Water quality dynamics of an extracted peatland and pond treatment

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Background

Peatlands provide important ecosystem services including nutrient storage. However, drainage of peatlands for horticultural peat extraction causes considerable changes in their hydrological regime [1]. This exposes the site to oxidizing conditions accelerating decomposition and subsequent nutrient leaching [2]. Ultimately, this affects the water quality of the effluents and poses a risk to the ecological status of surface waters downstream [3]. The situation has drawn attention to the need for mitigation measures, including rewetting and water treatment, in extracted degraded peatlands. This has been the case in an Irish raised bog under extraction, where treatment ponds were constructed as end-of-pipe solutions on the edge of the catchments (Fig. 1). This aimed to allow sedimentation of particles, thus decreasing the export of nutrients. However, annual climate variations are expected to influence the water regime and biogeochemical transformations. This potentially affects the water quality of the effluents and challenges the performance of the treatment pond.

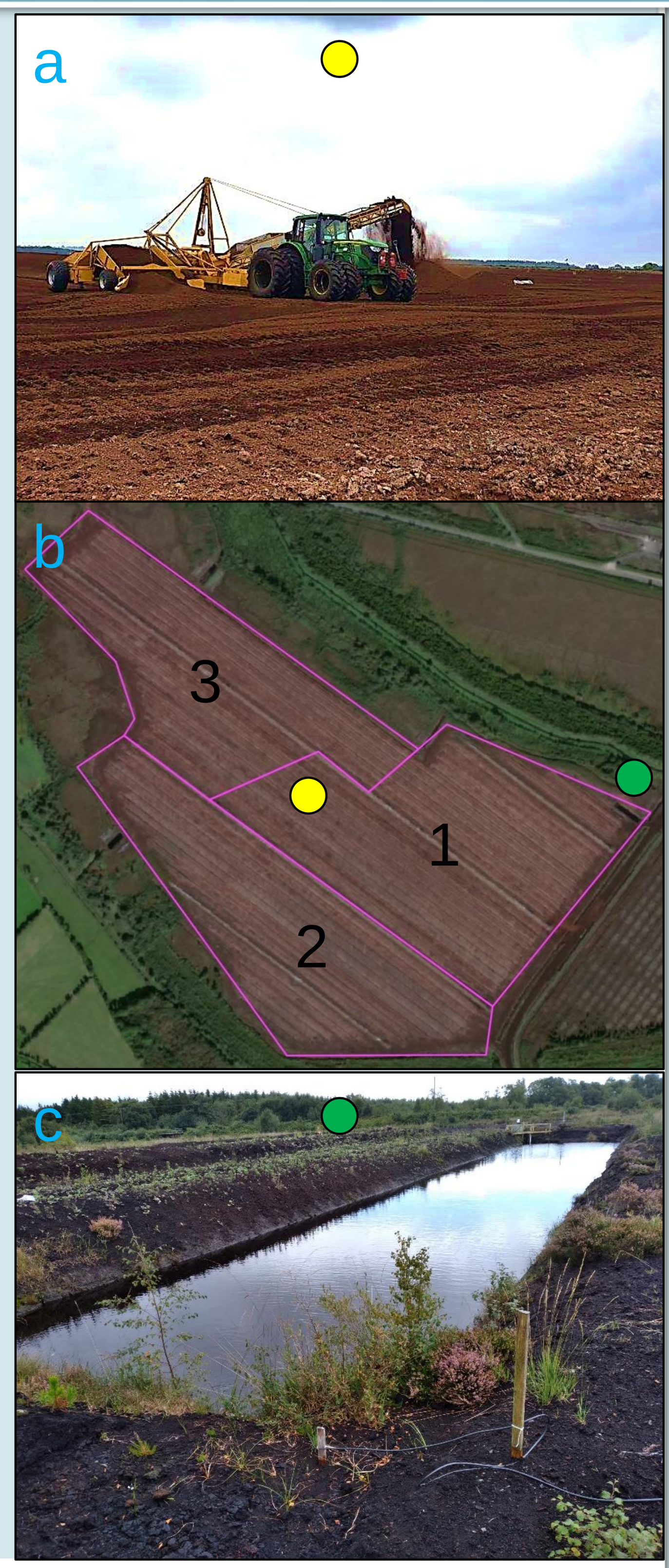

Fig. 1. (a) Peat extraction at an Irish raised bog, (b) aerial view showing 3 catchments, and (c) treatment pond located on the edge of catchment 1.

