Suspended Solids from Drained Peatlands in the East Coastal Zone of New Brunswick: Point Estimates and Climate Effects on the Environment

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Abstract: Peatlands represent one of the most important economic resources and abandoned peatlands after mining can be considered as ecological resources by re-vegetation restoration or management. However, some environmental problems like particles from peatlands and their effects in the water system have to be characterized. Since centuries, artificial drainage has been a current practice for the mining of peatlands. Mainly mined for horticultural purpose, New Brunswick's peatlands—predominantly located in the eastern of the province—cover about 140,000 ha. At the downstream end of the drainage system, the water from peatlands flow into sedimentation basins. Drainage waters are often laden with solid particles. Once they have flowed through the ponds to allow sediment settling, the water is released into the water system. This paper describes the spatio-temporal evolution of suspended solids from 12 New Brunswick drained peatlands. The studied sites were characterized by some heterogeneity in the concentration of suspended solids. This study also provides knowledge on the suspended solids amount that can be released by drained peatlands, and it proposes a function to estimate the concentration of suspended solids by using climate variables; and identifies some potential ecological risks.

Key words: Peatlands, drainage, sedimentation ponds, suspended matters, water system.

1. Introduction

Peatlands are organic soils constituting 3% of the land surface of the globe [1]. These approximately 400 million ha are located primarily in North America (about 37% in Canada) and in boreal areas of Asia and Europe (Fig. 1). These types of lands are ecologically distinctive because they are characterized by wetlands with very high carbon stocks. This high carbon content is mostly concentrated in a soil layer mainly composed of more or less degraded organic matter. Considering all the peatlands on earth, these carbon stocks—about 500×10^9 t—surpass those of other terrestrial ecosystems. This wealth leads to various human uses. Clarke and Joosten [2] revealed that around 80 million ha of peatlands are used for forestry, agriculture, paludiculture, and mining (Fig. 1). With

more than 110 million ha of peatlands widely distributed on all the Canadian territory, Canada is considered as one of the major producers and exporters of peat, mainly for commercial horticultural peat moss-based substrates. In New Brunswick, the exploitation is primarily for the production of growing media and soil amendments for the horticulture industry. Presently, less than 5% of the Canada's peatlands are operated, which corresponds to 5,500 ha; and from the 800 peatlands of New Brunswick, only 60 are exploited by about 25 companies in 2012. The operation of sites is mainly located in the Acadian Peninsula.

Peatlands exploitation requires drying of the harvested layers by water drainage. Despite best practices for drain-blocking techniques on blanket peat, peatlands drainage causes several problems [3]. The main ecological problems are biodiversity disturbance, greenhouse gas emissions, and soil

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Fig. 1 Global peatlands area in percentage by country, main peat uses and peatlands carbon stocks (modified from Refs. [4, 5]).

degradation. Several studies show that the sustaining of biodiversity can critically be disturbed by the drainage of peatlands [6]. In 2014, Whatley et al. [7] demonstrate that after the peatlands drainage, peat degradation induces a decline in submerged macrophytes leading to diminish the richness and densities of benthic invertebrate species.

Many studies related to greenhouse gas emissions focus on carbon dioxide. From 1990 to 2008, the total CO₂ emissions from degrading peatlands are estimated from 1.06×10^6 t to 1.23×10^6 t per year. The emissions from peatlands drained for peat extraction before 2008 is evaluated at 1.26×10^6 t per year. Concerning Canada, this latter type of emissions corresponded to 0.16×10^6 t per year in 2008 [8]. Hooijer et al. [9] conclude that greenhouse gas emissions are still significant even at the highest theoretical levels of water table. On the contrary, the laboratory experiments of Moore and Knowles [10] demonstrate a linear relationship between the increase of CO₂ emissions and a decrease of the level of the water table. Thus, the drainage of peatlands can greatly increase the global warming potential. Indeed, a regional study on drained peatlands in Belarus establishes—with a closed chamber approach—the influence of water table, land use, and annual weather conditions on the greenhouse gases emissions [11]. With a study on drained peatlands in southeast Asia,

Hooijer et al. [12] alert on the increasing contribution of CO₂ emission from peatlands drainage to those at global scale. A modelling approach in Ref. [13] also confirms the continuity of these predictions for decades.

