ADSORPTIVE REMOVAL OF SELECTED HEAVY METALS FROM URBAN STORMWATER RUNOFF

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Background

Urban stormwater runoff characteristics:

- contaminants,
- high velocity flow with very high picks.

Most frequently detected priority pollutants in urban runoff are:

- lead and zinc (94%), copper (91%), chromium (58%), arsenic (52%), cadmium (48%), nickel (43%), etc. (adopted from: Strassler, et al., 1999)

Heavy metals can have:

- acute and chronic toxic impact on aquatic life,
- adverse effects on human health.
Research Statement

Adsorption has proved to be a promising method for removing dissolved metal ions from water.

Many researches revealed that effective removal of heavy metals can be achieved by using:

- iron oxide based adsorbents e.g. Iron Oxide Coated Sand (IOCS) - by-product from water treatment plant

Research on heavy metal removal from stormwater runoff:

- majority of work using filtration/adsorption is conducted as treatment in a single heavy metal system.
Goal and Objectives

The goal of this research was to better understand and advance knowledge on adsorptive removal of selected heavy metals by using iron oxides coated sand (IOCS).

Main objectives:

- Assess effect of water quality (e.g. pH, $\text{HCO}_3^-$) on co-occurring stability of Cd, Cr(III), Cr(VI), Cu and Pb in water.
- To determine competitive adsorption efficiency of IOCS for removal of selected metals at different $\text{HCO}_3^-$ concentrations.
## Composition of Model Water

**Materials and Methods**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Model water *</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Cr(III)</td>
<td>25</td>
<td>µg/l</td>
</tr>
<tr>
<td>Cr(VI)</td>
<td></td>
<td>µg/l</td>
</tr>
<tr>
<td>Cd</td>
<td>25</td>
<td>µg/l</td>
</tr>
<tr>
<td>Cu</td>
<td>140</td>
<td>µg/l</td>
</tr>
<tr>
<td>Pb</td>
<td>525</td>
<td>µg/l</td>
</tr>
<tr>
<td>$\text{HCO}_3^-$</td>
<td>0 and 100</td>
<td>mg/l</td>
</tr>
</tbody>
</table>

* Model water was prepared with demineralized water.
Experimental Set-up
Materials and Methods

PHREEQC was used for equilibrium predictions of selected metals under studied conditions.
Extraction of IOCS Coating

Results

<table>
<thead>
<tr>
<th>Composition</th>
<th>Concentration</th>
<th>Unit</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0.7</td>
<td>µg/g</td>
<td>0.07</td>
</tr>
<tr>
<td>Calcium</td>
<td>12.3</td>
<td>mg/g</td>
<td>1.23</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>324.5</td>
<td>mg/g</td>
<td>32.45</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.3</td>
<td>mg/g</td>
<td>0.03</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.6</td>
<td>mg/g</td>
<td>0.16</td>
</tr>
<tr>
<td>Oxygen</td>
<td>182.5</td>
<td>mg/g</td>
<td>18.25</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>19.5</td>
<td>mg/g</td>
<td>1.95</td>
</tr>
<tr>
<td>Sand</td>
<td>54.2</td>
<td>mg/g</td>
<td>5.42</td>
</tr>
<tr>
<td>Silica</td>
<td>2.2</td>
<td>mg/g</td>
<td>0.22</td>
</tr>
<tr>
<td>Unknown compounds</td>
<td>402</td>
<td>mg/g</td>
<td>40.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table: Chemical composition of IOCS from WTP Brucht
Removal of Cr(III)

Results

Change in Cr(III) concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cr(VI)

Results

Change in Cr(VI) concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cd

Results

Change in Cd concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cu

Results

Change in Cu concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Pb

Results

Change in Pb concentration as a function of contact time and IOCS/other metals’ presence.
Influence of HCO$_3^-$ Concentration

Results

Example of Pb removal:

- Pb is removed by precipitation and adsorption processes.
- Presence of HCO$_3^-$ increases the precipitation.
- Precipitation at the pH=6 is different in presence of Cr(III) and Cr(VI).
- PHREEQC showed that precipitated fractions are in the form of Pb(OH)$_2$ and PbCrO$_4$ specie.
Conclusions

Short batch experiments:

- complete removal was achieved for all metals except for Cr(VI);
- two basic removal mechanisms: precipitation and adsorption;
- contribution of precipitation and adsorption to overall removal is a function of a metal type and water quality (e.g. pH and HCO$_3^-$ concentration);
- under studied conditions presence of Cr(VI) increased precipitation of metals;

Based on the presented study combination of precipitation and adsorption on IOCS could be feasible method for removal of heavy metals from urban stormwater runoff.
Thank you for your attention!
Removal of Cr(III)

Results

Change in Cr(III) concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cr(VI)

Results

Change in Cr(VI) concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cd

Results

Change in Cd concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Cu

Results

Change in Cu concentration as a function of contact time and IOCS/other metals’ presence.
Removal of Pb

Results

Change in Pb concentration as a function of contact time and IOCS/other metals’ presence.