Renewable energy and landfill diversion
-
recognising people's behaviours

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Fundamentals

- Legal obligation in EU to divert biodegradable municipal waste from landfill
- Climate change
  - each new policy should be a tested for its consequences
- Phosphate crisis
  - essential for all life,
  - we've passed 'peak P',
  - too precious to squander
  - each new policy should be a tested for its consequences
- People are individuals: one size won't fit all whatever we might think is good for them

Notes

- The National Audit Office predicts the UK won't meet the landfill directive targets because we started too late, don't have the treatment facilities and introduced supplementary targets that diverted attention. NAO warned, early diversion was from picking low hanging fruit, future performance will not be an extrapolation.
- Even if we hold climate change to 2^{o}C, which will be difficult, the consequences are going to be very uncomfortable.
- *"…life can multiply until all the phosphorus is gone, and then there is an inexorable halt which nothing can prevent…. We may be able to substitute nuclear power for coal, and plastics for wood, and yeast for meat, and friendliness for isolation - but for phosphorus there is neither substitute nor replacement*." Asimov, I. (1974) "Asimov on chemistry" Doubleday, New York
- At today's rate of use, current P resources will be exhausted in 70 years, new reserves might add 200 to 400 years – not much in human history.
- Adults excrete 98% of the P in their diets, because they are turning over cells rather than laying down new ones. We capture some [half] at WwTW but half [or more] goes to the sea – we could capture more. Use biosolids on land. Store ash for eventual P recovery.
- Waste collection agencies [here and abroad] find participation in kerbside collection is poor in flatted properties. Experience in Germany finds rigour of source segregation wanes with time. EC green paper on biowaste (2008) says only 30% is separately collected and treated biologically.

Kitchen food waste

- is the most difficult fraction of biodegradable municipal waste to manage
  - 70% moisture content
  - Biodegrades rapidly with high oxygen demand

  ∴ prone to become putrid and ooze leachate
    - Botulinum neurotoxin risk [DE]
  - Attracts scavengers and disease vectors
    - Respiratory risk to susceptible people when stored [NL]
  - Sticks to [potentially] dry recyclables
- We've picked the low hanging fruit – the future will not be an extrapolation (NAO - May 2007)
  - We have been emphasising kerbside collection for years but many citizens remain unwilling to participate – 70% is still in mixed waste (EC Green Paper on biowaste, 2009)

No place for absolutism – one solution won't suit all

- Home composting done well is great, especially for garden waste
  - Many are unwilling or unable
  - Done badly releases methane and attracts rats
- Source segregation – OK for some
  - Participation rates low in "flatted" properties
  - Physical contaminants

Grindsted DK 2002

£80/t for kerbside foodwaste

10% w/w of waste was kraft paper caddy liners

Even so there were physical contaminants

Environmental Impact Assessment

for Worcestershire CC & County Surveyors' Society

food waste management GWP $kgCO_2e/t$ food waste

Landfill (with landfill gas collection and use)	+743
Incineration (with energy recovery)	+13
Centralised composting	-14
Centralised AD	-162 or -215
Food waste disposers →sewer→WwTW→AD	-199