The study hypothesizes that (i) the water quality of effluents from extracted peatlands is highly dynamic, (ii) these effluents are harmful to surface waters all year round, and (iii) prolonging the hydraulic residence time of the effluents in situ does not suffice for treatment due to high proportion of soluble nutrients and lack of necessary biogeochemical conditions.

Methods

A monitoring station located at the outlet of the treatment pond 1 ensured continuous monitoring of water quality for approximately 2 years (Fig. 2). This was equipped with an YSI EXO2 Multiparameter Sonde, an area velocity flow meter and a Teledyne ISCO Sampler. The Sonde and flow meter were then moved to another station at the inlet. This, in addition to grab sampling, allowed the performance of the pond to be evaluated. The ISCO Sampler monitored during storm events. The monitoring included measurements of temperature, pH, electrical conductivity, turbidity and nutrient concentrations.

Fig. 2. Monitoring station of water quality at the outlet of the treatment pond.

Results

☞The water quality of effluents as well as the flow and temperature varied greatly between seasons (Fig. 3). High variances were generally found in autumn and winter.

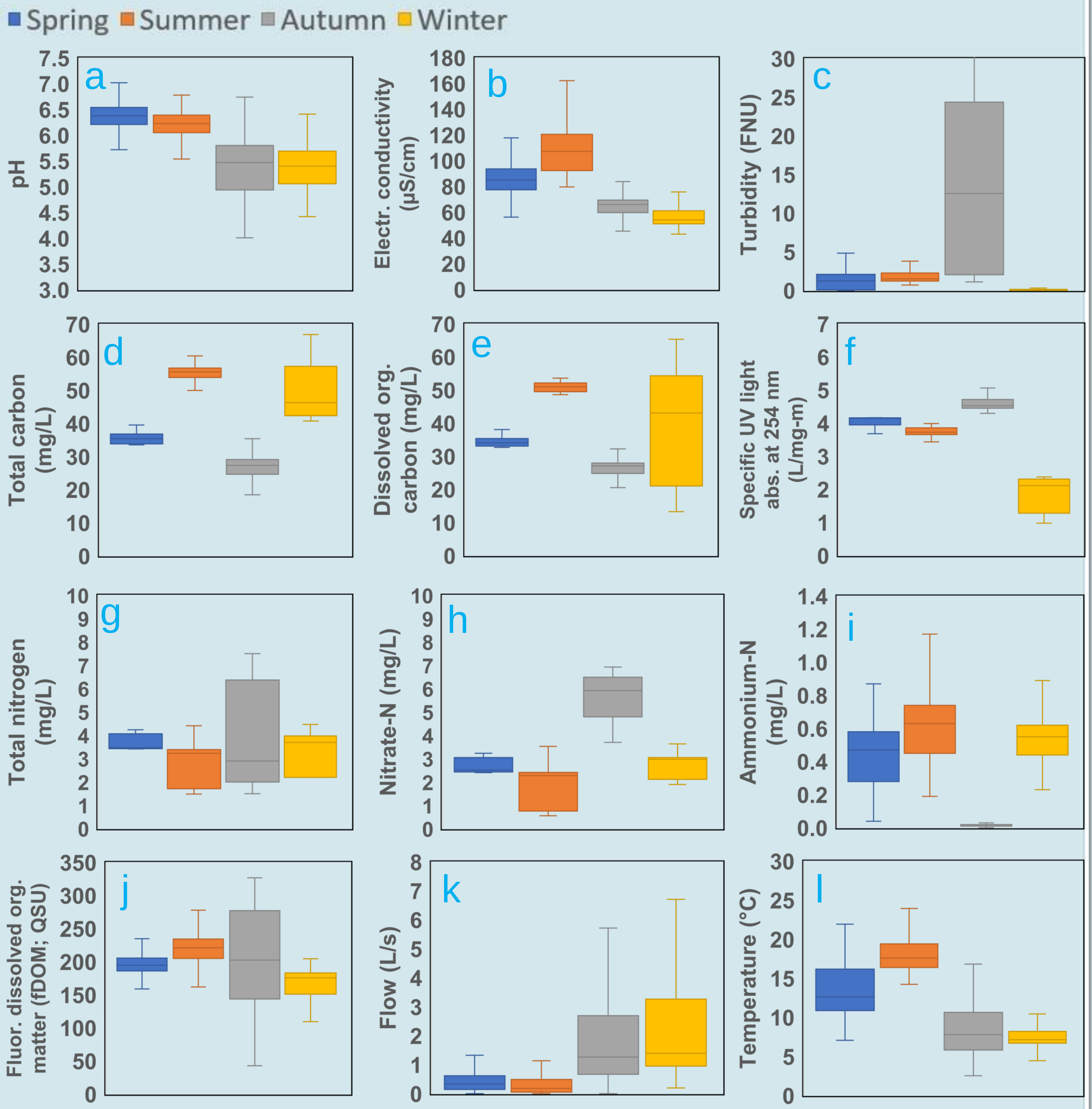

Fig. 3. Seasonal dynamics of water quality (a-j), flow (k) and temperature (l). Variations between seasons were significantly different ($p < 0.05$) for all parameters.

☞Acidic discharges, sudden rises in turbidity and high nutrient concentrations commonly occurred, which may impair the status of receiving waters (Table 1). Total phosphorus concentrations were < 0.05 mg/L.