Soil degradation of peatlands is also one result of the artificial drainage. After the drainage, several changes occur on hydrological, chemical, and physical properties of the soils of the drained peatlands [14, 15]. More recently, Kechavarzi et al. [16] focus their work on the physical and hydraulic properties induced by the drainage of residual peatlands; and they reveal that soil alterations have a great influence on the porosity and then on the hydraulic transfers in the medium. Peat soils degradation can be noticed through nutrient losses, modifications in pH level and bulk density [17, 18]. Peatlands degradation and that of the surrounding water quality can worsen with future climate change, the latter being able to greatly contribute to strengthening the importance of rill erosion during rainfall events [19]. By studying the runoff from blanket peat, Holden and Burt [20] demonstrate that disturbed peatlands are susceptible to generate higher suspended solids rates through hydraulic flow from deeper peat layers. Also, any physical alterations on peatlands will certainly disturb its overall hydrological behavior and favor runoff events [21].

It is increasingly becoming required to assist the peat industries to find alternatives to avoid ecological troubles caused by the peatlands drainage and the peat extraction. To limit the environmental damage associated to the post-drainage of peatlands, the use of buffer zones and sedimentation basins establishment seems to be part of the best options. Buffer zones can be used to reduce the amount of suspended solids produced from drained peatlands, at the condition of creating these buffer zones on large areas (more than 1 ha) [22]. There are several types of managed wetlands, some of which are associated with retention ponds: sustainable flood retention wetland, aesthetic flood treatment wetland, integrated flood retention wetland and natural flood retention wetland [23, 24]. These basins hold the water drainage to prevent it from direct flowing into the surrounding natural water system. Indeed, the water drainage from peatlands is composed by vegetable and mineral particles which can affect water quality, among other things by enhancing the dissolved organic carbon loss, by altering the color of the water, by increasing water turbidity, by encouraging further sediments deposition, and by causing further eutrophication of aquatic ecosystems [25, 26]. Thereby, sedimentation basins act as holding tanks allowing the deposition of suspended solids by gravity in a buffer zone before the water returns to the natural environment.

In New Brunswick, mined peatlands located in the east coastal zone are equipped with sedimentation basins. To evaluate the effectiveness of the retention basins implanted, a chronological survey—2008 to 2012—of the concentration of suspended solids is made. For each of the 5 years considered, the monitored period is lasted from June to September. The calculated suspended solids concentrations are then correlated with climate events and peatlands characteristics. The ecological impacts due to suspended solids in the hydrographic network are also discussed.

2. Material and Methods

Located in the east of New Brunswick, mainly

distributed along the coast, the studied sites were 12 peatlands actually mined for commercial horticultural peat moss-based substrates extraction (Fig. 2).

Undifferentiated mineral soils are present under the layer of peat deposits [27]. The studied peatlands are under a cool and wet maritime climate with a heavy rainfall [28]. The location, the total area, the mean value of the slope, the year of the beginning of the drainage, and the nearest weather station of all the 12 sites are given in Table 1.

Knowing that the concentrations of suspended matter from drained peatlands are usually higher in summer, the study interest focused on data collected from June to September of years 2008 to 2012 [29, 30]. A non-random sampling was done and composed of two populations of data. 1 L of water was sampled from the outlet of the sedimentation basin, delicately avoiding to brew water during sampling in a large opening plastic bottle. A sample was taken twice a month (one every 2 weeks) in normal weather conditions. But in case of heavy rain (more than 25 mm

Fig. 2 Location of studied sites. P1 to P12 symbolize the 12 studied drained peatlands.

Table 1 Some characteristics of studied sites.

