SALINITY INTRUSION THROUGH ESTUARY ANALYSIS DUE TO SEA LEVEL RISE USING DIRECT STEP METHODE
(Case Study: River Banyuasin and Telang)

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ABSTRACT
Direct step method usually use to compute a water surface profile due to backwater. On estuary, tidal could be assume as an obstruction for upstream river flow and cause a backwater. Assuming that backwater is bringing salty water into fresh water, where is known as salinity intrusion. Scenario had been arranged to model the intrusion, whether in the river or out from the river. Analysis result shows that 10 year return period high tide caused salinity in the Banyuasin River reach 75.94 km length. Since the elevation of bank higher than high tide level, inundate area is relatively small. Meanwhile, for Telang River, salinity reach 75.89 km length and the overflow through the bank is occurred. Combine with sea level rise, the affected area is wider.

INTRODUCTION
River Banyuasin and River Telang are major river in South Sumatra. These rivers bound tidal lowlands area, Delta Telang I and Delta Telang II with an estimated area about 40.480 ha and have elevation 0.5 m to 2.25 m above sea surface. Tidal influence is more dominant than rainfall (Rahmadi, 2009). These land have been developed into agriculture area with the main plant are paddy, coconut tree, and other hard plant. Some areas are provided as conservation area such as mangrove forest. In the future, these areas are planned to be into an integrated autonomous city (Depnakertrans, 2010). Since the tidal influence more dominant, the irrigation system on these areas had already set up to overcome flooding from river during the high tide by providing gates on channel downstream.

The problem might be occurred when sea level rise happen as an impact from climate change. Not only generate flood, also salinity intrusion. Nowadays, during high tide salinity spreading reaches 100 km from Bangka Strait (Ngudiantoro, 2009). This paper will discuss the relation between sea level rise and salinity intrusion through estuary. Direct step method is used to model intrusion length.

MATERIAL AND METHODS
It is believed that global warming carries with it the possibility of an increase in the intensity of extreme coastal flooding events (Hunt, 2002; Houghton, 2005). In its latest report, the Intergovernmental Panel on Climate Change (IPCC, 2007) states that it is likely that a trend of increasing heavy precipitation events, intense cyclone activity and incidence of extreme high sea levels have occurred after 1960’s and will continue into the 21st century. The direct step method was implemented to figure out surface water profile during high tide. Since climate change not only generate sea level rise, also increasing heavy precipitation, upstream flooding data will be needed to make a model scenario. Study area shows in figure 1.
Feril Hariati, Salinity Intrusion Through Estuary Analysis Due To Sea Level Rise Using Direct Step Methode (Case Study: River Banyuasin And Telang)

Tides level of study area is available in [www.mobilegeographic.com](http://www.mobilegeographic.com), for Air Musi station. For modelling purpose, highest high water level (HHWL) is use as input parameter. From year 1999 to 2008, value of HHWL tends to be increase gradually. In year 2004, 2005 and 2008, HHWL reach the highest value, 4.24 m and with normal distribution method to calculate return period, HHWL 4.24 m has a return period around 10 years.

To simplify the overflow model which is using SRTM data, HHWL should be referring to datum level. In SRTM datum level is zero, and from tidal analysis result mean sea level is 1.95 m. Therefore, HHWL is 2.29 m from datum.

Then the scenario is arranged within various upstream flow discharge and water level, which is has three variety, first high tide, second; high tide which is combine with rise of sea level within 0.25 m and third; within 0.5 m sea level rise. The model scenario is shown in table 1.
Table 1. Modelling scenario

<table>
<thead>
<tr>
<th>Flood Discharge (m³/dtk)</th>
<th>Tide</th>
<th>Tide + SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.29</td>
<td>0.25+2.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 2.54 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 2.79 m</td>
</tr>
<tr>
<td>1,000</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2,000</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4,000</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6,000</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Direct step method is implemented to figure out water surface profile. Tide could be assume as obstruction in river channel and caused a backwater and bring salt water to the river mouth and usually known as salt intrusion. Illustration for this process is shown in figure 3.

