



DSD International Conference 2014
**Sustainable Stormwater and
Wastewater Management**

**The Activated Sludge Process
in Service of Humanity**

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November 12-13, 2014

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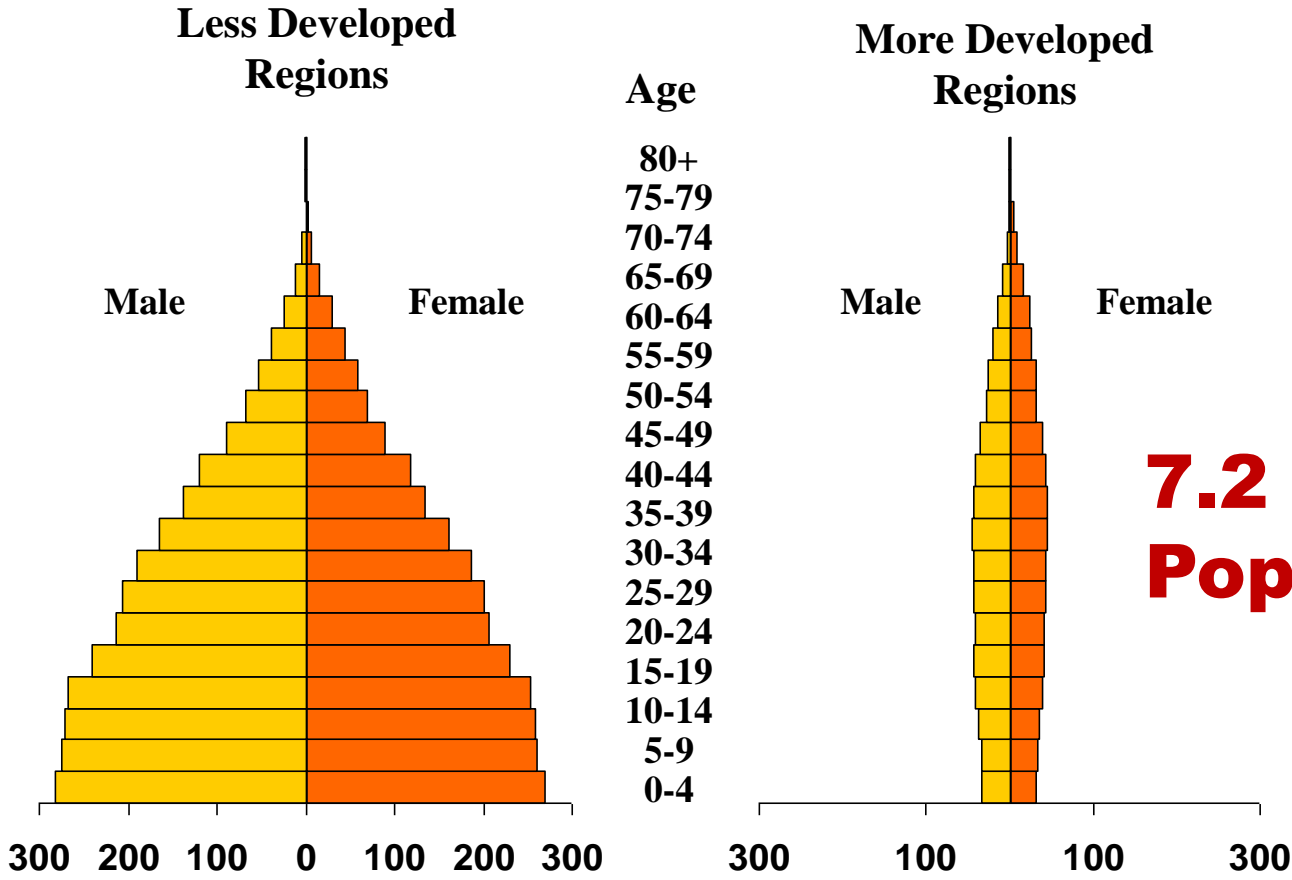


- ⌘ What is sustainability
- ⌘ The development of activated sludge
- ⌘ Eutrophication and indirect recycling
- ⌘ Energy self-sufficiency
- ⌘ Phosphorus recovery
- ⌘ Conclusions

Age Distribution of the World's Population

Population Structures by Age and Sex, 2005

Millions



**7.2 Billion
Population**

What is Sustainability?



“Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.”

(Brundtland Commission – 1987)



“Making informed decisions to effectively balance the long-term economic, environmental, and social impacts of one’s plans and actions.”

“We do not INHERIT the earth from our ancestors, we borrow it from our children.”

- David Brower



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Activated sludge plant as a sustainable process

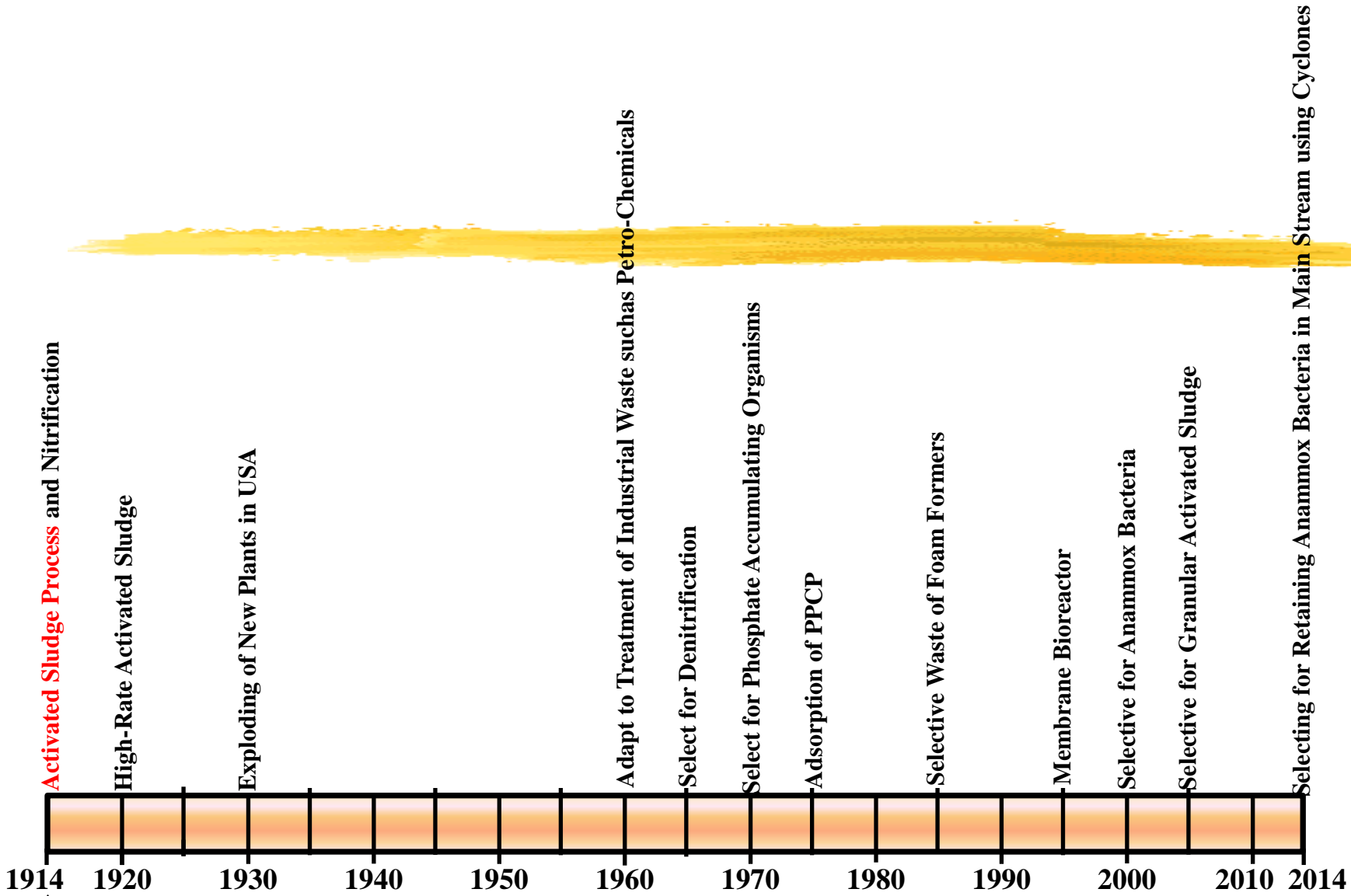


- ⌘ Developed in 1914 by Arden and Lockett
- ⌘ Has served us for a century to produce effluent fit for re-use
- ⌘ Used a batch reactor and observed nitrification some denitrification and removal of some phosphorus
- ⌘ They formed a granular sludge
- ⌘ The process keeps evolving to make it more versatile more adaptable while lowering energy and cost

A Process of Selection



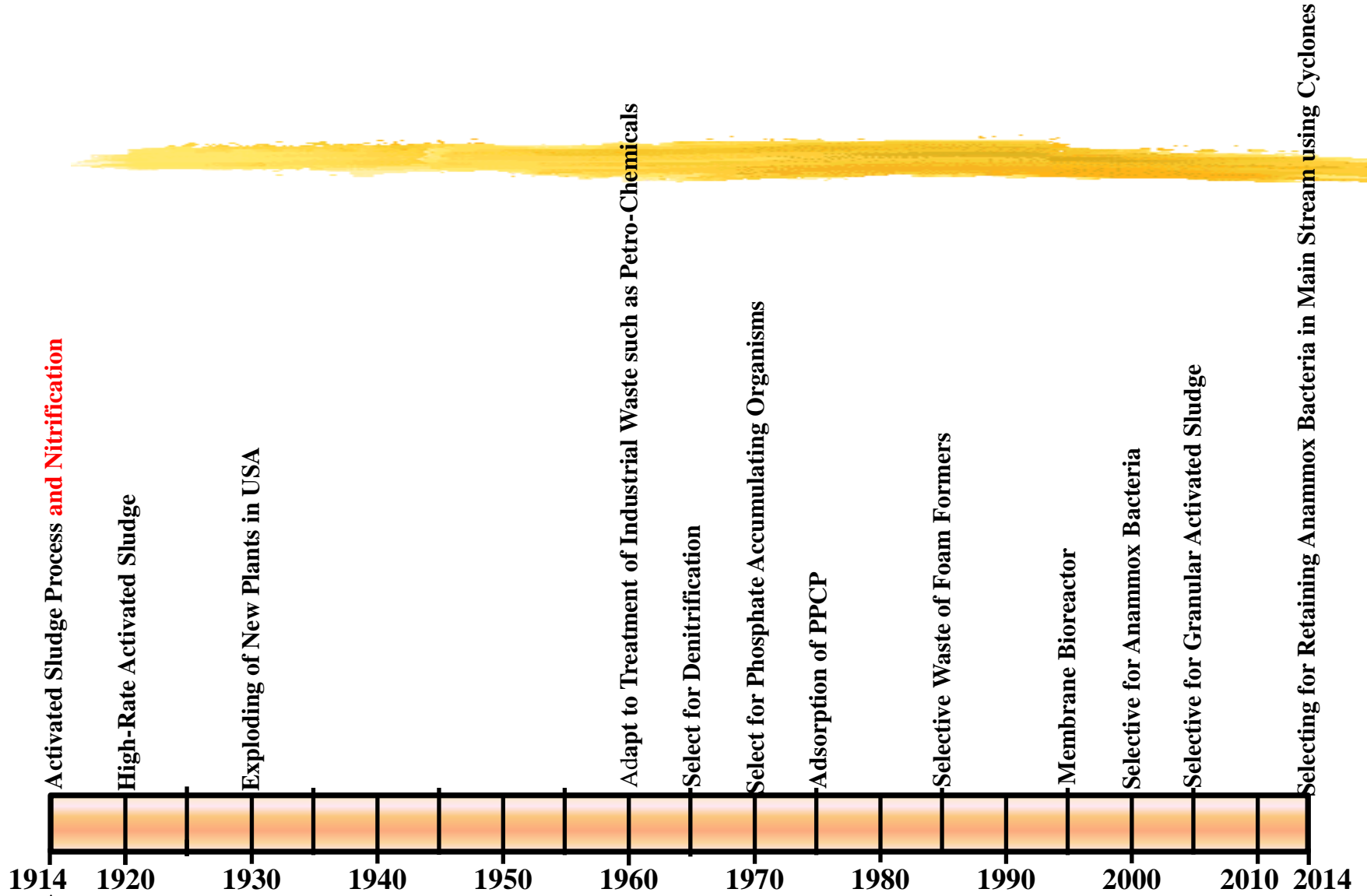
The basis of the process is to change conditions and select for specific organisms. Below is a rough time-line for developing of the process

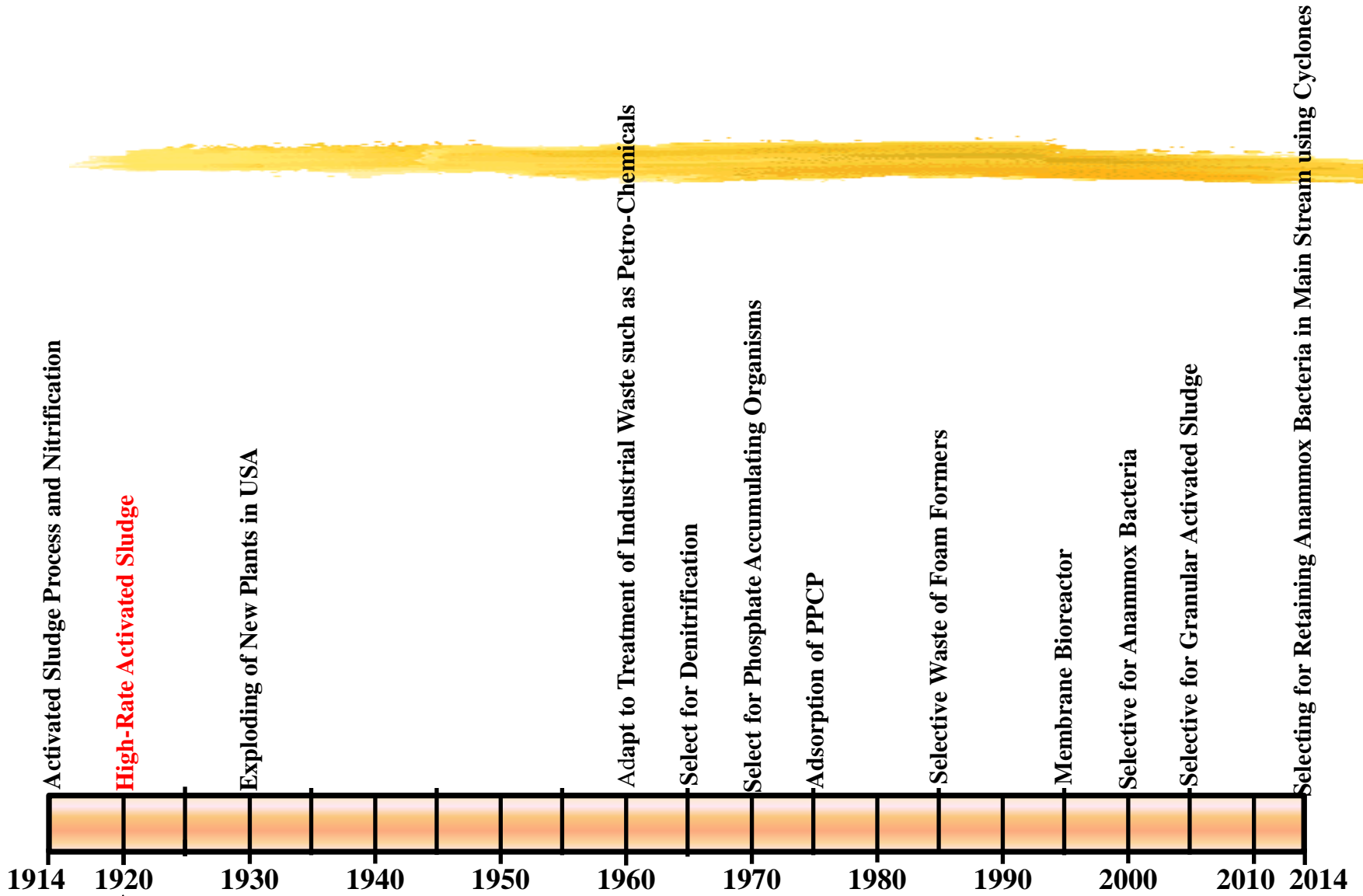


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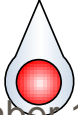