Peatlands	Geographic coordinates		Total area (ha)	Approximate year of drainage	Slope (mean value (%))	Nearest weather station considered
	N	W				
P1	47.003729	-64.913883	2,950.70	1960	nd	Miramichi
P2	46.988743	-65.026492	680.39	1998	nd	Miramichi
P3	46.372367	-65.025749	73.89	2006	nd	Miramichi
P4	47.596577	-64.927140	265.89	2006	1.51	Low-Caraquet
P5	47.181138	-65.160388	328.68	1990	nd	Miramichi
P6	47.625278	-64.845429	587.38	1954	1.97	Low-Caraquet
P7	46.327934	-65.050125	382.89	1983	nd	Miramichi
P8	47.726457	-65.338765	403.11	2003	nd	Low-Caraquet
P9	47.753009	-64.636155	1,241.31	1951	6.55	Miscou-Island
P10	47.827491	-64.620877	225.89	1969	7.16	Miscou-Island
P11	47.826820	-65.041447	505.41	1964	6.66	Low-Caraquet
P12	47.861593	-64.513074	289.19	1979	6.46	Miscou-Island

P1 to P12 symbolize the peatlands; nd: not determined.

in 24 h), water was sampled the day following the rain event. It was the same for the days of high winds (from $60 \text{ km}\cdot\text{h}^{-1}$ for at least 1 h, or gusts from $90 \text{ km}\cdot\text{h}^{-1}$) that could cause considerable wind erosion of peat. The sample of water was analyzed the same day of the sampling. At the laboratory, for each water sample, the total suspended solids dried at $103\text{-}105^\circ\text{C}$ was estimated by applying the 2540 D method from Ref. [31]. Precipitations and wind data were uploaded from the nearest weather stations from studied sites: Miscou-Island (48.008890°N , -64.494170°W), Low-Caraquet (47.802220°N , -64.833330°W) and Miramichi (47.009440°N , -65.465000°W) [32].

On the data obtained, the basic data treatments were carried out with analysis tool pack in Microsoft Excel 2013 (Microsoft, Seattle, Washington) software package: calculations of mean, median, maximum, minimum and numbers of samples. Weather data are presented in tables with sparkline graphs (a tiny visual representation of data allowing to monitor trends in a serie of values). A correlation matrix was established to evaluate the degree of (non)linearity of the variables. The coefficient of correlation (R), the coefficient of determination (R^2), the MAE (mean absolute error) and the $MAPE$ (mean absolute percentage error) of a multiple linear regression were

also calculated to verify the link between the monthly average CSS (concentration of suspended solids), the monthly average speed of the winds (W), the mean value of the slope of peatland (S), and the monthly accumulated precipitations (P) on the drained peatlands. The SE (standard error) of the estimate of the CSS calculated by the function using W , S and P has also been calculated. With n , the number of sample; x , the measured value; y , the forecast value; and $\bar{x}$ and $\bar{y}$, the mean values of x and y ; the MAE , the $MAPE$, and the SE are estimated by Eqs. (1)-(3):

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - x_i| \quad (1)$$

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{x_i - y_i}{x_i} \right| \quad (2)$$

$$SE = \sqrt{\frac{1}{(n-2)} \left[\sum (y - \bar{y})^2 - \frac{[\sum (x - \bar{x})(y - \bar{y})]^2}{\sum (x - \bar{x})^2} \right]} \quad (3)$$

Comparisons between sites, years and months were done. For all the three types of comparison, a covariance analysis has revealed a dependence between variables to compare. Thus, Friedman tests were performed. Corresponding to a non-parametric analysis of variance, the Friedman test compares the averages of several dependent groups. With a significance level, α equals to 0.05, the defined hypotheses are H_0 and H_1 : for H_0 , there was no

difference between samples; and for H1, there was a difference between samples. The result of the Friedman test will be presented by given in brackets the Chi square (χ^2), the degree of freedom (*df*) and the *p* value (*p*).

3. Results

3.1 Suspended Solids Concentrations

The concentrations of suspended solids in waters of the majority of samples meet the standard recommended by the Canadian Council of Ministers of the Environment, with results of no more than 25 mg·L⁻¹ above natural levels on average (Table 2 and Fig. 3) [33]. The trends varied from one site to another, but from the 12 sedimentation basins, only four showed a CSS exceeding 25 mg·L⁻¹ for some months: P2, P3, P5 and P8. The highest and the lowest concentrations of suspended solids were recorded at 61.75 mg·L⁻¹ in July 2010 for P5, and at 0 mg·L⁻¹ in September 2008 for P7, respectively (Table 2 and Fig. 3).

