Reducing the environmental impact : characterizing the efficiency of sedimentation basins downstream of harvested peat bogs

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Abstract

Harvested peat is a very lucrative industry in both Quebec and New-Brunswick (Canada). Peat enters in many potting mix used for horticulture. However, harvesting this resource can have some impacts on the environment.

To harvest peat, industries need to drain the peat bog to dry the superficial layer. Then, it is harvested with industrial vacuums (Figure 1) and the underlying layer is allowed to dry.

The drained water can often be laden with suspended sediments (mostly organic peat fibers) that may affect biota of the stream where it is discharged. To counter the problem, this water does not go directly on the stream but first flows through a sedimentation basin, built to reduce suspended sediment loads. The province of New-Brunswick's guidelines stipulates that concentrations should not exceed 0.025g/L downstream of those basins. Previous research showed that many Canadian streams and rivers have natural background SSC that often exceed this value. This work focuses

Figure 1. Tractor used to harvest peat by vacuuming

Site description

Eight sites were studied near Rivière-du-Loup, Escoumins and Victoriaville (Québec, Canada). All sedimentation basins are rectangular (Figure 2), but they can also be in parallel (basin 4) or in series (basin 6). The area drained by these basins range between 0.22km^2 and 0.66km^2 and the efficient volume of basins range between 161m^3 and 1658m^3. However efficient volumes varies as the basins accumulate sediments during the harvesting season.

To continuously monitor the sediment load entering and leaving of a basin, a nephelometer and a level logger were installed in the water column upstream and downstream of each basin. A tipping bucket rain gauge was also installed to measure rain amounts on each harvested site. The basins have been emptied using a manure pump or a shovel and it has affected both the hydrology and the turbidity for most of the sites.

The monitoring lasted the whole 2014 ice-free season (2013 for basin 2), i.e. from May to November. Most sediments are brought in the basin during rain events.

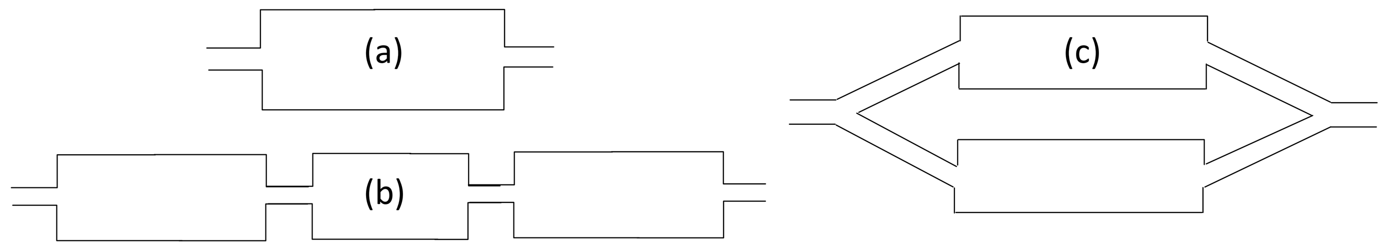

Figure 2. Shema of sedimentation basins shapes (a) simple, (b) in parallèle, (c) in series.

Methodology

To evaluate the efficiency of a sedimentation basin, the sediment mass entering (S_{in}) and leaving (S_{out}) the basin were used. To do so, the suspended sediment concentration (SSC) and the water flow are needed.

$$S_{in} = flow_{in} \times SSC_{in}$$

$$Efficiency = 100 \times \frac{S_{in} - S_{out}}{S_{in}}$$

Calibration

The nephelometer monitor the turbidity (the intensity of light backscattered on sediments) which is an indirect measurement of the SSC. A relation between turbidity and point measurements of SSC (g/L) was established for each nephelometer.

Rating Curves

To obtain the water flow entering and leaving each basin, relations between instantaneous flow measurements and water level have been established.

