Bachelor's Thesis
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Preliminary Study of Water Quality from Kåtån, Lake Flyxen to Lake Kösen

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Lund’s spring unfolded like an oil painting, yet we must now bid it farewell. We are grateful for every smiling face encountered during our four months in Europe. May future opportunities allow us to linger longer in Sweden, perhaps during its most radiant season.

Abstract

The Lake Flyxen, as the headwater of the watershed, maintains good water quality. However, as the river flows downstream and intersects several peatlands, the water quality deteriorates significantly, highlighting the urgent need to investigate the influencing factors in this watershed. This study examines the spatial and temporal variations in water quality along the Kåtån River from Flyxen Lake to Lake Kösen in southern Sweden, focusing on the impacts of peatlands and nearby human activities. Through six field surveys conducted between February and April 2025, ten water quality parameters were monitored at fifteen sites, resulting in 209 data sets. The results show that downstream sites near peat industries and agricultural areas experienced a significant decline in DO and notable increases in EC, TDS, and salinity, exceeding the river ’ s self-purification capacity and causing severe water quality degradation. Even natural peatlands were found to negatively affect water quality under certain hydrological conditions. This study emphasizes that peat industry activities within the watershed have a significant negative impact on river water quality, and measures should be taken to reduce peat industrial activities to curb further degradation.

Sammanfattning

Flyxensjön, som utgör källan till avrinningsområdet, har god vattenkvalitet. Men när floden rinner vidare och korsar flera torvmarker försämras vattenkvaliteten avsevärt, vilket understryker det akuta behovet av att undersöka påverkansfaktorerna i detta avrinningsområde. Denna studie undersöker de rumsliga och tidsmässiga variationerna i vattenkvaliteten längs Kåtån, från Flyxensjön till sjön Kösen i södra Sverige, med fokus på torvmarker och närliggande mänskliga aktiviteter. Genom sex fältundersökningar mellan februari och april 2025 övervakades tio vattenkvalitetsparametrar vid femton provtagningspunkter, vilket resulterade i 209 datamängder. Resultaten visar att nedströms provpunkter nära torvindustrin och jordbruksområden uppvisade en tydlig minskning av DO och en markant ökning av EC, TDS och salthalt, vilket överskred flodens självrensningskapacitet och orsakade allvarlig vattenförsämring. Även naturliga torvmarker visade sig påverka vattenkvaliteten negativt under vissa hydrologiska förhållanden. Studien betonar att torvindustrins verksamhet inom avrinningsområdet har en betydande negativ inverkan på flodens vattenkvalitet, och att åtgärder bör vidtas för att minska torvindustrins aktivitet för att motverka fortsatt försämring.

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1 Introduction

1.1 Background

Peatlands are wetland ecosystems characterized by the accumulation of partially decomposed plant material (peat) under prolonged waterlogged or saturated conditions. Globally, peatlands cover approximately 4 million square kilometers, predominantly in northern temperate and subarctic regions. Despite occupying less than 3% of the Earth's terrestrial surface, they store one-third of global soil carbon, making them critical carbon sinks and among the ecosystems most vulnerable to climate change (Yu *et al.*, 2010; Page *et al.*, 2011; Harenda *et al.*, 2018). Peatlands are broadly classified into two types based on hydrological and nutrient sources: ombrotrophic bogs, which rely solely on precipitation for water and nutrients and exhibit strong acidity (pH < 4), and minerotrophic fens, which receive groundwater inputs and are less acidic (Johnson, 1963). Beyond their role as carbon reservoirs, peatlands provide essential ecosystem services, including water regulation, biodiversity conservation, and habitat provision (Page *et al.*, 2016).

Between the 1950s and 1980s, large-scale drainage activities were conducted globally to convert peatlands for forestry, agriculture, and peat extraction. In temperate and boreal regions, an estimated 15 million hectares of peat soils were drained for forestry (Paavilainen & Päivänen, 1995). In Sweden alone, approximately 1 million hectares of productive forests now grow on drained peat soils, accounting for 10% of the country's total forest stock (Nieminen *et al.*, 2021).

Over recent decades, significant water discoloration (termed brownification) has been observed in lakes and rivers across much of the Northern Hemisphere (Monteith *et al.*, 2007; Erlandsson *et al.*, 2008). This phenomenon is linked to rising concentrations of total organic carbon (TOC) and iron (Fe) in freshwater systems, driven by factors such as reduced acid deposition, climate warming, increased precipitation, and land-use changes (Monteith *et al.*, 2007; Ekström *et al.*, 2011; Kritzberg *et al.*, 2020). For instance, a study on Sweden's Lake Bolmen revealed a strong correlation between TOC levels and water color, with land-use shifts (e.g., afforestation) and seasonal climatic variations further influencing brownification trends (Klante *et al.*, 2021). Similarly, an analysis of 133 peatland-dominated catchments in Sweden and Finland identified historical peatland drainage for forestry as a key driver of elevated TOC concentrations in high-latitude waterways, aligning with the “greening effect” hypothesis that links increased forest biomass to rising TOC export (Nieminen *et al.*, 2021; Finstad *et al.*, 2016).

The high water retention capacity of peatlands acts as a critical buffer, enhancing ecosystem resilience to disturbances (Waddington *et al.*, 2015). However, drainage activities lower water tables, accelerating aerobic peat decomposition and nutrient release (Macrae *et al.*, 2013), which exacerbates downstream brownification. A striking example is observed along the Kåtån River in southern Sweden, where water clarity deteriorates markedly from the clear headwater Lake Flyxen to the turbid, coffee-ground-like appearance at its outlet into Lake Kösen, severely compromising ecological functions such as drinking water provision, fisheries, and biodiversity. Given the river’s intersection with multiple active peat bogs, we hypothesize that these wetlands are a primary pollution source. Yet, systematic studies on the Kåtån’s water quality dynamics—particularly the role of peat bogs in downstream contamination and the ecological consequences of brownification—remain lacking. Supported by municipal authorities and the Fisheries Association, this study aims to address these gaps, providing scientific insights for watershed management and wetland restoration while laying the groundwork for long-term aquatic monitoring.

1.2 Study Objectives

This study aims to quantify spatial variations in water quality along the Kåtån River, from its upstream source at Lake Flyxen to its downstream outlet at Lake Kösen, through field-based water quality monitoring. Additionally, the study seeks to identify the drivers of water browning, with a specific focus on evaluating the impacts of peat bogs on downstream water quality degradation.

1.3 Study Methodology

Field measurements will be conducted using a multiparameter water quality meter to assess key physicochemical parameters at selected sampling sites along the Kåtån River, Lake Flyxen, and Lake Kösen. By analyzing repeated measurements across multiple sampling campaigns, this study will delineate spatial patterns of water quality changes from upstream to downstream and preliminarily investigate their causative factors. Special attention will be given to understanding how the river’s transit through peatland areas influences these dynamics.

2 Materials and Methods

2.1 Study Area

This study conducted water quality tests along the Kåtån River, which flows from Lake Flyxen to Lake Kosen in southern Sweden. The region exhibits a typical temperate maritime climate, influenced by the North Atlantic Current and the Baltic Sea, characterized by warm summers (mean July temperature 17.2°C) and mild winters (mean January temperature -0.7°C), with evenly distributed precipitation throughout the year and annual rainfall ranging from 500 to 700 mm.