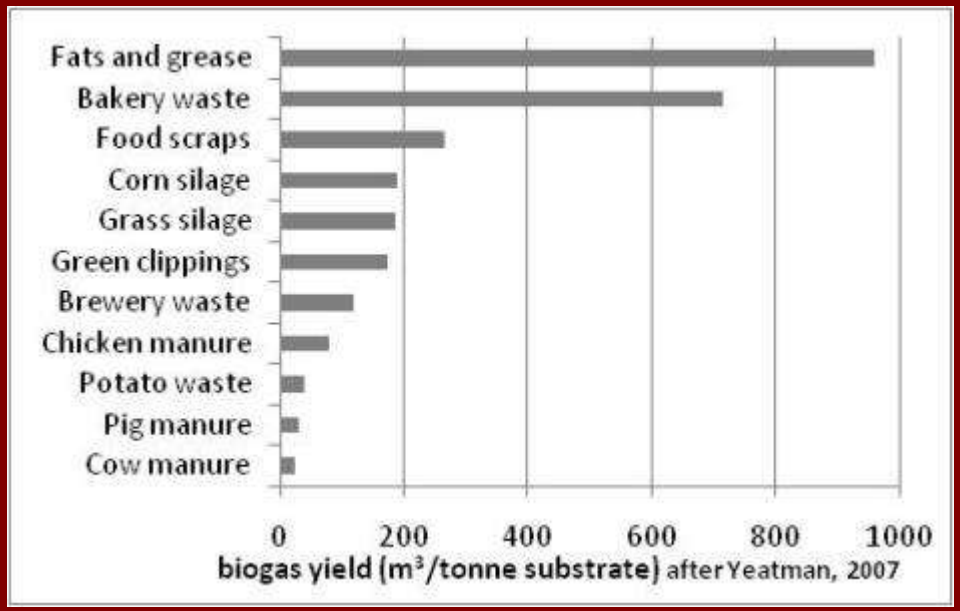
www.sinkyourwaste.com <environmental report>

Literature review of in sink food waste disposers

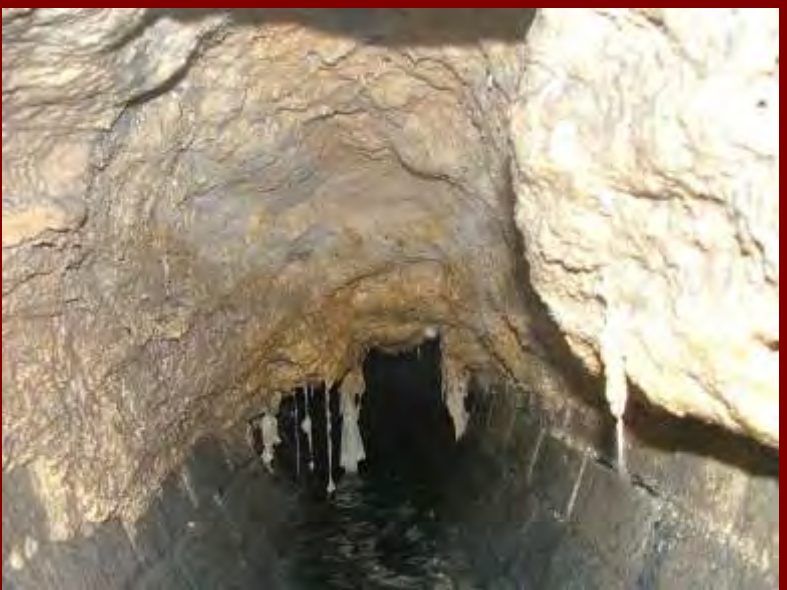
- FWD separates at source
- Grinds, does not chop
- Negligible effect on water use (1 toilet flush / hh
- FWD uses 3.5 kWh/y – biogas = 70 kWh/y
- No change in electricity to activated sludge treatment
- Output carried/resuspended at sewer design velocities
- Increases biogas
- Proven, safe, simple, reliable technology
  - USA: 50% of households
  - New Zealand: 34% of households
  - Increasing in Europe
- Very high user satisfaction rates

FOG is another issue

- Great biogas potential
- Saponification in sewer converts to blockage
  - elevated pH implicated;
  - strength related to calcium content;
  - forms 100-200m downstream of FSE
  - no evidence of FWD output in FOG samples around USA



Solving problems and exploiting opportunities



What is cost transfer to Water Co?