Results

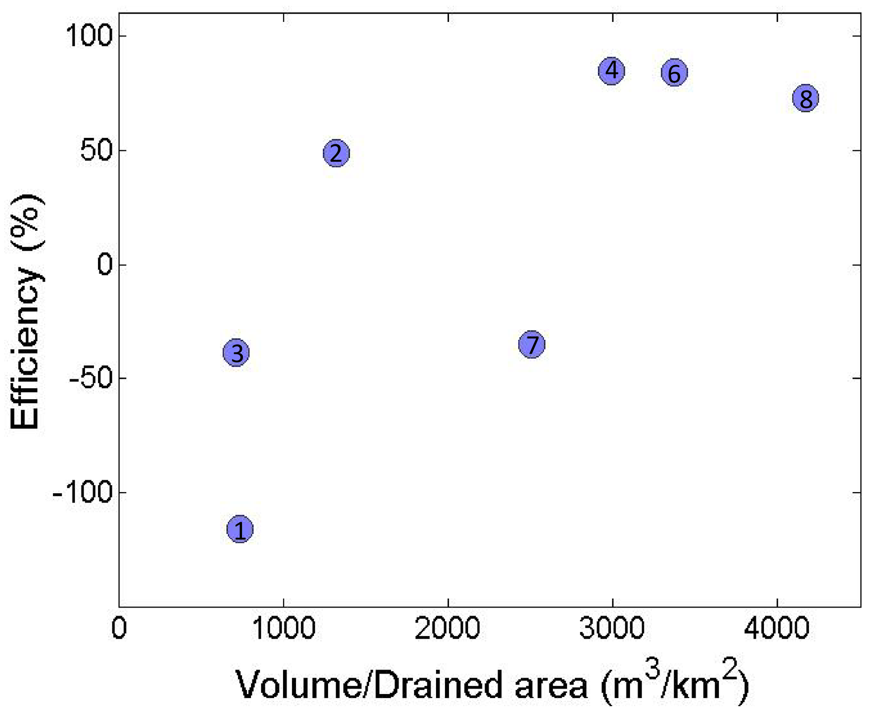

Figure 3. Efficiency of each basin relative to their V/D ratio. Basin #5 have been removed because of its too low efficiency (710;-380)

Seasonal efficiency have been calculated for each basin and linked to its Volume/Drained area ratio (V/D ratio) (Figure 3). It appears that efficiency increases with V/D, up to a value of approximately 4200 m^3/km^2.

The efficiency of every rain event have been isolated. The pre-wash events for basin 4 are shown in Table 1. It appears that the efficiency decreases during the season

It is possible to make a link between the decrease in the efficiency and the accumulation of rain or the amount of water/peat entering the basin. However, it is not possible to fix the absolute amount of peat or water entering the basin for each event ; the last wash that emptied the basin was in August 2013 (i.e. the basin was not empty when the season began).

Table 1. Efficiency of rain events for basin 4 before the wash (August 18). The accumulations are from the beginning of the season to the end of each event.

Date	Rain	**Efficiency**	cumul rain	cumul water in	cumul load in
	mm	**%**	mm	m^3	tons
Jun 4	13,9	**83,9**	14,1	1308,0	0,37
Jun 12	41,9	**77,5**	56,5	5650,4	1,40
Jul 6	11,7	**63,2**	86,1	9833,3	3,32
Jul 27	58,4	**-44,4**	166,8	11475,7	3,52
Aug 13	21,7	**-33,4**	197,8	12930,4	3,75

The colored lines on Figure 4 show that most of the peat seems to enter during the fall period (October-November). This tendency is also observed on basins 2,4,5,6 and 8. The 0.025g/L threshold is exceeded the majority of the time (60%), even when no rain occurs. Moreover, highest SSC periods (July and September) don't coincides with the highest peat outputs (October).

