Natural organic matter export from boreal catchments (the Salaca River basin, Latvia) and its influencing factors

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ABSTRACT

A noteworthy increase in the organic matter concentration and export, as well as water colour, in the catchments of the Salaca River has been observed during the last decades. This study investigates factors behind this increase: the impact of climate, land use and human loading changes on the concentrations and export of the organic matter in the Salaca River/Lake Burtnieks catchments. Proportion of wetlands in the river basin, type of land use, and runoff regime can be considered as the main factors influencing the organic carbon loadings. Despite a steady overall tendency of increase, considerable oscillations of organic matter loadings influenced by the changes in the river discharge regime were observed for extended periods of time.

Key words | chemical oxygen demand, climate change, Latvia, organic matter, total organic carbon

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INTRODUCTION

Natural organic matter (NOM) in the forms of total organic carbon (TOC), dissolved organic carbon (DOC) and particulate organic carbon (POC) has an important role in the carbon global biogeochemical cycle and in surface waters, influencing mineral weathering, nutrient cycling, photochemical processes and aquatic communities (Stevenson 1994). The organic substances accumulated in wetlands and soils are important reserves of dissolved and particulate organic matter. However, human activities (e.g., peat extraction, agricultural activities and changes in land use) as well as global climate change can intensify the release of stored carbon both as greenhouse gases and as organic substances dissolved in surface waters (Hope *et al.* 1994). Considering this, the flows of natural organic matter could be a very important indicator of climate change (Hejzlar *et al.* 2003; Worrall *et al.* 2003; Arvola *et al.* 2004; Evans *et al.* 2005). A recent significant increase in organic matter concentration in surface waters in several regions of the world has incited discussions about the reasons of water 'brownification' (as organic substances are a major source of brown colour of surface waters) (Evans *et al.* 2005; Mattsson *et al.* 2005; Clair *et al.* 2008).

Biogeochemical processes within the water body can be influenced by organic matter produced within the waterbody (autochtonous sources) or terrestrial supply (allochtonous sources) (Clark *et al.* 2008). Natural organic matter production processes interfere with human-induced changes in their intensity and character and direct human impacts on organic matter production and export (e.g., discharge of wastewaters, etc.). A multitude of factors influencing NOM production cause a high seasonal and spatial variability depending on the climatic and geological factors and land use in the catchment.

Several studies have correlated dissolved organic matter concentrations with a range of watershed properties (Worrall & Burt 2007). Peatland areas are often considered as the major source of natural organic matter in terms of concentration and loadings (Clark *et al.* 2008). The concentration in peat bog drainage water can range from 10 to 60 $\mathrm{mg\,l^{-1}}$ in comparison with common values 2–10 $\mathrm{mg\,l^{-1}}$ worldwide in lakes and rivers (Thurman 1985).

The aim of this paper is to study the export of organic matter (chemical oxygen demand (COD), TOC, DOC, POC) from boreal catchments in Latvia and to characterise the factors influencing the NOM export and trends of concentration changes.

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MATERIALS AND METHODS

The study was conducted in the Salaca River/Lake Burtnieks basin over the period from 1977 to 2009 (Figure 1). The Salaca River basin is located in the northern part of Latvia (3,184 km^2) and in Estonia (237 km^2). The length of the Salaca River is 95 km. Lake Burtnieks is located within the Salaca River basin and has a surface area of 40.07 km^2 (Druvietis *et al.* 2007). It is the fourth largest lake in Latvia, and its basin is for the most part situated in the territory of the North Vidzeme Biosphere Reserve (established in 1995). Due to intensive agricultural pollutant load during the second half of the 20th century and lake-level lowering, presently the lake is eutrophic (Bilaletdin *et al.* 2004). The bedrock of the Salaca River basin is covered by Quaternary deposits consisting of moraine material and limnoglacial and fluvioglacial deposits. A large part of the Salaca River basin is occupied with mires developed as a result of the paludification of land after the Ice Age. The area of the largest Seda mire is estimated at 7,582 ha. Intensive peat mining takes place in the area, and the abandoned mining sites are gradually transforming to lakes.

The climatic conditions can be characterised as humid with a mean annual precipitation of 650–700 mm. As a result of the influence of cyclones, summer temperatures are slightly lower and winter temperatures are higher than the average for temperate zones. The mean temperature in January varies from -2.6 to $-6.6\,^{\circ}C$ and in July from $+16.8$ to $+17.6\,^{\circ}C$. The tributaries of the Salaca River and Lake Burtnieks have mixed water feeding: rain, snowmelt and groundwater. The river discharge in spring is 45–55% of the total annual discharge, and winter contributes only 15–20% of the annual discharge (Klavins *et al.* 2002). The Salaca River discharges into the Gulf of Riga.

Long-term monitoring data on COD, water colour, parameters of basic water chemistry and river discharge at the mouth of the Salaca River were obtained from the Latvian Environment, Geology and Meteorology Centre for the period of 1977–2009 (COD for the period of 1983–2002). Water colour was determined colourimetrically until 1995 and spectrophotometrically after 1995, using the Pt/Co scale. COD was determined by oxidation with $K_2Cr_2O_7$ and subsequent titration with ferrous ammonium sulphate (Standard Methods 1973).

