

activated sludge modelling from past to future



imre takács

TG Good Modelling Practice

what happened in 25 years?

```
C:\>wastewater model
'wastewater' is not recognized as an internal or external command,
operable program or batch file.
C:\>_
```

Google Web Images Groups News Local Desktop more »
wastewater model Search Advanced Search Preferences
Search: the web pages from Canada
Web Results 1 - 10 of about 933,000 for wastewater model.

disclaimer

brief recap of last 20 years

what's happening now?

discussion starters

short history

summer of 1858: "Great Stink" in London

activated sludge process from early 1900's

empirical design

early "models" based on BOD, μ , K_s

experiments at UCT from 1950's

first structured (simplified, mechanistic)

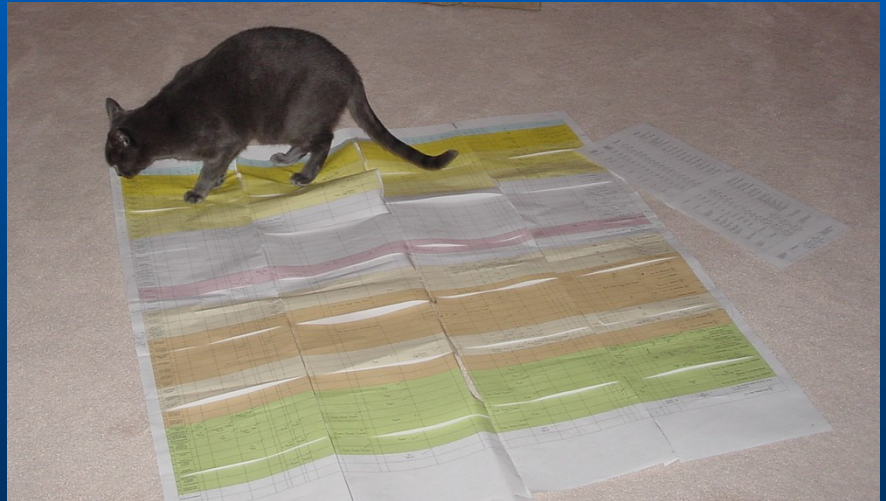
dynamic model ASM1 1986 from IWA TG

gave a framework to research

ASM time zero! 1986

Table 1. The ASM1 process matrix (Gujer et al., 1987)

Process	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	S_{19}	S_{20}	Parameter(s)	
1. Hydrolysis of particulate substrate	1																					k_{hyd}
2. Assimilation of substrate		1																				μ_{max} , K_{S1} , K_{S2} , K_{S3} , K_{S4} , K_{S5} , K_{S6} , K_{S7} , K_{S8} , K_{S9} , K_{S10} , K_{S11} , K_{S12} , K_{S13} , K_{S14} , K_{S15} , K_{S16} , K_{S17} , K_{S18} , K_{S19} , K_{S20}
3. Growth of biomass			1																			μ_{max} , K_{S1} , K_{S2} , K_{S3} , K_{S4} , K_{S5} , K_{S6} , K_{S7} , K_{S8} , K_{S9} , K_{S10} , K_{S11} , K_{S12} , K_{S13} , K_{S14} , K_{S15} , K_{S16} , K_{S17} , K_{S18} , K_{S19} , K_{S20}
4. Decay of biomass				1																		b
5. Production of extracellular polymeric substances (EPS)					1																	μ_{max} , K_{S1} , K_{S2} , K_{S3} , K_{S4} , K_{S5} , K_{S6} , K_{S7} , K_{S8} , K_{S9} , K_{S10} , K_{S11} , K_{S12} , K_{S13} , K_{S14} , K_{S15} , K_{S16} , K_{S17} , K_{S18} , K_{S19} , K_{S20}
6. Hydrolysis of EPS						1																k_{hyd}
7. Assimilation of EPS							1															μ_{max} , K_{S1} , K_{S2} , K_{S3} , K_{S4} , K_{S5} , K_{S6} , K_{S7} , K_{S8} , K_{S9} , K_{S10} , K_{S11} , K_{S12} , K_{S13} , K_{S14} , K_{S15} , K_{S16} , K_{S17} , K_{S18} , K_{S19} , K_{S20}
8. Decay of EPS								1														b
9. Production of particulate substrate									1													μ_{max} , K_{S1} , K_{S2} , K_{S3} , K_{S4} , K_{S5} , K_{S6} , K_{S7} , K_{S8} , K_{S9} , K_{S10} , K_{S11} , K_{S12} , K_{S13} , K_{S14} , K_{S15} , K_{S16} , K_{S17} , K_{S18} , K_{S19} , K_{S20}
10. Hydrolysis of particulate substrate										1												k_{hyd}