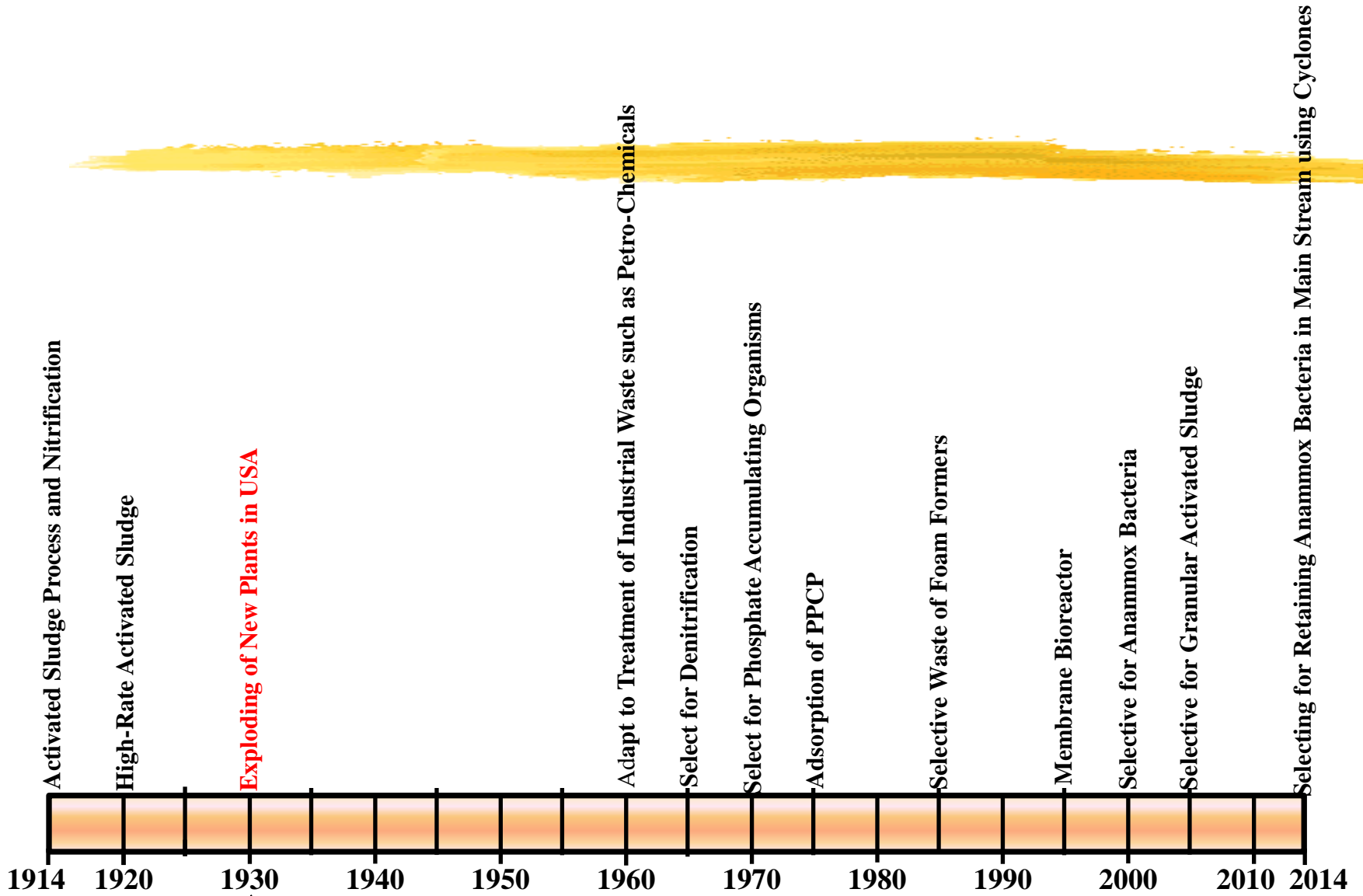
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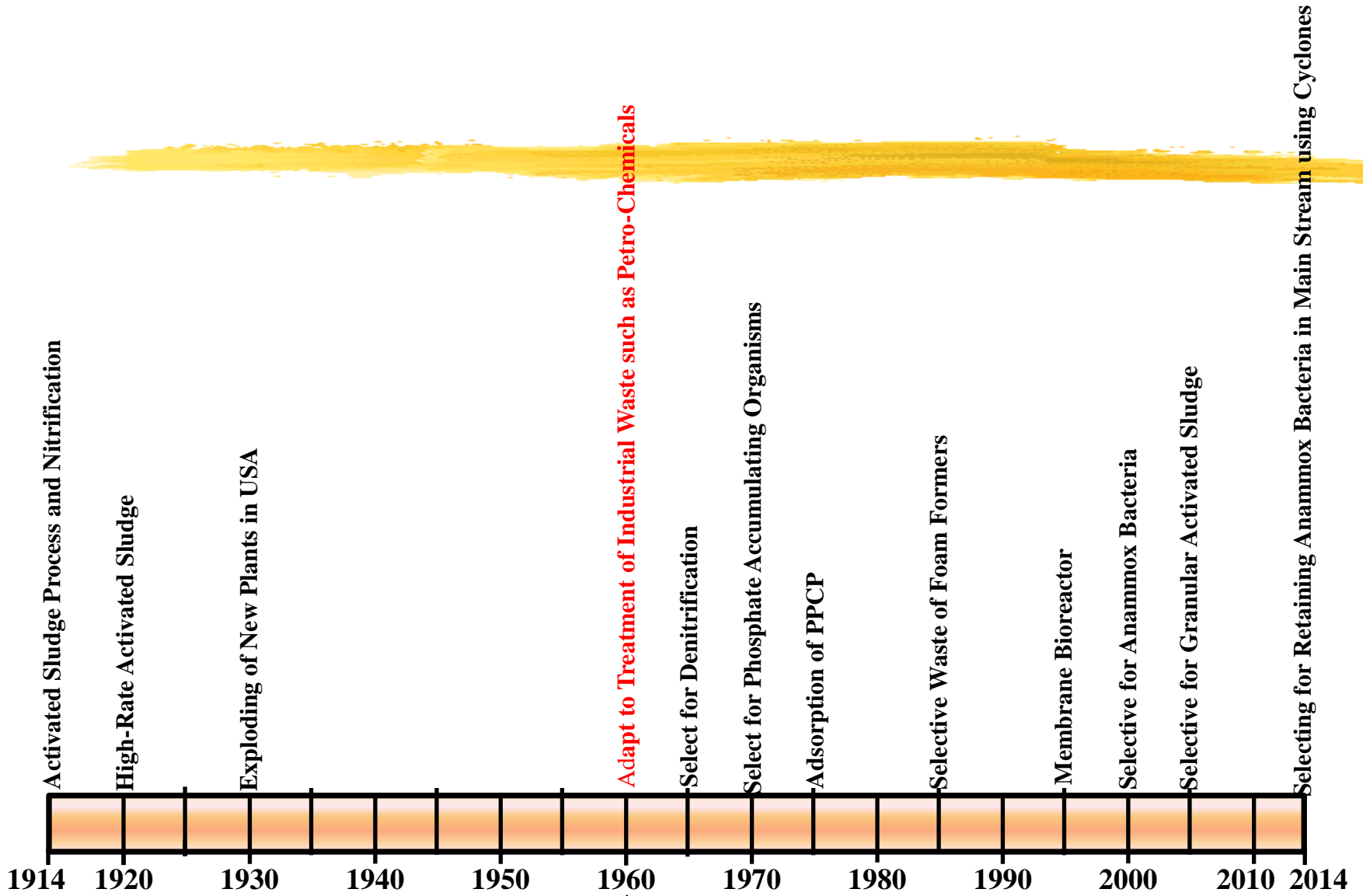
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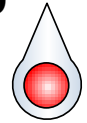
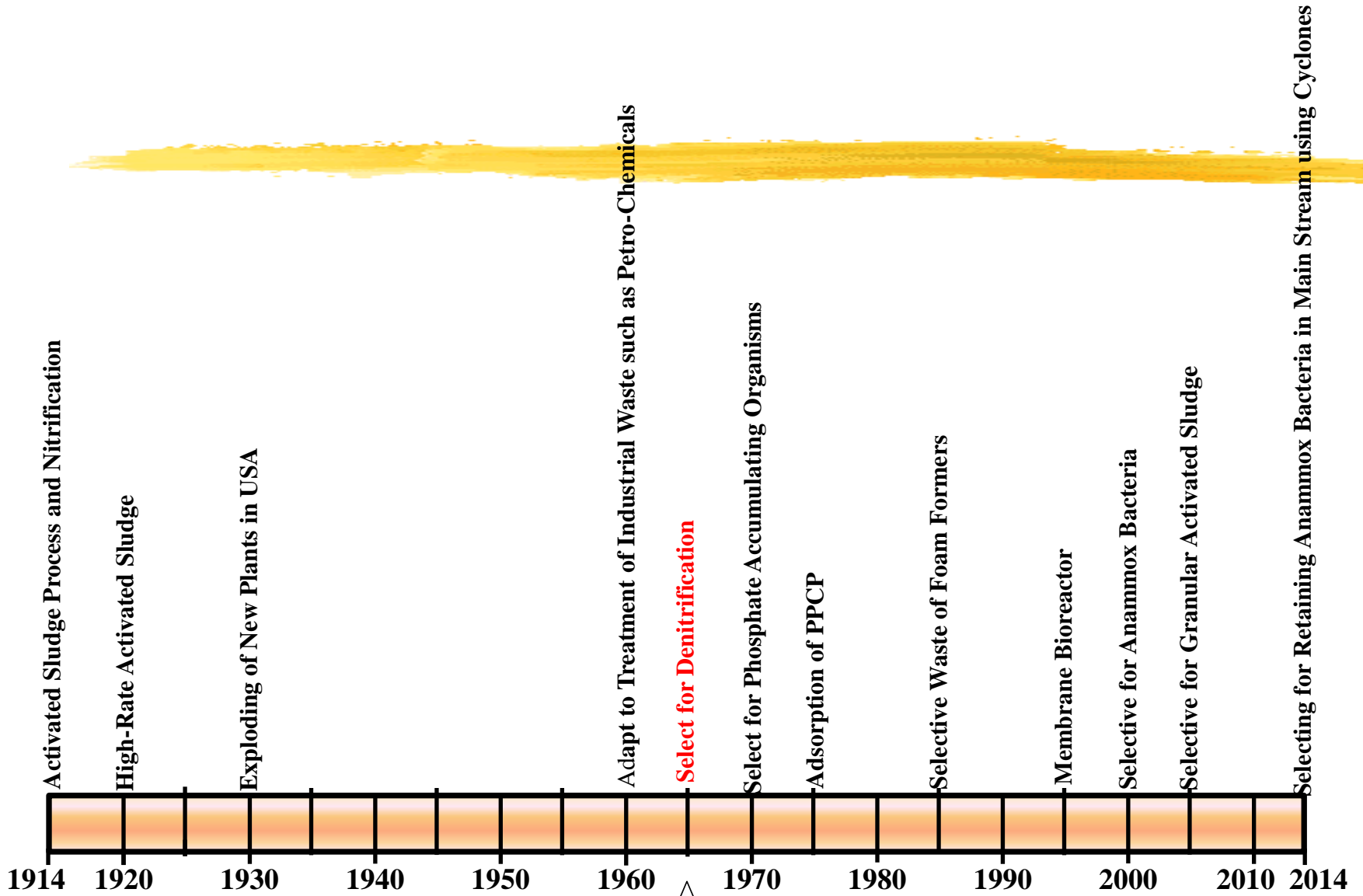
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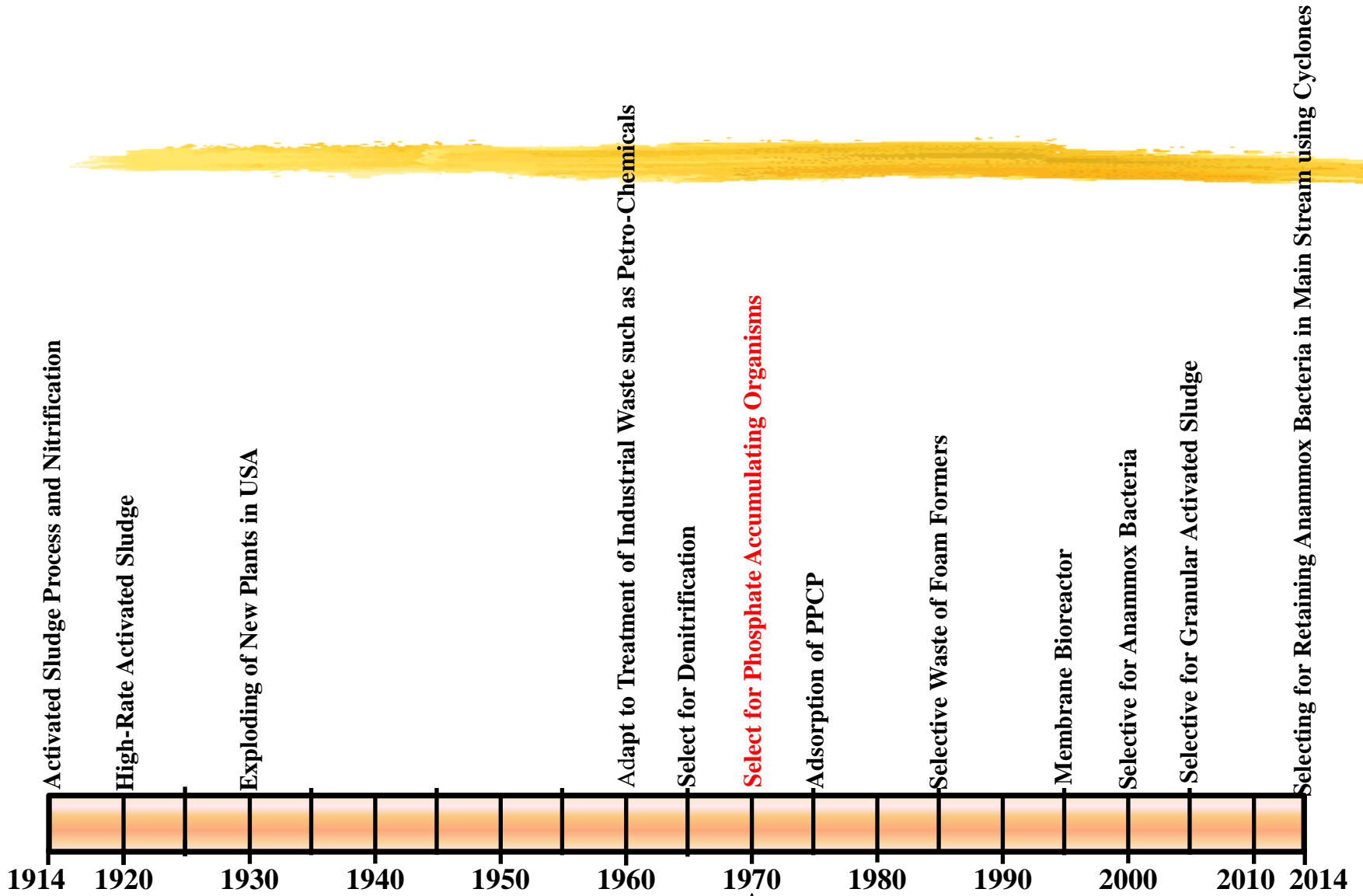