Fifteen sampling sites were strategically established along the watershed based on peatland distribution and accessibility, with their geographic coordinates and water body types detailed in Table 2.1. As illustrated in Figure 2.1, Site 1 is situated in Lake Flyxen, while Sites 7, 8, 8B, and 9 are distributed across different orientations of Lake Kosen (the larger lake). Five sampling sites (2-6) were evenly spaced along the main channel connecting the two lakes at approximately equal intervals. Additionally, Site 5B was positioned on a tributary joining the main stream upstream of Site 5 (directly connected to a peat extraction facility), Sites 9A and 9C were located on an eastern tributary of Lake Kosen (flowing through forested areas), Site 9B was established in a small isolated lake adjacent to Site 9 (hydrologically disconnected from the river system), and Site 10 was placed on a northern tributary of Lake Kosen. Drainage outlets from four peatlands were identified between Sites 2 and 3 (two outlets), between Sites 4 and 5 (one outlet), and between Sites 5 and 6 (one outlet). Photographs documenting each sampling site are provided in the Appendix (App 1).

2.2 Water Quality Measurement Procedures

Between February and April 2025, we conducted six water quality tests across 15 sampling sites on the following dates: February 12, March 5, March 19, March 26, April 19, and April 23. At each site, we measured 13 water quality parameters using a portable multiparameter meter (HI98594, Hanna Instruments). During the tests, the meter's probe was immersed in water without touching the bottom, and data was recorded once the parameters stabilized. Each test was repeated three times per site. After testing, data was exported from the meter for further processing and analysis. Photos of the testing process are included in the appendix. (App 1).

2.3 Division of Labor Among Members

The two project members jointly conducted six water quality tests and analyzed the data. In the paper writing and presentation defense, Xinyang Zhong was mainly responsible for the results analysis and discussion sections, while Yibi Wu focused on the introduction and materials and methods sections.

Table 2.1 Coordinates and water body types of sampling sites

Site	Latitude (° N)	Longitude (° E)	Water body type
1	56.9718	13.8931	Lake (Flyxen)
2	56.9208	13.8923	River
3	56.8808	13.8950	River
4	56.8534	13.8980	River
5	56.8240	13.8729	River
5B	56.8245	13.8747	Tributary
6	56.8083	13.8136	River
7	56.7935	13.7808	Lake (Kosen)
8	56.7897	13.7725	Lake (Kosen)
8B	56.7900	13.7723	Lake (Kosen)
9	56.8240	13.7678	Lake (Kosen)
9A	56.8246	13.7687	Tributary
9B	56.8245	13.7684	Lake (near Kosen)
9C	56.8245	13.7686	Tributary
10	56.8267	13.7643	Tributary

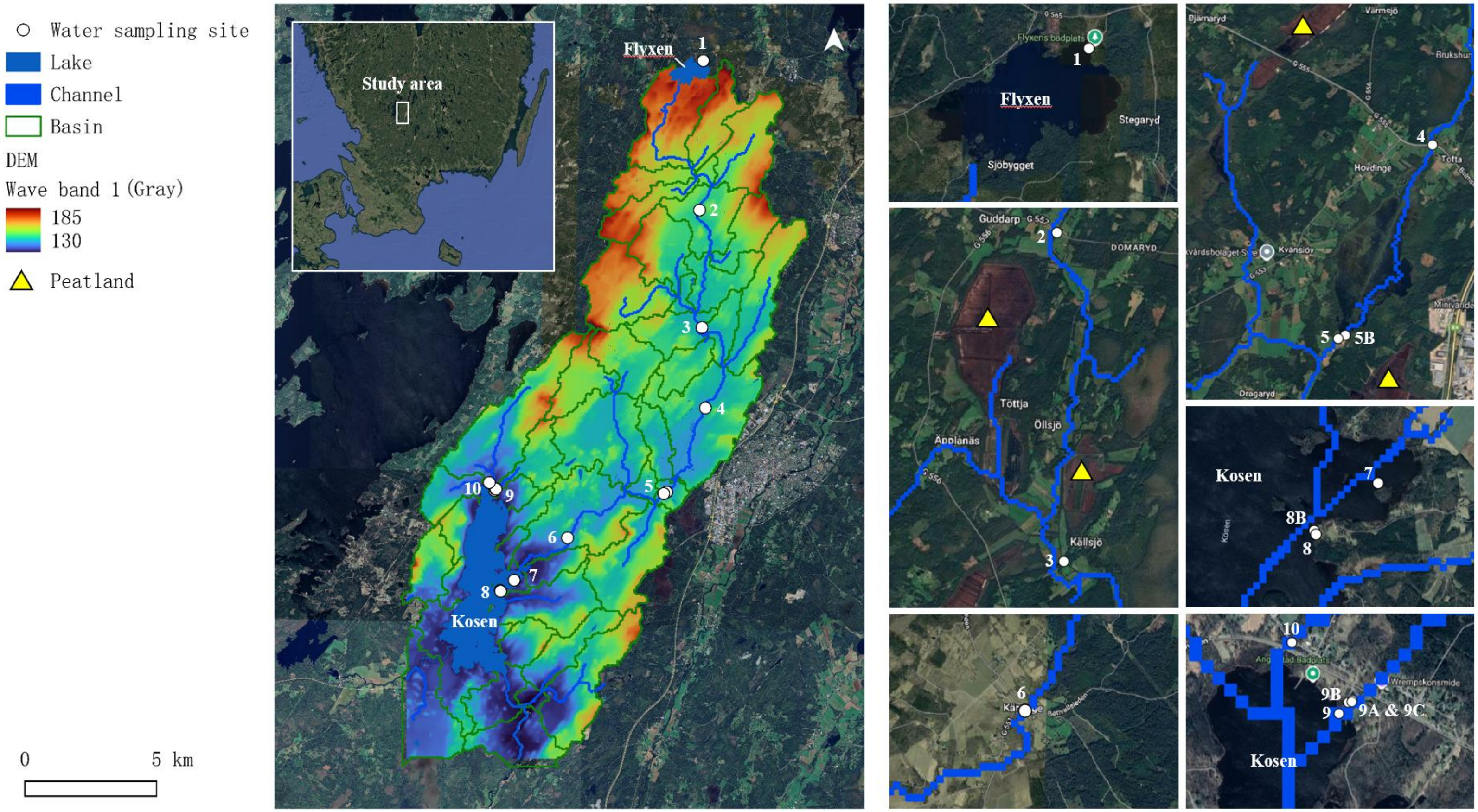

Figure 2.1 Location of the sampling sites

Tab 2.2 Water quality parameters and units

Parameter	Unit
mVpH	
pH	
ORP (Oxidation-Reduction Potential)	mV
DO (Dissolved Oxygen)	%
DO (Dissolved Oxygen)	ppm
EC (Electrical Conductivity)	μS/cm
EC (absolute)	μS/cm[A]
Resistivity	Ω-cm
TDS (Total Dissolved Solids)	ppm
Salinity	PSU
Turbidity	FNU
Temperature	°C
Atmospheric Pressure	psi

3 Results

3.1 Raw Data Record

This study conducted six field surveys between February 12 and April 23, 2025, measuring ten water quality parameters at fifteen sampling sites, resulting in a total of 209 data sets, as shown in Table 3.1.

