Dual Media Filtration System for Reducing Pollutants in Storm Water Runoff

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# Dual Media Filtration System for Reducing Pollutants in Storm Water Runoff

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<thead>
<tr>
<th>a. REPORT</th>
<th>b. ABSTRACT</th>
<th>c. THIS PAGE</th>
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</thead>
<tbody>
<tr>
<td>unclassified</td>
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</tbody>
</table>

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Outline

• Background

• Dual Media Treatment Technology Demonstration

• Technology Transition
Background

• The Navy is required to self-monitor their storm water discharges, identify and install best management practices (BMPs) appropriate to their facilities.

• The EPA is establishing guidelines for total maximum daily loadings (TMDL) for impaired water bodies. This will result in stricter discharge limits being placed on Navy storm water discharges.

• Navy industrial activities and other DoD components will be forced to implement storm water treatment systems in order to comply with stricter permit requirements.
Background

Navy industrial sites have limited real estate and limited resources.
The ideal storm water treatment system concept should:

1. Have a low capital cost
2. Be easy to install
3. Require little land area
4. Be inexpensive to maintain
5. Enable sites to comply with permit requirements
Project Approach

- Identify Navy industrial site storm water runoff permit requirements.
- Analyze storm water runoff characteristics.
- Evaluate commercially available structural BMP treatment technologies.
- Demonstrate new storm water treatment technology to address Navy industrial site specific requirements.
- Transition technology.
The Naval Regional Recycling Center (NRRC) was selected because they must comply with an order from the California Regional Water Quality Control Board (CRWQCB) that requires them to:

1. pass a 96-hour acute toxicity test,
2. reduce copper discharges to less than 63 ppb, and
3. reduce zinc discharges to less than 117 ppb.

In the past, NRRC discharges significantly exceeded the metals discharge limits and failed the toxicity tests.
Location of Test Site

Naval Regional Recycling Center (NRRC) San Diego

Location of demonstration
Storm drain system
Previous Method of Handling Storm Water Runoff at NRRC
Characterize Storm Water Runoff

Simulated Rain Event at NRCC
Storm Water Runoff from Simulated Rainfall Event

<table>
<thead>
<tr>
<th>Metals</th>
<th>Runoff Level (µg/L)</th>
<th>Hydrant Level (µg/L)</th>
<th>Permit Limit (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>138</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>18</td>
<td>ND</td>
<td>168</td>
</tr>
<tr>
<td>Beryllium</td>
<td>ND</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>136</td>
<td>ND</td>
<td>15.9</td>
</tr>
<tr>
<td>Chromium</td>
<td>102</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>3,350</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Lead</td>
<td>1,200</td>
<td>5</td>
<td>82</td>
</tr>
<tr>
<td>Mercury</td>
<td>ND</td>
<td>ND</td>
<td>2.4</td>
</tr>
<tr>
<td>Nickel</td>
<td>245</td>
<td>ND</td>
<td>1417</td>
</tr>
<tr>
<td>Selenium</td>
<td>14</td>
<td>6</td>
<td>238</td>
</tr>
<tr>
<td>Silver</td>
<td>4</td>
<td>ND</td>
<td>32</td>
</tr>
<tr>
<td>Thallium</td>
<td>ND</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>6,860</td>
<td>169</td>
<td>117</td>
</tr>
<tr>
<td>Aluminum</td>
<td>19,900</td>
<td>9</td>
<td>750</td>
</tr>
</tbody>
</table>
• Compliance with the CRWQCB order will require a significant investment by the Navy.

• Commercial off the shelf (COTS) technologies are expensive. (> $57K per acre of drainage area)

• COTS technologies have not reliably passed toxicity test.
Evaluate Available Structural Best Management Practices

Large scale StormWater Management, Inc. Installation

This 165 cartridge SMI installation at NASSCO costs $530K
NFESC developed and tested a storm water runoff treatment system that meets the stated Navy industrial site requirements. The system is similar to a sand filter. However, instead of using sand as the filter medium, heavy metals from storm water are removed by flowing the runoff through a bed of special filter-adsorption materials.
Storm Water Treatment System
Overview

Pollutants in storm water will be removed through an innovative three staged filter process.