A detailed survey of the Salaca River basin was carried out from January 2007 until March 2009. Monthly water samples were taken at the sites shown in Figure 1.

The concentration of dissolved oxygen, pH, temperature and conductivity were measured in the field by a HACH HQ40d portable meter. TOC, DOC and total N were

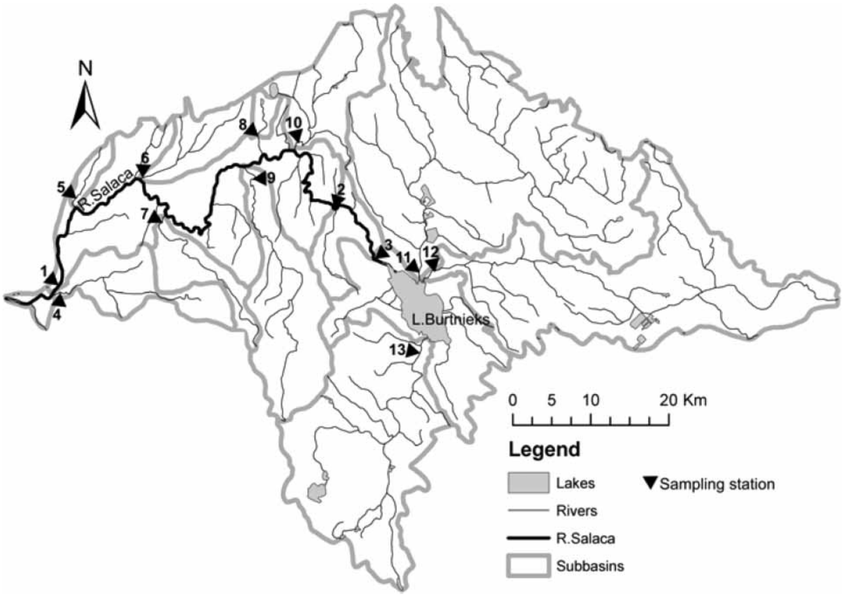

Figure 1 | Location of monitoring sites (▾). Number of sampling stations as in Table 1.

measured using a Shimadzu Total Organic Carbon Analyzer TOC – V_{CSN}. Unfiltered samples were used for TOC analysis, but samples for DOC analysis were filtered through 0.45 μm nylon filters (Whatman GD/X) before analysis. The TOC analyser directly measures total carbon and inorganic carbon, while the concentrations of TOC are expressed as the difference between total carbon and inorganic carbon. A sample for total carbon analysis undergoes oxidative combustion at 680 °C to form carbon dioxide. For inorganic carbon analysis, the sample is acidified with HCl to pH3; as a result, carbonates produce CO_2. Concentration of carbon dioxide is detected by means of a non-dispersive infrared (NDIR) gas analyser. A sample volume for total nitrogen analysis is combusted at 720 °C; in effect, the nitrogen compounds present in the sample are converted into nitrogen monoxide, the concentration of which is then detected using a chemiluminescence gas analyser. Fresh, ultra-pure water (Millipore, Direct-Q3 Water Purification Systems) containing less than 10 ppb TOC were used for preparing standard solutions. Reagent grade potassium hydrogen phthalate and potassium nitrate were used to prepare standard solutions for total carbon and total nitrogen, respectively, whereas sodium hydrogen carbonate and sodium carbonate solutions were used as standards for inorganic carbon. Multi-point calibration curves were made for each component. The accuracy and precision of the results were checked by analysing standard reference solution with each series of samples.

Correlation between COD and TOC was estimated using a calibration experiment, and the following ratio between the recorded COD and TOC values was obtained:

$$\mathrm{TOC} = (0.2928 \times \mathrm{COD}) + 7.9503;\ R^2 = 0.611,\ p\text{-value} < 0.05;\ n = 215$$

(R^2, determination coefficient; n, number of observations).

A similar approach has been used in other studies (e.g., Hejzlar *et al.* 2003; Worrall *et al.* 2003; Worrall & Burt 2007; Erlandsson *et al.* 2008) to calculate the DOC or TOC values from historical data of water colour, COD_{Mn} or COD_{Cr}.

Long-term changes of TOC concentrations were studied by using the non-parametric Mann–Kendall test (Hirsch *et al.* 1982; Hirsch & Slack 1984). This test can be applied for data sets that have non-normal distribution, missing values or 'outliers' and serial character (e.g., seasonal changes). If the Mann–Kendall test value is greater than 1.96, the trend is increasing at a significance level $p < 0.05$.

