Monitoring and modelling of sediment transport in Selenga transboundary river system

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Transboundary rivers of Russia

Foreign parts of Russian transboundary rivers

Selenga-Baikal drainage area case study
Cities

Land use

Mining

Sediment budget

Metal contamination and budget

Organic matter spreading
Field campaigns 2011-2012
Flow measurements
Suspended and bed load measurements
Geochemical studies
Vertical compose suspended sediments determination
River valley tacheometrical survey
Principal approach to field campaigns

Water fluxes

Suspended load

Bed load

Bed deposits
Hydrological conditions over Mongolia

- Precipitation total km3
- Surface water resources, km3
- Surface water runoff (km3) and annual SSC (mg/l)

Batsukh et.al, 2008
Hydrological conditions over Russia

(by Potemkina, 2011)

Q – water discharge
1 – average for 5 years
R – suspended sediment load
2 – average for 5 years
3 – linear trends
Integrating continuous meso-scale (red) and episodic large-scale monitoring

Period of episodic monitoring in 2011

Q, m³/s

1.1 20.2 11.4 31.5 20.7 8.9 28.10 17.12

Kharaa

Tuul

Orkhon

Selenga
Human impacts: pollution and water consumption

<table>
<thead>
<tr>
<th>Sectors that use water and associated total water use (million m³)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Drinking water supply</td>
<td>71.35</td>
</tr>
<tr>
<td>2. Agricultural water</td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td>71.00</td>
</tr>
<tr>
<td>Crop irrigation</td>
<td>52.28</td>
</tr>
<tr>
<td>3. Exploitation industry</td>
<td></td>
</tr>
<tr>
<td>Extractive mining industry</td>
<td>35.8</td>
</tr>
<tr>
<td>Industrial water supply, Energy production, Energy production, Power plants</td>
<td>93.8</td>
</tr>
<tr>
<td>Hydro Power Plant</td>
<td>27.6</td>
</tr>
<tr>
<td>3. Tourism water supply (excl. spa resorts)</td>
<td>80.0</td>
</tr>
<tr>
<td>4. Green area</td>
<td>1.68</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>433.78</strong></td>
</tr>
</tbody>
</table>

Batsukh et. al, 2008
Climate-induced drivers of water and pollutants dynamics

Precipitation, mm

Orkhon June 2012

Orkhon river (July 2011)
Suspended sediment concentration (SSC) assessment
Suspended sediment grain size

Map of Mongolia showing the distribution of suspended sediment grain size. The legend indicates the average diameter in millimeters, with different colors representing different size ranges.
Organic matter content

Map of Mongolia showing organic matter content levels in different regions.
Reliability for annual sediment yield for Selenga river basin (2011)

Daily sediment discharges SL → Monthly sediment load → Annual yield

Wi = SL * number of days

W = Wi * monthly rating

Example for Kharaa basin

4350 t/year (single measurements in 2011)

28600 t/year (continuous monitoring in 2011)

Monthly rating = total sediment yield / monthly sediment load
Contribution of storm events

1 – water levels
2 - suspended sediment load
3 – grain size
Storm events signatures in pollutants transport

As, g/m³

Ag, g/m³
### Daily sediment budget calculations for Selenga river basin (2011)

<table>
<thead>
<tr>
<th>Grain size</th>
<th>Tuul river</th>
<th>Orkon river, middle</th>
<th>Orkon river, low</th>
<th>Selenga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy (&gt;0,05 mm)</td>
<td>7,3 (3,2 %)</td>
<td>237,8 (9,7 %)</td>
<td>265 (19,5 %)</td>
<td>302,3 (26,3 %)</td>
</tr>
<tr>
<td>Silt 0,001 – 0,05 mm</td>
<td>210,3 (92,9 %)</td>
<td>1869,6 (76 %)</td>
<td>1048 (76,7 %)</td>
<td>720,9 (62,7 %)</td>
</tr>
<tr>
<td>Clay &lt; 0,001 mm</td>
<td>8,8 (3,88 %)</td>
<td>352,2 (14,3 %)</td>
<td>51,7 (3,79 %)</td>
<td>125,8 (10,95 %)</td>
</tr>
<tr>
<td>Total t/day (100%)</td>
<td>226,4</td>
<td>2460</td>
<td>1365</td>
<td>1149</td>
</tr>
</tbody>
</table>

Calculation of sediment load for various grain size classes
Sediment delivery into Baikal lake: Remote sensing application
ntribution of channel erosion
Contribution of channel erosion: Tuul river

1894444 t/year is up to 90% of total sediment yield

1 – channel in 1970; 2 – channel in 2006; 3 – channel deformations;
Flood at kharkhorin
Zaamar gold mining

Ulaanbaator
Sediment transport modelling

1D и 2D modelling at the case study reaches (HEC – RAS, MIKE 2D)

Decision-support system (0D-modelling)
Zaamar Goldfield primarily impacts the closest (within couple kilometers from the mines) environments. However, contaminated sediments that are deposited in the vicinity of the goldfield can move much further downstream during peak flow events. Also during slowly descending flow conditions, the mining waste may continue to be transported, to the Orkhon River and its downstream areas.
Thank you for your attention