![Diagram of Fresh Water and Salt Water](image)

**Figure 3.** Process of salt intrusion (a) condition during low tide, (b) condition where water level in river and sea is equilibrium and (c) condition during high tide and salt water infiltrate to the river mouth.

The direct step equation is derived from energy equation:

\[
\frac{z_1 + h_1 + \frac{V_1^2}{2g}}{2g} = \frac{z_2 + h_2 + \frac{V_2^2}{2g}}{2g} + h_f
\]

(1)

Consider that \( h + \frac{V^2}{2g} \) is equal to \( E \) and \( Z_1 - Z_2 \) is equal to \( S_o \Delta X \), then

\[
E_1 + S_o \Delta X = E_2 + S_f \Delta X
\]

(2)

\[
\Delta X = \frac{E_2 - E_1}{S_o - S_f}
\]

(3)
Where,

\[
\bar{S}_f = \frac{S_{f1} + S_{f2}}{2} \tag{4}
\]

For Manning coefficient, equation (4) become,

\[
S_f = \frac{Q^2 n^2}{A^2 R^{\frac{5}{3}}} \tag{5}
\]

**RESULT AND DISCUSSION**

Sea level rise increase the water level during high tide. Using backwater analysis, during high tide with various river flood discharge, length of river which is impact by salinity intrusion is shown at table 2.

<table>
<thead>
<tr>
<th>Upstream Flood Discharge (m$^3$/s)</th>
<th>Sea Level</th>
<th>River Banyuasin</th>
<th>River Telang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>2.29</td>
<td>75,937</td>
<td>75,888</td>
</tr>
<tr>
<td></td>
<td>2.54</td>
<td>78,832</td>
<td>78,757</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>81,680</td>
<td>81,583</td>
</tr>
<tr>
<td>2,000</td>
<td>2.29</td>
<td>72,070</td>
<td>72,075</td>
</tr>
<tr>
<td></td>
<td>2.54</td>
<td>75,471</td>
<td>75,477</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>78,748</td>
<td>78,754</td>
</tr>
<tr>
<td>4,000</td>
<td>2.29</td>
<td>57,272</td>
<td>54,362</td>
</tr>
<tr>
<td></td>
<td>2.54</td>
<td>63,409</td>
<td>61,271</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>68,724</td>
<td>67,088</td>
</tr>
<tr>
<td>6,000</td>
<td>2.29</td>
<td>low water</td>
<td>low water</td>
</tr>
<tr>
<td></td>
<td>2.54</td>
<td>5,623</td>
<td>low water</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>5,623</td>
<td>336</td>
</tr>
</tbody>
</table>

Table 2. shows that without sea level rise parameter, the salinity intrusion during low discharge is the longest and reduce if the river discharge increase. But if sea level parameter is take into account, salinity intrusion become longer.

Besides spreading over the river, salinity also will spread to the land through river overflow. Using SRTM, the overflow through river bank is modelled, with sea level variation. The result is as follow:
From figure 3, with or without sea level rise, during the high tide the river will be overflow, but the inundate will be wider for 0.5 m sea level rise.

For Telang River, the overflow always occur during the high tide. The occurrence of sea level makes inundate level more higher. For developed lowland, salinity intrusion should be avoided, especially for paddy-field, salt water inundated caused death for plantation.

CONCLUSION

Direct step method could be implemented to calculate the length of salinity intrusion through estuary. From case study, during high tide, without sea level rise parameter, the salinity intrusion for Banyuasin River is reach 75.94
km and Telang River 75.89 km. Previous study shows that salinity intrusion in Musi River is reach 100 km from Bangka Strait.

REFERENCE


http://ktm.depnakertrans.go.id/?show=ktm&category_id=19&sub=profile Kota Terpadu Mandiri (online, download June 18, 2010)