Table 1 | Land cover types in the Salaca River basin (CORINE Land Cover 2000 Latvia, 2003)

No. of sampling site[a]	Basin	Total area, km^2	Forests and natural areas, %	Arable land, %	Other agric. land, %	Bogs, %	Water, %	Urban areas, %
1	Salaca – total	3,420.0	55.94	20.98	16.80	4.01	1.89	0.38
2	Salaca – Skaņaiskalns	2,086.2	51.61	24.30	17.72	3.23	2.71	0.43
3	Salaca – Vecate	1,985.0	52.48	23.27	17.75	3.29	2.82	0.39
4	Korģe	112.0	64.63	20.67	11.03	3.43	0.24	0.00
5	Melnupe	20.0	75.09	14.46	5.45	5.00	0.00	0.00
6	Glāžupe	89.2	71.66	8.75	5.84	13.52	0.00	0.23
7	Jogla	49.0	63.41	12.32	21.96	1.48	0.37	0.46
8	Piģele	50.0	14.85	0.06	0.45	83.01	1.63	0.00
9	Iģe	226.0	57.08	15.21	23.24	4.37	0.00	0.10
10	Ramata	195.0	66.88	14.31	12.99	4.40	1.42	0.00
11	Rūja	962.0	52.34	29.99	14.65	1.76	0.73	0.53
12	Seda	542.5	57.78	16.86	20.22	3.78	0.92	0.44
13	Briede	449.0	55.51	17.09	20.20	5.50	1.51	0.19

[a] Sampling sites as in Figure 1.

Table 2 | Chemical composition of the studied river water (2007–2009; mean ± S.D.)

No	Station	NH_4^+, mg l^{-1}	N_{tot}, mg l^{-1}	PO_4^{3-}, mg l^{-1}	Si_{tot}, mg l^{-1}	HCO_3^-, mg l^{-1}	TOC, m g l^{-1}	pH	Conductivity, μS cm^{-1}	O_2, mg l^{-1}
1	Salaca – Vecsalaca	0.31 ± 0.06	1.46 ± 0.49	0.020 ± 0.007	4.75 ± 1.47	210.2 ± 46.3	24.48 ± 3.00	8.02 ± 0.37	306.4 ± 46.0	12.08 ± 1.46
2	Salaca – Skaņaiskalns	0.29 ± 0.09	1.68 ± 0.54	0.019 ± 0.005	5.29 ± 1.57	207.6 ± 19.2	23.89 ± 2.34	7.91 ± 0.22	334.0 ± 20.8	10.00 ± 2.59
3	Salaca – Vecate	0.30 ± 0.07	1.63 ± 0.61	0.018 ± 0.005	5.08 ± 1.73	206.1 ± 16.7	24.44 ± 2.58	8.00 ± 0.40	325.9 ± 20.3	10.30 ± 2.10
4	Korģe	0.32 ± 0.11	1.23 ± 0.53	0.017 ± 0.005	4.76 ± 1.48	233.1 ± 75.3	25.81 ± 4.49	8.02 ± 0.48	331.2 ± 93.0	12.20 ± 1.69
5	Melnupe	0.47 ± 0.15	1.21 ± 0.46	0.025 ± 0.007	6.03 ± 1.79	215.4 ± 98.1	29.24 ± 8.56	7.67 ± 0.36	305.3 ± 126.3	11.10 ± 2.04
6	Glāžupe	0.57 ± 0.17	1.15 ± 0.26	0.017 ± 0.004	4.11 ± 1.57	129.3 ± 69.9	34.78 ± 9.12	7.40 ± 0.36	181.6 ± 106.5	11.03 ± 2.37
7	Jogla	0.32 ± 0.11	1.40 ± 0.76	0.031 ± 0.006	5.56 ± 1.61	230.9 ± 60.0	21.77 ± 5.21	7.83 ± 0.33	355.5 ± 67.7	11.19 ± 1.85
8	Piģele		0.69 ± 0.14	0.023 ± 0.011	3.01 ± 2.75	28.5 ± 7.7	35.48 ± 6.16	6.37 ± 0.32	31.0 ± 6.6	10.21 ± 1.39
9	Iģe	0.34 ± 0.08	1.46 ± 0.67	0.022 ± 0.005	5.04 ± 1.54	221.5 ± 51.2	25.53 ± 5.28	7.88 ± 0.27	335.0 ± 66.7	11.33 ± 1.90
10	Ramata	0.39 ± 0.08	1.21 ± 0.35	0.021 ± 0.004	4.60 ± 1.28	226.1 ± 64.8	26.64 ± 4.04	7.64 ± 0.40	317.8 ± 72.6	10.71 ± 2.12
11	Rūja	0.32 ± 0.09	1.73 ± 0.86	0.021 ± 0.005	5.09 ± 1.28	249.2 ± 50.7	24.21 ± 5.01	7.69 ± 0.31	388.7 ± 64.8	9.95 ± 2.12
12	Seda	0.34 ± 0.08	1.69 ± 0.93	0.026 ± 0.009	5.27 ± 1.35	217.7 ± 41.4	26.87 ± 6.80	7.58 ± 0.38	341.5 ± 59.8	9.34 ± 1.34
13	Briede	0.37 ± 0.10	1.62 ± 0.92	0.023 ± 0.005	5.30 ± 1.22	221.3 ± 66.3	24.98 ± 5.17	7.64 ± 0.43	340.0 ± 85.3	10.28 ± 1.55
	L. Burtnieks	0.30 ± 0.08	1.62 ± 0.52	0.017 ± 0.006	4.97 ± 1.91	207.9 ± 22.2	25.07 ± 3.10	8.33 ± 0.48	321.7 ± 23.2	11.0 ± 1.67

If the test value is less than −1.96, the trend is decreasing at a significance level $p < 0.05$. Trends were quantified by Sen's method for the estimation of slope. A version of MULTIMK/CONDMK programme, which also includes estimates for Sen's slope, was used for the purpose of detecting and quantifying trends (Sen 1968; Libiseller & Grimvall 2002). To avoid the impact of changes in analytical methods on the study results, the Mann–Kendall test was applied for the period of 1996–2005 separately, because water colour was measured by uniform methods over this period.