Table 3.1 Field measurement raw data record sheet. "Re" is used to denote Resistivity, "Sal" for Salinity, and "Tur" for Turbidity.

Site	Date	pH	ORP (mV)	DO (%)	EC (μS/cm)	Re (Ω-cm)	TDS (ppm)	Sal (PSU)	Tur (FNU)	T (℃)	AP (psi)
1	2.12	5.7	262	79.7	36	27778	18	0.02	0.3	1.42	14.566
	3.5	6.1	201.5	80	34	29412	17	0.02	7.1	3.95	14.312
	3.19	6.11	185.6	82.5	35	28571	17	0.02	1.5	6.57	14.531
	3.19	6.07	192.5	82.4	35	28571	17	0.02	1.7	6.51	14.531
	3.19	6.01	198.8	82	35	28571	18	0.02	1.5	6.61	14.531
	3.26	6.22	184.2	82.1	34	29412	17	0.02	3.7	6.9	14.427
	3.26	6.17	190.8	82.4	34	29412	17	0.02	0.9	7.49	14.427
	3.26	6.13	194.5	82.5	34	29412	17	0.02	0.8	8.21	14.427
	4.16	6.37	165.6	74.7	37	27027	18	0.02	0.4	12.28	14.341
	4.16	6.34	164.7	74.7	37	27027	18	0.02	0.5	12.19	14.341
	4.16	6.29	164.7	74.7	37	27027	18	0.02	0.7	12.39	14.342
	4.23	6.45	157.5	81.9	37	27027	18	0.02	0.7	13.78	14.454
	4.23	6.41	161.9	81.9	37	27027	18	0.02	0.7	13.79	14.455
	4.23	6.37	166	81.9	37	27027	18	0.02	0.6	13.79	14.455
2	2.12	6.09	121	80.8	55	18182	28	0.03	7.7	0.82	14.608
	3.5	6.17	121.8	75.8	54	18519	27	0.03	6.3	4.43	14.357
	3.19	6.3	93.4	76.4	58	17241	29	0.03	10.5	4.77	14.573
	3.19	6.31	93	76.3	57	17544	29	0.03	10.8	4.77	14.573
	3.19	6.32	92.8	76.1	57	17544	29	0.03	10.3	4.77	14.574
	3.26	6.35	92.1	78.1	58	17241	29	0.03	13.2	6.49	14.47
	3.26	6.37	90.3	78.5	58	17241	29	0.03	13.5	6.48	14.47
	3.26	6.4	89.4	77.9	59	16949	29	0.03	13.9	6.48	14.47
	4.16	6.32	81.3	75.2	67	14925	33	0.04	18.6	9.84	14.382
	4.16	6.31	79.2	75	67	14925	33	0.04	21.1	9.84	14.382
	4.16	6.3	78.1	74.9	67	14925	33	0.04	19.5	9.84	14.382
	4.23	6.52	71.2	78.2	69	14493	35	0.04	20.4	10.32	14.498
	4.23	6.52	72.1	78	69	14493	35	0.04	22.8	10.32	14.499
	4.23	6.52	72.8	77.9	69	14493	35	0.04	21.1	10.32	14.498
3	2.12	6.16	126.3	80.5	59	16949	30	0.03	32.9	0.78	14.609
	3.5	6.16	127.6	76	57	17544	28	0.03	8.7	4.39	14.363

	3.19	6.25	93.4	74.6	61	16393	31	0.03	12.7	4.73	14.574
	3.19	6.27	92.7	74.5	61	16393	31	0.03	11.5	4.73	14.575
	3.19	6.28	92.4	74.4	61	16393	31	0.03	12.1	4.73	14.574
	3.26	6.28	96.3	76.6	63	15873	32	0.03	17.5	6.34	14.467
	3.26	6.32	93.3	76.2	63	15873	32	0.03	17.2	6.35	14.468
	3.26	6.35	91.6	75.8	63	15873	32	0.03	16.3	6.35	14.468
	4.16	6.56	66.2	71.5	76	13158	38	0.04	32	10.07	14.39
	4.16	6.53	67.6	71.4	76	13158	38	0.04	23.9	10.08	14.39
	4.16	6.52	68.1	71.3	76	13158	38	0.04	23.1	10.07	14.39
	4.23	6.43	85.1	76.3	80	12500	40	0.04	24.9	10.38	14.5
	4.23	6.44	82.3	75.8	80	12500	40	0.04	26.3	10.38	14.501
	4.23	6.45	80.8	75.5	80	12500	40	0.04	26.2	10.38	14.5
4	2.12	6.11	138.5	82	62	16129	31	0.03	54.5	0.55	14.606
	3.5	5.92	155.7	73.9	60	16667	30	0.03	7.7	4.23	14.365
	3.19	7.24	77.6	80.3	62	16129	31	0.03	11.3	3.49	14.582
	3.19	7.15	79.7	77.6	62	16129	31	0.03	26.4	3.49	14.584
	3.19	7.12	79.8	76.2	62	16129	31	0.03	11.6	3.48	14.583
	3.26	6.04	120.3	76.3	69	14493	34	0.04	16.5	5.43	14.466
	3.26	6.08	115.7	75.4	70	14286	35	0.04	32.8	5.44	14.466
	3.26	6.13	111.3	75.7	70	14286	35	0.04	15.8	5.43	14.467
	4.16	6.3	113.1	73.2	85	11765	43	0.05	26.3	10.68	14.406
	4.16	6.29	111.8	72.4	85	11765	43	0.05	26.4	10.66	14.406
	4.16	6.27	111.2	71.7	85	11765	43	0.05	28.5	10.65	14.406
	4.23	6.21	134.4	70.2	89	11236	45	0.05	30.4	9.74	14.509
	4.23	6.22	132.8	70.1	89	11236	45	0.05	29.1	9.76	14.509
	4.23	6.24	130.8	70.1	89	11236	45	0.05	29.2	9.76	14.509
5	2.12	5.57	173.9	61.2	67	14925	33	0.04	7.5	0.77	14.632
	3.5	6.13	190.8	69.7	59	16949	30	0.03	7.5	4.58	14.358
	3.19	7.02	101.6	70.9	67	14925	34	0.04	14.2	3.5	14.588
	3.19	6.89	103.5	67.6	68	14706	34	0.04	12.8	3.49	14.586
	3.19	6.84	104	66.3	67	14925	34	0.04	13.8	3.49	14.588
	3.26	6.39	98.6	74.3	75	13333	37	0.04	72.2	5.24	14.457
	3.26	6.4	96.9	73.7	74	13514	37	0.04	17.2	5.25	14.457
	3.26	6.4	95.8	72.8	74	13514	37	0.04	17.1	5.24	14.457
	4.16	6.11	75.6	58	94	10638	47	0.05	52.2	10.56	14.399
	4.16	6.11	74.6	57.2	94	10638	47	0.05	46.5	10.55	14.399
	4.16	6.1	74.4	56.9	94	10638	47	0.05	49.8	10.58	14.4
	4.23	6.37	60.4	57.3	100	10000	50	0.05	53.4	10.04	14.504
	4.23	6.38	60.1	56.8	100	10000	50	0.05	57.6	10.05	14.504
	4.23	6.37	60.3	56.6	100	10000	50	0.05	54.9	10.05	14.505
5B	2.12	4.98	274.9	53.3	123	8130	61	0.07	3.3	3.67	14.358