For P1, with close values of mean and median (10.94 mg·L⁻¹ and 10.00 mg·L⁻¹), the concentrations of suspended solids varied from 2.50 mg·L⁻¹ recorded in July 2009 to 21 mg·L⁻¹ measured for June 2008. For P2, the minimum value of the concentrations of suspended solids has been measured in September 2012 at 2.00 mg·L⁻¹. The 25 mg·L⁻¹ standard recommended was respected with values smaller than or equal to 18.50 mg·L⁻¹ unless in June and July 2011, months for which the concentrations of suspended solids were estimated at 33.50 mg·L⁻¹ and 39.00

mg·L⁻¹, respectively. With a lowest concentration of suspended solids estimated at 2.00 mg·L⁻¹ in September 2011 for P3, the 25 mg·L⁻¹ standard recommended was also mostly respected with values smaller than or equal to 18.00 mg·L⁻¹ unless in June 2008 (28.00 mg·L⁻¹) and September 2010 (37.00 mg·L⁻¹). P4 was one of the sites with the lowest values of concentrations of suspended solids always inferior or equal to 11.00 mg·L⁻¹ with a minimum value at 2.00 mg·L⁻¹ recorded in September 2008, September 2009 and July 2011. At P5, the majority of values of concentrations of suspended solids was lower than 19.00 mg·L⁻¹. In June 2010, the concentration of suspended solids was equal to 25 mg·L⁻¹ and this threshold was exceeded in July 2010 (61.75 mg·L⁻¹), July 2011 (28.00 mg·L⁻¹), and June 2012 (30.00 mg·L⁻¹).

All the measured values at P6 were lower than 24.88 mg·L⁻¹, with a minimum value of concentrations of suspended solids at 0.50 mg·L⁻¹ in August 2008. Similar to P4, P7 was also one of the sites with the lowest estimations of suspended solids always inferior or equal to 12.00 mg·L⁻¹ with a null minimum value in September 2008. For P8, the concentrations of suspended solids varied from 2.17 mg·L⁻¹ recorded in September 2011 and 56.00 mg·L⁻¹ measured for June 2012; aside from June 2012, the 25 mg·L⁻¹ standard recommended was not respected in September 2008 (27.33 mg·L⁻¹). For P9, the concentrations of suspended solids varied between 2.83 mg·L⁻¹ and 15.33 mg·L⁻¹, respectively estimated in June 2010 and August 2012. For P10, with almost homogeneous

Table 2 Brief descriptive statistics of suspended solids concentrations data of sedimentation basins from peatlands.

Peatlands	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Mean (mg·L ⁻¹)	10.94	11.65	10.01	4.90	14.42	9.30	5.27	13.37	7.48	13.64	8.78	8.69
Median (mg·L ⁻¹)	10.00	8.50	6.00	4.17	10.00	7.88	4.00	10.51	6.94	13.63	8.88	7.00
Minimum (mg·L ⁻¹)	2.50	2.00	2.00	2.00	3.50	0.50	0.00	2.17	2.83	6.80	3.00	4.00
Maximum (mg·L ⁻¹)	21.00	39.00	37.00	11.00	61.75	24.88	12.00	56.00	15.33	22.33	17.33	23.00
Number of samples	16	20	17	15	18	17	20	20	20	20	20	19

P1 to P12 symbolize the peatlands; the highest and the lowest values of suspended solids concentrations are in bold characters.

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Fig. 3 Temporal evolution of the concentration of suspended solids from 2008 to 2012 in summer. ND: no data; P1 to P12 symbolize the peatlands; on some graphs, the horizontal grey line represents the 25 mg·L⁻¹ standard for the Canadian guidelines for water quality for the protection of aquatic life.

values and with a very close mean and median values ($13.64 \text{ mg}\cdot\text{L}^{-1}$ and $13.63 \text{ mg}\cdot\text{L}^{-1}$), the concentrations of suspended solids ranged from $6.80 \text{ mg}\cdot\text{L}^{-1}$ (June 2008) to $22.33 \text{ mg}\cdot\text{L}^{-1}$ (August 2010). Similarly to P10, P11 presented close mean and median values ($8.78 \text{ mg}\cdot\text{L}^{-1}$ and $8.88 \text{ mg}\cdot\text{L}^{-1}$) with nearly identical values around $10 \text{ mg}\cdot\text{L}^{-1}$. At P11, the concentrations of suspended solids were between $3.00 \text{ mg}\cdot\text{L}^{-1}$ in September 2012 and $17.33 \text{ mg}\cdot\text{L}^{-1}$ in July 2008. Finally, all the measured values at P12 were lower than $23.00 \text{ mg}\cdot\text{L}^{-1}$, with a minimum value of concentration of suspended solids at $4.00 \text{ mg}\cdot\text{L}^{-1}$ calculated for August 2008 and September 2008.