RESULTS AND DISCUSSION

Organic carbon concentrations in surface waters are influenced by natural and human-induced processes. In this study, the Salaca River basin was selected mostly because of the relatively low impact of human activities in its basin. Both the spatial and seasonal variability in the concentrations of organic substances in the Salaca River basin waters were comparatively high. The larger proportion of wetlands (Table 1) in the Piģele River (83%) supported higher TOC concentrations in the waters of this river. The TOC concentrations varied from 21–25 mg l^{-1} in the Salaca, Iģe and Jogla River waters to 35–40 mg l^{-1} in the Piģele, Glāžupe and Melnupe Rivers (Table 2, Figure 2). Agricultural areas within the studied river basin occupy a relatively small part (Table 1), and the population density (especially if compared with Western European countries) is low; hence, it can be supposed that the impact of direct human loading on TOC concentrations was comparatively low. It can also be supposed that the TOC values in surface waters were influenced by abundant wetlands, a high degree of eutrophication in Lake Burtnieks, surface leakage of soil humus (more intense during spring and autumn floods) and the impact of wastewater.

A very important aspect as to why the Salaca River basin was selected for in-depth study was the observed increase in water colour – also known as brownification (concentration of coloured dissolved organic substances) – during the last few decades (Figure 2). This phenomenon is also known in other European countries and elsewhere (Worrall *et al.* 2003; Hongve *et al.* 2004; Roulet & Moore 2006; Worrall & Burt 2007). During the period of increased water colour, human impact (agricultural activities and urban development) was relatively stable – considering the protected area status of the study region.

To obtain more detailed information on the flow of organic matter, monthly sampling was carried out in the Salaca River basin for the period from 2007 to 2009. The year 2008 was characterised by higher discharges, especially during spring and late autumn (Figure 3). January 2007 was unusually warm (monthly average air temperature +0.3 °C) and wet. Air temperatures in January 2008 and February

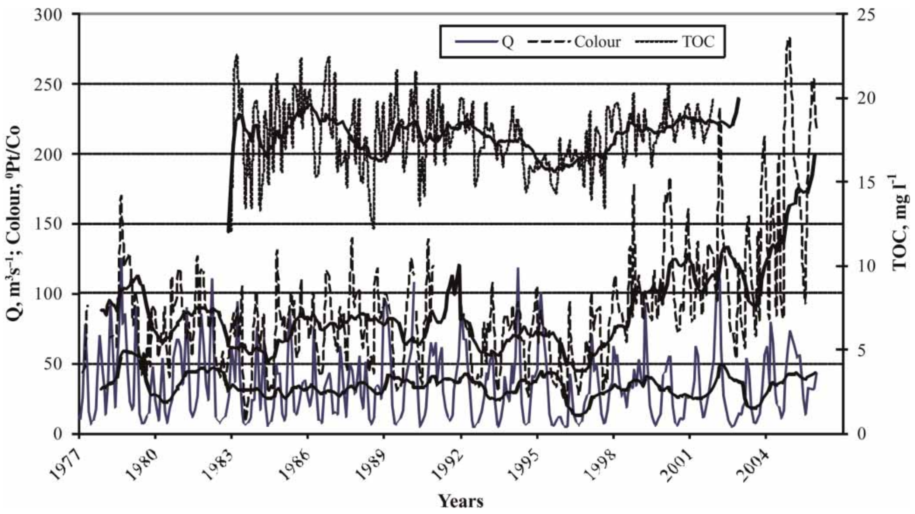

Figure 2 | Long-term (1977–2005) changes in the Salaca River discharge, TOC concentrations and water colour (data were smoothed with a 12-month moving average).