- Herefore & Worcestershire audited data$_{2005/06}$
  - FWD saves £18.63$_{2005/06}$ per hhd.year and
  - diverts 180 kg/hhd.year
    - LATS
    - ≈ 20-25% w/w of bin

- Severn Trent Water
  - 100% AD
  - target for 30% self-generated electricity by 2012
  - welcomes extra substrate (biosolids to farmland)
- Food waste >90%VS (sewage sludge 80%VS)
  - VS reduction ≈ 70% (sewage sludge 50-60%VSR)
  - ≈53% total solids reduction (sewage sludge 20-28% TSR)

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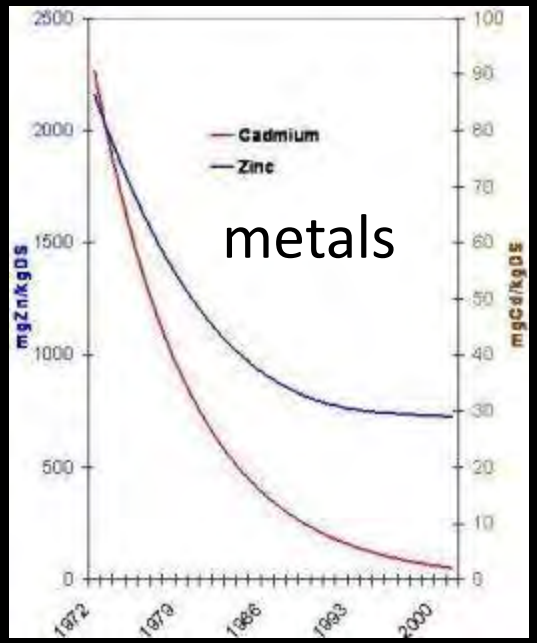
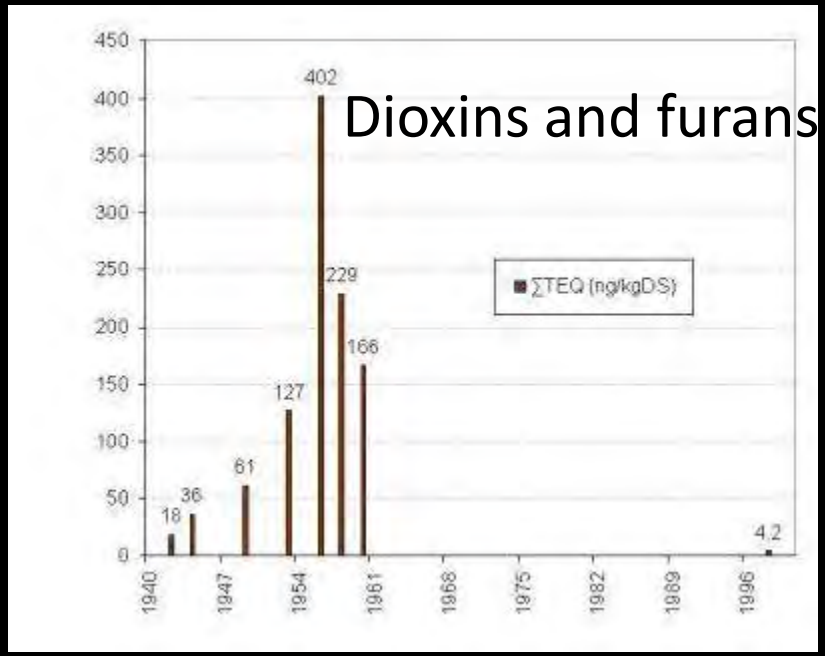
Isaac Asimov, "Asimov on chemistry" (June 1974) Doubleday Company, New York