3.2 Characterization of the Climate Events

In the case of this study, some climate events were analyzed. Because they could greatly influence a peat erosion by wind and/or water, data analysis was focused on the accumulated monthly precipitations and the speed of maximal gust (Table 3).

In summers from 2008 to 2012, the rain events were not always comparable from one year to another and from one weather station to another. The correlation matrix reveals no clear closeness between the three weather stations ($0.38 < R < 0.63$); and it was the same for months comparison ($-0.02 < R < 0.31$) (Table 3). The results interpretation took facts into account that: (1) summer rains could be very local; (2) weather stations considered were not located on the experimental sites. By considering the three weather stations, in 2008, no clear trend was observed about the rainfall. On the contrary, for the other years, the highest rainfalls were mainly recorded in June and July in 2009 and in September in 2010. In 2011, an almost equality of accumulated precipitations was noticed for June and July. In 2012, peaks of rainfall were mostly observed in June. By considering all data, the lower accumulated monthly precipitation (15.70 mm) was recorded in August 2010 and the highest one (164.80 mm) in September 2010 both at Low-Caraquet; the mean, the median and the modal

values were estimated at 88.27, 93.10 and 111.20 mm , respectively (Table 3).

The speed of maximal gust was also heterogeneous from one year to another considering the three weather stations in summers from 2008 to 2012. The correlation matrix between the three weather stations revealed a similarity between values from Low-Caraquet and Miscou-Island ($R = 0.93$). Otherwise, by comparing the 4 months of all considered years, there was no clear correlation ($0.16 < R < 0.63$) (Table 3). By taking all data into account, the lower speed of maximal gust ($32.67 \text{ km}\cdot\text{h}^{-1}$) was recorded in June 2011 at Low-Caraquet and the highest one ($44.50 \text{ km}\cdot\text{h}^{-1}$) was in September 2010 at Miscou-Island; the mean, the median and the modal values were estimated at 36.61, 36.48 and $36.94 \text{ km}\cdot\text{h}^{-1}$, respectively (Table 3).

In 2008, the highest values of wind for the three stations were recorded in September, and the lowest values were observed in June and July, except for Miramichi for which the minimum value was noticed in August. In 2009, the minimum value was observed at Low-Caraquet in July and the uppermost in August at Miscou-Island. In 2010, the maximum value was noticed at Miscou-Island in September and the lowermost in August at Miramichi. In 2011, the lowest value was observed at Low-Caraquet in June and the highest in September at Miscou-Island. In 2012, the peak value was noticed at Miscou-Island in September and the smallest value in July at Miramichi.

4. Discussion

4.1 Suspended Solids Concentrations: Spatial and Temporal Variability

For the comparison of the concentration of suspended solids between sites, whatever the years, the result of the Friedman test ($\chi^2 = 42.32$, $df = 11$, $p = 1.00\text{E} - 05$) revealed the presence of significant differences among some of the 12 studied sedimentation basins: P2 versus P4, P4 versus P10, P4

Table 3 Monthly temporal evolution of climate parameters (accumulated precipitation (mm) and speed of maximal gust (km·h⁻¹), respectively at the left and right side) recorded at three weather stations and correlation matrices of months, then weather stations. Sparkline graphs are illustrated at the right side of each sub-tables.