- Screen out trash
- Filter out particles
- Adsorb heavy metals
## Adsorption Media Tested

<table>
<thead>
<tr>
<th>Organic Materials</th>
<th>Active Minerals</th>
<th>Inert Minerals</th>
<th>Proprietary Materials</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose peat moss</td>
<td>A-400 activated alumina</td>
<td>Perlite</td>
<td>Forager sponge cubes</td>
<td>Iron chips and filings</td>
</tr>
<tr>
<td>Hardwood chips</td>
<td>FS-50 activated alumina</td>
<td>Washed plaster’s sand</td>
<td>Dynaphore granules</td>
<td>Sodium alginate beads</td>
</tr>
<tr>
<td>Bone char</td>
<td>DD-2 activated alumina</td>
<td>Washed concrete sand</td>
<td>Ancor M-20/80 zero valence iron</td>
<td>geotextile</td>
</tr>
<tr>
<td>Anthracite</td>
<td>Chabasite</td>
<td>Washed well-packing gravel</td>
<td>Stormwater Management Metal Rx</td>
<td></td>
</tr>
<tr>
<td>Sulphonated peat moss</td>
<td>Manganese green sand</td>
<td></td>
<td>Environmental H20, LLC White Karbon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ilmanite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glauconite</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Treatment Media Test Stands

Test Column Setup

Dual Chamber Test Device

Tanks hold runoff water from NRRC; cylinders contain filter/adsorption media
Media Selection

The performing media selected are: activated alumina with surface coating of iron oxide and bone char. Both are readily available and inexpensive.

- **Bone char** is used to adsorb heavy metals, fluorides, and iron.
- **Activated alumina** is commonly used to remove arsenic and fluoride.
1/20th Scale Model Test Setup

Scale model installed at NRRC
# 1/20th Scale Model Treatment Test Results

<table>
<thead>
<tr>
<th>Metal</th>
<th>Influent, mg/L</th>
<th>Effluent, mg/L</th>
<th>Permit Limit, mg/L</th>
<th>Detection Limit, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>.330 - .860</td>
<td>ND - 0.100</td>
<td>.750</td>
<td>0.04</td>
</tr>
<tr>
<td>Cadmium</td>
<td>ND - .012</td>
<td>ND</td>
<td>.0159</td>
<td>.008</td>
</tr>
<tr>
<td>Chromium</td>
<td>ND - .018</td>
<td>ND</td>
<td>.020</td>
<td>.008</td>
</tr>
<tr>
<td>Copper</td>
<td>1.90 – 4.70</td>
<td>ND – 0.021</td>
<td>.064</td>
<td>.006</td>
</tr>
<tr>
<td>Iron</td>
<td>3.00 – 8.20</td>
<td>ND – 0.170</td>
<td>1.0</td>
<td>.008</td>
</tr>
<tr>
<td>Lead</td>
<td>0.150 - .360</td>
<td>ND</td>
<td>.082</td>
<td>.014</td>
</tr>
<tr>
<td>Zinc</td>
<td>.680 – 1.70</td>
<td>ND – 0.041</td>
<td>.117</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Test Method EPA 200.7

Below practical detection limit - ND
Basic Design Overview

Collection piping
Fiber-glass grating
Paved apron
Pre-cast concrete vault
Gravity flow to storm drain
Porous pavement curb acts as coarse filter
Parking lot serves as temporary pond

Pre-cast concrete vault
Fiber-glass grating
Paved apron
Parking lot serves as temporary pond
Gravity flow to storm drain

Sand  Bone char  Activated alumina
Cell Water Level Control

- Float
- Water
- Sand
- Bone char
- Activated alumina

Control rod in protective casing

Direct lift gate valve

Mechanical Level Control Valve
Containment Cell Installation
Drain Manifold Installation
Backfilling and Pouring Concrete
Sampler and Instrumentation Shed

• Samples are taken from influent and effluent.
• Takes first flush and composite samples.
Completed System