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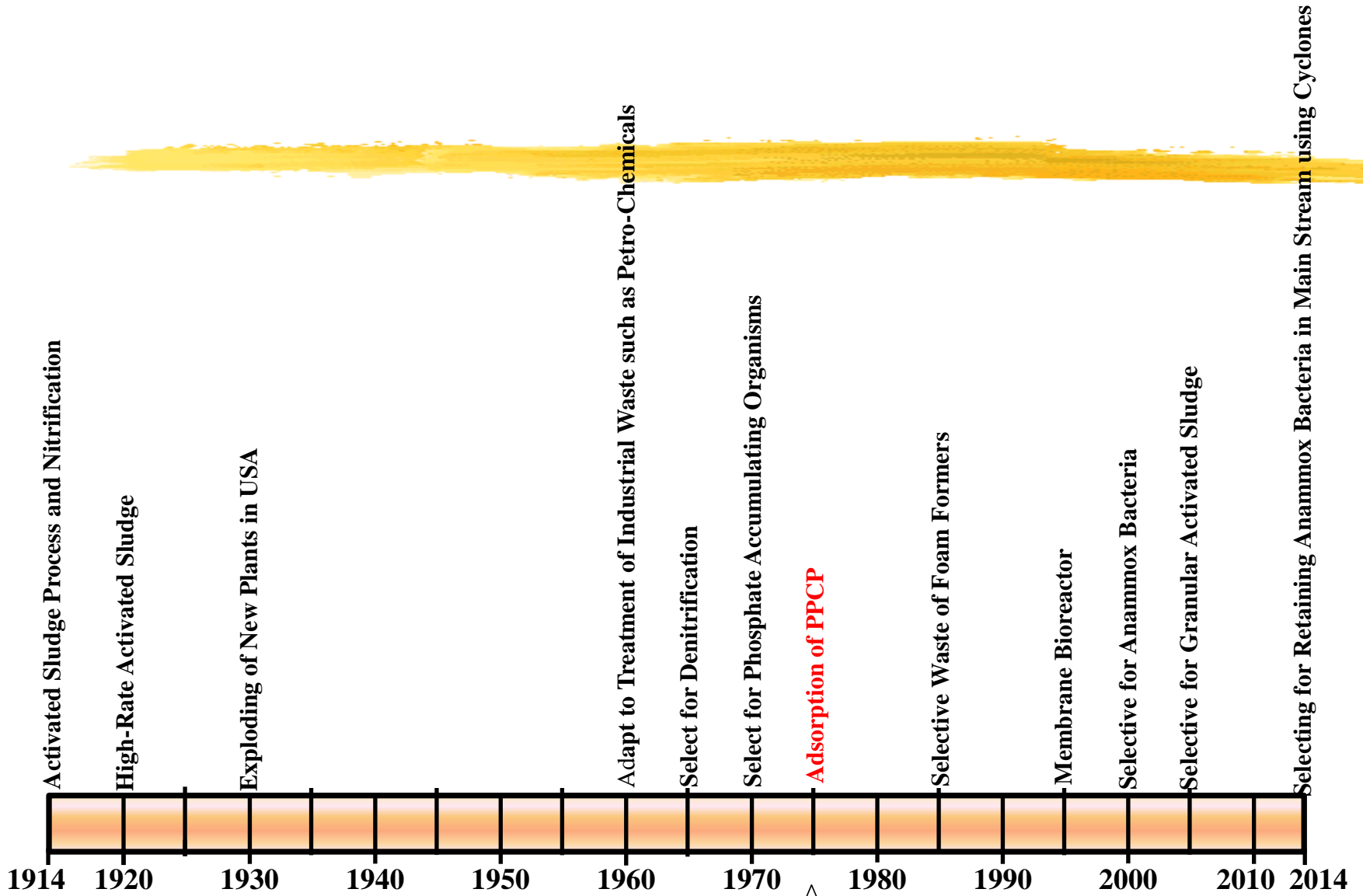


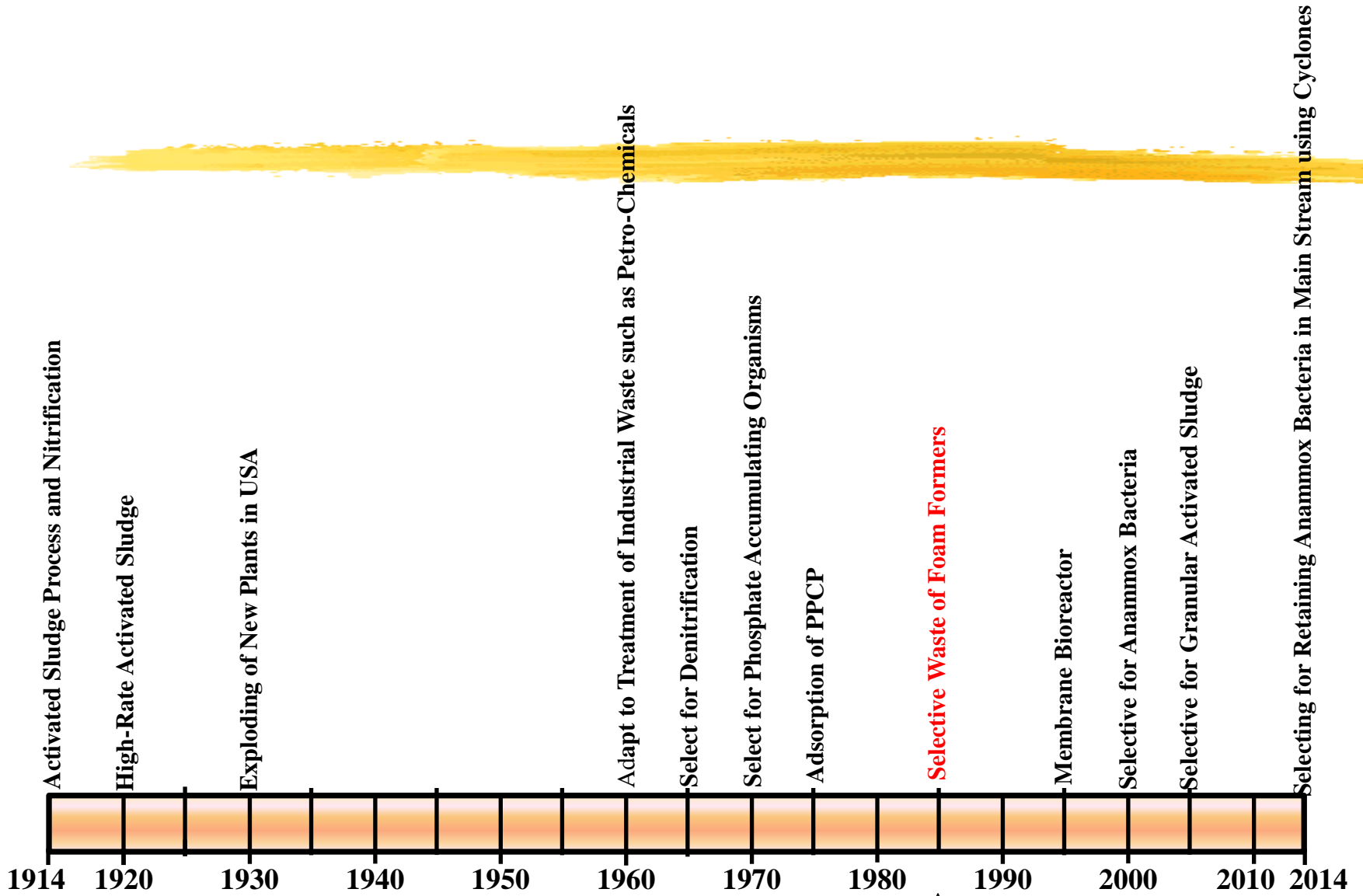




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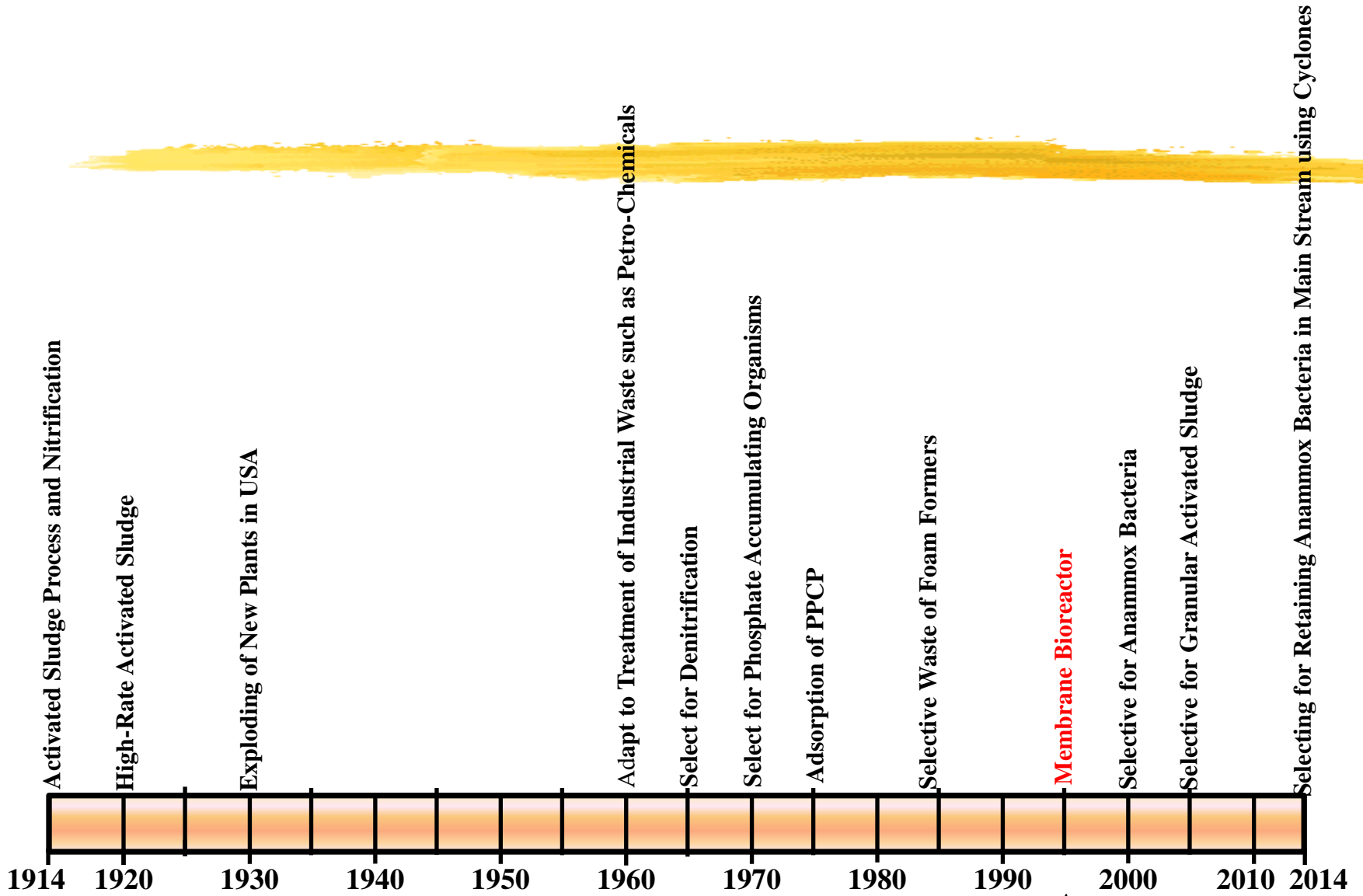