2008 were $-0.6\,^{\circ}\mathrm{C}$ and $+1.7\,^{\circ}\mathrm{C}$, respectively, i.e. above the average long-term values. Wet and warm winters will possibly be common for future climate according to the existing climate change modelling results (Andreasson *et al.* 2004). Concentrations of TOC varied between different sampling stations (Table 2) and may have been influenced by land use patterns in the basins. The concentration of dissolved organic matter in streams can range from <1 to about 50 mg l^{-1} (Mulholland 2003), and the abundance of wetlands within a watershed has a strong influence on the organic matter concentration (Eckhardt & Moore 1990). The highest nutrient concentrations in both 2007 and 2008 were observed in January and February (total nitrogen was about 3.0 mg l^{-1}). Typically, the highest nutrient concentrations in the Latvian rivers are observed during the spring

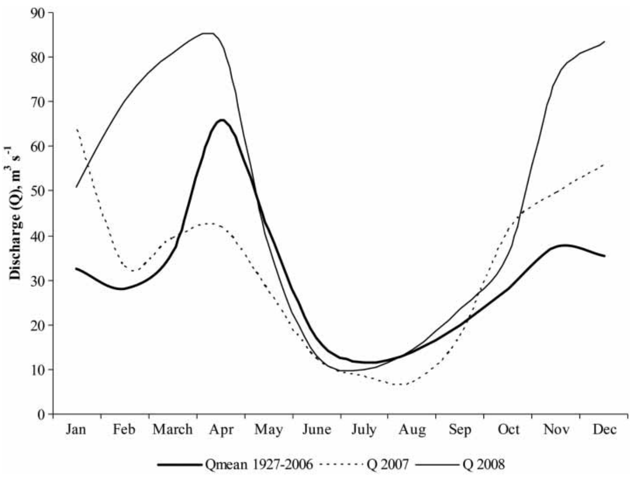

Figure 3 | Monthly long term (1927–2006) and monthly mean (for 2007 and 2008) discharge of the Salaca River at the Lagaste hydrological station (river mouth station No. 1 in Figure 1).

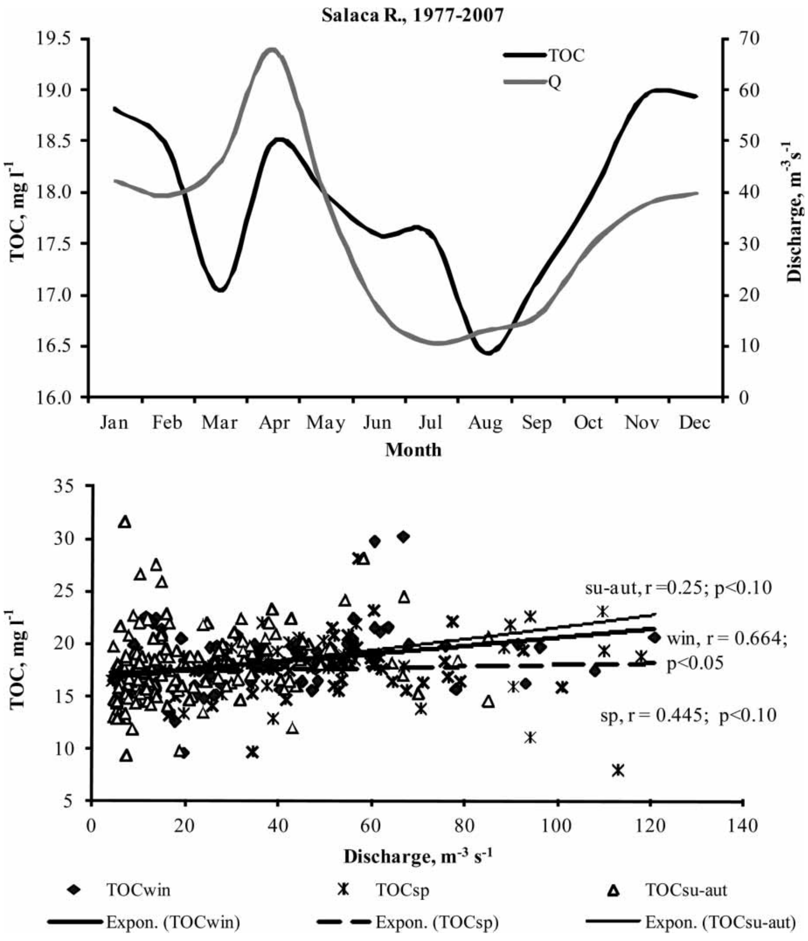

Figure 4 | Seasonal changes of TOC and discharge in the Salaca River and Spearman's rho correlation for seasonal changes of discharge and TOC (Lagaste station, monthly average values for the period 1983–2005).

Table 3 | Long-term changes of water chemical composition according to the Mann–Kendall test in the Salaca River (N = number of observation; in bold, $p < 0.05$)

Period	Colour	TOC	N-NO_3^-	P-PO_4^{3-}	HCO_3^-	SO_4^{2-}	Mg^{2+}	Na^+	pH
1983–2005	**3.33**	0.38	**– 1.76**	**1.71**	0.71	**– 2.70**	0.54	**– 2.06**	**– 3.48**
	$N = 243$	$N = 222$	$N = 241$	$N = 252$	$N = 164$	$N = 164$	$N = 164$	$N = 166$	**254**
1996–2005	**2.90**	**2.16**	–0.83	–0.51	–0.54	**– 2.61**	–1.36	–0.38	**– 1.94**
	$N = 109$	$N = 77$	$N = 109$	$N = 107$	$N = 83$	$N = 83$	$N = 83$	$N = 85$	$N = 109$

flooding (Klavins *et al.* 2001). Our findings are in agreement with experimental observations (Patil *et al.* 2010) and modelling results (e.g. Kastea *et al.* 2006) that predict increased leaching of nitrates from boreal catchments in the winter season. Concentrations of HCO_3^-, Ca^{2+} and other major ions were low in those rivers that are draining waters from wetlands (the Glāžupe and Piġele Rivers). The aquatic chemistry of the Salaca River was much more influenced by the composition of water in eutrophic Lake Burtnieks than by the composition of its tributaries, since as much as ~60% of the river discharge volume is formed as runoff from Lake Burtnieks and ~40% from the tributaries.

