Brown AND Caldwell

2011 Idaho Reuse Conference

The Future of Rapid Infiltration Land Treatment

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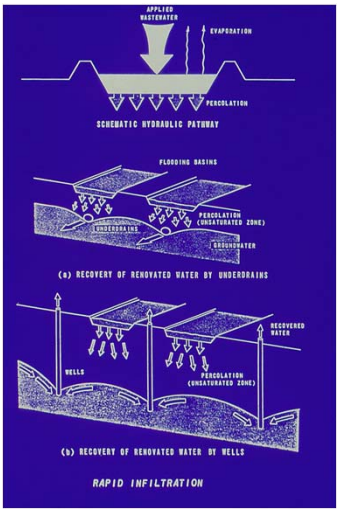
What is Rapid Infiltration?

- Rapid Infiltration (aka Soil Aquifer Treatment) is an in-situ, media based treatment process
- Subset of land treatment, where wastewater is applied to sandy soils principally for treatment in the soil media
- It is a process first, disposal second (if at all)



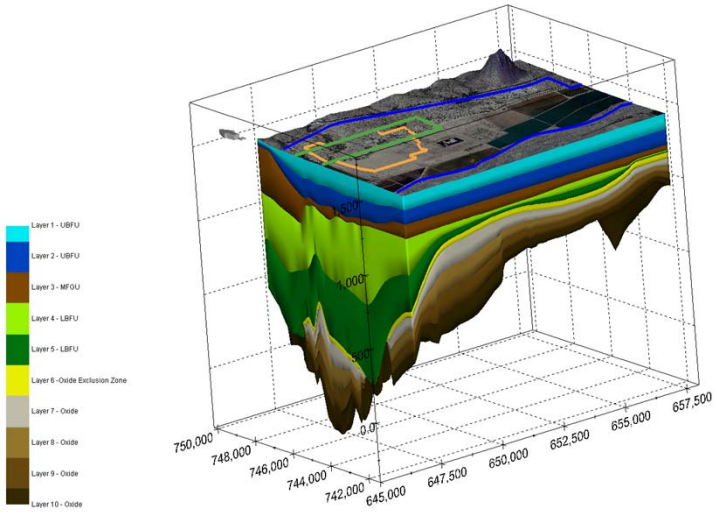
In-Situ Processes Have a Long History of Effectiveness

- Often low capital cost and energy
- Often low tech hardware
- For optimal effectiveness, require detailed understanding of site-specific processes (transport and transformation)

In-Situ Processes Are the Wave of the Future in Many Industries

- Instead of leveling the forest, "in situ" oil sands developments in Canada's Alberta just cut strips in the land (CNN Tech).
  - Subsurface steam injection

Futuristic In-Situ Processes Cont.



Mining copper by in-situ leaching

Media Based Treatment Combines Multiple Treatment Processes

- Film flow
- Multiple concurrent treatment effects (physical, chemical, biological)
- Potentially low energy
  - Microbes anchored rather than suspended
  - Pressurized air not required
- Often low capital cost

It is because slow sand filtration combines within itself so many of these purification functions that it is still the most useful all-round treatment process. Within a single unit it incorporates settlement, straining, filtration, organism removal, organism inactivation, chemical change, and (to some extent) storage.

W.H.O., 1984

History of Rapid Infiltration

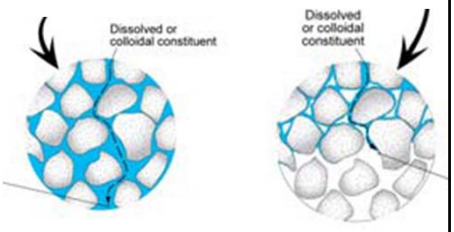
- Over 100 years of practice
- Calumet, Michigan system operating since 1888
- Denitrification of up to 93 percent of nitrogen loaded
- A history of high removal efficiency even with “low tech” design and management