• Installation completed 4/22/2005.
## Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Total Rainfall (inches)</th>
<th>First Flush Intensity (in/hr)</th>
<th>Survival 100% Concentration (%)</th>
<th>First Flush Influent/Effluent Cu (µg/L)</th>
<th>Cu % Removal</th>
<th>First Flush Influent/Effluent Zn (µg/L)</th>
<th>Zn % Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/28/06</td>
<td>0.35</td>
<td>0.17</td>
<td>95</td>
<td>1170/339</td>
<td>71</td>
<td>1480/343</td>
<td>77</td>
</tr>
<tr>
<td>4/14/06</td>
<td>0.16</td>
<td>0.07</td>
<td>85</td>
<td>550/201</td>
<td>63</td>
<td>981/711</td>
<td>28</td>
</tr>
<tr>
<td>4/23/06</td>
<td>0.11</td>
<td>0.08</td>
<td>60 (^3)</td>
<td>351/228</td>
<td>35</td>
<td>1270/913</td>
<td>28</td>
</tr>
<tr>
<td>5/22/06</td>
<td>0.60</td>
<td>0.4</td>
<td>90</td>
<td>987/397</td>
<td>60</td>
<td>2620/1140</td>
<td>57</td>
</tr>
<tr>
<td>10/16/06</td>
<td>0.40</td>
<td>0.06</td>
<td>45 (^4)</td>
<td>1070/401</td>
<td>63</td>
<td>4810/1330</td>
<td>72</td>
</tr>
<tr>
<td>1/29/07</td>
<td>0.85</td>
<td>0.11</td>
<td>85</td>
<td>488/85</td>
<td>83</td>
<td>1960/277</td>
<td>86</td>
</tr>
<tr>
<td>2/18/07</td>
<td>0.9</td>
<td>0.06</td>
<td>100</td>
<td>307/63</td>
<td>79</td>
<td>1170/180</td>
<td>85</td>
</tr>
<tr>
<td>2/22/07</td>
<td>0.2</td>
<td>0.19</td>
<td>100</td>
<td>143/29</td>
<td>80</td>
<td>572/102</td>
<td>82</td>
</tr>
<tr>
<td>2/27/07</td>
<td>0.24</td>
<td>0.07</td>
<td>97</td>
<td>356/34</td>
<td>91</td>
<td>1870/167</td>
<td>91</td>
</tr>
<tr>
<td>3/22/07</td>
<td>0.06</td>
<td>0.25</td>
<td>100</td>
<td>335/81</td>
<td>76</td>
<td>928/222</td>
<td>76</td>
</tr>
<tr>
<td>4/20/07</td>
<td>0.53</td>
<td>0.18</td>
<td>100</td>
<td>342/88</td>
<td>74</td>
<td>1260/251</td>
<td>80</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Al</th>
<th>Cd</th>
<th>Cu</th>
<th>Fe</th>
<th>Pb</th>
<th>Ni</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/18/2007</td>
<td>893</td>
<td>10</td>
<td>150</td>
<td>1229</td>
<td>43</td>
<td>11</td>
<td>561</td>
</tr>
<tr>
<td>2/22/2007</td>
<td>651</td>
<td>7</td>
<td>116</td>
<td>826</td>
<td>28</td>
<td>9</td>
<td>515</td>
</tr>
<tr>
<td>2/27/2007</td>
<td>952</td>
<td>13</td>
<td>181</td>
<td>1242</td>
<td>51</td>
<td>14</td>
<td>865</td>
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<tr>
<td>3/22/2007</td>
<td>3180</td>
<td>11</td>
<td>335</td>
<td>5350</td>
<td>66</td>
<td>29</td>
<td>928</td>
</tr>
<tr>
<td>4/20/2007</td>
<td>739</td>
<td>7</td>
<td>210</td>
<td>1084</td>
<td>38</td>
<td>15</td>
<td>738</td>
</tr>
<tr>
<td><strong>Last 5 Storm Events Efficiency Ratio</strong></td>
<td>1283</td>
<td>10</td>
<td>198</td>
<td>1946</td>
<td>45</td>
<td>16</td>
<td>721</td>
</tr>
</tbody>
</table>

1. ER in parenthesis.
Other Applications
Other Applications
Potential Sites

• Industrial areas
  – Recycling Centers
  – DRMOs
  – Drydocks & Boatyards
  – Maintenance Facilities
  – Storage yards
  – Facilities with copper gutters, galvanized roofs & fences.
1. Enable sites to comply with permit requirements.

2. Treatment system has a low capital cost. ($20,000 per acre of watershed)

3. Virtually no operational/maintenance costs.

4. Requires little land area.

5. Installation similar to other commercially available systems.
Technology Transfer

• Technology is patented and will be commercially licensed.

• The NAVFAC-ESC Technology Integration Team is actively identifying potential user of this technology.

• NAVFAC-ESC has published project results.
Publications:


• R. E. Kirts, et. al., *METHOD AND MATERIALS TO REDUCE POLLUTION CAUSED BY COPPER, ZINC, AND OTHER METALS IN WASTE WATER*, Patent application, November, 2004,
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• Engineering Field Division Southwest
• San Diego Navy Regional Recycling Center San Diego
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