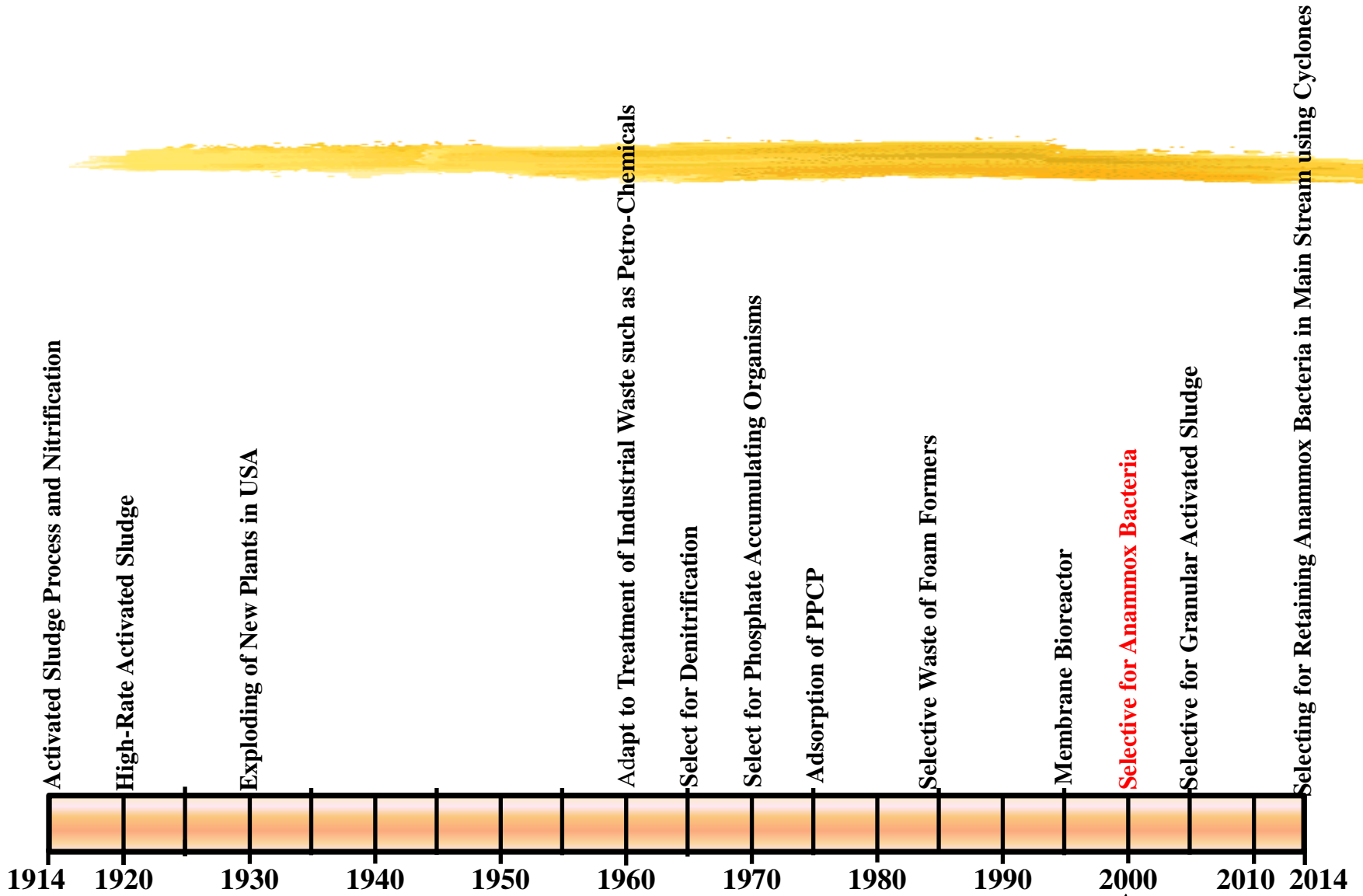




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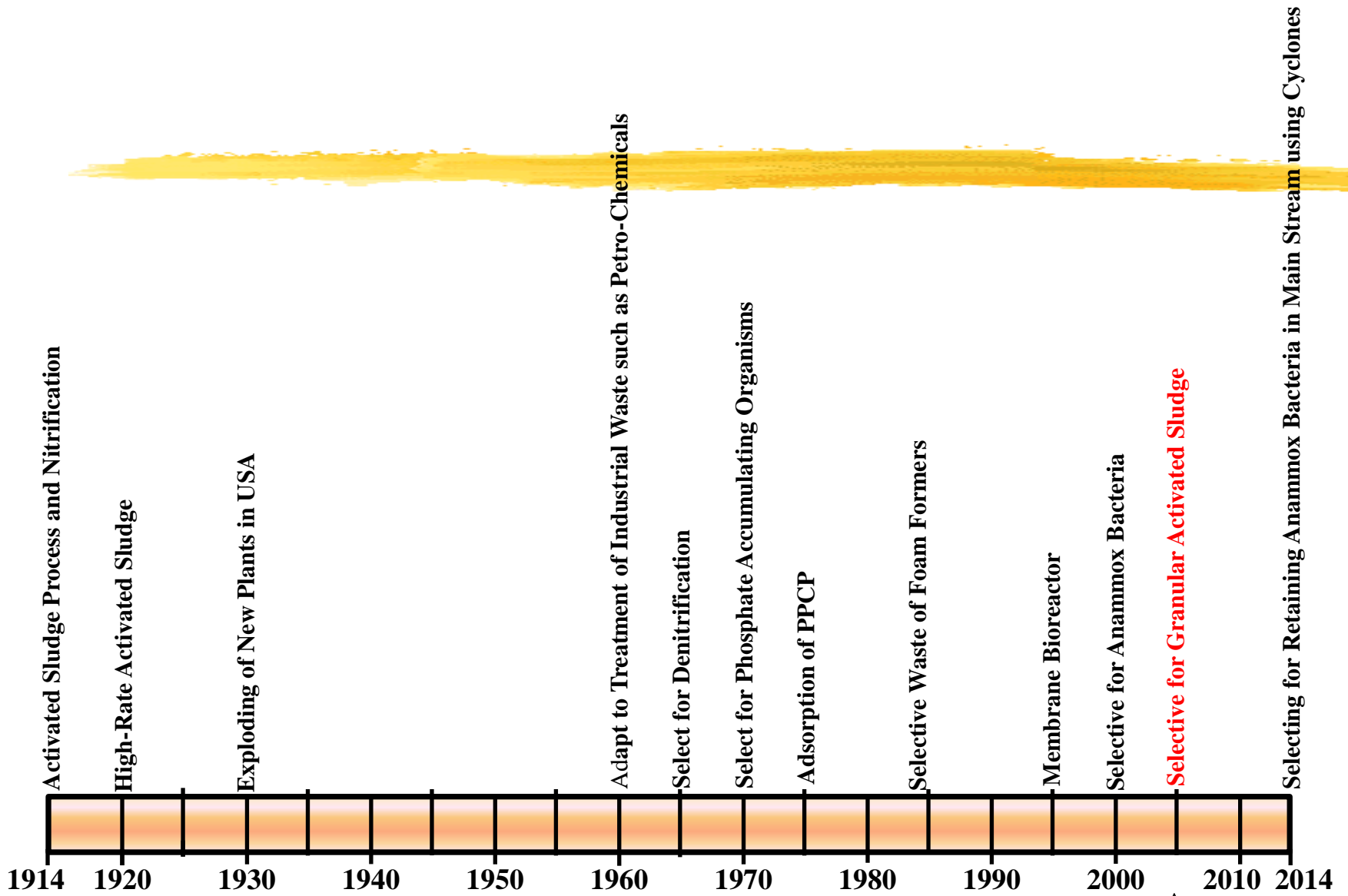


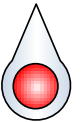
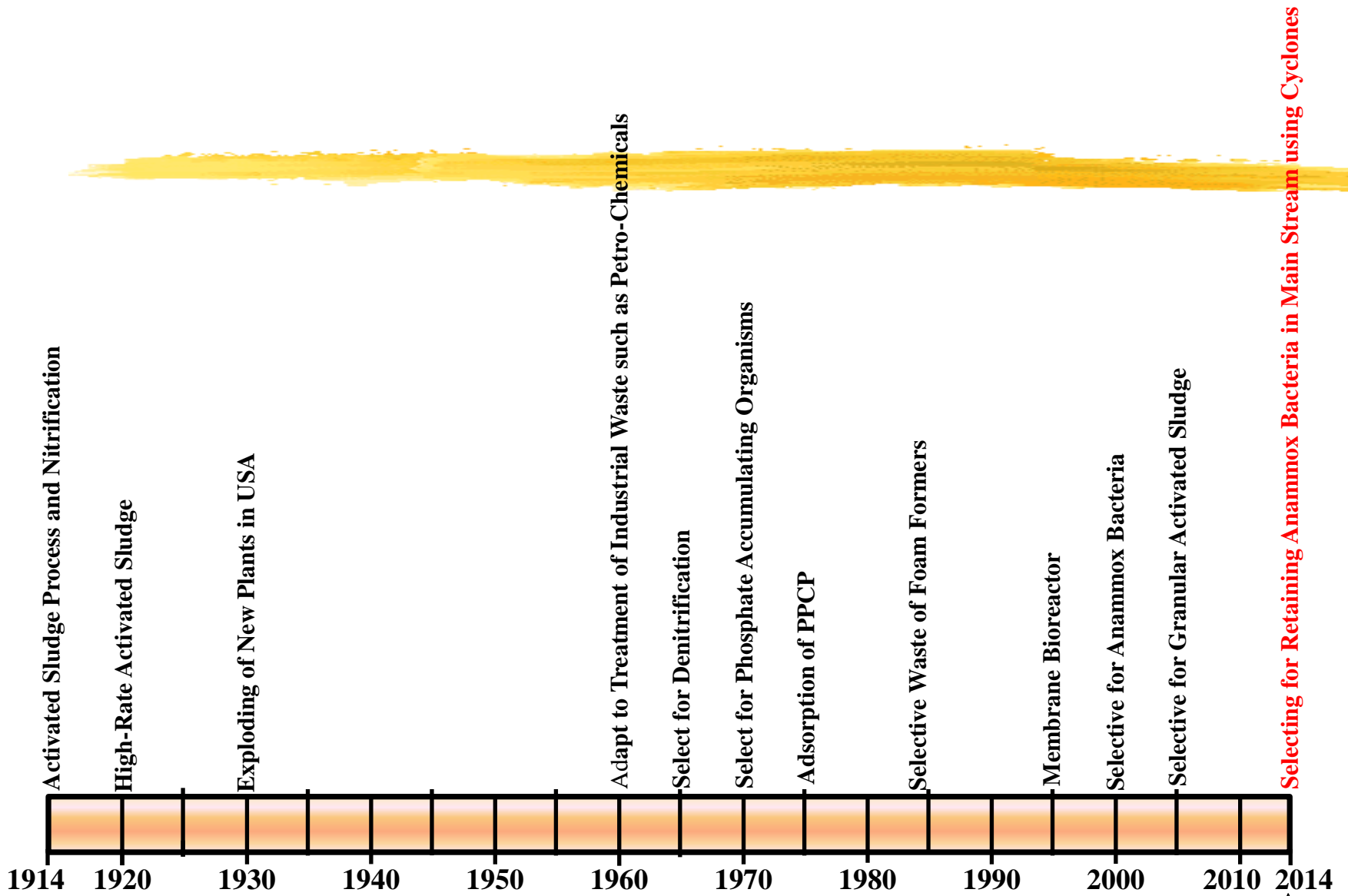




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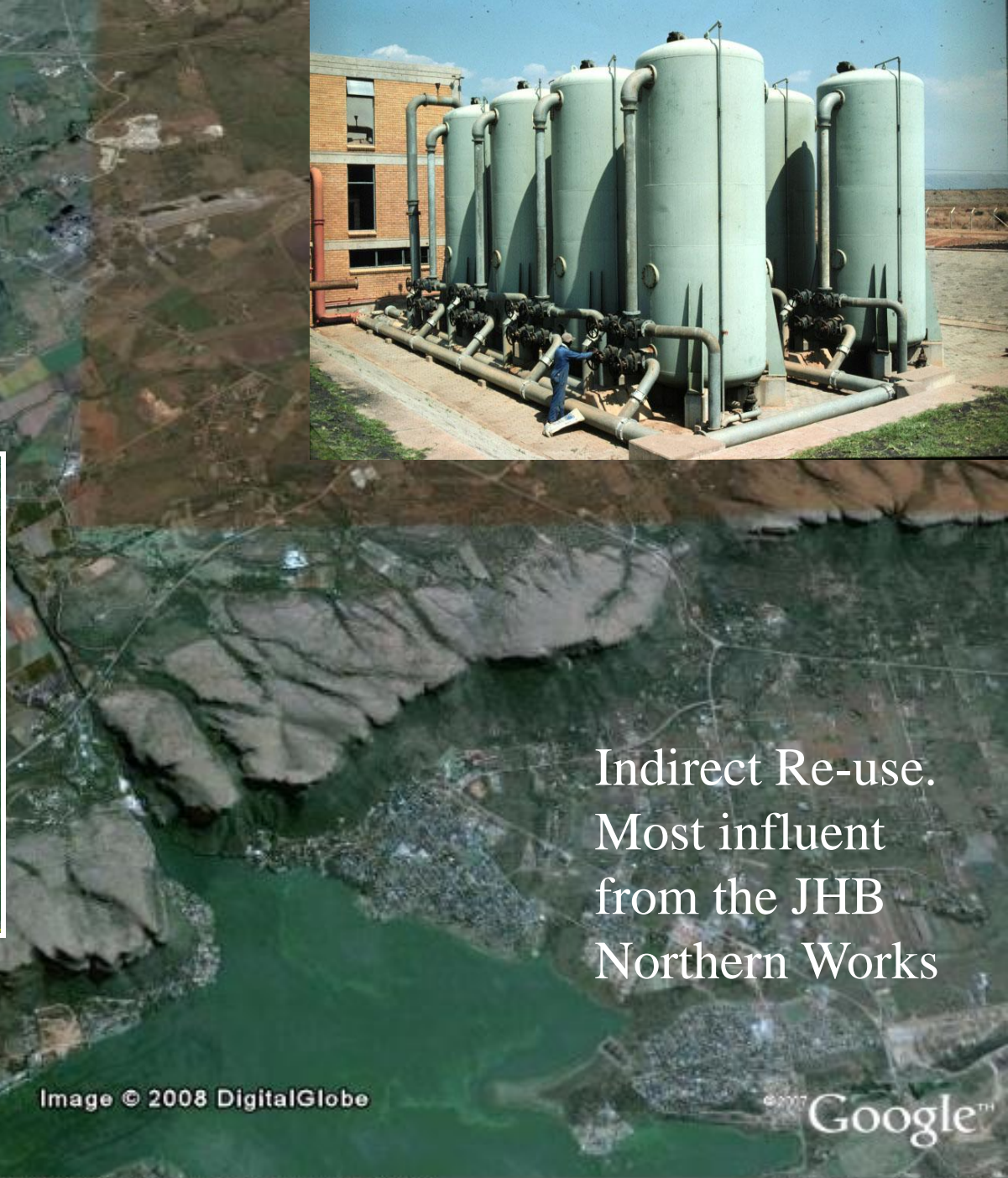




Eutrophication and Water Quality for Re-use

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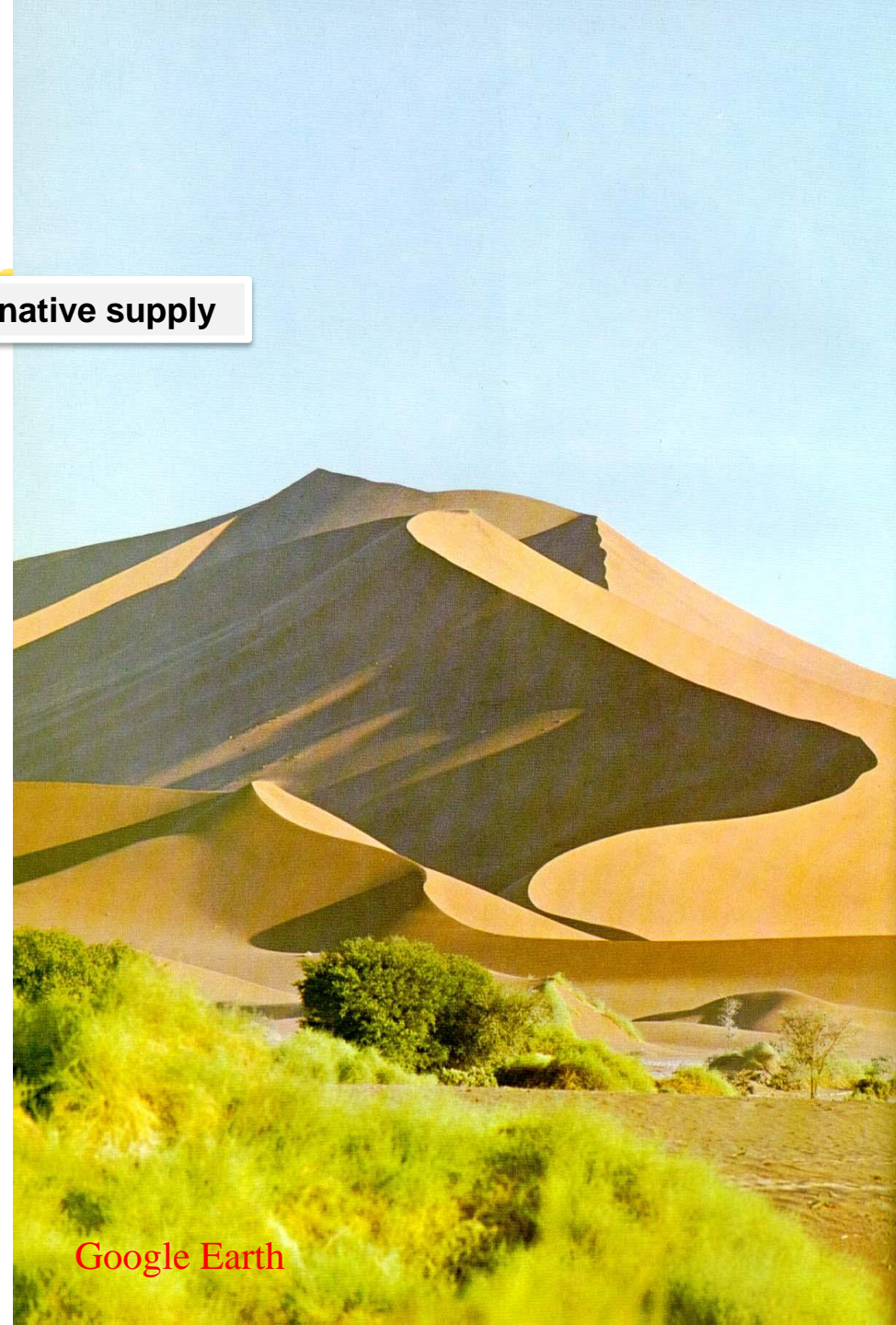
Town of Brits