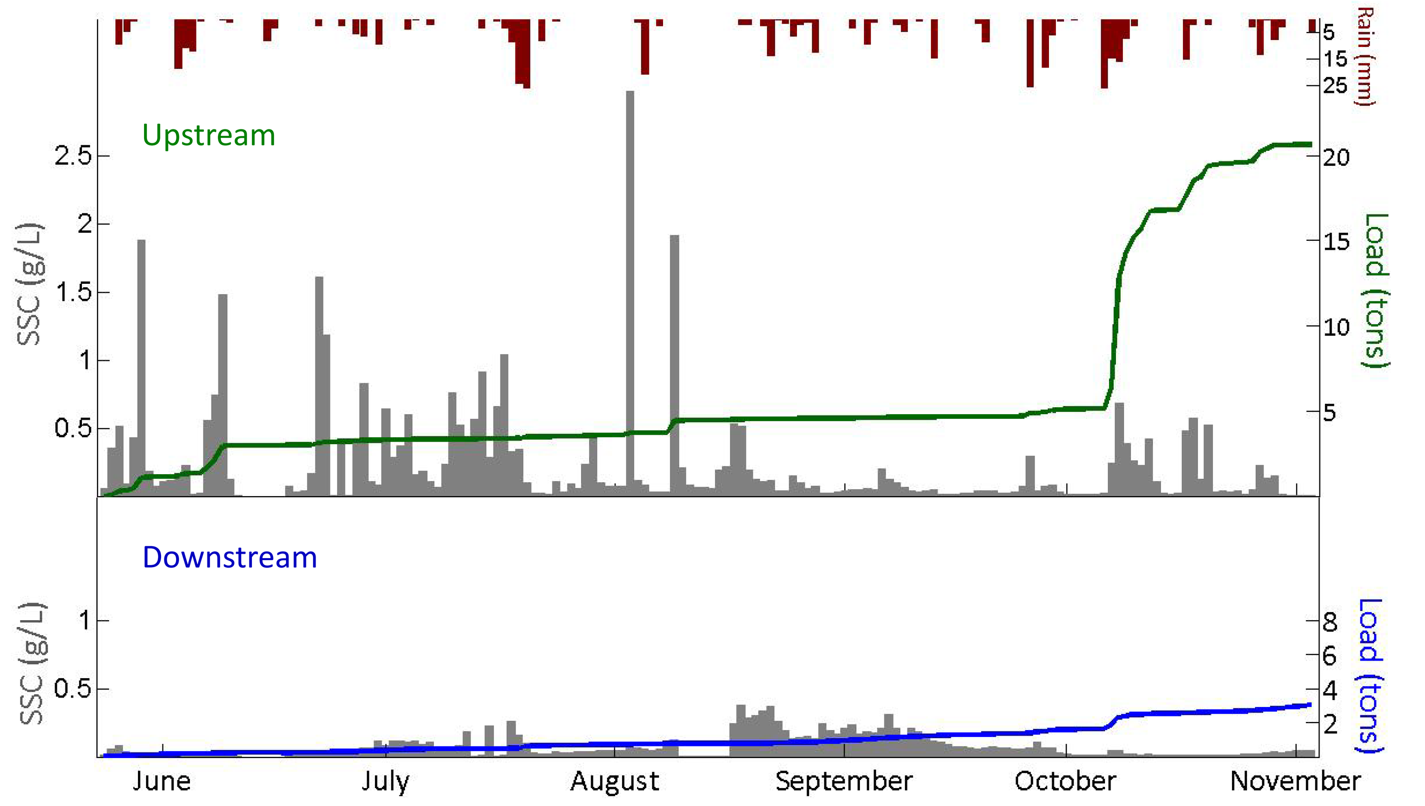

Figure 4. Upstream (green) and downstream (blue) accumulation of peat load, daily SSC (gray bars), and daily rain (brown bars) on basin #4 for the 2014 season.

Conclusion

- Bigger basins can be more efficient than basins with smaller V/D ratios. Basins 4 and 6, respectively in parallel and in series, seem to be slightly more efficient than basin 8. This suggests that multiple basins with more than one outlet structure can provide greater efficiency than a single basin.

- The efficiency appears to decrease during the season for basin 4 (Table 1), thus peat accumulation in the basin affect its capacity to catch sediments. It is too early to say when the basin should be emptied, but it might be after a certain amount of rain, water or peat entering in the basin.

- Rain events in the fall season seem to bring more sediments in the basins studied (Figure 4). This wetter season is often associated with greater soil water content, which could bring larger loads to the sedimentation basins.

- The SSC threshold of 0.025g/L is the actual quality standard in New-Brunswick (Canada) and could be the one used in the neighbouring province of Québec. This guideline is questionable, as many Canadian streams and rivers have natural background SSC that often exceed this value. A combination of a higher maximum concentration with a total annual allowable load may be an alternative to the current guideline.

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