	June	July	August	September			June	July	August	September	
2008							2008				
Miramichi	111.20	101.90	152.00	93.80		Miramichi	34.10	35.97	32.94	37.50	
Low-Caraquet	97.60	46.90	54.40	108.90		Low-Caraquet	34.40	34.32	35.94	40.97	
Miscou-Island	78.20	49.70	163.40	125.40		Miscou-Island	36.60	35.71	38.10	44.17	
2009							2009				
Miramichi	131.10	118.00	82.40	62.10		Miramichi	37.07	35.10	36.97	34.27	
Low-Caraquet	84.30	106.70	24.20	42.50		Low-Caraquet	36.90	33.58	38.87	38.30	
Miscou-Island	61.20	99.90	32.00	42.30		Miscou-Island	38.73	37.10	42.58	41.90	
2010							2010				
Miramichi	96.90	69.60	31.80	136.70		Miramichi	34.64	36.48	33.10	35.73	
Low-Caraquet	93.10	44.10	15.70	164.80		Low-Caraquet	36.59	34.61	33.42	39.10	
Miscou-Island	82.50	62.30	34.50	149.50		Miscou-Island	42.17	36.74	35.81	44.50	
2011							2011				
Miramichi	106.80	102.20	140.30	53.40		Miramichi	33.07	35.16	36.94	33.97	
Low-Caraquet	121.20	129.70	81.20	110.10		Low-Caraquet	32.67	36.52	34.97	37.50	
Miscou-Island	94.60	98.60	77.70	73.20		Miscou-Island	35.23	38.39	38.71	41.27	
2012							2012				
Miramichi	110.10	27.10	81.60	88.30		Miramichi	35.83	33.71	34.87	37.33	
Low-Caraquet	96.90	84.40	99.50	73.80		Low-Caraquet	36.60	36.94	33.74	38.90	
Miscou-Island	95.40	73.00	67.40	48.80		Miscou-Island	38.73	38.42	36.71	43.87	
	June	July	August	September			June	July	August	September	
June	1					June	1				
July	0.30	1				July	0.24	1			
August	0.31	0.13	1			August	0.32	0.16	1		
September	-0.02	-0.53	-0.15	1		September	0.63	0.44	0.35	1	
	Miramichi	Low-Caraquet	Miscou-Island			Miramichi	Low-Caraquet	Miscou-Island			
Miramichi	1					Miramichi	1				
Low-Caraquet	0.38	1				Low-Caraquet	0.48	1			
Miscou-Island	0.61	0.63	1			Miscou-Island	0.45	0.93	1		

versus P11, and P7 versus P10. By taking all the years whatever the location of sites into account, the result of the Friedman test ($\chi^2 = 6.28$, $df = 4$, $p = 1.79E - 01$) showed no significant difference among the 5 years considered. Finally, by considering each month whatever the years and the studied sites, the result of the Friedman test ($\chi^2 = 17.81$, $df = 3$, $p = 4.80E - 04$) indicated the existence of just one significant difference between July and September.

Besides the statistical analyses, the lowest values of concentrations of suspended solids were mainly observed in September (for two-thirds of sites); and the highest ones in June and July (with three highest values) (Fig. 3). Some exceptions were noticed: the highest value for P3 and P12 were estimated in September 2010 ($37.00 \text{ mg}\cdot\text{L}^{-1}$) and September 2012 ($23.00 \text{ mg}\cdot\text{L}^{-1}$), respectively; the lowest values for P9 and P10 were observed in June 2010 ($2.83 \text{ mg}\cdot\text{L}^{-1}$) and June 2008 ($6.80 \text{ mg}\cdot\text{L}^{-1}$), respectively. Otherwise, based on all the sedimentation basins of all peatlands and by comparing the months of each year relative to each other, the calculation of correlation matrix demonstrated a resemblance between values obtained for months of July 2009 and 2012 ($R = 0.77$), for months of September 2011 and 2012 ($R = 0.81$), and between September 2008 and June 2012 ($R = 0.70$). This observation implied a seasonality probably related to the seasonality of precipitation. From the comparison between months of each year, 50% of coefficients of correlation were inferior or equal to the absolute value of 0.30; and more than 75% of values of coefficients of correlation were inferior or equal to the absolute value of 0.50.

These results on the concentration of suspended matters in the sedimentation basins of drained peatlands confirm those previously done in eastern New Brunswick [34-36], except that these previous studies were focused in spring and autumn with continuous measurements. The results acquired for the suspended solids rate in this case of study could probably be explained by climate events (excessive

precipitations or winds) or by the knowing of the maintenance conditions of sedimentation basins.

