Natural Systems for Treatment

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(With the contributions from

SWITCH WP3.2 – WP3.3 – WP5.3 colleagues)

Presented by : Avi Aharoni, Mekorot

SWITCH Scientific Conference

13-16 October 2010, Lodz (Poland)

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Natural Systems for Treatment

- **"Water/wastewater treatment system in which the process of pollutant removal is not aided by the input of significant amounts of energy and/or chemicals"**
- Sustainable, robust and remove multiple contaminants
- Two main categories
  - **Terrestial (Soil/Aquifer-based)**
  - **Aquatic (Vegetation/Pond-based)**
- Employed for treatment of
  - Drinking water, wastewater, storm water, groundwater, surface water

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Focus of the Subject Group in SWITCH Project

- To analyze how robust are these natural systems for treatment of water and wastewater in the cities of the future

  - meeting water quality guidelines, emerging contaminants, water scarcity, climate change, energy crisis

- To determine pre-treatment and post-treatment required for a natural system for particular water use/reuse
- To develop tools for selection of appropriate natural treatment systems under given conditions
- To disseminate the knowledge on the benefits of and for the planning, design and O&M of natural systems for water and wastewater treatment

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Related SWITCH Work Packages

- WP 3.2 – Safe water reuse

  Soil Aquifer Treatment (SAT), Engineered Artificial Reservoir (EAR), Aquifer Storage and Recovery (ASR)

- WP 3.3 – Urban water supply and use – other productive uses

  Constructed Wetland (CW) with Electroflocculation (EF); SAT pre- and post-treatment (from secondary effluent)

- WP 5.3 – Natural systems and the urban water cycle

  Bank filtration (BF), Artificial Recharge and Recovery (ARR), Constructed Wetlands (CW), High-rate stabilization ponds (WSP), Hyporheic zone treatment (HZT), Ecohydrology measures (EH)

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Main Partners Involved in "Natural Systems for Treatment"

1. UNESCO-IHE, The Netherlands
2. Mekorot Water, Israel
3. University of Birmingham, UK
4. TU Berlin, Germany
5. City/University of Lodz, Poland
6. Hebrew University of Jerusalem, Israel
7. Univalle Cali, Colombia
8. KNUST, Ghana

Highlights of Some Main Outputs (Key Scientific Achievements)

Framework for Feasibility Analysis and Performance Assessment of Soil Aquifer Treatment Systems

- Guidelines were developed for estimation of removal of bulk organic matter, nitrogen species, trace organics and microbes for different travel times and travel distances.

Guidelines for estimation of DOC removal from secondary effluents during SAT

Influent DOC (mg/L)	**Travel time (days)**	Removal efficiency (%)			Effluent DOC (mg/L)
		Minimum	Average	Maximum	
2-24	1-10	10	50	70	1.5-16
	10-30	20	60	90	
	30-50	70	80	90	
	>50	>70	>80	>90	

Source: Sharma *et al*. (2008) Water Science and Technology, **57** (6), 941-946.

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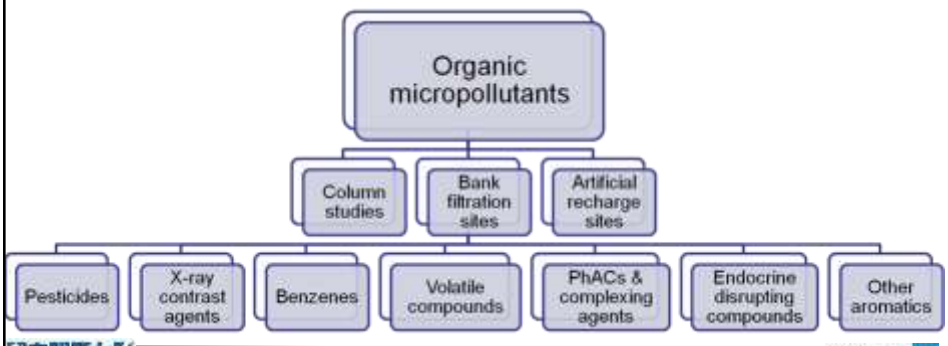
Multiple Objectives Treatment Aspects of Bank Filtration – PhD Study Andrew Maeng

(Public Defense on 29 October 2010)