	3.5	4.98	274.9	53.3	123	8130	61	0.07	3.3	3.67	14.358
	3.19	5.94	203.9	59.7	129	7752	65	0.07	4	3.15	14.585
	3.19	5.82	207.3	57.4	130	7692	65	0.07	3.8	3.15	14.586
	3.19	5.77	209.1	55.9	130	7692	65	0.07	3.6	3.14	14.584
	3.26	5.41	228	55.5	149	6711	75	0.08	11.7	5.32	14.459
	3.26	5.3	231.4	54.2	149	6711	75	0.08	6.3	5.36	14.46
	3.26	5.25	234	51.5	149	6711	75	0.08	4.4	5.37	14.461
	4.16	5	188.7	45.5	146	6849	73	0.08	12.2	9.76	14.399
	4.16	4.97	189.8	43.8	146	6849	73	0.08	6.2	9.75	14.399
	4.16	4.96	190	41.8	146	6849	73	0.08	6	9.76	14.4
	4.23	5.43	166	40.7	141	7092	71	0.08	12.4	10.12	14.505
	4.23	5.41	166.5	40.4	142	7042	71	0.08	8.7	10.16	14.506
	4.23	5.39	167.2	40.2	142	7042	71	0.08	13.9	10.16	14.507
6	2.12	5.83	169.3	67	66	15152	33	0.04	122	0.7	14.634
	3.5	6.13	196.3	72.7	63	15873	32	0.03	6.3	4	14.363
	3.19	6.34	120.7	78.5	70	14286	35	0.04	8.4	3.26	14.595
	3.19	6.25	121.5	75	71	14085	35	0.04	8.7	3.26	14.594
	3.19	6.2	123	73.7	70	14286	35	0.04	8.8	3.27	14.594
	3.26	6.43	112.6	77.8	78	12821	39	0.04	14	5.41	14.462
	3.26	6.43	105.6	76.9	78	12821	39	0.04	15.9	5.42	14.463
	3.26	6.34	104.2	76	78	12821	39	0.04	14.6	5.42	14.463
	4.16	6.54	89.1	74.3	92	10870	46	0.05	9.2	10.46	14.425
	4.16	6.51	89.7	74	92	10870	46	0.05	8	10.46	14.425
	4.16	6.19	105.6	73.8	92	10870	46	0.05	8.2	10.48	14.425
	4.23	7.01	127.1	75.7	99	10101	49	0.05	53.5	9.73	14.502
	4.23	6.51	133.5	75	99	10101	50	0.05	53.4	9.74	14.502
	4.23	6.51	130.8	74.9	99	10101	49	0.05	54	9.74	14.502
7	2.12	6.87	175.6	75.1	68	14706	34	0.04	9.2	0.37	14.638
	3.5	6.16	240.8	78.7	48	20833	24	0.03	10.7	3.55	14.374
	3.19	6.18	181.8	80	57	17544	28	0.03	5	4.24	14.599
	3.19	6.4	172	79.4	57	17544	28	0.03	5.5	4.24	14.599
	3.19	6.45	167.8	79.1	57	17544	28	0.03	4.3	4.24	14.599
	3.26	6.45	196.7	80.6	54	18519	27	0.03	4.2	6.05	14.476
	3.26	6.48	188.1	80.2	54	18519	27	0.03	3.8	6.05	14.476
	3.26	6.5	184.5	80.1	54	18519	27	0.03	3.7	6.05	14.476
	4.16	6.69	150.7	86.7	54	18519	27	0.03	3.4	13.46	14.436
	4.16	6.7	149.4	87.5	54	18519	27	0.03	13	13.52	14.435
	4.16	6.71	147.9	87.6	54	18519	27	0.03	4.3	13.55	14.435
	4.23	6.99	179.3	80.8	70	14286	35	0.04	14.6	11.2	14.513
	4.23	7.07	167.1	80.2	70	14286	35	0.04	14.7	11.23	14.513
	4.23	7.04	164.2	80	70	14286	35	0.04	14.5	11.2	14.513

8	2.12	7.21	167.8	86.8	12.27	47	30	21277	23	0.02	1.2
	3.5	6.05	178	78.4	10.18	46	32	21739	23	0.02	10.5
	3.19	6.29	167.4	82.8	10	48	36	20833	24	0.03	7.8
	3.19	6.33	164.7	82.9	10.01	48	36	20833	24	0.03	3.5
	3.19	6.35	163.5	82.7	9.99	48	36	20833	24	0.03	6.1
	3.26	6.14	163.4	81	9.94	48	35	20833	24	0.02	1.1
	3.26	5.85	178.5	80.4	9.87	47	35	21277	24	0.02	1.1
	3.26	5.89	184.4	80.6	9.9	47	35	21277	24	0.02	1.2
	4.16	6.71	130.8	86.1	9.4	50	41	20000	25	0.03	0.5
	4.16	6.61	139.3	85.8	9.35	50	41	20000	25	0.03	0.8
	4.16	6.22	164.5	84.3	9.2	50	41	20000	25	0.03	1.3
	4.23	6.93	127.6	82.8	9.04	53	44	18868	26	0.03	3.1
	4.23	6.91	129.3	82.5	9.01	53	44	18868	26	0.03	3.6
	4.23	6.88	130.7	82.2	8.98	53	44	18868	26	0.03	2
8B	2.12	6.94	253.5	83.7	48	20833	24	0.03	2	0.77	14.652
	3.5	6	190.8	77.3	47	21277	23	0.02	36.6	3.62	14.38
	3.19	6.45	149.4	79.9	47	21277	23	0.02	3.1	4.47	14.605
	3.19	6.56	146.9	79.7	47	21277	23	0.02	3.2	4.47	14.605
	3.19	6.56	147.1	79.5	47	21277	23	0.02	5.4	4.47	14.605
	3.26	6.29	188.5	82	48	20833	24	0.03	6.4	6.26	14.481
	3.26	6.09	185.8	82.1	48	20833	24	0.03	1.5	6.31	14.481
	3.26	6.21	181.4	81.5	48	20833	24	0.03	1.2	6.29	14.479
	4.16	6.21	163.1	86.1	50	20000	25	0.03	2.8	11.24	14.441
	4.16	6.22	162.9	87.2	50	20000	25	0.03	4.7	11.32	14.441
	4.16	6.23	162.7	86.9	50	20000	25	0.03	2	11.37	14.441
	4.23	6.77	148.9	81.6	53	18868	26	0.03	2.8	10.88	14.521
	4.23	6.76	149.4	81.4	53	18868	26	0.03	2.5	10.88	14.521
	4.23	6.76	149.6	81.3	52	19231	26	0.03	4.5	10.88	14.522
9	2.12	6.83	160.3	77.3	68	14706	34	0.04	4	1.07	14.654
	3.5	6.2	199.5	79.3	47	21277	24	0.03	27.4	3.55	14.376
	3.19	5.74	200	76.8	49	20408	24	0.03	1.1	4.68	14.597
	3.19	5.72	201.1	76.5	48	20833	24	0.03	1.1	4.65	14.598
	3.19	5.71	197.4	76.3	48	20833	24	0.03	1	4.67	14.599
	3.26	4.7	241.5	80.8	51	19608	26	0.03	2.4	4.84	14.478
	3.26	4.67	244.2	80.6	52	19231	26	0.03	2.4	4.82	14.478
	3.26	4.64	246.6	78.8	51	19608	25	0.03	0.8	4.86	14.479
	4.16	6.01	140.9	80.4	51	19608	26	0.03	2	12.3	14.44
	4.16	6.03	144.5	80.6	51	19608	26	0.03	1.6	12.04	14.44
	4.16	6.05	142.3	79.9	51	19608	26	0.03	1.7	12.14	14.44
	4.23	6.01	124.7	79	52	19231	26	0.03	2.3	11.94	14.523
	4.23	6.04	124.8	79.1	52	19231	26	0.03	2.2	11.93	14.524
	4.23	6.07	124.9	79.1	52	19231	26	0.03	2.7	11.95	14.524