Indirect Re-use.
Most influent
from the JHB
Northern Works

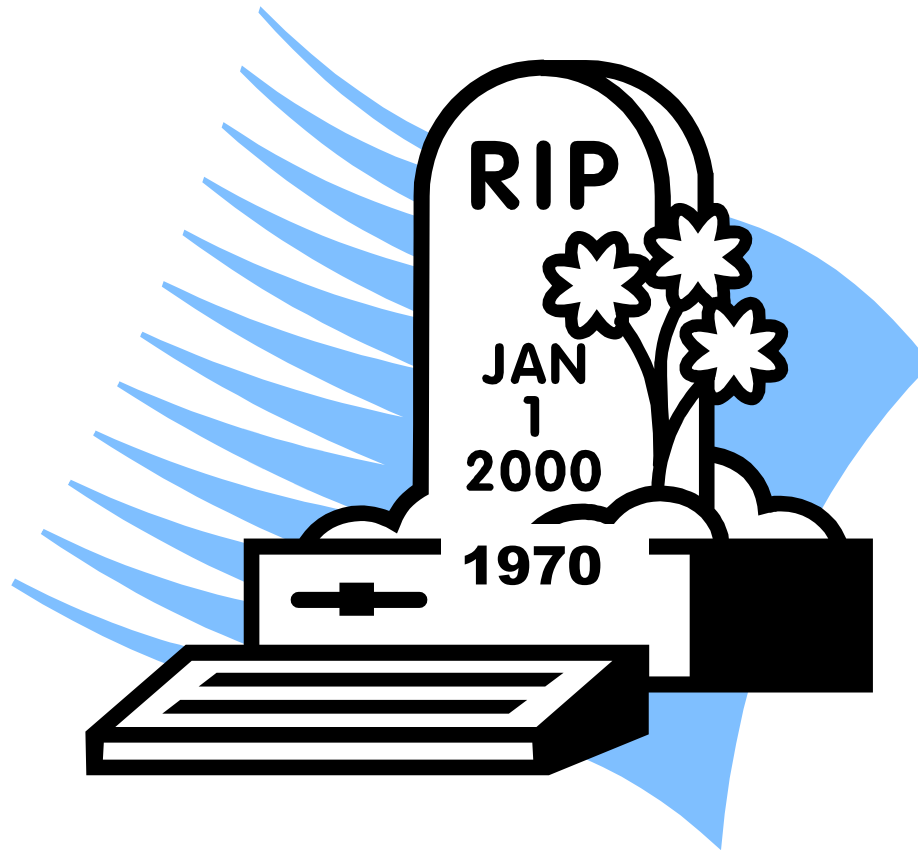


Namibia — Direct Water re-use



Google Earth

The Demise of Activated Sludge 1970?



Was the activated sludge process reliable enough for nutrient removal?

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Replace with Tertiary High Lime and Ammonia Stripping

Lake Tahoe – Right and Pretoria Left



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Or Clinoptilolite Ion Exchange for Ammonia Recovery



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Development of BNR Changed Perceptions

- ⌘ Removal of N&P without chemicals
- ⌘ Remove PPCP
- ⌘ Remove many industrial compounds
- ⌘ Low energy use



World's 1st Potable re-use at Windhoek Namibia



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NITROGEN REMOVAL PROBLEMS REQUIRED ADDITION OF AN ACTIVATED SLUDGE PLANT

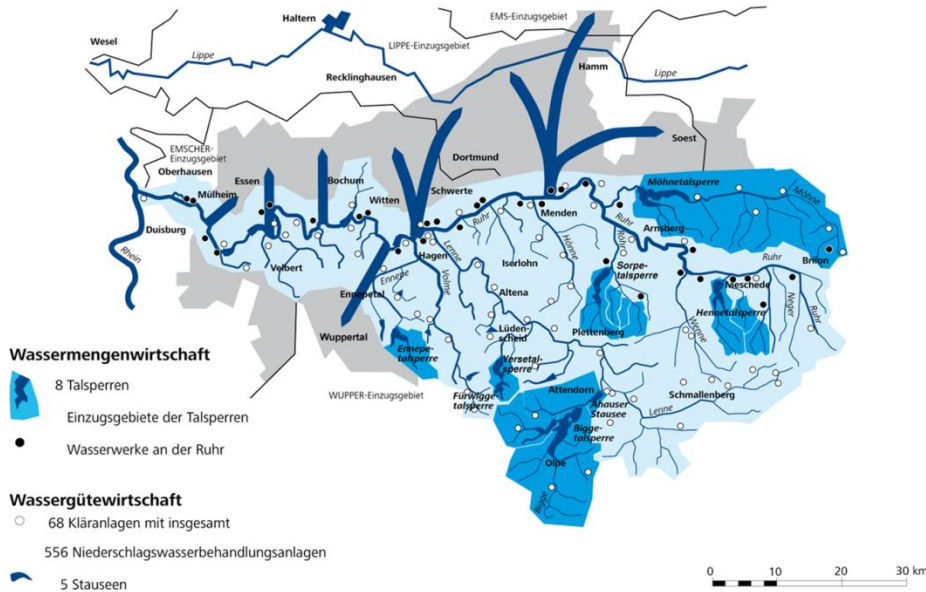




Indirect re-use

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Ruhr – Indirect re-use



River Ruhr receives treated wastewater from 2.1 Mio. inhabitants

River Ruhr receives treated wastewater from 0.4 Mio. PE from industry

River Ruhr serves as raw water source for drinking water supply for 4.6 Mio. inhabitants (plus industry)

all WWTP with full nutrient removal, discussion on the elimination of micropollutants is on the way

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Source: Ruhrverband, Essen

ACTIVATED SLUDGE FOR INDIRECT RE-USE IN ZIMBABWE



**Needed even in
Developing countries**

NITRATES ARE BENEFICIAL



Recent studies showed that nitrates discharged to lake has benefits – Cubas et al Wat Res, Feb. 2014

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Future Health Concerns – EDCs, PPCPs.....

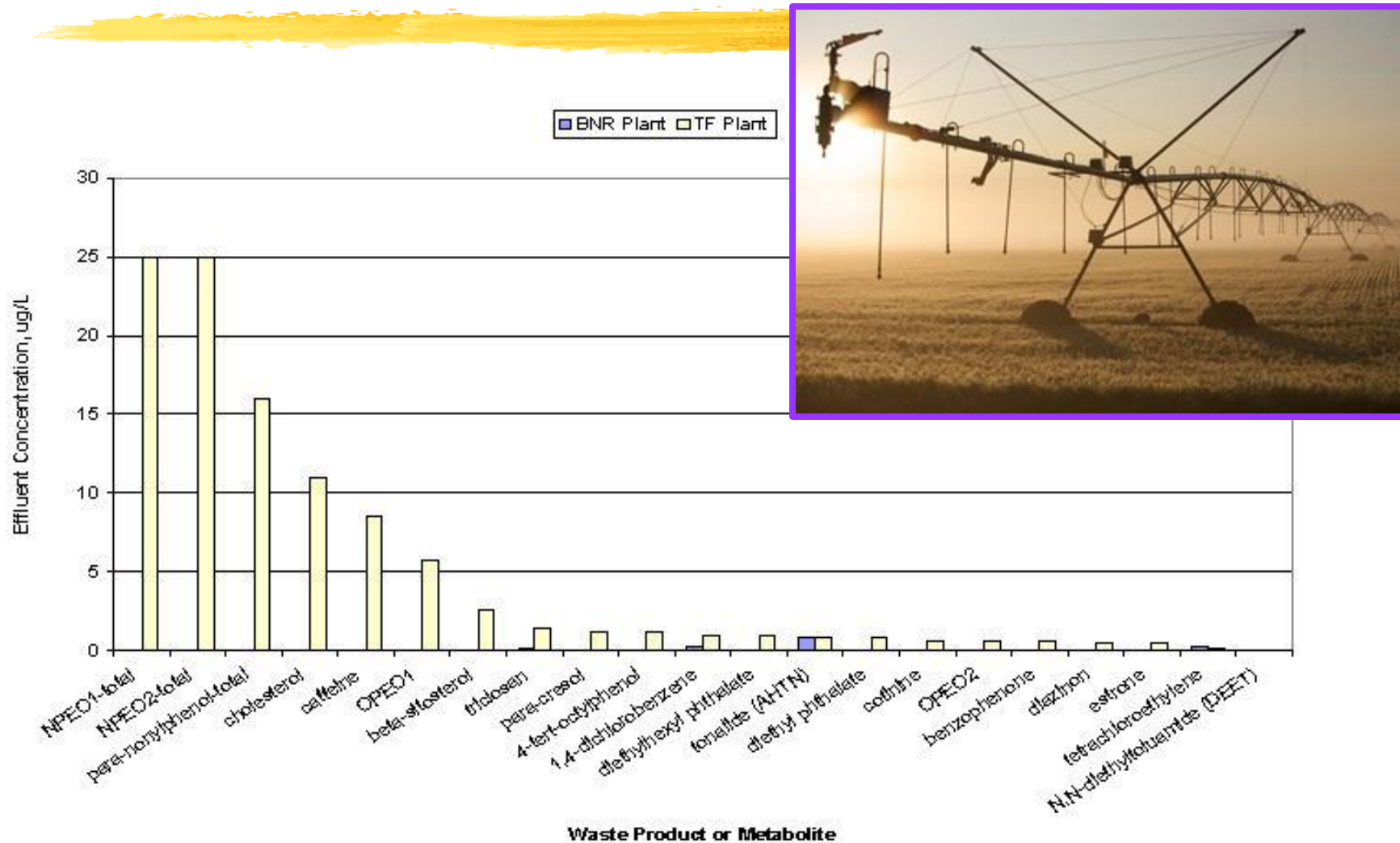
- ⌘ Aka: Microconstituents or micropollutants
- ⌘ Most likely a wastewater treatment issue
- ⌘ Source control, product modification?

EDC

PPCP

COEC

Removal of PPCPs

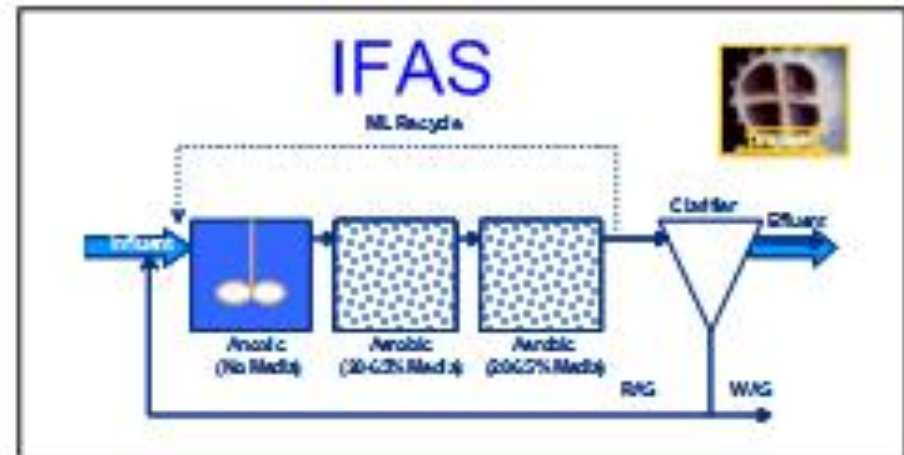
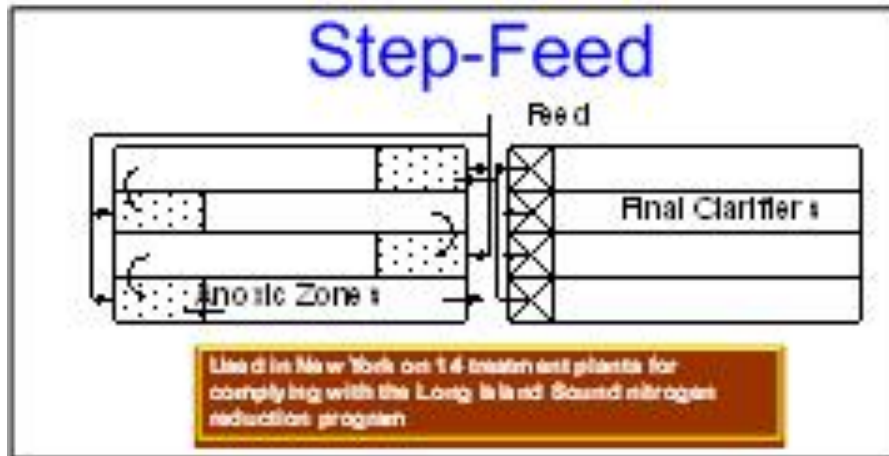


Trends to Smaller Footprint and Energy Efficiency

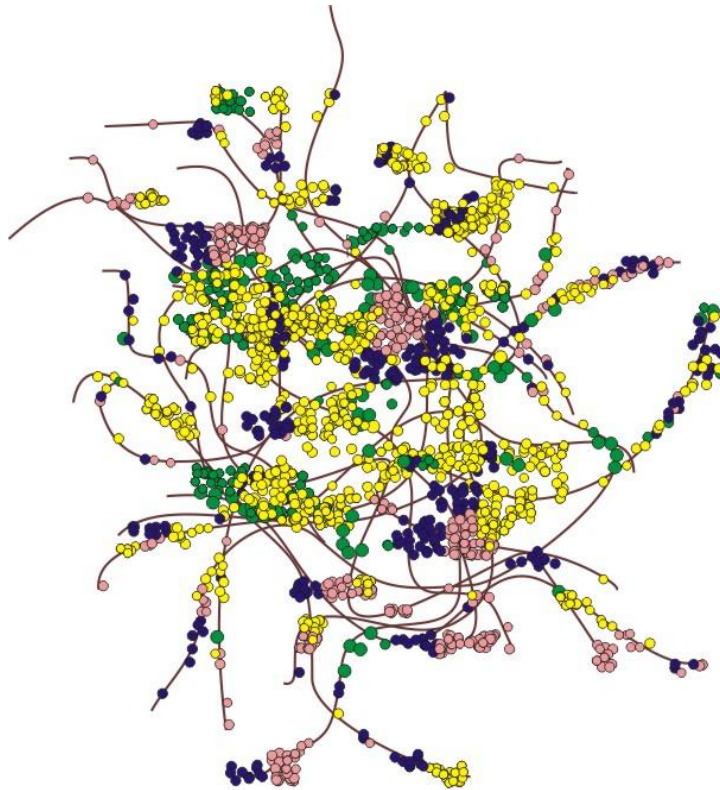


- ⌘ Step-feed nitrification/denitrification
- ⌘ Integrated Fix Film Activated sludge
- ⌘ Membrane Bio-reactors
- ⌘ Stacked SBR
- ⌘ Granular sludge
- ⌘ Anammox for Mainstream
- ⌘ Cyclone selectors for improving SVI

