-mesophilic aerobic technology has shown the potential for treating waste MWFs.
- ❖ The process demonstrated effective treatment performance with the TASP stage acting to break down recalcitrant and complex compounds, with the 'soft' compounds being discharged for the MASP to biodegrade.

Conclusions

- ❖ Final effluent sCOD was still occasionally more than 4000 mg l⁻¹. Therefore, a longer HRT or a shorter SRT should be considered.
- ❖ Dice Index (Cs), indicated that a dynamic bacterial community structure actually improved the treatment efficiency, as well as providing a relatively stable treatment performance.

Conclusions

- ❖ The bacteria identified here, which were thought to be mesophiles rather than thermophiles, have been shown to thrive in a thermophilic condition.
- ❖ This proves that through acclimatisation mesophiles can shift to be thermophilic-tolerant species and capable of biodegradation.

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Further Work

- ✦ Investigation of biofilm bioreactor, i.e. Fluidised Bed Bioreactor
- ✦ Investigation of whether a dynamic or a stable bacterial community structure is the most optimal condition for treating complex wastewater.

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Acknowledgements

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