We have a P crisis – comparable to climate change

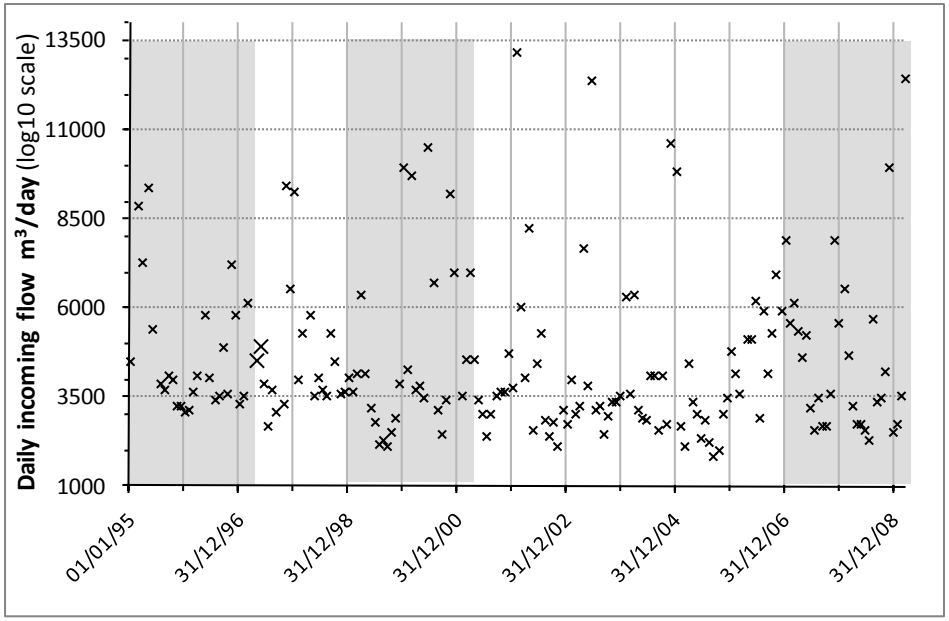
- capturing and using the P in sewage (and food) is important
- sewage sludge recycling is well understood, controlled and SAFE



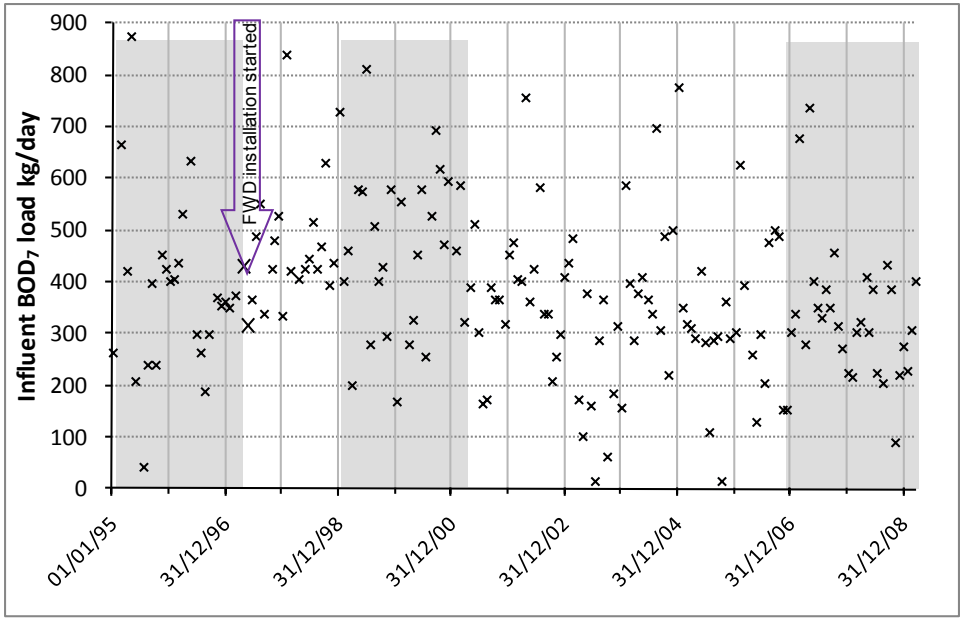


	Flow m^3/d	BOD_7 kg/d	N kg/d	NH_4/ kg/d	P kg/d	biogas m^3 /d
Mean pre FWD 120 weeks 11/01/95-30/04/97	4706	408	113.6	74	18.0	331
Variance	3034123	46620	979	405	49.9	1036
Mean post FWD 120 weeks 13/12/06-01/04/09	4678	331	107	71	13.3	484
Variance	5675190	17138	548	282	12.7	3147
Difference (post-pre)	-0.59%	-19.0%	-6.1%	-3.9%	-26.1%	+46%
P (1-tail T-test)	0.50 NS	0.06	0.18 NS	0.28 NS	0.002	0.01