Prediction Tools for Removal of Organic Micropollutants

- based on travel time, distance, redox conditions & compound properties



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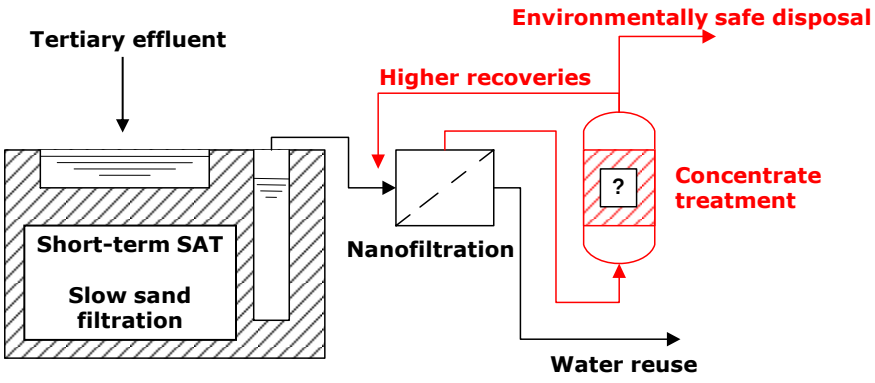
Engineered Environmental Buffer – TU Berlin

- Slow sand filter (short-term SAT) as pre-treatment
- Post-treatment of membrane brines



SAT-NF pilot has also been investigated in WP 3.2.1 at the Demo site Tel-Aviv - TU Berlin supported Mekorot for chemical analysis of trace organic pollutants

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Pre-biofiltration for foulant removal

Secondary effluent from wastewater treatment plant

Ultrafiltration for water reuse

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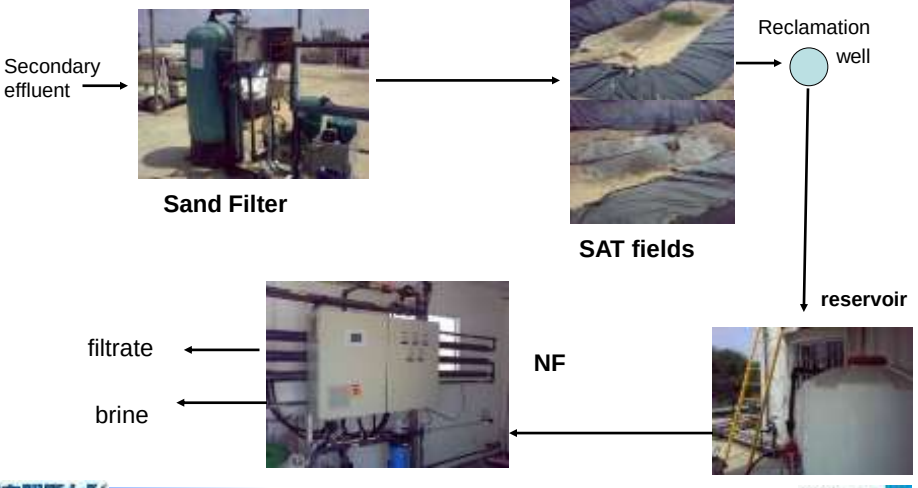
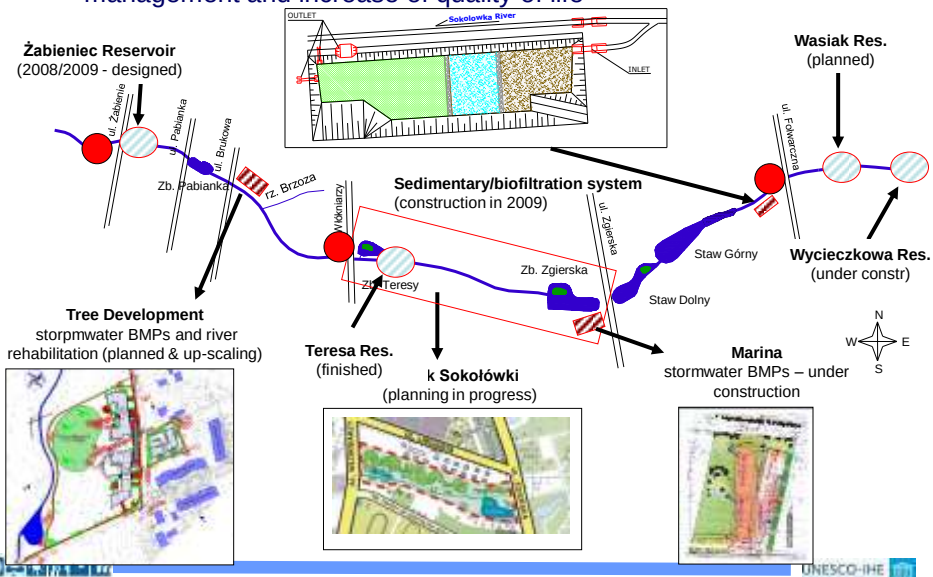
Alternative Hybrid SAT Treatment