Table 1. Mean ± standard deviation of water quality parameters between seasons. Note: units as per Fig. 3.

Season	pH	Electr. conductivity	Turbidity	Dissolved org. carbon	Nitrate-N	Ammonium-N
Spring	6.3 ± 0.4	85.1 ± 11.6	1.1 ± 1.2	34.4 ± 1.9	2.7 ± 0.3	0.4 ± 0.2
Summer	6.2 ± 0.4	108.3 ± 17.9	2.6 ± 2.9	50.4 ± 2.8	2.0 ± 1.3	0.7 ± 0.3
Autumn	5.4 ± 0.6	68.5 ± 17.3	94.8 ± 227.4	26.5 ± 4.3	5.7 ± 1.0	0.1 ± 0.2
Winter	5.4 ± 0.4	58.6 ± 13.8	0.1 ± 0.3	39.7 ± 15.7	2.7 ± 0.5	0.5 ± 0.1
EQS*	**4.5 – 9.0**	**-**	**-**	**-**	**≤ 1.8**	**≤ 0.065**

* Environmental quality standards (EQS) for good ecological status of surface waters as per the EU Water Framework Directive.

☞ Water quality parameters were significantly affected by climatic factors (Table 2).

Table 2. Multiple regression of flow and temperature as independent variables with water quality parameters as dependent variables. Note: units as per Fig. 3.

Water quality parameter	Number of observa-tions	R^2	*p*-value	*p*-value: Flow	*p*-value: Temper-ature	Coefficient: Flow	Coefficient: Temper-ature
pH	17048	0.49	0.00	0.00	0.00	-0.03	0.06
Electr. Conductivity	17048	0.57	0.00	0.00	0.00	-0.47	3.04
Turbidity	17046	0.05	0.00	0.00	0.00	0.48	-4.17
Total carbon	97	0.60	0.00	0.00	0.00	-1.22	0.77
Dissolved org. carbon	97	0.56	0.00	0.00	0.00	-1.14	0.52
Specific UV light abs. at 254 nm	81	0.38	0.00	0.08	0.09	0.00	0.00
Total nitrogen	117	0.37	0.00	0.01	0.00	0.06	-0.16
Nitrate-N	117	0.37	0.00	0.00	0.00	0.11	-0.14
Ammonium-N	17048	0.18	0.00	0.00	0.00	-0.01	0.02
Fluor. dissolved org. matter (fDOM)	17046	0.15	0.00	0.00	0.00	-0.19	3.23

☞ Treatment of effluents in the pond was statistically negligible (Fig. 4).