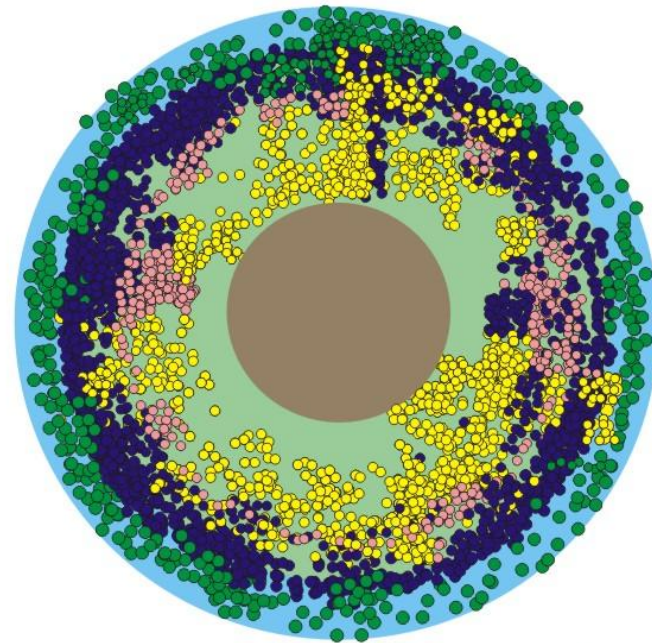
Reduced Footprint



Granular Activated Sludge



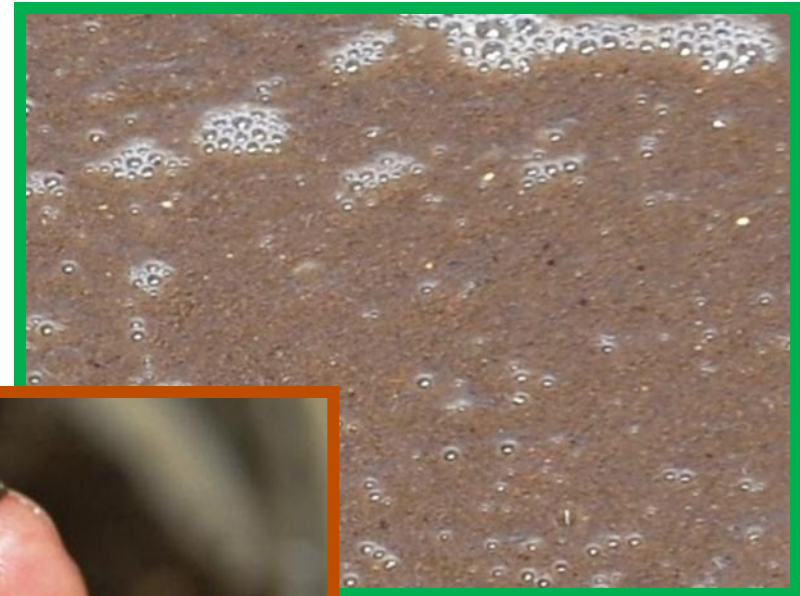
PAO
Denitrifiers
Nitifiers
GAO



Aerobic
Anoxic
Anaerobic

**With Permission from Prof. Mark van Loosdrecht TU Delft*

Granular Activated Sludge



Sludge is wasted from the top layer.
Possible WERF project to look at other forms of selection

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- LT 40% of footprint
- LT 60% of power
- Simple operation
- No mixers
- No recycle pumps

Epe - Netherlands



November 2, 2014

NEREDA: One -Tank Process for Biological Nutrient Removal



10 plants build
since 2012

Approx. 20
under design

Total N < 5 mgN/l; total P < 0.5 mgP/l
70 % less space; 30 - 40 % lower energy;
25 % lower investment

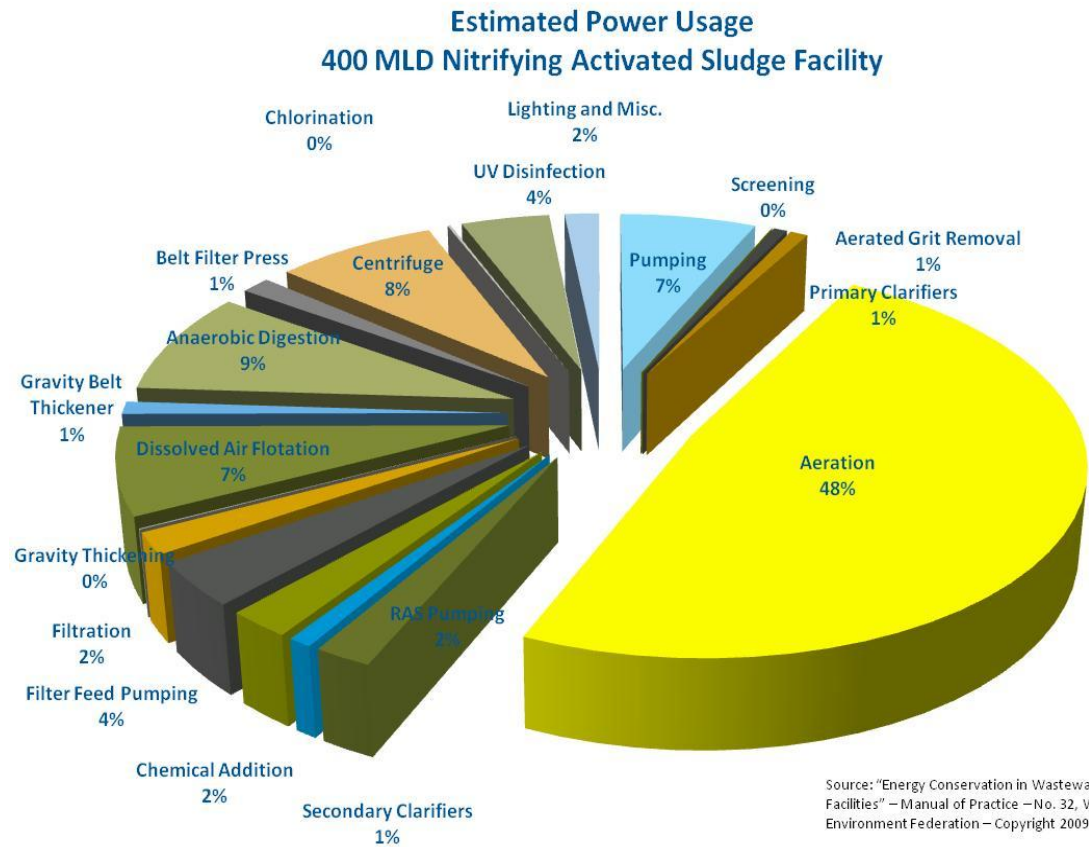


Energy self-sufficiency

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WERF ENER1C12 – ENERGY EFFICIENCY AND PRODUCTION

End product is a practical tool for use to monitor and manage energy



Source: "Energy Conservation in Wastewater Treatment Facilities" – Manual of Practice – No. 32, Water Environment Federation – Copyright 2009

Comparative Energy Use

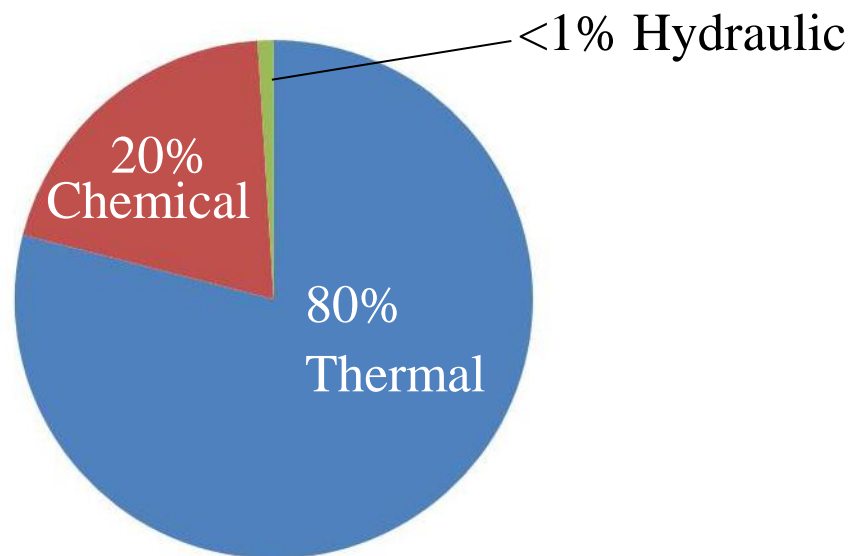
Energy used for	kWh/c/a
BNR Wastewater Treatment only	30
Switching one lamp to low energy fixtures	102
Pumping water from north to south of California	355
Lack of switch in my office	360
Household per person (2 persons)	14,000

Prof Helmut Kroiss – Our first obligation is to produce the quality of effluent required then look at energy cost

Wastewater Sector Energy Recovery Estimates

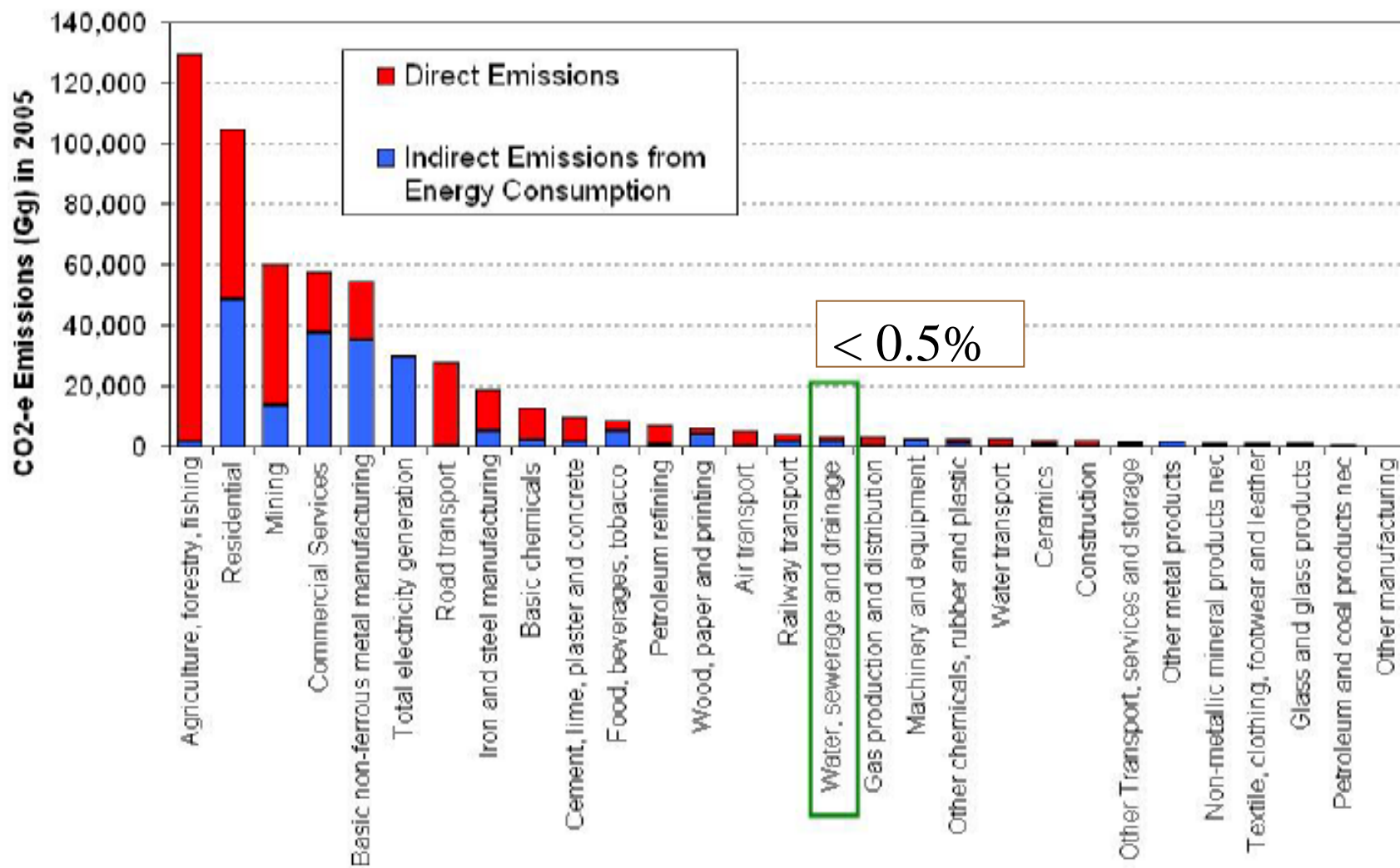
(from WERF ENER6C13)

- There is more energy in wastewater than is needed for treatment – about 5X more
- Total primary energy potential is **851** trillion BTU/year, 80% of which is thermal energy