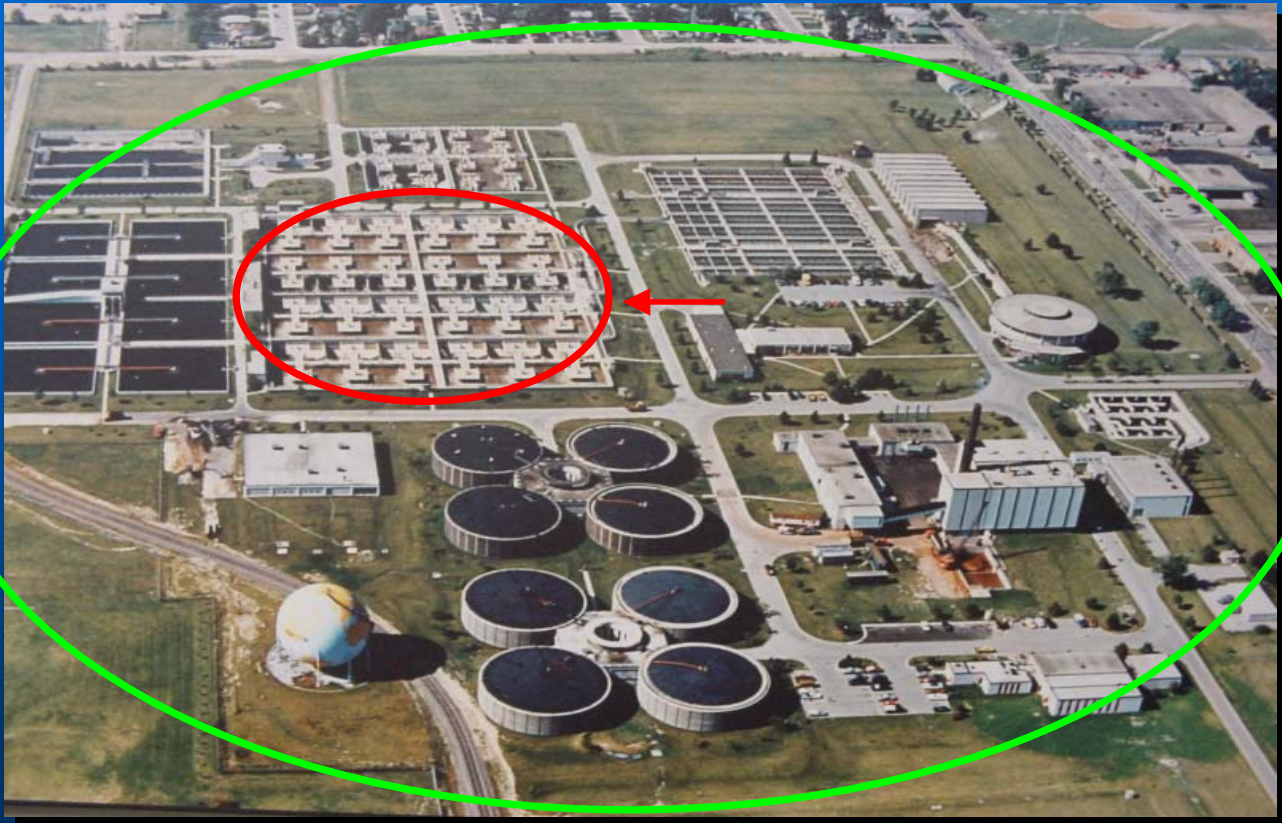


available models

ASM1, ASM2, ASM2d, ASM3, ASM3C, Eawag bio-P, TUDM, Mantis, General, ASDM, Wentzel, Comeau, Mino, Barker-Dold, many others...