The yearly trends in changes of organic matter concentration indicators (TOC) are highly variable and have well-expressed seasonal character (Figure 4). There is a positive correlation between TOC and discharge in the Salaca River during the winter, spring and autumn seasons; however, the correlation on a yearly basis is lower than the seasonal correlation. The closest relationship between TOC concentration and discharge is observed in winter ($r = 0.664$; $p < 0.05$), possibly indicating that warmer winters, when most of the precipitation falls out as rain, can lead to increased concentrations of organic matter.

On a seasonal basis, the highest TOC concentrations are observed during late winter/spring (from March to April and May) and can be associated with spring floods. During this season, statistically significant ($p < 0.10$) correlation between TOC and river discharge is observed, and the character of changes is nearly coherent. The lowest concentrations of TOC are observed in early spring before flood maximum and in summer (Figure 4). Organic matter concentration indicator values increase during summer as well (June–August). In autumn (September–November), TOC values are increasing (possibly due to the decay of organic matter commonly formed in eutrophic Lake Burtnieks as well as decay of higher vegetation). Relatively weaker correlation ($r = 0.25$; $p < 0.10$) is between discharge, TOC and colour, and it is common for summer and autumn seasons.

The Mann–Kendall test and Sen's slope estimator were applied to detect changes in TOC and the parameters of basic aquatic chemistry over the last decades. TOC concentrations show a statistically significant increase ($p < 0.05$) – by 0.68 mg l^{-1} per year from 1996 to 2003. There are no significant linear trends for the period 1983–2003; an oscillating pattern can be observed instead (Table 3, Figure 2). According to Sen's slope estimator, a sharp increase (by 15.5° Pt/Co units) of water colour values is observed starting from the mid-1990s, while there are no statistically significant changes ($p < 0.05$) of water colour for the period 1983–1995 if treated separately. Moreover, Sen's slope estimator shows that colour values have even slightly decreased (by 5.6° Pt/Co units per year) during 1983–1995. Nutrient concentrations as well as bicarbonate and sodium ion concentrations for the study period do not show statistically significant trends. Concentrations of sulphate and magnesium ions show a decreasing trend for the study period, while the statistically significant decrease in sulphate ion concentrations might be related to a decreasing trend of acidic precipitation. The latter is considered as one of the factors causing 'brownification' of surface waters (Evans *et al.* 2005), and this factor might be effective also in the Salaca River basin. Coloured dissolved organic matter comprises part of the total DOM pool, which is characterised by high molecular weight as well as hydrophobic and refractory substances. Water colour values have almost doubled since the mid-1990s. It is also possible that the increasing trends of TOC are due to increased concentrations of coloured organic matter. Hongve *et al.* (2004) have observed increased water colour values along with no significant changes in DOC concentration in Norwegian lakes. The increase of water colour is ascribed to increased total precipitation and rainfall intensity that favours leaching of coloured compounds with higher molecular weight from upper soil horizons. In accordance with our results, a major increase in water colour occurred in November, December and January, indicating possible leaching from catchment areas in milder winters, as there exists a correlation between the discharge and concentration of organic matter. Seasonal trends of TOC (Figure 5) demonstrate that the most significant increase of TOC concentrations takes place during spring season and January. The increasing trend in spring can be related to the increased supply of allochtonous organic matter from terrestrial environment, including wetlands.

There are significant differences in the concentrations of TOC, DOC and POC in waters depending on the concentration levels and season (Figure 6). In the waters of Lake Burtnieks, the maximal values of POC are observed during the summer season, and consist of phytoplankton, whose biomass can reach up to 6 mg l^{-1} (Druvietis *et al.* 2007), whereas in the waters of the studied rivers, as can be seen in the example of the Salaca and Glāžupe Rivers, the maximal POC values can be observed during the autumn season, and can thus be related to the combination of particulate matter coming as surface runoff and decay of biota. In previous studies (Wetzel *et al.* 1977; Dawson *et al.* 2008), the highest POC loading in small hardwater streams was found during the reduced stream discharge in summer, and the maximum vegetative growth, in early winter. The minimum POC concentrations, in turn, occurred during the deciduous leaf-fall in autumn (Wetzel