Treatment Mechanisms

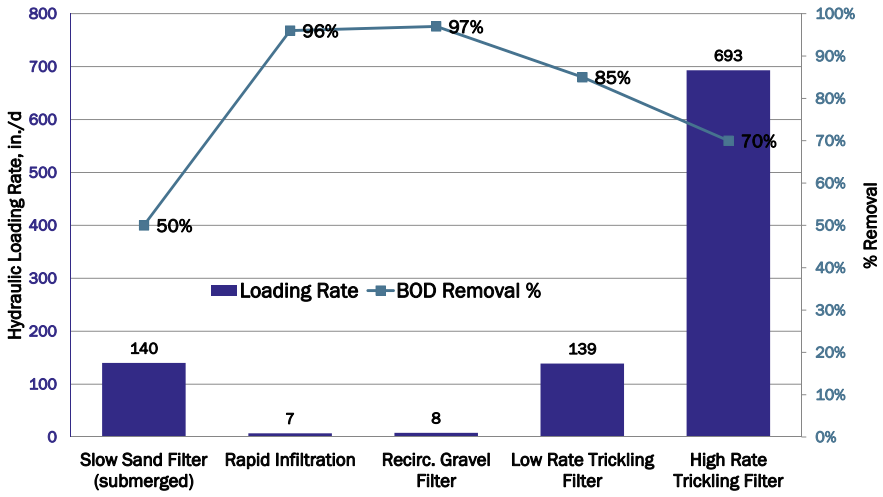
- Biological filter - microbes remove organics and nitrogen
- Surface spreading allows volatilization and photodecomposition
- Physical filter - soil filters out suspended solids, bacteria and turbidity
- Chemical filter - soil adsorbs organics, viruses, metals and phosphates
- Temperature – equalization with ground and aquifer thermal mass
- Soil is a sponge, not just a sieve

Treatment Effectiveness

- Effectiveness of RI depends on:
  - Soil type
  - Loading rate and cycle
  - Distribution system and operation
  - Travel distance
  - Degree of pretreatment
  - Biodegradability of constituent
- Maximize hold-up time (G. Tchobanoglous)
- Lagoon+RI can = MBRs for many constituents
- P removal a function of soil iron & aluminum oxides, water hardness

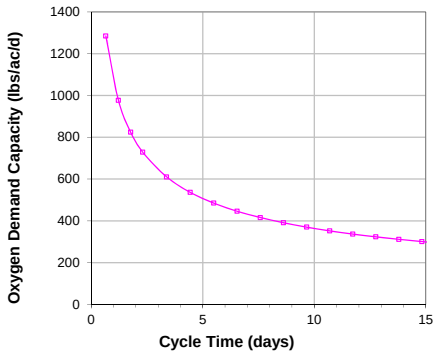


Comparison of RI with Other Media Based Treatment



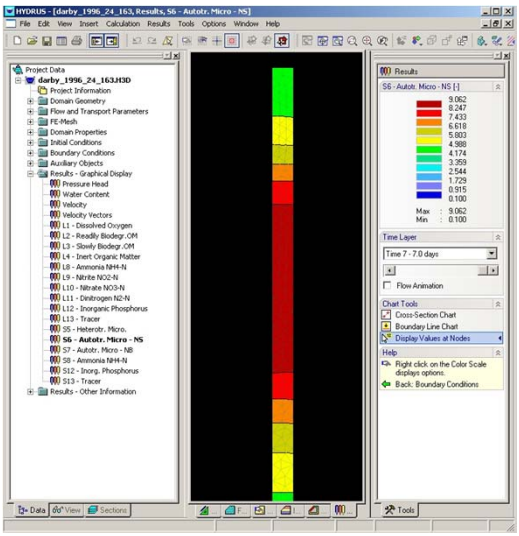
Optimizing RI

- Improving distribution – horizontal and vertical
  - Short duration flood, smaller basins, level basins, low pressure sprinklers, minimize short circuiting
- Managing anoxic conditions for N removal
- Improving oxygen transport
  - Wet/dry cycling
  - Plowing, ripping
  - Drains, air drains
  - Recirculating RI
- Matching design to site



