Development of Treatment Media for Advanced Stormwater Treatment at an Industrial Site

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Santa Susana Field Laboratory Site

- 2800-acre (1150 ha) former federal government rocket engine testing and energy research facility (1950-1988)
- Owned by the Boeing Company (post-1966) and the U.S. Government
- Activities currently limited to demolition, remediation, and restoration
- Future parkland and open space

Astronaut Buzz Aldrin at SSFL
(Ref: Rocketdyne Archives)

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Introduction

- The site stormwater discharges are permitted by the Los Angeles Regional Water Quality Control Board through an individual industrial NPDES permit that includes Numeric Effluent Limits for a wide range of constituents, including dioxins and metals.
- A large portion of the site uses distributed source stormwater controls with natural treatment systems utilizing chemically active media.
- As part of this approach, extensive research was conducted to develop a robust media for use in these controls to meet the discharge objectives.

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Stormwater Control Performance Optimization

- With numeric effluent limits, site requires designs refined to a much higher degree than in typical practice
- Need to optimize stormwater control performance through various design factors:
  - Treatment trains using combinations of sedimentation and media filtration
  - Long sedimentation pre-treatment drainage time
  - Sufficient media contact time to increase control of critical constituents
  - Specially-selected filtration media
- Bench-scale laboratory and pilot-scale media testing was therefore conducted to provide needed performance and design information.

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Evaluation of Media for Soil Amending and Biofiltration

- Different media can be used to target different categories of contaminants
- Fine particulate removal is the most critical as most stormwater toxicants are associated with the solids
- However, significant portions can be associated with the filterable phases and media mixtures can be optimized

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Tests on media filtration

- Batch kinetic tests to estimate expected capacity and uptake rate
- Full-depth, long-term column tests to measure removal and maintenance
- Vary-depth column tests to measure effects of contact time on removal
- Aerobic and anaerobic exposure tests to examine interevent leaching of previously captured materials

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Media Tested

Media	Description
Granular Activated Carbon (GAC)	VCC 8X30 Virgin Coconut Shell Activated Carbon (Baker Corp.); 29 lbs/ft^3 (1.8 to 2.1 g/cm^3); $0.98/lb
Rhyolite Sand	D1 biofilter media sand (Rhyolite Topdressing Sand) from Golf Sand, Inc., North Las Vegas, NV;75 in/hr infiltration rate; particle density 2.38 g/cm^3; bulk density 1.28 g/cm^3; 98.6% sand, 1.1% silt, 0.3% clay; 45.4% greater than 0.25 mm; 44.6% between 0.18 and 0.25 mm.
Site Zeolite	Z-200 Modified Zeolite (Baker Corp.); $1.36/lb
Surface Modified Zeolite	14-40 Saint Cloud Zeolite with 325 µm Modified Zeolite at 3% Vol:Vol
Sphagnum Peat Moss	Purchased from nursery in Elizabethtown, PA
Site Sand	Fine textured silica sand

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Constituents Evaluated during Laboratory Media Tests

- Critical site constituents (possible periodic permit exceedences if untreated): cadmium, copper, lead, zinc, oil and grease, mercury, and TCDD (2,3,7,8-Tetrachlorodibenzo-p-Dioxin).
- Other constituents listed on permit (rarely, if ever, expected to exceed permit limits if untreated): pH, TDS, sulfate, chloride, nitrates plus nitrites, fluoride, ammonia, nickel, antimony, boron, thallium, perchlorate, tritium, uranium, gross alpha, gross beta, radium, and strontium-90.

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Constituents Evaluated during Laboratory Media Tests (Cont.)

- Other constituents that affect performance of media in removal of contaminants: flow rate, suspended solids, suspended sediment, particle size distribution, turbidity, sodium, calcium, magnesium, potassium, conductivity, oxidation-reduction potential, filtered aluminum, and filtered iron.
- Other constituents that help in understanding removal mechanisms of media: COD, UV-254, phosphate, nitrate, *E. coli* bacteria, alkalinity, hardness, and other filtered metals (Cd, Cr, Cu, Pb, Zn).

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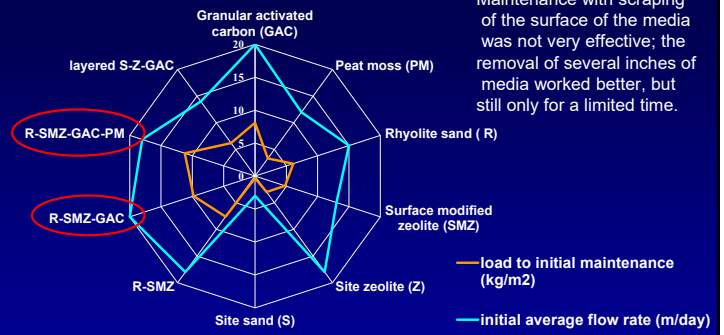
Column test results: Hydraulics and Clogging



Maintenance with scraping of the surface of the media was not very effective; the removal of several inches of media worked better, but still only for a limited time.

