Introduction

The Eastern Apennine rivers have a strong impact on the depositional record of the Adriatic Sea. They are the most important sediment source (over 62%) for the basin although their drainage area is less than half of that of the Po river [7]. During the past several centuries, human perturbation has caused decreasing sediment output due to damming.

In the EuroSTATAFORM project, sediment flux pre- and post-emplacement of reservoir dams, is simulated for five Apennine rivers (fig. 1) with the climate-driven hydrological model HydroTrend. The model simulates sediment trapping efficiency (TE) depending on the reservoir volume either by the Brown equation, for reservoirs < 0.5 km³, or the modified Brune equation, for reservoirs > 0.5 km³.

HydroTrend has a daily resolution, more hyperpycnal events are likely if hourly dynamics are considered. We convert the daily average concentrations to 6h values [3], see table 1.

Table 1. Input parameters and output statistics of 100yr daily simulations of the 5 Eastern Apennine rivers.

<table>
<thead>
<tr>
<th>River</th>
<th>Area (km²)</th>
<th>Relief (m)</th>
<th>Length (km)</th>
<th>Dams</th>
<th>TE (%)</th>
<th>Qavg (m³/s)</th>
<th>Qpeak (m³/s)</th>
<th>Csavg (kg/m³)</th>
<th>Qs (MT/a)</th>
<th>Qb (MT/a)</th>
<th>Hydropycnal events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metauro</td>
<td>1400</td>
<td>1050</td>
<td>91</td>
<td>Yes</td>
<td>32</td>
<td>414</td>
<td>1.6</td>
<td>0.55</td>
<td>0.08</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>89</td>
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<td>30</td>
<td>218</td>
<td>2.4</td>
<td>0.39</td>
<td>0.09</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Chienti</td>
<td>1300</td>
<td>1625</td>
<td>99</td>
<td>No</td>
<td>25</td>
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<td>17.2</td>
<td>2.05</td>
<td>0.54</td>
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<tr>
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<td>2460</td>
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<td>350</td>
<td>2</td>
<td>0.5</td>
<td>0.15</td>
<td>0</td>
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<td>Pescara</td>
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<td>2910</td>
<td>154</td>
<td>Yes</td>
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<td>29.2</td>
<td>26.4</td>
<td>1.7</td>
<td>0.5</td>
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<td>1</td>
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</tbody>
</table>

Figure 1. A NASA Moderate Resolution Imaging Spectroradiometer (MODIS) from the Terra Satellite image of Italy on March 25, 2003. Notice the hypopycnal river plumes.

Suppressed hyperpycnal flows

Compared to HydroTrend simulations the Pescara River for example is a highly regulated river (fig. 2). Water regulation keeps the river to a minimal discharge of 20-25 m³/s. Peak discharge events are rare and dampened.

Simulations without reservoir dams show that the Apennine Rivers are likely to generate hyperpycnal flows (table 1). A few will last longer than 24h, but many more events are likely to occur for shorter duration [2], see figure 4.

Human influence reduces the number of hyperpycnal events that could last greater than 12h according to the simulations (table 1).

The limited amount of hyperpycnal flows still account for 20 to 40% of the total sediment flux from these Apennine Rivers.

The 5 modeled rivers with reservoirs transport on average between 0.4 and 1.2 MT yr⁻¹. However, a single hyperpycnal event can transport between 0.3 and 4 MT in one day.

The fact that hyperpycnal plumes are much less likely to occur, will influence the recent offshore stratigraphy.

The average suspended sediment load as well as the bedload was seen to decrease with approximately one third after placement of the reservoirs. This affects river plume dynamics, e.g. by a reduced spread into the basin. The decrease of the sediment accumulation for the Adriatic west coast between 1940-1980 has been corroborated with core data [1].

Figure 2. 5yr daily average discharge (Q) data (measured vs. modeled) of the Pescara river. 200 day zoom-in shows detailed dynamics.

Figure 3. 10yr daily average suspended sediment discharge (Qs) and bedload discharge (Qb) simulations of the Pescara river, pre- and post-emplacement of reservoir dams.

Figure 4. 85yr daily average sediment concentration (Cs) of the Potenza river, pre- and post-emplacement of reservoir dams. The horizontal lines indicates the 24h threshold for hyperpycnal flows.

Boundary conditions

The Brown equation is used for all reservoir simulations because all reservoirs are considered < 0.5 km³:

\[ TE = 1 - \left( 1 + \frac{K_a}{K_w} \right) \frac{V_a}{V_w} \]

\[ K_w = \frac{1}{t} \]

= reservoir volume (km³)

= drainage area above the reservoir (km²).

Using buoyancy considerations alone, a hyperpycnal flow requires around 40 kg/m³ of sediment concentration to overcome the density contrast between freshwater and ocean water.

References