4.2 Suspended Solids Concentrations Related to Climate Events

In the context of agricultural soils, the assessment of the amount of suspended solids released in the water system is usually done by software and models. Among many of them, it could be cited the USLE (universal soil loss equation) model [37, 38], the SWAT (soil and water assessment tool) model [39, 40], and the STREAM (sealing and transfer by runoff and erosion in relation with agricultural management) software [41, 42]. For estimating soil loss by erosion, these models and software take several parameters related to climate, soil physical properties and vegetation/land cover or land use into account. More specifically with respect to the land cover, they are interested in the nature, the density, and the presence/absence of vegetation cover. Considering the soil, they focus on the topography, the crusting, the erodibility, the particle size distribution, and the structural stability. And about the climate, they are primarily concerned with rainfall erosivity and precipitation amounts.

In the context of the study, all these cited parameters were unavailable making these software and models un-adapted for the studied sites. The best and simple method to assess the CSS in the sedimentation basins of the drained peatlands is to sample the water and then calculate it by sieving. Nevertheless, knowing that the slope, the precipitations and the winds could greatly influence the loss of peat particles, the relationship between these factors and the CSS was verified. The statistical tests reveal that the CSS was insignificantly correlated exclusively with precipitation ($R = -0.01$), and this results confirm those of Ref. [36]. Then, from the preceding results, based on peatlands P4, P6, P9, P10, P11 and P12, a simple function that allows calculating the CSS has been derived. By knowing the accumulated monthly

precipitation (P in mm), the mean value of the slope on the peatlands (S in %), and the speed of the wind (W in $\text{km}\cdot\text{h}^{-1}$), the CSS ($\text{mg}\cdot\text{L}^{-1}$) can be expressed as:

$$CSS = 57.59 \times S + 7.18 \times \sqrt{\log_{10}(W)} - 0.35 \times \sqrt{P} \quad (n = 111) \quad (4)$$

This function can be considered acceptable with a R , a R^2 , a MAE and a $MAPE$, respectively evaluated at 0.87%, 0.76%, 4.01% and 3.61%. The SE measuring the degree of error in predicting CSS calculated (via the proposed formula) from CSS measured was estimated at 1.47. From Eq. (4), an estimation of the CSS can rapidly be done just by using the slope and simple weather parameters that are easy to obtain.

4.3 Suspended Solids Impacts

The role of sedimentation basins is not always accomplished: an optimal sedimentation efficiency was not permanently reached, allowing a release of particles in the water system. Indeed, a previous study done by Es-Salhi et al. [36] in New Brunswick demonstrated that the rate of suspended matters from sedimentation basin of drained peatlands exceeded $25 \text{ mg}\cdot\text{L}^{-1}$ several times; the same observation was found in a study completed during the spring season in Ref. [34]. Thus, the peatlands drainage is one of the causes of an excess of solids suspension in the water system. These suspended matters lead to environment changes. The ecological impacts that could be caused by suspended solids in the water system may affect the water quality, and then the environment and the ecosystem [43]. Depending on the hydrograph and the speed of flow of the water entering in the water system, the shape of the latter could be modified by creating new areas of sedimentary deposits. Also, the color of the water may be darken because of the increase of turbidity [26]. But the most problematic impact could certainly be related to the aquatic biota. Indeed, Laine [44] showed how the consequences of the drainage of peatlands can affect the size and the eating habits of salmon. High CSS could even cause

anoxia in a standing water or a water with lowest flows. There are several parameters allowing to determine the effect of the suspended solids on aquatic biota including impacts on fishes living in the hydrographic network [45-47]. Among others, the main factors are the concentration, the chemical composition, the physical properties (particle-size distribution, particles shape and degree of peat decomposition) and the residence time of the various particles in the water. Further investigation concerning these latter factors on the 12 sites will precisely give an idea of the ecological impacts of the measured suspended solids concentrations on the aquatic life.

5. Conclusion

This study found that the amount of suspended matters in peatlands sedimentation basins of the east coastal zone of New Brunswick did not always meet the environmental standards of the province. Water from these sedimentation basins are among those that join the streams and surrounding rivers being an integral part of the hydrographic system of the watersheds in that region of New Brunswick. Thus, the knowledge of the water state and the water quality of these sedimentation basins through this study was important, especially since it is a region where the largest peat industry production in Canada is concentrated. Undertaken on some sites, the recent managements of abandoned peatlands will initiate a long-term monitoring program to study the impact of agro-ecological management on the quality and quantity of suspended solids in Canadian peatlands sedimentation basins.

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