Alternative Hybrid SAT Treatment

- **Hybrid SAT system (SAT + NF) has been found be an attractive for water reuse application**
  - Removes majority of organic micropollutants
  - Reduces fouling potential of membranes
  - Increases recharge/treatment capacity as higher filtration rates are feasible.
- **Hybrid SAT system (SAT + NF) can be used to increase the performance of existing SAT systems worldwide and can also be considered as a relatively cheap alternative for UF-RO systems for unrestricted water reuse**

Restoration of a municipal river for stormwater management and increase of quality of life

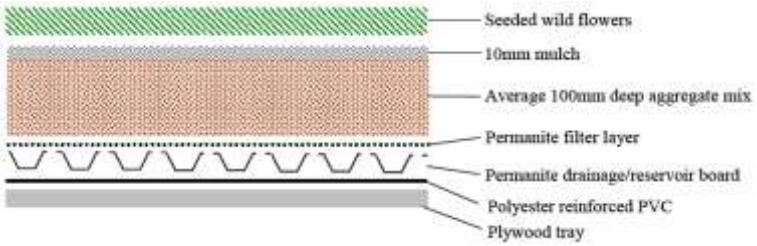


Electroflocculation–Constructed Wetland Hybridization – Hebrew University of Jerusalem, Israel

- **Removal of phosphorus and humics**

Brown Roof research – University of Birmingham, UK

- **designed for biodiversity & examines their propensity for use in sustainable urban water management**
- ecological, hydrological, meteorological and water quality monitoring



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Hyporheic zone – Riverbed natural attenuation processes

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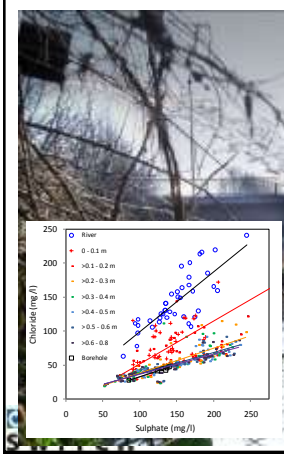
- River Tame SWITCH Hyporheic zone site, Birmingham
- *Rivett, Cuthbert, Mackay, Durand, Aller, Greswell*

- Datasets obtained on the spatial and temporal dynamic behaviour of flow and contaminants
  - Natural (storm event based) flow transients in riverbed exert critical control on attenuation
- Regulatory perspective: HZ buffers impacts, but with heterogeneity → need for engineered
- Findings supported by two other river sites in/near Birmingham
- Publish: Environment Agency reporting & journal papers in press / in revision / in prep



Are Viruses a Hazard in Waste Water Recharge of Urban Sandstone Aquifers?

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University of Birmingham Campus Borehole Research Site

Riley, Tellam, Durand, Aller, Greswell

- Bacteriophages PRD1 (surrogates for human pathogens) suffered insignificant attenuation.
- Viruses showed less dispersion than a non-reactive tracer – so very high peak concentrations. Viruses were only slightly retarded.
- **Yes, they can migrate with little attenuation.**
- Key publications: **Greswell et al. (submitted)** Simultaneous convergent tracer tests in a multilayered sandstone aquifer. ***Ground Water*.** **Riley et al. (submitted)** Convergent tracer tests in multilayered aquifers: the importance of vertical flow. ***Water Resources Research*.**
- **Practitioner** publications – in consultation with Learning Alliance (October 2010 meeting) - Environment Agency is key stakeholder