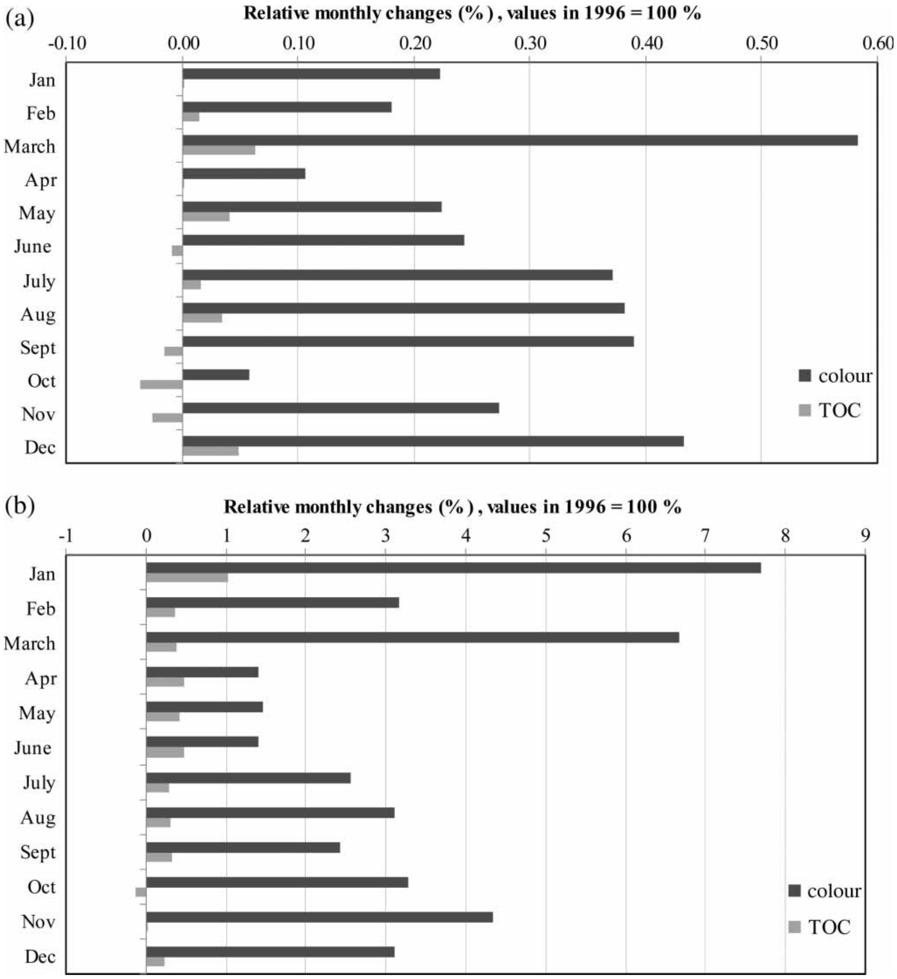

Figure 5 | Relative change (%) of monthly Sen's slope values for water colour and TOC in the Salaca River for the periods 1983–2005 and 1996–2005 (for TOC – up to 2003). Negative values indicate decreasing concentrations.