	2.12	4.33	299.7	83.3	-	-	-	-	61.2	0.93	14.662
	3.5	4.07	306.4	74.5	53	18868	27	0.03	2.3	3.63	14.373
	3.19	4.63	270.1	77.2	52	19231	26	0.03	0.2	4.2	14.602
	3.19	4.58	270	76.4	52	19231	26	0.03	0.2	4.2	14.6
	3.19	4.56	269.9	75.6	52	19231	26	0.03	0.2	4.2	14.601
	3.26	4.71	260.2	73	52	19231	26	0.03	0.4	4.79	14.477
9A	3.26	4.54	266	72.9	52	19231	26	0.03	0.4	4.79	14.476
	3.26	4.48	268.7	72.7	52	19231	26	0.03	0.6	4.79	14.476
	4.16	5.39	174.8	72	54	18519	27	0.03	0.9	10.65	14.431
	4.16	5.24	183.3	71.5	54	18519	27	0.03	1.1	10.68	14.431
	4.16	4.91	207.4	71.9	54	18519	27	0.03	0.9	10.64	14.432
	4.23	4.76	213.4	68.4	55	18182	28	0.03	1.1	9.31	14.519
	4.23	4.74	213.7	68.4	55	18182	28	0.03	1.1	9.31	14.52
	4.23	4.73	214.3	68.3	55	18182	28	0.03	1.1	9.28	14.52
	2.12	4.98	293.6	80.8	55	18182	27	0.03	0.4	0.97	14.656
	3.5	6.2	199.5	79.3	47	21277	24	0.03	27.4	3.55	14.376
	3.19	5.62	257	61	60	16667	30	0.03	2	4.96	14.6
	3.19	5.6	263.8	65.2	60	16667	30	0.03	1.8	4.96	14.6
	3.19	5.58	267.9	66	60	16667	30	0.03	1.6	4.84	14.601
	3.26	5.51	235.6	56.1	62	16129	31	0.03	1.3	5.83	14.476
9B	3.26	5.56	239.7	54.7	62	16129	31	0.03	1.6	5.88	14.476
	3.26	5.57	242.2	48.3	62	16129	31	0.03	1.5	5.91	14.476
	4.16	5.54	133.4	14.9	68	14706	34	0.04	3.5	9.85	14.431
	4.16	5.74	118.2	18.1	68	14706	34	0.04	3.1	9.93	14.431
	4.16	5.74	104.2	16.2	68	14706	34	0.04	3.6	9.63	14.431
	4.23	6	208.9	35.1	69	14493	34	0.04	1.5	10.05	14.518
	4.23	5.99	209.7	34.5	69	14493	34	0.04	1.4	10.08	14.518
	4.23	5.95	211.6	33.9	69	14493	34	0.04	1.4	10.07	14.518
	2.12	4.49	205.6	45.1	58	17241	29	0.03	187	1.13	14.653
	3.5	5.93	246.5	52.9	58	17241	29	0.03	4.3	4.42	14.373
	3.19	4.52	271.1	76.3	52	19231	26	0.03	0.4	4.33	14.603
	3.19	4.51	270.7	75.8	52	19231	26	0.03	0.4	4.33	14.602
	3.19	4.51	270.6	75.3	52	19231	26	0.03	0.6	4.32	14.602
	3.26	4.47	262.8	76.2	52	19231	26	0.03	0.5	4.8	14.477
9C	3.26	4.46	262.9	75.5	52	19231	26	0.03	0.8	4.8	14.477
	3.26	4.45	263.7	74.8	52	19231	26	0.03	0.8	4.79	14.476
	4.16	5.16	203.2	72.1	55	18182	27	0.03	1.1	10.9	14.44
	4.16	5.15	203.1	70.8	55	18182	27	0.03	13.9	10.89	14.44
	4.16	5.13	203.5	70.4	55	18182	27	0.03	1	10.91	14.44
	4.23	4.76	212.5	68.7	56	17857	28	0.03	1.3	9.42	14.522
	4.23	4.75	212.5	67.2	56	17857	28	0.03	1.2	9.46	14.523
	4.23	4.74	212.7	66.5	56	17857	28	0.03	1.3	9.39	14.523

	3.5	5.94	144.2	71.5	68	14706	34	0.04	5.8	4.34	14.368
	3.19	5.83	137.4	74.5	72	13889	36	0.04	4	4.64	14.606
	3.19	5.91	132.5	73.4	72	13889	36	0.04	4.3	4.64	14.605
	3.19	5.94	131.1	73.1	72	13889	36	0.04	4.2	4.64	14.605
	3.26	5.6	150.6	73.8	78	12821	39	0.04	9.5	5.52	14.483
	3.26	5.61	147.5	74.2	78	12821	39	0.04	8.1	5.52	14.483
10	3.26	5.69	141.8	73.8	78	12821	39	0.04	8.2	5.52	14.484
	4.16	6.4	122.2	75.4	97	10309	48	0.05	43.4	11.24	14.432
	4.16	6.43	121	75.3	97	10309	48	0.05	42.2	11.24	14.432
	4.16	6.46	119.6	75.2	97	10309	48	0.05	42	11.24	14.432
	4.23	6.21	93.9	74.5	94	10638	47	0.05	8.8	8.98	14.521
	4.23	6.18	94.5	74.4	95	10526	47	0.05	8.7	8.98	14.521
	4.23	6.04	101.8	74.1	94	10638	47	0.05	14.4	8.97	14.521

Since March 19th, each sampling point has been measured in parallel three times, and the average value was used for analysis to eliminate errors. The data were visualized and analyzed using Origin software, and the results and analysis are as follows.