many modifications, additions
treasure trove of information - or a mess?
trend towards whole plant modelling

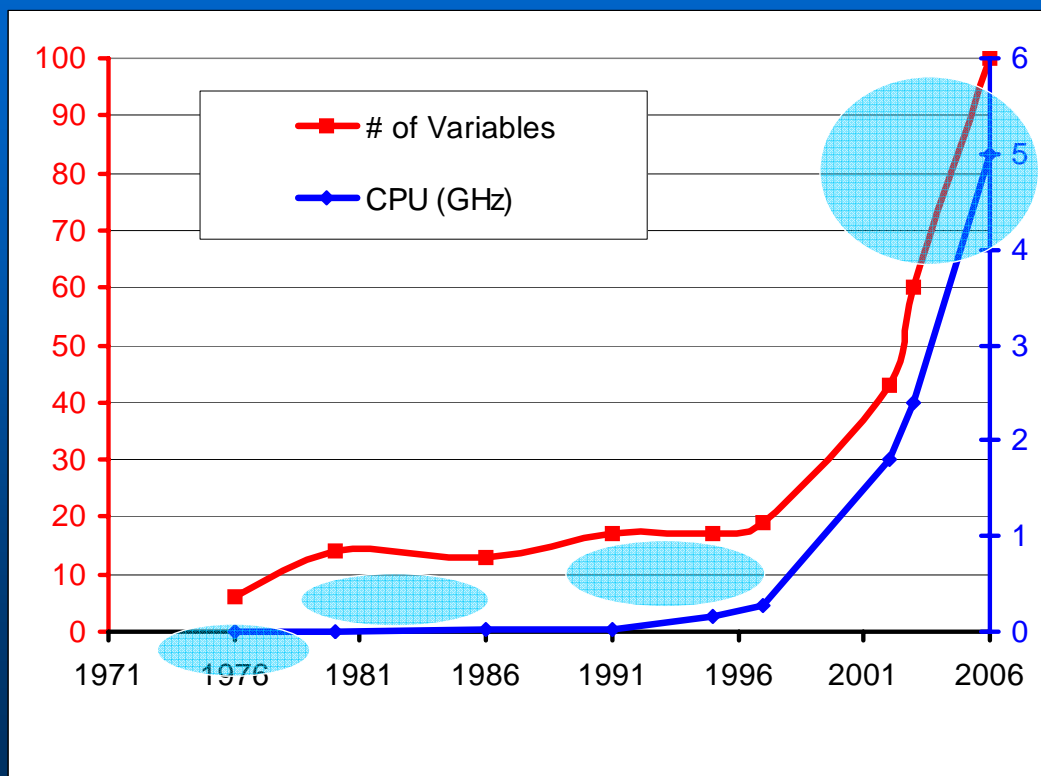
- whole plant models
- interfaced process models



13.09.2006

GMP and BSM TGS | activated sludge modelling – from past to future | imre takacs

models and computer capacity



13.09.2006

GMP and BSM TGS | activated sludge modelling – from past to future | imre takacs

late 80s: started (slowly)

90s: sudden bursts and gradually increased use

today: used on almost every plant in the US,
Australia, and many countries in Europe

what do you believe more? model or data?

commercial

- GPS-X, SIMBA, STOAT, WEST, BioWin, ...

research/training

- SSSP, ASIM, AQUASIM, ...

other (specialized, steady-state, extinct, etc.)