1. Site sand clogged first and had the lowest flow rate
2. Site zeolite and peat alone were next to clog
3. Biofiltration mixed media combination performed better than current site layered media combination

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Rhyolite Sand - Surface Modified Zeolite - Granular Activated Carbon (R-SMZ-GAC) Removals by Particle Size Range

Particle Size (µm)	Mean Influent Concentration (mg/L) (approximate range)	Mean Effluent Concentration (mg/L)	Reduction (%)
< 0.45	199 (80 to 250)	225	0
0.45 to 3	9.9 (3 to 22)	7.2	0
3 to 12	54.9 (22 to 90)	2.9	95
12 to 30	54.5 (18 to 90)	0.67	99
30 to 60	37.4 (3 to 80)	1.0	97
60 to 120	20.0 (2 to 58)	0.76	96
120 to 250	5.1 (0 to 17)	0.08	98
>250	13.9 (3 to 45)	4.1	71
SSC	206 (50 to 400)	13.6	93
TSS (0.45 to 75 µm)	171 (50 to 310)	10.2	94

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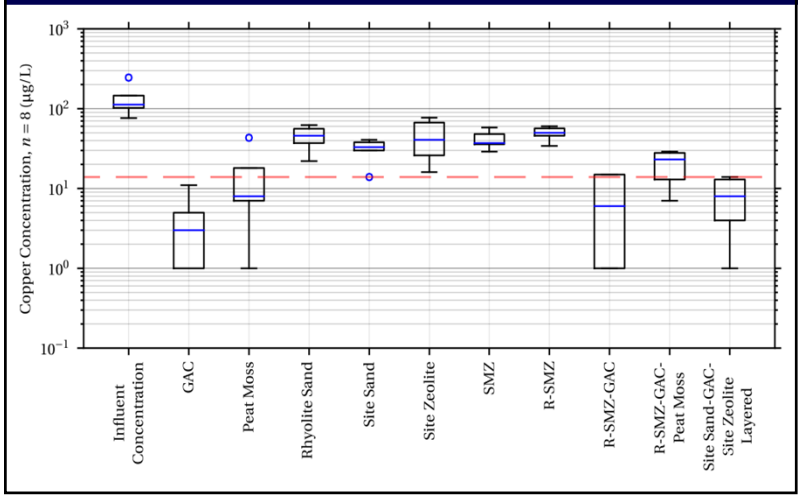
Media Performance Plots for Copper, Full-Depth Long-Term Column Tests



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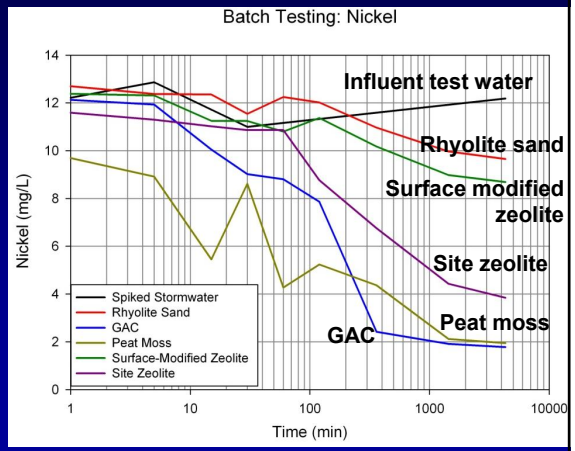
Contact Time for Filtered Metals

- Minimal filtered metal removal when contact time <10 minutes (except peat).
- Optimal contact times removal ranged from 10 to 1,000 minutes, depending on metal and media type.



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Breakthrough Capacity Compared to Clogging Period

Ratios of Media Capacity to Clogging Period	R-SMZ	R-SMZ-GAC	R-SMZ-GAC-PM	Site Sand-GAC-Site Zeolite Layered
Cadmium, Total	>230	>170	>130	>150
Copper, Total	>2.2	>3.4	>1.7	>2.2
Gross Alpha radioactivity	>0.3	>0.3	>0.2	>0.2
Lead, Total	>2.1	>1.6	>0.9	>0.9
Mercury	>250	>230	>130	>140
Oil and Grease	0.1	>0.1	>0.1	<0.1
TCDD	>3.1	>2.5	>1.3	>1.5

Green: will clog before breakthrough
Red: breakthrough before clogging

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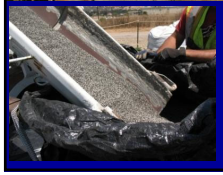
Preparing Recommended Media for Large Biofilters

1. Filling individual media bags prior to mixing

2. Loading Rhyolite sand media bags into mixer

3. Loading surface modified zeolite media bags into mixer

4. Loading granular activated carbon media bags into mixer



5. Finished mixed media loaded into final bags

6. Mixed media ready for placement into biofilters

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- Most devices fail because of clogging.
  - Design for clogging first (assume with vegetation, solids loading for most media mixes approximately 25 kg/m^2).
  - Maintenance has limited effectiveness. Vegetation likely will extend lifespan because of biological disturbance of soil helping deeper penetration of solids and pollutants.

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- Evaluation of potential chemical removal.
  - Physical removal primary mechanism, even in media with "good" sorption/ion-exchange potential.
  - Removal based on influent quality (including "speciation" or "association" of pollutants with particulates of all sizes).
  - Evaluate media choices (either individually or as part of a mix) based on both adequate removal of pollutants and ensuring that the exchanged ions are not causing degradation.
    - CEC, AEC, OM, P-content, SAR, soil pH predict, but may not be able to quantify, removal efficiency or effluent quality. Also not precise measurements of lifespan.
    - Increasing OM and P content has an unquantified maximum effect. Above a certain amount, the media releases nutrients, color compounds, and colloids that may have associated pollutants.

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Acknowledgements

- The Boeing Co., supported the bench-scale and full-scale studies and Geosyntec provided site support and project management.
- The EPA, Urban Watershed Management Branch, provided support for data analyses and modeling through our wet weather flow emerging contaminant research.
- Many students and staff at the University of Alabama and Penn State – Harrisburg assisted with the sampling and analyses.

- http://www.boeing.com/aboutus/environment/santa_susana/water_quality/tech_reports/techreports_10-10-19_FinalMediaReport051010.pdf
- Megan Otto will present full-scale monitoring performance results later in the conference.
- There is a SSFL site visit scheduled for Thursday.

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