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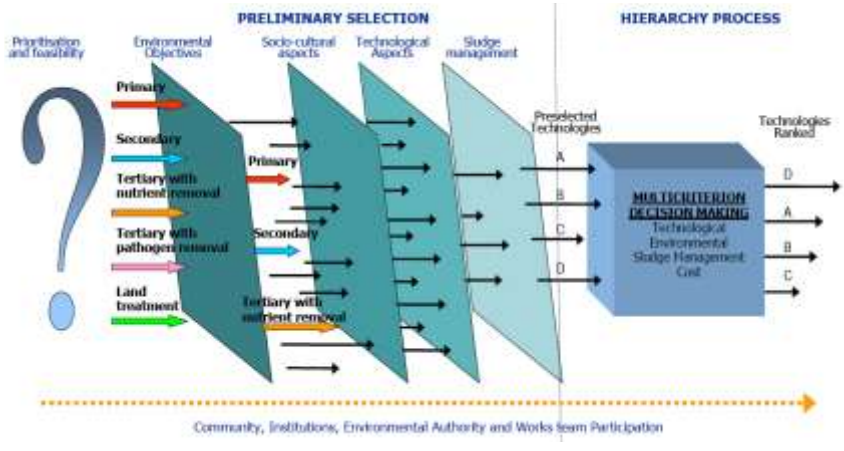
Development of Design Guidelines & Decision Support Systems for Application

♦ **PhD Alberto Galvis – Technology selection model**



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Ongoing PhD Studies on Vegetation-based Natural Treatment Systems

- **PhD Juan Pablo Silva (Colombia): Greenhouse gas emissions from natural treatment systems**
  - Equipment was developed for easy and reliable measurement of GHG
  - First data have been collected from stabilization ponds and constructed wetlands
- **PhD Mohamed Babu (Uganda): High-rate algal ponds (effect of attached growth in ponds)**
  - Experiments completed, thesis being finalised
  - Biofilm stabilization ponds have higher N removal efficiency and require 50% less of the land area than conventional ponds

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Deliverables/Information Dissemination

- **Literature reviews**
- **Papers in Journals and Conference Proceedings**
- **Guidelines and Prediction/Selection Tools**

Training

•SAT workshop in Tel Aviv(11.2007)
• SAT workshop in Accra (2.2009)
•Workshop NTS in Cali (9.2009)
• SAT training in the context of sludge treatment workshop in Accra (6.2010)
•Development of online courses/SWITCH Modules

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Natural Systems for Treatment – Summary of Outputs/Publications

Partner	WP	MSc thesis	PhD thesis	Conference Paper	Journal Paper (peer reviewed)	Others
UNESCO-IHE	3.2	4		3	2	
Birmingham	3.2	5		1	2	1
MEKOROT	3.2			2	2 (in prep.)	1
TU Berlin	3.2	5	2 (in prog.)	5	6	
HUJ, Israel	3.3	4	1 comp. 2 (in prog.)	3	4	1
UNESCO-IHE	5.3	7	4 (in prog.)	8	4 published 3 (in prep.)	
Birmingham	5.3	5			3 (in prep.)	1
LODZ	5.3	12	2	9	10	1
TOTAL		**42**	**11**	**31**	**36**	**5**

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Key Outputs of Subject Group Natural Systems

- Prediction Tool of removal of organic micropollutants during bank filtration (SOMA)
- Guidelines for selection of natural WWT systems
- Guidelines for design, operation and maintenance of SAT and hybrid SAT systems
- Manual for design, operation and maintenance of CW-EF hybrid system
- Framework for ecohydrological (stimulation of self-purification) approach in cities (BOOK)

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Presentations in Subject Group Meeting (Session 6)

1. **Avi Aharoni (Mekorot Water, Israel):** Alternative Hybrid SAT Treatments to Upgrade Effluent Quality
2. **Wojciech Fratczak (Lodz, Poland):** Application of Ecohydrology principles for Multi Chamber Sedimentation Biofiltration System (MCSB) in restoration of a municipal
3. **Juan Pablo Silva V. (Colombia):** Fluxes of Carbon Dioxide, Methane and Nitrous Oxide from two pilot-scale Waste Stabilization Ponds
4. **Avner Adin (Israel):** Biofouling Control in Water UF Systems by Pre-treatment with Silver Nanoparticles
5. **Alberto Galvis (Colombia)** - Poster Presentations
   1) Minimization and pollution prevention as a control strategy of contamination due to domestic wastewater in the expansion area of Cali
   2) Developing an early warning prototype to mitigate the pollution effects of the Cauca river in the operation of the water system treatment in Cali

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Acknowledgements

- **EU SWITCH Project no 018530-2 under the Sixth Framework Programme**

- **For further information please visit:**
  www.switchurbanwater.eu
  www.unesco-ihe.org
- **THANK YOU FOR YOUR ATTENTION!**

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