GROUNDWATER AND SEDIMENT ANALYSES OF A MANGROVE SWAMP NEAR BOVONI LANDFILL, ST THOMAS, USVI

Jess Keller
Mangroves and Ecosystem Services

- Mangroves buffer the interaction between terrestrial and oceanic environments
  - trapping terrestrial pollutants (Tam and Wong 1999; Clark et al. 1998; Harbison 1986).
• Largest intact stand of mangroves on St. Thomas is between Bovoni Landfill and Mangrove Lagoon, a protected marine reserve.

• Pait et al. (2014) found heavy metal concentrations (Cr, Cu, Pb, Hg and Zn) in Mangrove Lagoon sediments
  – Bovoni Landfill possible source?
Mangroves in St Thomas

- No published papers on the mangroves themselves

- Little known about impacts from the landfill

- The EPA observed violations of waste management at Bovoni Landfill:
  - improper disposal of medical and septic waste, used oil, lead-acid batteries, and migration of leachate into the adjacent mangroves (Complaint at 16, USA v. The Government of the Virgin Islands et al. 2006)).
Mangroves in St Thomas

• The Nature Conservancy (TNC) expressed concern about the health of these mangroves (Anne-Marie Hoffman, pers. comm.).

• Natural or man-made causes? What influences mangrove health?
Seasonal Variation in Standing Water

Photos A, C, and D were taken by JAK, photo B was taken by KW

• Standing water levels in the mangroves varies throughout the year.
  – No strict wet and dry season in the Virgin Islands, it is generally drier from December to July (Crossmand and Palada 2003).

• How does this variability affect the mangrove swamp?
Research Questions

• Does groundwater flow from the landfill toward Mangrove Lagoon?

• Does groundwater flow change throughout the year?

• Are heavy metals found in groundwater and sediments?

• What are implications for management decisions?
Methods – An Integrated Approach

- Groundwater wells
  - Vertical and horizontal flow, influences on groundwater levels
  - Groundwater chemistry

- Sediment cores
  - Stratigraphy, dry bulk density, percent water content, percent organic content, shear strength
  - Heavy metal presence in sediment particles
• Rainfall more influential in the upland area.
• Tides more influential near the lagoon
• Daily tidal signal after rise in mean sea-level and two large rain events
Groundwater Contour Maps

- Groundwater flow direction changed seasonally
- During the dry season, groundwater flows into the mangroves
- During the wet season, groundwater flows into the lagoon
## Heavy Metals in Groundwater

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>TDN (mg/L)</th>
<th>Cr (µg/L)</th>
<th>Ni (µg/L)</th>
<th>Sn (µg/L)</th>
<th>Zn (µg/L)</th>
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<tbody>
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<tr>
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<td>99</td>
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</table>

- **Surface and shallow groundwater is a more important conduit**
- **Only one round of water chemistry tests was performed and not all sites were tested.**
Sediment Cores

- Environmental interpretations (mangrove peat and mud flat or pool) were based on stratigraphy.
- Dry bulk density (g/cm³), percent water content, percent organic content, and shear strength (kPa) were compared between these interpretations.
Heavy Metals Found in Sediment Particles

- At least two samples from each site were tested (more from sites 4 and 5)
- Titanium and Bismuth were found in samples from site 4
- Titanium, Bismuth, Iron, Tin, and Zinc were found in samples from site 5.
- Stratigraphy from sediment cores help explain the distribution of metals in the area

<table>
<thead>
<tr>
<th>Site</th>
<th>Depth</th>
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<tr>
<td>5</td>
<td>19</td>
<td>13</td>
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</table>
Clay rich sediments closer to the landfill are likely slowing groundwater flow and trapping particles containing heavy metals.
Conclusions

• Groundwater flow direction changed based on precipitation and sea-level

• Chemical constituents from terrestrial sources would be transported into the Mangrove Lagoon during the wet season

• Groundwater was more responsive to precipitation than tides near the landfill, vice versa
Changes in the hydrologic regime or increased sediment input could be causing patches of dead mangroves
Conclusions

• Diurnal tide signals were only present when groundwater levels were above a certain point (~45 cm)
  – presence of some sort of barrier?

• Metals are entering the mangroves via physical transport in the sediment and via chemical transport in the surface water and groundwater

• The mangroves swamp is trapping heavy metals, protecting the lagoon from terrestrial-based pollutants

• This system should be preserved and protected, but may be in jeopardize
Thanks to…

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