3.2 Data Analysis

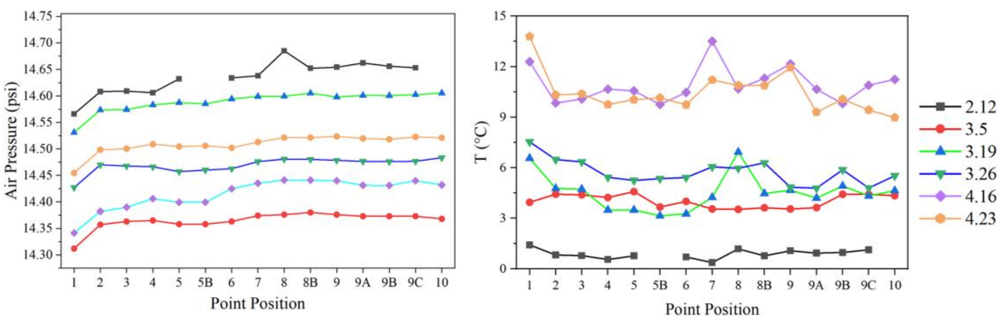

Figure 3.1 Variations in Air Pressure and Temperature across different sites

Figure 3.1 illustrates the variations in air pressure and temperature at different sampling sites. As shown, air pressure remained relatively stable across all locations, fluctuating between 14.3 and 14.7 psi. Notably, Site 1 exhibited significantly lower air pressure than the others, attributable to its higher elevation. The other sites, being at similar altitudes, showed minimal variation. Similarly, water temperature remained relatively stable across sites but exhibited a gradual increase over time, with daily averages rising from 0.88 °C to 10.93 °C, consistent with seasonal expectations. It is worth noting that certain sites recorded temperatures markedly higher than the daily average, likely due to lower water levels on the sampling day. This would increase the relative surface area exposed to sunlight, enhancing solar heat absorption per unit volume and subsequently raising water temperature.

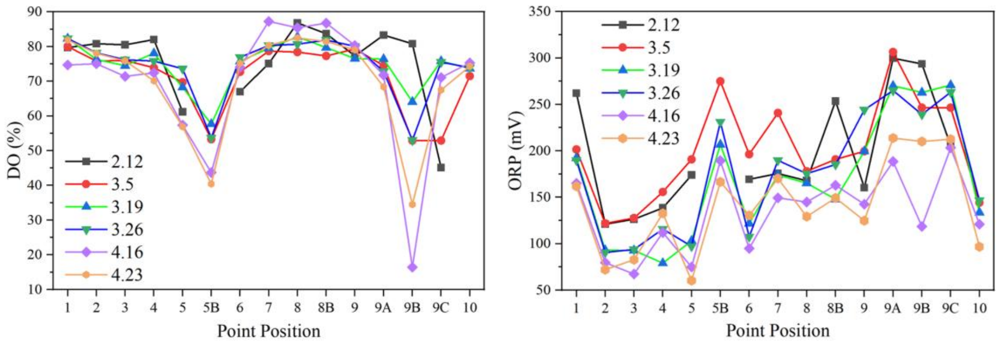

Figure 3.2 Variations in DO and ORP across sites

Previous studies have shown that waterlogged peatlands create anaerobic conditions favorable to anaerobic microbial activity, which suppresses aerobic decomposition of plant residues, leading to the accumulation of humic substances and other organic compounds. When such organic matter is released into rivers, it can significantly impact DO levels. As shown in Figure 3.2, DO levels remained stable (around 80%) between Sites 1 and 2 but declined slightly (by about 0.3%) between Sites 2 and 3. A more pronounced drop occurred after Site 4, reaching a minimum of 43% at Site 5B. Subsequently, DO levels rebounded between Sites 6 and 8B, peaking at 87%, followed by another decline between Sites 8B and 10.

Hydrological mapping indicates that downstream of Site 2 lies a peat-processing facility, suggesting that organic pollutants discharged into the river are metabolized by aerobic microorganisms, which consume large amounts of DO, thereby reducing its concentration. In addition, the presence of extensive farmland and pasture between Sites 2 and 5 suggests that agricultural and livestock-related non-point source pollution may also contribute to water quality deterioration. The recovery of DO between Sites 6 and 8B indicates the river's self-purification capacity: as the river flows, it dilutes the pollutants, and microbial communities gradually decompose the organic matter, reducing oxygen demand and improving DO levels.

DO levels at Sites 5B and 9B were markedly lower than at other sites. Site 5B is located near a tributary close to the peat-processing facility, while Site 9B is from an inland lake near Site 9, both characterized by poor water circulation and weak self-purification capacity, which facilitates pollutant accumulation and further water quality degradation. Similarly, low DO levels were observed at Sites 9A and 9C, which are located on a tributary flowing through forested peatland, indicating that even natural peatlands can negatively impact nearby river water quality.

ORP is a critical indicator of a water body's redox condition, reflecting the balance between oxidizing and reducing agents. ORP fluctuations are driven by changes in the concentration and activity of these substances. As shown in Figure 2, ORP varied considerably across sites: it decreased sharply from Site 1 to Site 2, remained around 100 mV between Sites 2 and 5, spiked to about 200 mV at Site 5B, and fluctuated between 100 and 300 mV from Sites 6 to 10. The substantial agricultural and pastoral land downstream of Site 1 likely introduces reducing organic substances, such as those found in fertilizers and animal waste, thereby lowering ORP values between Sites 2 and 5. In contrast, the sharp increase at Site 5B, which is close to a peat facility, suggests the presence of oxidizing substances, such as minerals and salts, in the industrial effluents. Elevated ORP at Sites 9A and 9C, which flow through forest peatlands, further supports this inference.

