

Development of a method for quantifying bioadditives' performance in Food Service Establishment (FSE) wastewater

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Introduction

200,000 sewer blockages annually in the UK

75% caused by deposits formed from fats, oils and grease (FOG)

Legislation - FSEs must employ grease separator or "other effective means of grease removal"

Cost over £15 million to clear

Sewer overflows present public health and environmental hazards

AIM: Develop a protocol to demonstrate the efficacy of FOG-degrading bioadditives

Methodology

Design bioadditive test protocol

Culture in batch reactors under realistic and reproducible environmental conditions

Define environmental test conditions

Design synthetic WW, and set physical parameters based on data from FSE WW characterisation

Quantify FOG removal

Develop novel method to quantify FOG in emulsified systems

Method	HEM recovery with protein (%)	HEM recovery with protein and detergent (%)	Reference
EPA Method 1664 liquid/liquid hexane extraction (LLE)	44 - 58	Not tested	(Wang & Ducoste 2012)
Modified LLE method: Ducoste et al.	111 - 117	Not tested	
Modified LLE method: Barton	99 - 102	47 - 63	(Barton 2012)
Solid phase extraction (SPE)	43 - 84	12 - 92	This study

- Standard FOG quantification methods are based on hexane solvent extraction (EPA 1664A)
- Surfactants, including proteins and detergents, interfere with hexane extraction

FOG quantification method development

Modified Gerber (milk fat determination) method

- Application in bioadditive test protocol - stable emulsion**
- Application in environmental WW - partial emulsion**

Caseinate adsorbs on to emulsified oil droplets; pH adjustment induces iep co-precipitation

Free FOG is first removed from the sample surface with oil adsorbent material, and eluted with hexane

Emulsified FOG is extracted from the precipitate through sulphuric acid digestion in Gerber butyrometers

FOG recovery 92 - 100%

Effect of SDS surfactant on FOG recovery

SDS (mg/l)	Free oil (%)	Emulsified oil (%)
0	96	102
30	107	108
60	98	88
100	98	88
200	98	88
500	98	88

Bioadditive test protocol

Bacterial dose: little variation in FOG removal response over dose range $10^3 - 10^6$ cfu/ml (*Bacillus pumilus* NCIMB 1522)

Removal (mg/l) vs Contact time (hours)

Removal (mg/l) vs Contact time (hours)

Bioadditive trials: over 90% FOG removal observed within 4 - 5 days for two multi-strain commercial products. Temperature 40°C, pH 7.

Efficacy to be reported as removal rates

- Fast: > 20 mg/l/h
- Medium: 5 - 20 mg/l/h
- Slow: < 5 mg/l/h

Future work

Validate new FOG quantification method:

- Define limit of detection and precision
- Comparison with EPA Standard Method in:
 - synthetic wastewater formulations with varying detergent types and concentrations, protein sources
 - real FSE wastewaters

Bioadditive test protocol:

- Quantify response to varying environmental conditions - pH, temperature, oxygen availability
- Relate FOG removal in synthetic medium with performance in real WW
- Determine influence of native WW microbial populations
- Pilot scale to evaluate impact of biofilm development

References

Barton, P. (2012). Enhancing separation of fats, oils and greases (FOGs) from catering establishment wastewater

Wang and Ducoste, J. (2012) Challenges in the Measurement of Fats, Oils and Grease (FOG) in Food Service Establishment Waste Streams



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