Using Advanced In-Situ Technologies for RI Planning, Design, and Monitoring

- Borrow from remediation
- Use to design new systems
  - Sophisticated modeling – Treatment and plugging
- Vadose zone monitoring
- Isotope tracers



Regulatory Issues

- Designation of Treatment Zone
  - Where treatment ends and beneficial use begins
- Compliance with Idaho Ground Water Rule
  - Well Location Acceptability Analysis
  - Mixing/capture zone analysis
- Setback from surface waters
  - Site-specific evaluation
- Designing for recapture
  - Ex. Fresno, San Bernardino
- Monitoring
  - Soil samples
  - Drains
  - Multiple completion wells

Microconstituents – The Latest Concern

Class of compound	Potential ecological or Class of compound human health effects	Examples
Pharmaceuticals	Endocrine disrupting	Antibiotics, painkillers, caffeine, birth-control pills, antiepileptics
Personal care products	Bioaccumulative, endocrine disrupting	Soaps, fragrances, triclosan
Detergent metabolites	Bioaccumulative, endocrine disrupting	Ocylphenol, nonylphenol
Plasticizers	Weakly endocrine disrupting	Phthalate esters, bisphenol A
Perfluorooctane surfactants	None at environmental relevant concentrations	Stain-resistant coating for clothing and furniture
Brominated flame retardants	Bioaccumulative, suspected endocrine disruptors	Polybrominated diphenyl ethers
Disinfection by-products	Carcinogenic	N-nitrosodimethylamine

Removal of PhPCP at Tucson, AZ

- 99.9% removal of Atenolol
- 90% removal of Caffeine
- 98% removal of Triclosan
- 96+% removal of Ibuprofen
- 90% removal of Naproxen

Indirect Potable Reuse – Newly Proposed Indicator Parameters

Reuse Practice	Health-based Indicator	MRL (ng/L)	Performance-based Indicator	Expected Removal[8]	MRL (ng/L)	Surrogate
Groundwater Recharge	17β-estradiol[1]	1	Δgemfibrozil[5]	>90%	10	Δammonia
SAT	Triclosan[2]	50	ΔDEET[6]	>90%	10	Δnitrate
	Caffeine[3]	50	ΔCaffeine[3]	>90%	50	ΔDOC
	NDMA[4]	2	Δiopromide[5]	>90%	50	ΔUVA
			ΔSucralose[7]	<25%	100	

from: *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water (prepared for California State Water Board, June 2010)*

RI, Recharge, and Extraction

- Whittier Narrows
  - Operational since 1962
  - First secondary effluent, now tertiary, blended with stormwater and imported water
  - Private wells downgradient
- Rapid infiltration/recovery (RIX)
  - San Bernardino (33 mgd secondary)
  - Fresno (68 mgd secondary)
    - 6 log virus removal equivalent

Pilot Work at Chino Basin

Research on Rapid Infiltration

- WERF study on microconstituents removal in the RI/SAT process
- Establishment of distance/time of travel relationships
- Utility of boron and boron isotopes as tracers
- Constituent attenuation during saturated zone transport

Trends Favoring Rapid Infiltration

…the Saudis announced last weekend that they had cut oil production by 800,000 barrels a day… (New York Times, 4/22/2011)

"0.07 mg/L phosphorus? – You've got to be kidding!!" (me, 5/23/2011)

1. Energy is getting more expensive
2. Surface discharge TMDLs are getting more challenging
3. Great technological progress in in-situ treatment understanding
   - Site remediation
   - Mining
4. Water is getting more valuable
   - Recharge aspect is desirable

Summary

- RI is a process first, disposal second (if at all)
- Applying new process understanding, modeling technology, and monitoring technology can turn RI into an attractive treatment process, even in today's increasingly stringent regulatory climate

Questions?

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Thanks to:

Indirect Potable Reuse – Draft California Regulation