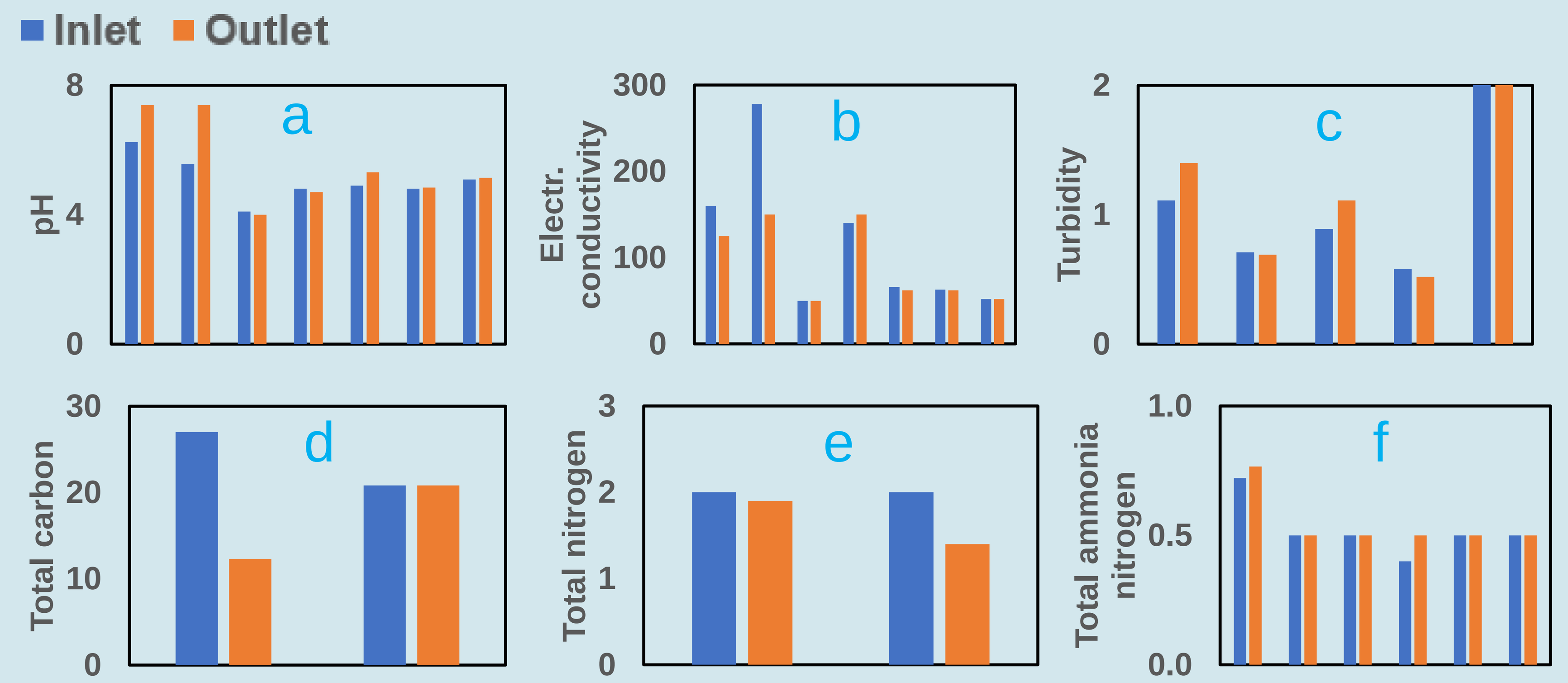

Fig. 4. Water quality parameters at the inlet and outlet of the treatment pond on different dates within the period Sep/22–Mar/23 (a-f). Differences between inlet and outlet were not significantly different ($p > 0.05$) for all parameters. Note: units as per Fig. 3.

Conclusions

The results corroborate the hypotheses. This indicates that the water quality of effluents from extracted peatlands is sensitive to seasonal or climatic variations, highlighting the need of long-term or annual monitoring in order to properly evaluate it. Moreover, the results suggest little effect of the treatment pond highlighting the need of proper mitigation measures in extracted peatland catchments to ensure good status of surface waters.

References

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