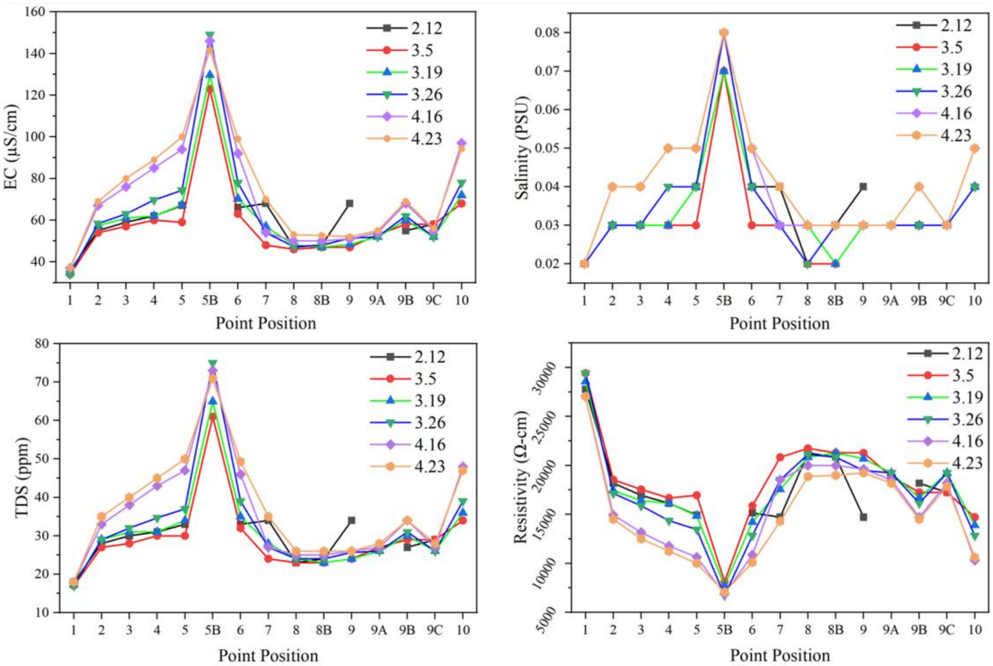

Figure 3.3 Variations in EC, Salinity, TDS, and Resistivity across sites

Figure 3.3 presents changes in electrical conductivity (EC), salinity, total dissolved solids (TDS), and resistivity across different sampling sites. EC increased sharply from Site 1 to Site 5B, rising from a minimum of about 35 μS/cm to a peak of abuot 140 μS/cm, before gradually declining to ~50 μS/cm and stabilizing. EC values rose again at Site 10. The trend in salinity mirrored that of EC but with lower absolute values, ranging from 0.02 to 0.08 PSU.

Research suggests that peatlands, being persistently waterlogged, promote the accumulation of minerals and salts due to limited leaching. These substances can become concentrated through evaporation and plant uptake. The increase in EC and salinity between Sites 1 and 5 confirms that minerals and salts from peat industries can enter rivers via groundwater or surface runoff. The subsequent decline between Sites 6 and 9, along with the flattening trend, indicates the river's natural self-purification in the absence of continued pollutant input. Peaks at Sites 5B and 9B again highlight the pollutant accumulation tendency of slow-moving water bodies.

TDS followed a pattern similar to EC, rising sharply from about 17 ppm to about 70 ppm between Sites 1 and 5B, then decreasing to about 25 ppm and leveling off, before increasing again at Site 10. This indicates that the soluble pollutants from peat industries are primarily composed of salts and minerals. Conversely, resistivity exhibited a clear negative correlation with EC, dropping from about 28,000 Ω-cm to about 7,000 Ω-cm between Sites 1 and 5B, then rising to about 20,000 Ω-cm before declining again at Site 10. This inverse relationship is expected, affirming the reliability of the data.

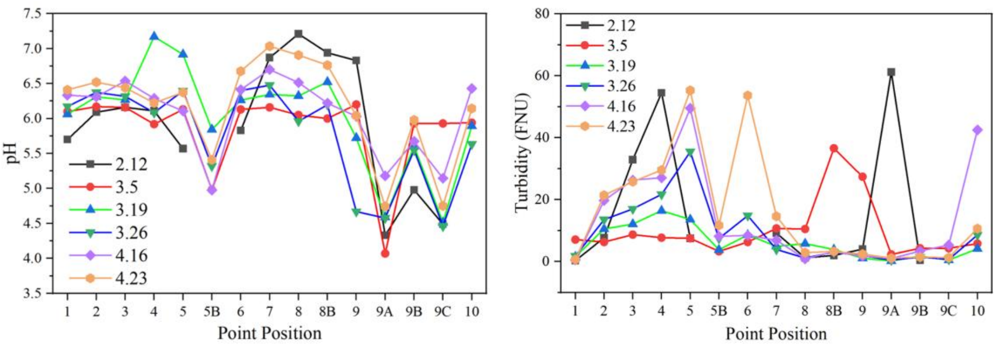

Figure 3.4 Variations in pH and Turbidity across sites

As shown in Figure 3.4, pH levels varied significantly across sites. Sites 1 and 2 maintained a pH around 6.2, while Sites 5B and 9A recorded extremely low values below 4.5. Other sites exhibited pH values between 6.0 and 7.0. The markedly low pH at Sites 5B, 9A, and 9C, all near peatlands, indicates that peatlands can acidify nearby water bodies, adversely affecting aquatic ecosystems. However, the impact appears localized and temporary, with river dilution restoring pH levels quickly.

Turbidity also varied across sites. Peaks of about 60 FNU were observed at Sites 4, 5, 8B, 9A, and 10, while most other sites had turbidity around 10 FNU. Site 1 had almost no turbidity, indicating very clear water. Slight increases in turbidity downstream suggest that suspended solids from peatlands may marginally affect water clarity. Isolated spikes may result from low water levels, causing sampling instruments to disturb bottom sediments.

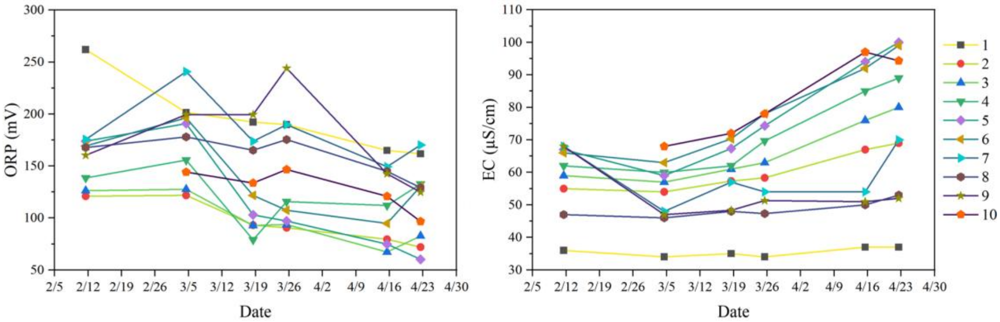

Figure 3.5 Time series of ORP and EC across sites

Figure 3.5 shows the temporal evolution of ORP and EC across sites. Initially, ORP increased by approximately 17 mV but began to decline after March 5, with a total drop of around 50 mV. EC displayed a slight initial decline (typically 2 μS/cm, up to 20 μS/cm), followed by a continuous rise, peaking at a 40 μS/cm increase. Studies suggest that reductive pollutants like hydrogen sulfide and methane in peat effluents reduce ORP, indicating severe water contamination. Organic matter from these effluents also contributes to rising EC. Between February 12 and March 5, extensive river freezing limited external pollutant input, allowing partial recovery of water quality, as reflected in rising ORP and falling EC. However, post-thawing, renewed pollution exceeded the river's self-purification capacity, exacerbating degradation and underscoring the urgency of river conservation.

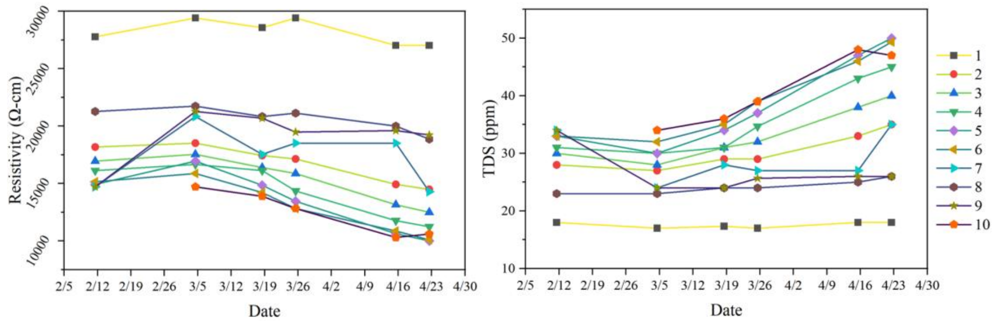

Figure 3.6 Time series of Resistivity and TDS across sites

Figure 3.6 depicts time-series trends for resistivity and TDS. As previously observed, resistivity maintained a negative correlation with EC, while TDS closely mirrored EC patterns. Site 1 exhibited the highest resistivity and lowest TDS, indicating minimal pollution and superior water quality. In contrast, downstream sites, even with partial recovery via self-purification, failed to return to pristine conditions, highlighting the need for active remediation of peatland-related pollution.