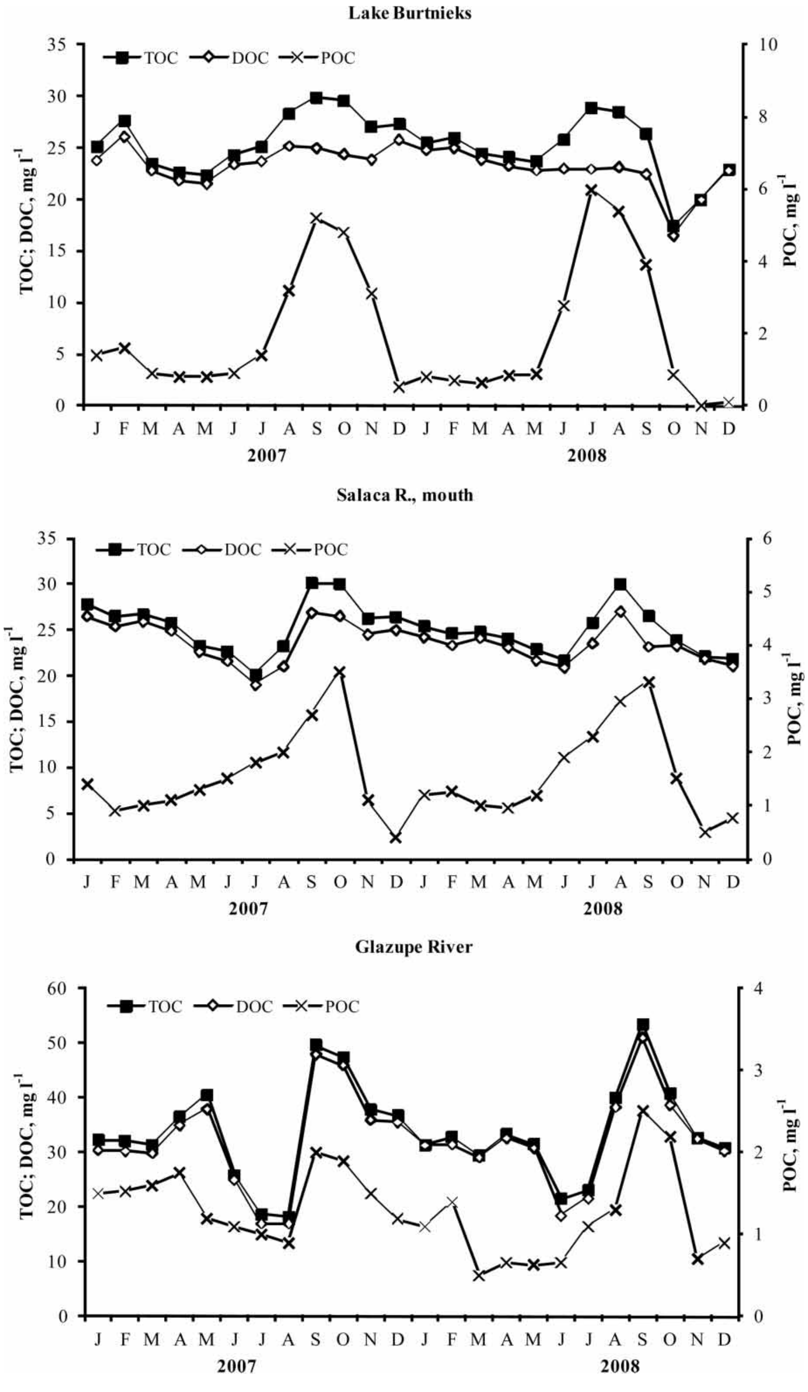

Figure 6 | Seasonal changes of organic matter concentration (in the waters of Lake Burtnieks and the Salaca and Glāžupe Rivers).

et al. 1977). Our study demonstrates a significantly different pattern of seasonal POC export and TOC/DOC/POC balance (Table 4) and highlights the dominance of local hydrobiological conditions (production of detritus composing a significant part of POC in the eutrophic lake), a possible impact of specific organic matter sources (bogs) and a major influence of climatic factors in each studied site. The importance of the landuse pattern on the

Table 4 | Seasonal export of natural organic matter from the Salaca River basin

	Rūja	Seda	Briede	Ramata	Melnupe	Glāžupe	Jogla	Iģe	Korģe	Salaca
Annual runoff, mm yr^{-1}	261	276	278	262	282	351	335	293	380	272
Annual TOC export, kg ha^{-1} yr^{-1}	89	129	116	97	138	139	98	110	111	105
Relative seasonal TOC export, %										
Summer	6	5	5	6	4	7	5	5	6	6
Autumn	16	15	16	25	26	28	24	25	24	24
Winter	36	36	35	34	35	32	36	34	35	34
Spring	43	44	43	35	35	34	36	37	35	37
Relative seasonal POC export, %										
Summer	8	1	4	6	7	11	5	5	17	9
Autumn	11	8	14	21	37	32	19	23	30	23
Winter	41	20	17	41	43	34	42	25	37	31
Spring	39	71	65	33	19	22	35	46	15	36
Daily TOC export, kg ha^{-1} day^{-1}										
Summer	0.05	0.06	0.07	0.06	0.06	0.10	0.08	0.05	0.07	0.07
Autumn	0.15	0.21	0.20	0.26	0.39	0.41	0.41	0.29	0.29	0.26
Winter	0.35	0.52	0.45	0.35	0.52	0.47	0.63	0.41	0.43	0.38
Spring	0.42	0.62	0.54	0.37	0.51	0.50	0.61	0.43	0.42	0.41

organic matter production emphasises the significant correlation between annual TOC export and area of wetlands in the study area (Figure 7).

The dominance of wetlands in several of the studied river basins, in line with intensive eutrophication in Lake Burtnieks, thus can be considered as an important factor influencing organic matter export from the Salaca River and its tributaries.

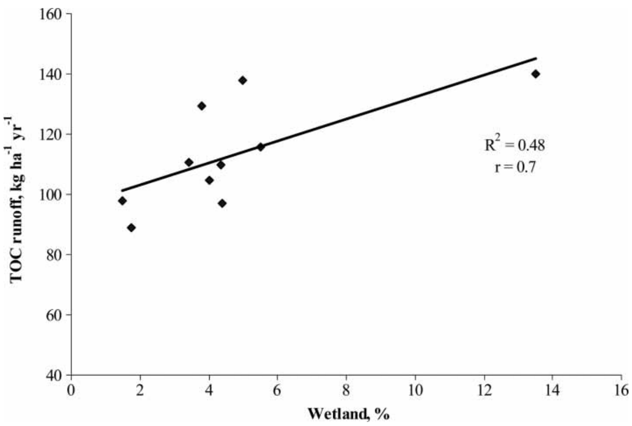

Figure 7 | Correlation between the annual TOC export and wetland areas in the studied catchments.

CONCLUSIONS

Concentration of natural organic matter as indicated by water colour and total organic carbon concentrations in surface waters in Latvia have high spatial and temporal variability. River discharge can be considered as the main factor influencing organic substances. At the same time, processes influencing organic matter production and decay determine seasonal variability of changes and balance between TOC/POC export. The high percentage of wetlands in the studied river basins, in combination with eutrophication, can be among factors influencing high organic matter export values from the Salaca River/Lake Burtnieks system as well as from the sub-basins in this region.

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