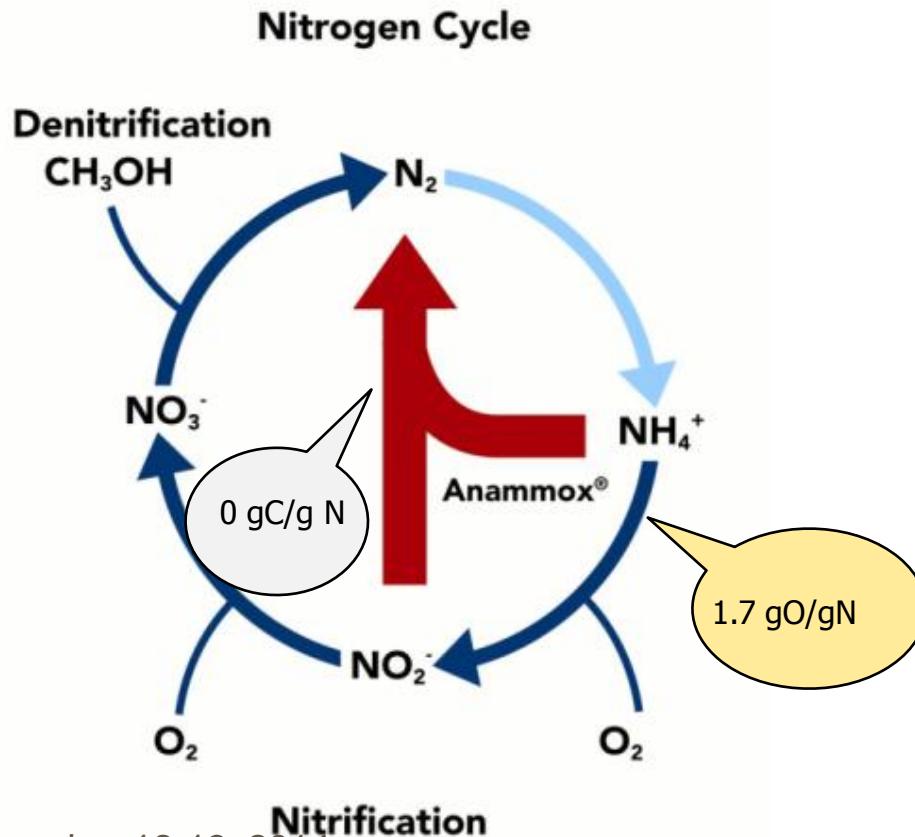
WWTP GHGs In Context

Australian GHG's in 2005



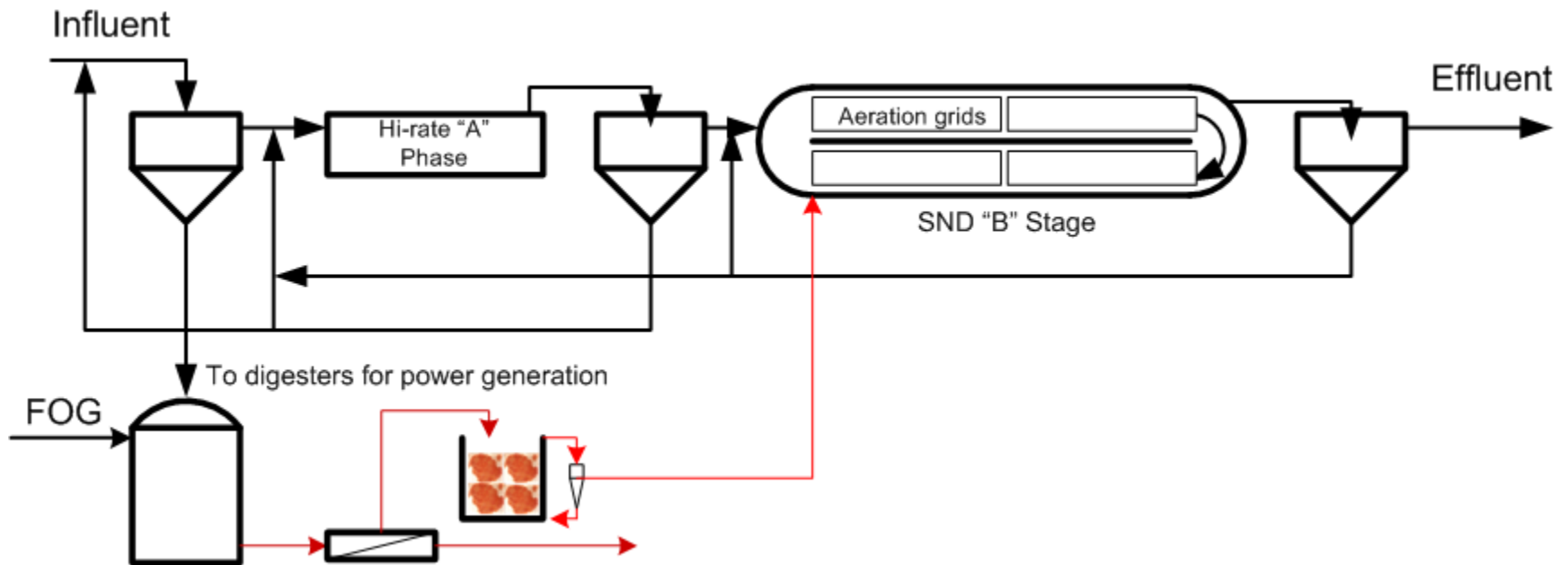
SIDE-STREAM N REMOVAL

ANAMMOX PROCESS



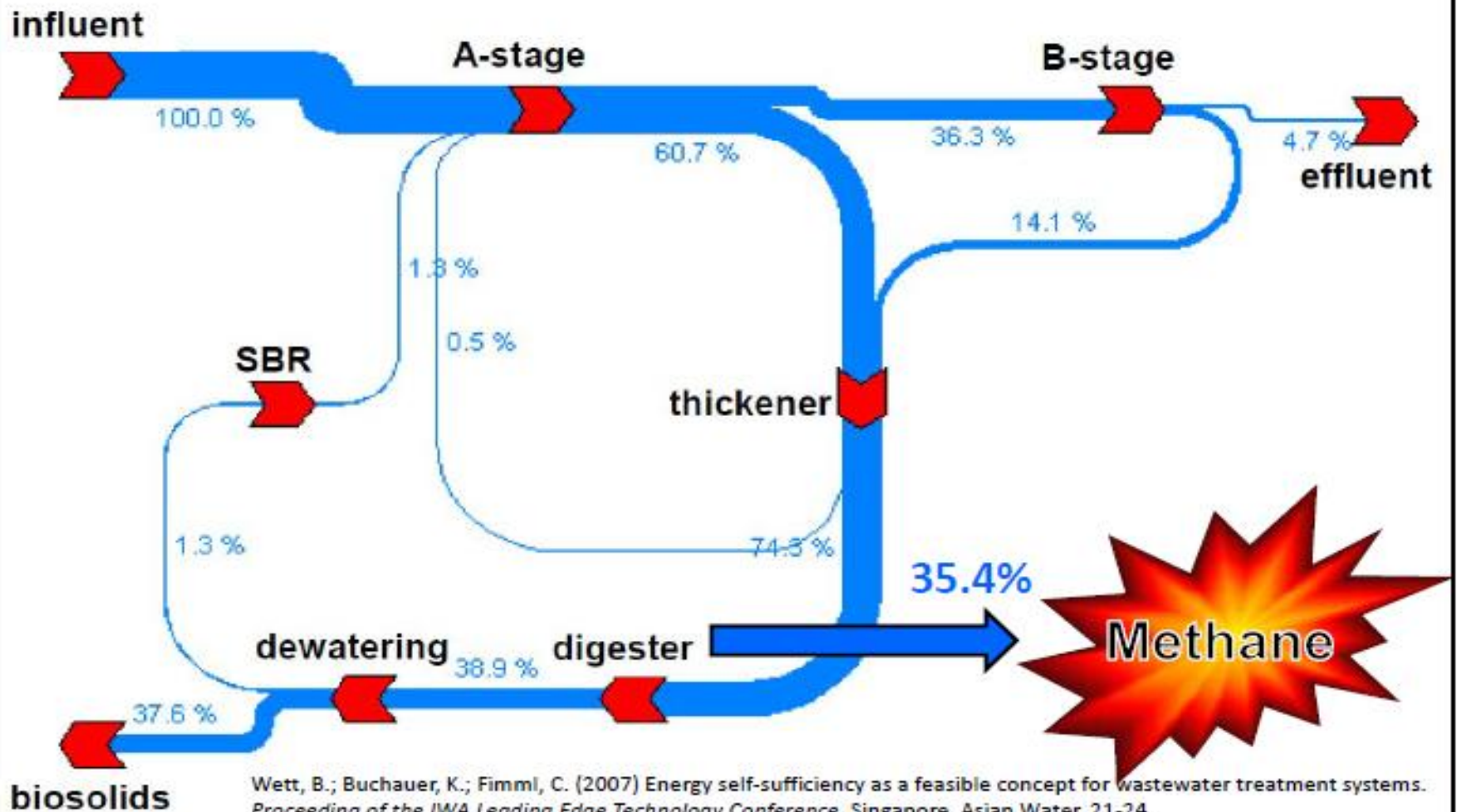
Makes N recovery less cost effective

Strass Plant Austria



- Produces 8% more energy than it consumes
- Effluent Ammonia varies – Design < 14 TN
- Removed no Phosphorus
- SVI enhanced with cyclone selectors

Simulated COD Balance of the AIZ Strass WWTP



GHG increase with lower N&P

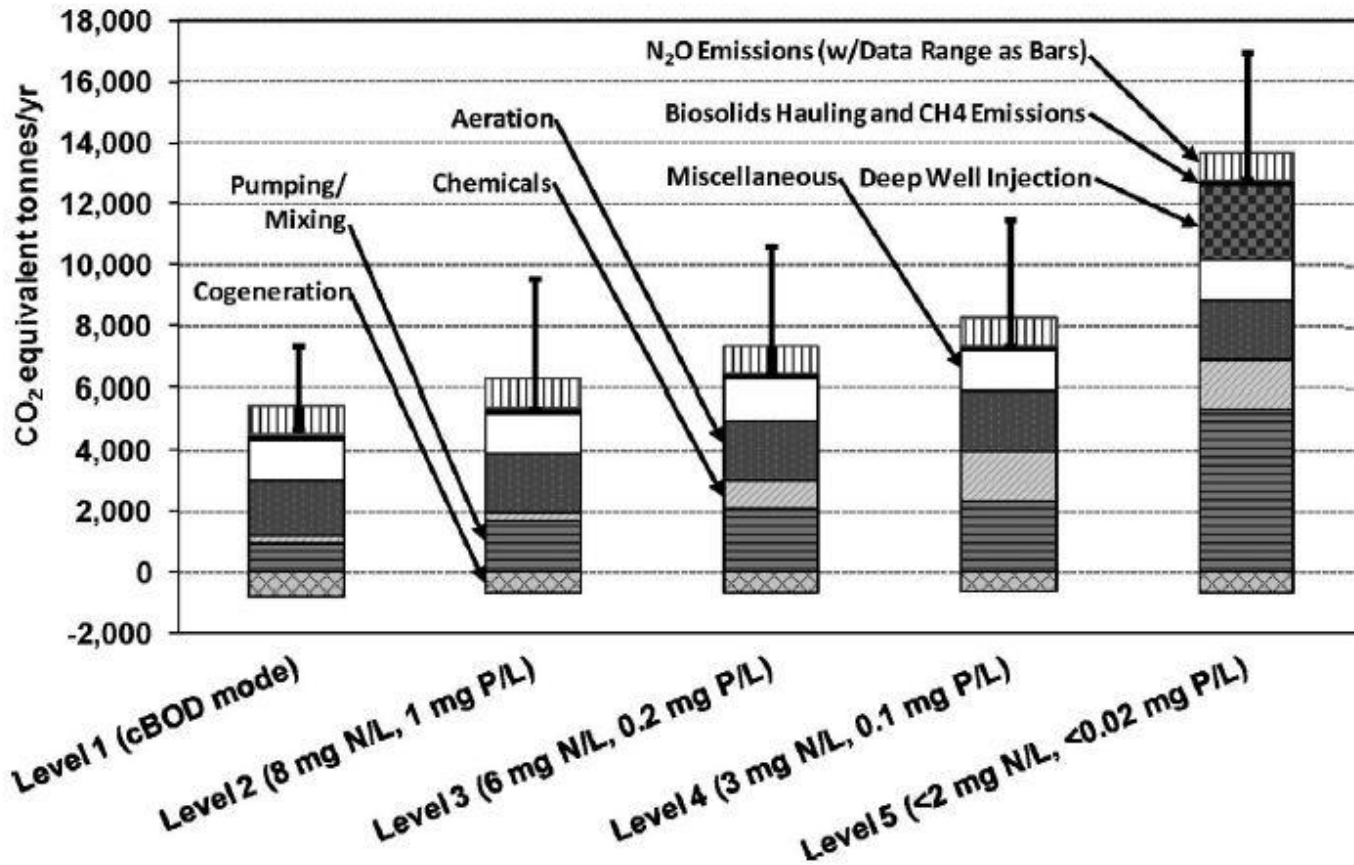


Figure 2—Greenhouse gas emissions distribution per treatment level. cBOD, carbonaceous biochemical oxygen demand.

Nitrogen recovery



- Only viable if less energy is used than fixing Nitrogen from the atmosphere
- Haber-Bosch process uses about 12 kWh/kg nitrogen fertilizer

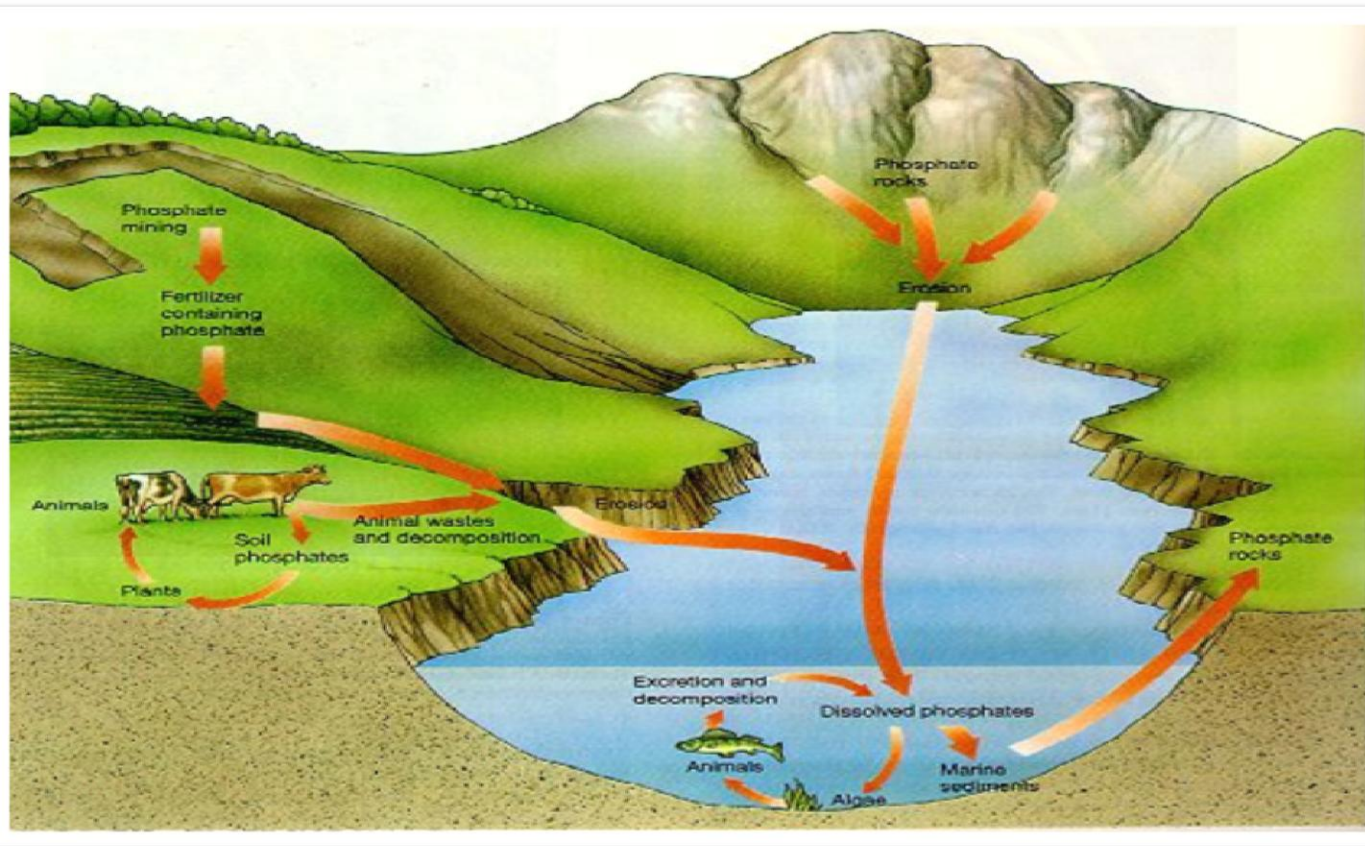


PHOSPHORUS CYCLE

A study in Unsustainability

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The Eternal Phosphorus Cycle

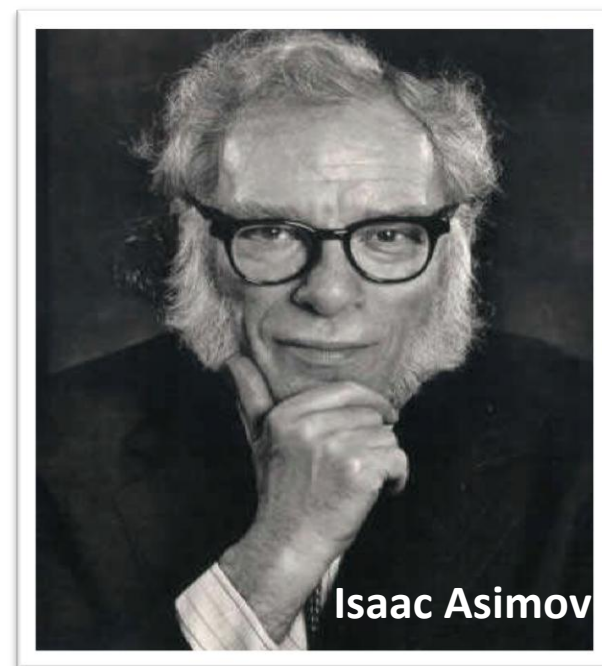


The phosphorus cycle in terrestrial and aquatic environments. Recycling of phosphorus is slow because no important form of phosphorus exists in gaseous form. Phosphorus that becomes part of the marine sediments may take millions of years to solidify into rock, uplift as mountains then erode away to become available to living things.