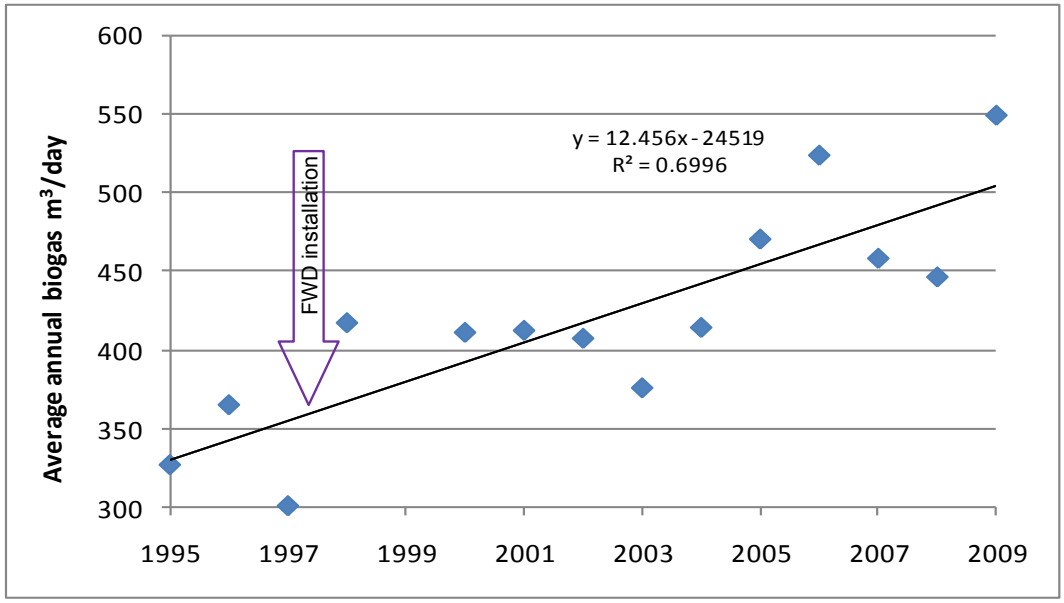
Surahammar SE: 4-weekly, 24-hour composite samples
3700 households to a single WwTW
comparing zero FWD with 50% FWD installed
Contemporaneous ban on P detergents