- CapDet, DSP, Plan-It Stoat, Pro-2D, SassPro, ToxChem, EFOR, VIB, VNP, UCTASP, spreadsheet implementations, ...

first a process engineer
familiar with the plant modelled
does not believe the data without checking

and by the way...
understands the model

processes modelled

BOD and COD (organic material) removal

- Oxygen demand, sludge production

nitrification, denitrification

- Oxygen demand, aerobic anoxic tank volumes, NH_3 and NO_3^-

biological phosphorus removal

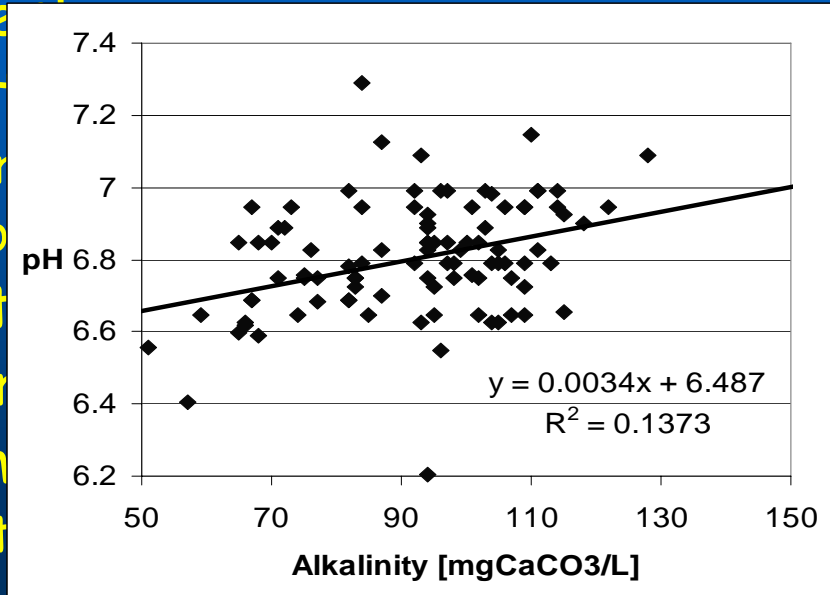
- PO_4^- , acetate requirement

alkalinity

based on:

- substrate transformations,
- growth and decay of various biomasses

oxygen transfer
pH and alkalinity
anaerobic digestion
chemical reactions
• chemical P release
• precipitation
additional unit
side stream products
gas phase components
• true O₂ saturation



new buzzwords

elemental balancing
metabolic models
supermodels and interfaces

1) are we using these models to their full potential?

we still make it too complicated!

is there a difference between usage in North America and Europe?

must solve practical problems, easily

2) what's "wrong" with the AS models?