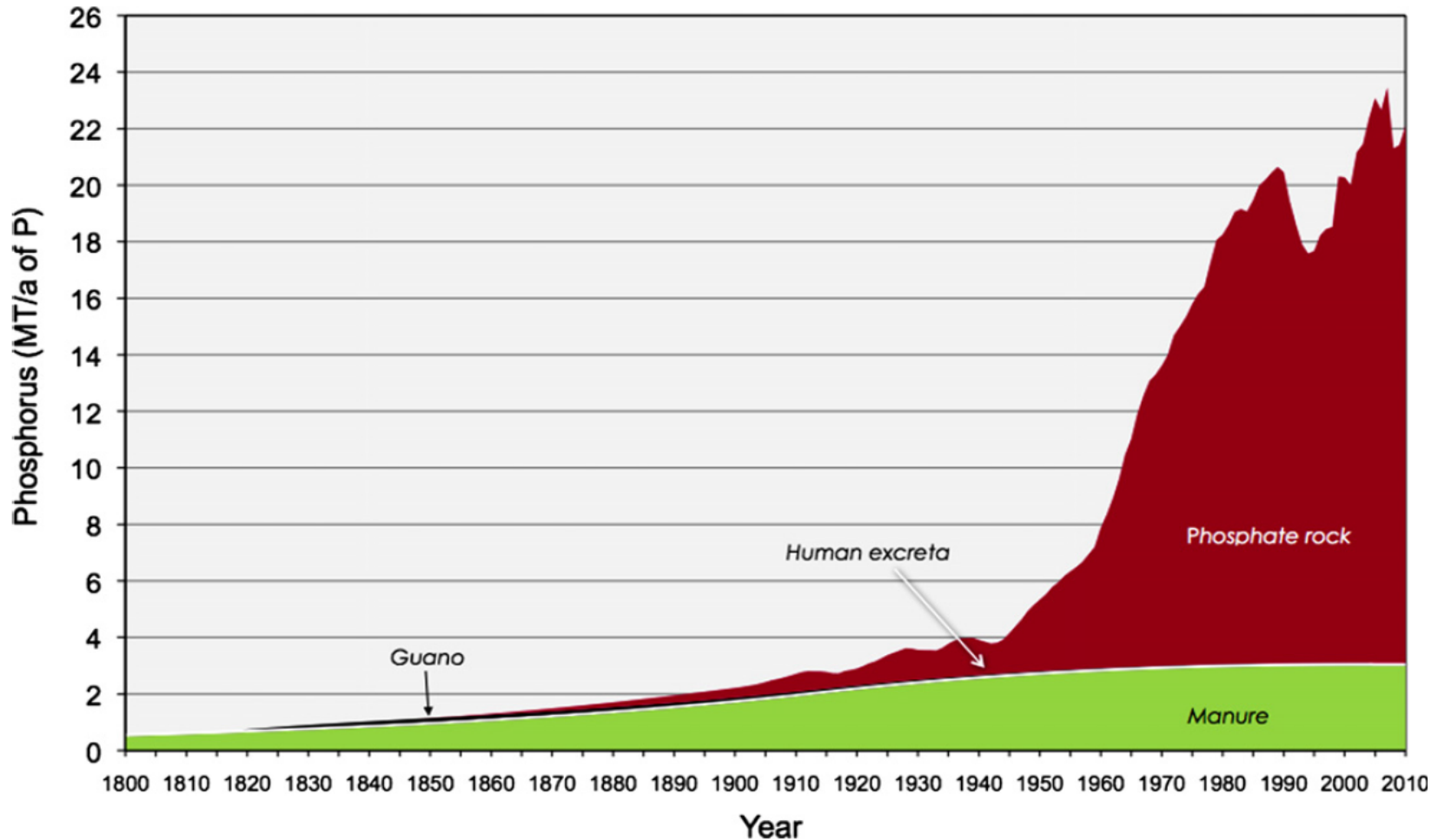
Asimov on Chemistry

About Phosphorus

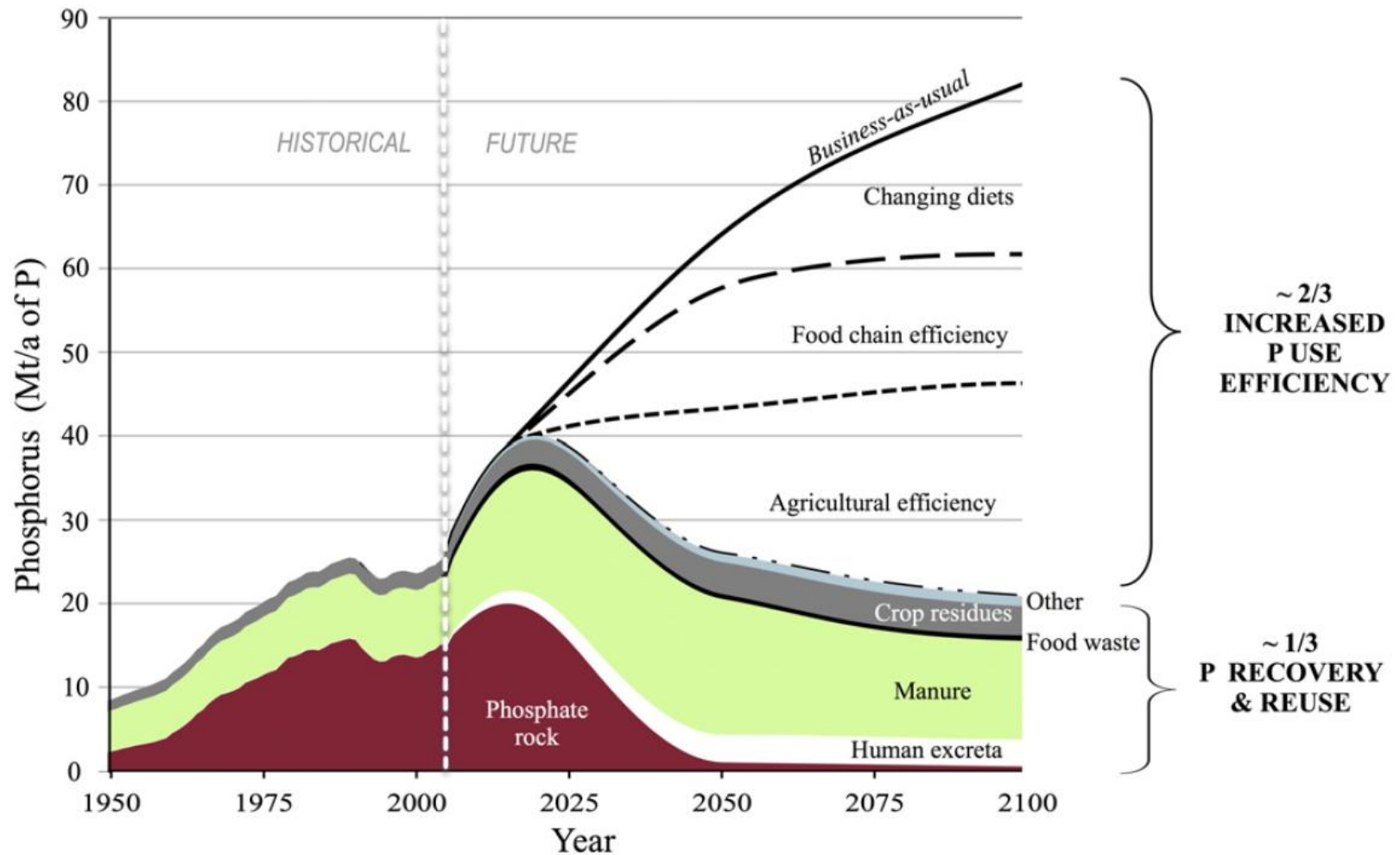
“We may be able to substitute nuclear power for coal power, and plastics for wood, and yeast for meat, and friendliness for isolation, but for phosphorus there is neither substitute nor replacement.”



Historical Sources of Phosphorus Fertilizer



Future Scenarios



The first step



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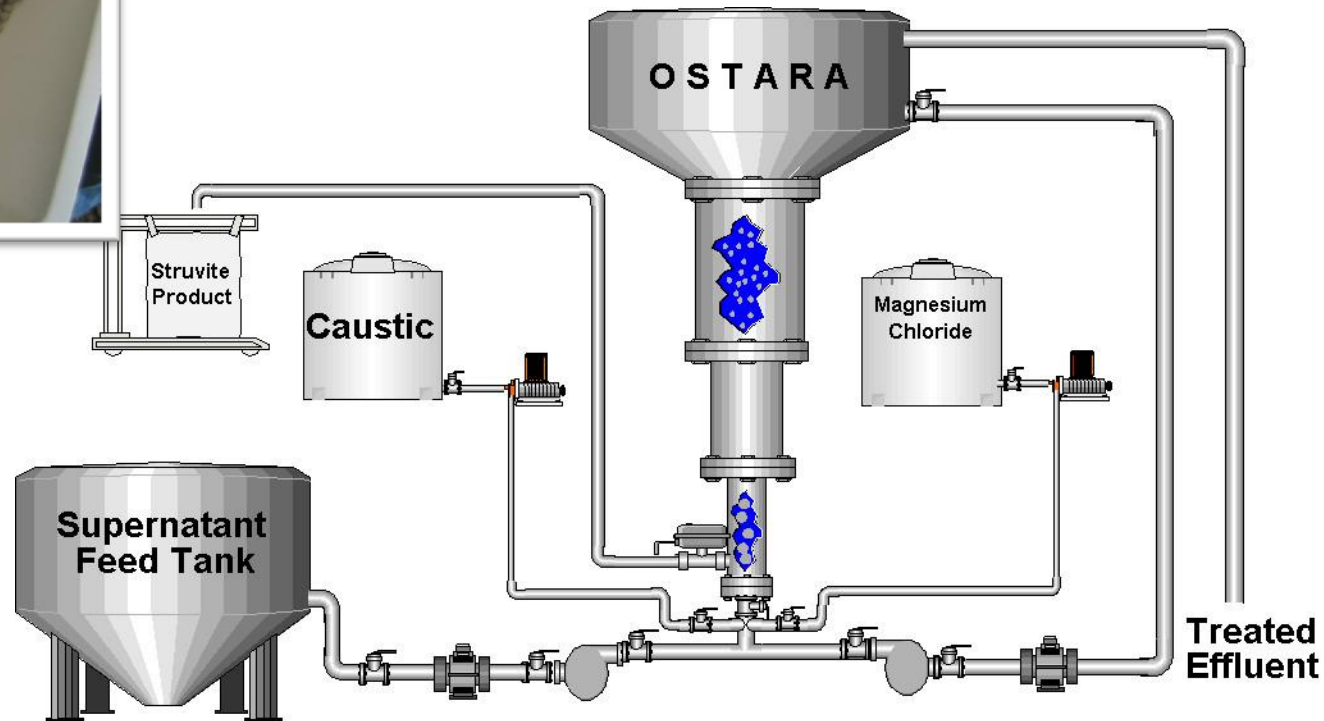
Phosphorus recovery

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Activated sludge process allows recovery of struvite



Struvite



Also recovers
up to 20%
of nitrogen

100% Recovery of Incinerator P Noord-Brabant, Holland



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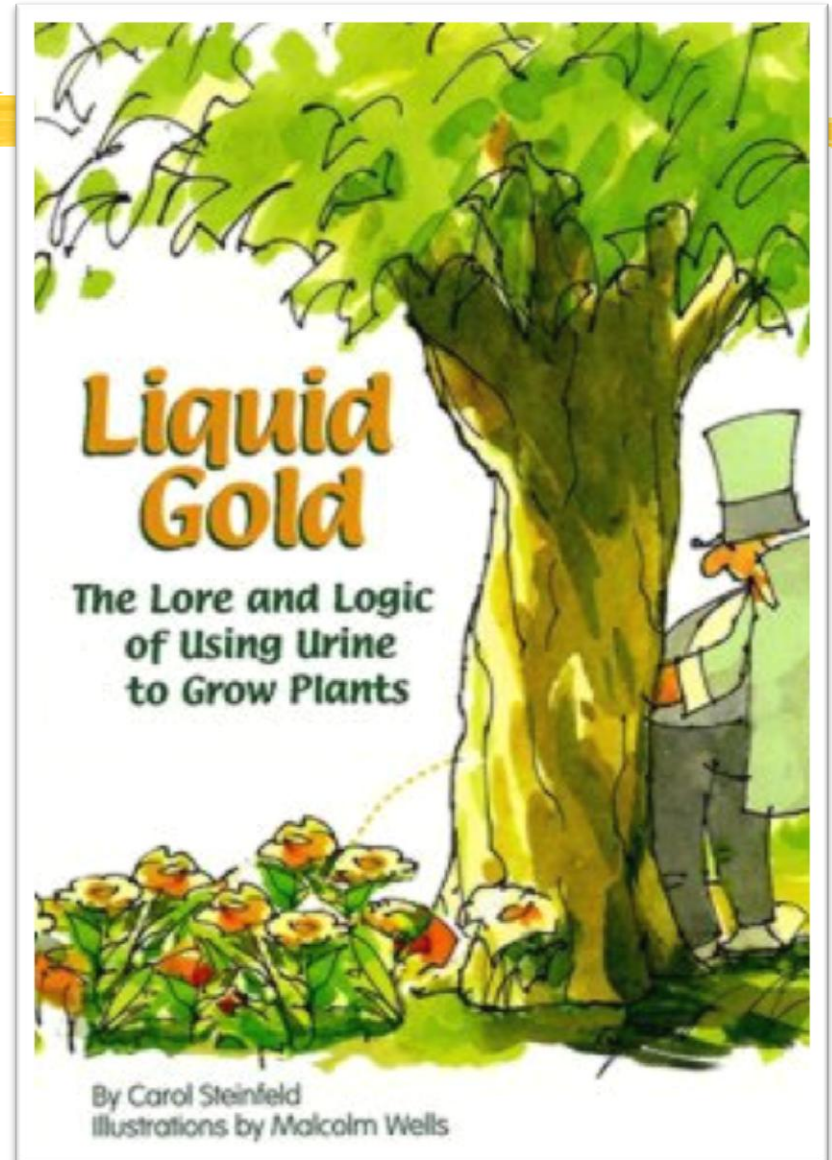


The Ultimate Nutrient Recycle

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Urine recovery

- Urine contains 70% to 80% of the Nitrogen and Phosphorus in domestic wastewater
- When urine is separated and stored ammonia is hydrolyzed and the pH goes up
- Within a few weeks the urine is totally free of pathogens
- Research underway to recover struvite
- Excess ammonia recovered with stripping and production of ammonia sulphate



Backyard garden Kampala Uganda



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Do-it-yourself Fertilizer

urine → fertilizer

DIY KIT



Apartments in Hong Kong



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By Choice or by Need



Working in the garden is also a shared experience for the family, and instills in children an understanding of the natural cycles of growth which provide lessons of lifelong value

Future vegetable gardens?



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FINAL MESSAGES



- **Over a century the activated sludge process has proved to protect receiving water bodies**
- **The activated sludge process keeps evolving with more energy efficiency**
- **Recovery of nitrogen needs to be cost effective**
- **Phosphorus ore is in limited supply and all efforts to recover phosphorus should be made**
- **Granular activated sludge has a future in the scheme of things**
- **Energy efficiency is important but energy self-sufficiency should not be the only goal**

MOTTO OF THE DAY

What doesn't kill you makes you stronger !!!!!!!





Discussions

The First Commandment According to Wendell Berry

*Do unto those downstream as you
would have those upstream do unto you*



And thank you all for coming

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