Flow = hydraulic load perhaps ≈ water use

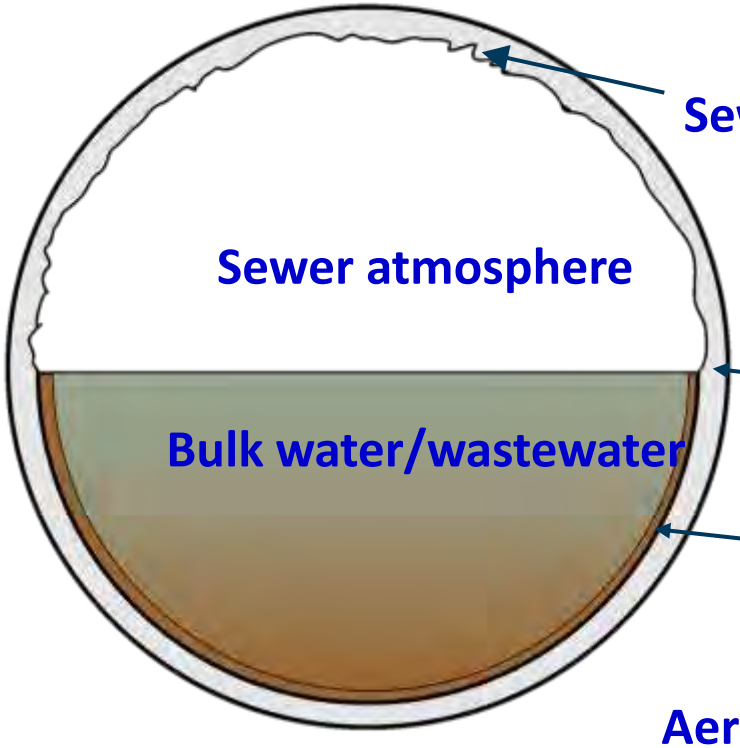


Biochemical oxygen demand ≈ opex



Annual average biogas m3/day

Sewer are both conveyance systems and ecosystems
treatment starts in sewers



Sewer "dry" biofilm

"intertidal" biofilm

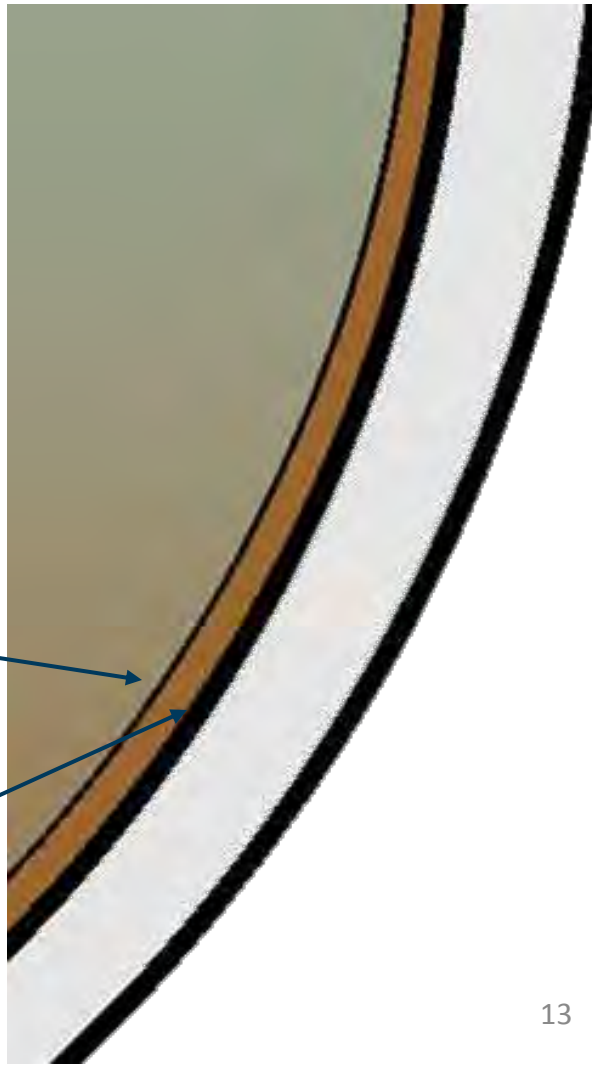
Sewer "wet" biofilm

Aerobic e.g. *Nitrosomonas*

$NH_4^+ \rightarrow NO_2^- + H^+$

Anaerobic e.g. *anammox*

$NO_2^- + NH_4^+ \rightarrow N_2$



Notes

Surahammar is unique in that we have influent monitoring data (4-weekly, 24-hour composites) for 2.5 years before FWD were installed followed by rapid installation by 30% of the 3700 households and then continued installation up to 50% of households. The WwTW is conventional [primary clarification, activated sludge, chemical P-removal, mesophilic anaerobic digestion]. There has been no increase in sewer blockage, sewer corrosion or rats. Flow has not changed. BOD_7 has decreased, nitrogen has not changed significantly. In-sewer biological transformation is hypothesized as the mechanism. Biogas has increased by 46% (P=0.002). BOD7 has decreased (P=0.06) , flow, N and ammonia have not changed. P has decreased but there's been a contemporaneous ban of P in detergents.

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What goes into sewers is not the same as comes out at the other end because of in-sewer biology. We are starting to increase our knowledge of sewer ecosystems but it is still incomplete. We know the DNA profiles of biofilms differ from one place to another, which indicates that the microbial ecosystem changes, adapts, acclimates, to the particular conditions

It is important to look at the whole breadth of environmental impact, not just our own "silo" in isolation

Conclusions

- People need different options because they won't all do the same thing
- AD of food waste is good for recycling (conserving organic matter and nutrients) AND for energy
- The GWP of AD is the same whether the source segregated food waste is delivered by truck or by sewer
- FWD do not add to WwTW load when sewer process has acclimated but they do add to biogas
- FWD save municipality >£20 /household/year
- FWD are a valuable tool in the box of options
- I have looked and have not found evidence published of adverse effect

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