TSS prediction - colloids

denitrification - yields

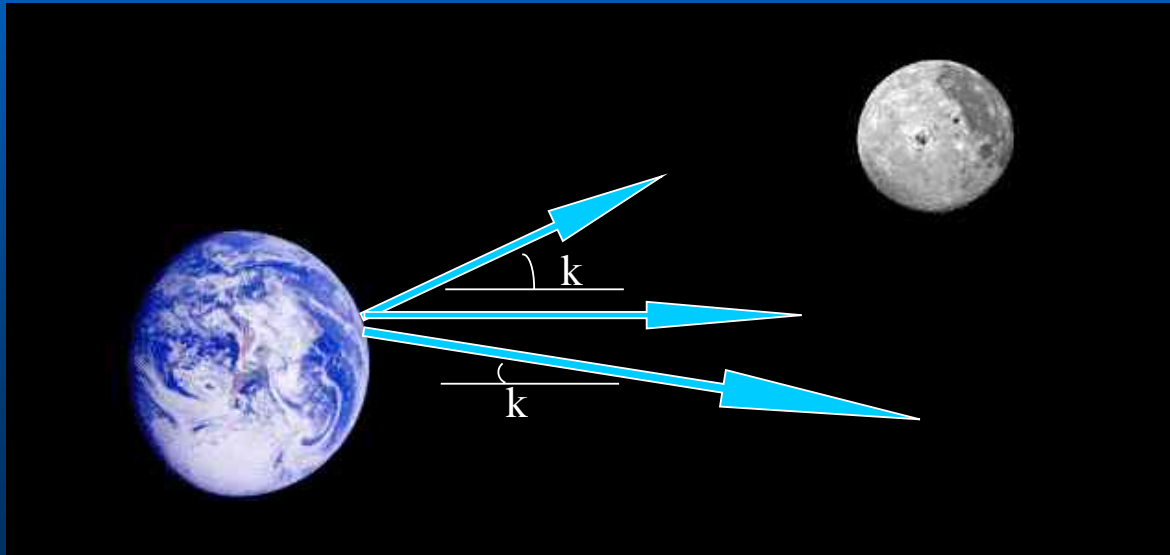
different carbon sources

N, P fractions

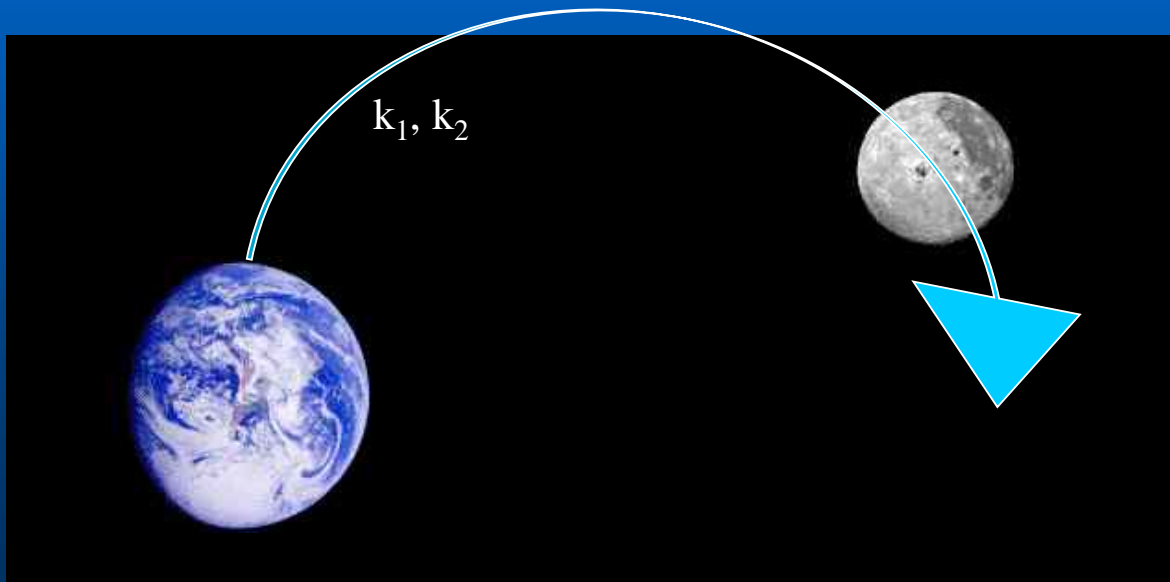
inorganic suspended solids

new knowledge must be incorporated and made easily available for the users

3) are there too many parameters in our models?



3) are there too many parameters in our models?



4) is there any need for further modelling research and development?

many real engineering situations are still not handled (well)

- whole plant
- low nutrient limits
- multiple substrates
- specialist biomass (industry)
- adaptation, acclimation
- sidestream, Anammox
- GAOs, G-bacteria
- effect of diffusion on K_S
- etc., etc...

no synthesis

no independent training

we need better models and better user manuals

we are missing Kollekolle!

there are guidelines out there

WERF - influent fractionation only

HSG - outline only

STOWA - now this is a good simple one

BioMath - just perfect but who has the time?

Japanese Sewage Works - in Japanese

here comes the GMP TG

so do we think now that:

modelling:

- tools are available
- is used widely in parts of the world
- needs specialized knowledge
- lots of questions remain open
- is fun!

this is me

imre takács

EnviroSim
ASSOCIATES LTD.
CANADA

imre@envirosim.com