4 Discussion

4.1 Impacts of Peatlands, Agriculture, and Livestock on River

To better discuss the variation trends of different parameters across sites, I applied normalization to the data. I first averaged the six measurements for each parameter, and then divided each parameter by a specific scaling factor to ensure that the resulting values fell within the range of 0 to 1. This allowed me to analyze all parameters on two charts without altering their individual variation trends.

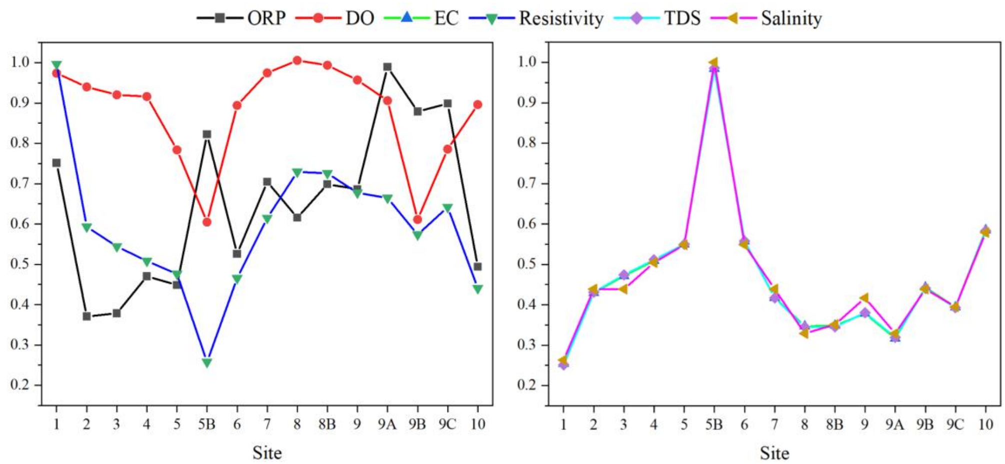

Figure4.1 Summary of trends in different parameters across sites

This study investigates the multiple impacts of peatlands and surrounding human activities on river water quality. As the source of the watershed, Flyxen Lake (Site 1) is subject to minimal pollution, and thus its water quality is significantly better than that of downstream rivers and lakes. As the river flows downstream, a marked decline in various water quality indicators is already evident at Site 2, indicating that peat industry and agriculture along the banks have direct, rapid, and significant negative effects on the river.

After peatlands are reclaimed, they often experience a drop in groundwater levels and enhanced organic matter mineralization. Large amounts of organic substances and mineral ions are discharged into the river via drainage, causing increases in EC, TDS, and Salinity between Sites 2 and 5. Meanwhile, the decomposition of organic matter released from the peatland consumes large amounts of DO, resulting in oxygen deficiency in the water, which threatens aquatic life and disrupts the stability of the aquatic ecosystem.

In addition, specific hydrological conditions can exacerbate pollution. Site 5B, which is close to peat industry operations and is relatively enclosed with poor water exchange, allows pollutants to accumulate. This results in noticeably darker river water, an oily film on the surface, and significantly poorer water quality indicators (App 1).

Sites 9A and 9C, which flow through a drained peatland in the forest, also show poor water quality parameters, suggesting that even drained peatlands can negatively impact water quality under certain hydrological conditions. When water bodies are slow-flowing or enclosed, the accumulated reductive organic matter in peatlands may be released into the water in large quantities, causing hypoxia, changes in microbial communities, a reduction in benthic organisms, and ultimately a decline in biodiversity and ecosystem services.

In addition to peatlands within the watershed, agricultural and livestock activities along the riverbanks are also key contributors to water quality degradation. Unlike the high ORP value at Site 5B, the unexpectedly low ORP values between Sites 2 and 5 suggest that the river is affected not only by peat industry. The presence of agriculture and livestock in this area means that organic fertilizers and animal manure may enter the river through surface runoff after rainfall or irrigation, introducing large amounts of organic matter and resulting in abnormally low ORP values. The subsequent biological oxygen demand further reduces DO levels, potentially leading to aquatic organism mortality and disruption of the food chain. Moreover, soil disturbance and surface exposure from agricultural activities exacerbate sediment runoff, increasing the concentration of suspended solids and turbidity in the river, which impairs the water body's self-purification capacity. Agricultural non-point source pollution is highly concealed, spatially extensive, and difficult to manage, making it one of the most challenging issues in watershed water quality management.

Time-series graphs of multiple water quality parameters clearly show that water quality at other sites is significantly worse than at the source (Site 1), and that it continues to deteriorate over time. This indicates that the current watershed, under the combined influence of peatlands, agriculture, and livestock, has already exceeded the river’s self-purification capacity and is causing severe degradation of water quality.

4.2 Recommendations for River Protection

To effectively protect the water quality and ecological integrity of rivers such as those from Flyxen to Lake Kösen, it is essential to implement a multi-level strategy that involves government authorities, local communities, and industries. Below are several targeted recommendations, especially for governmental bodies:

4.2.1 Strengthen Environmental Monitoring and Regulation

The government should establish a robust, continuous water quality monitoring system across key points in the river network. This includes increasing the frequency of sampling and expanding the range of parameters tested (e.g., heavy metals, emerging pollutants like PFAS). Real-time data collection using sensor technologies and remote sensing could also improve early detection of pollution events.

4.2.2 Implement Buffer Zones and Land Use Controls

Strict land-use planning policies should be enforced to prevent agricultural and industrial encroachment near vulnerable riverbanks. Establishing vegetated buffer zones along the rivers can significantly reduce nutrient and sediment runoff from adjacent lands. Incentives (such as subsidies or tax reductions) could be provided to landowners who maintain or restore riparian vegetation.

4.2.3 Support Sustainable Agriculture Practices

Agriculture is a major non-point source of nutrient pollution. Government agencies should promote sustainable farming techniques such as precision fertilization, reduced pesticide use, and organic farming through training programs and financial incentives. Policies encouraging the adoption of constructed wetlands and other nature-based solutions for runoff treatment should also be considered.

4.2.4 Enhance Wastewater Treatment Infrastructure

Investments should be directed towards upgrading municipal and industrial wastewater treatment plants, especially in smaller towns or rural areas where outdated systems may still discharge inadequately treated water into the river system. Government programs can provide co-financing or technical assistance for such upgrades.

4.2.5 Strengthen Legal Framework and Enforcement

Environmental protection laws and water management policies should be reviewed and updated to reflect current challenges such as climate change and population growth. Stricter enforcement of existing regulations (e.g., pollutant discharge limits, licensing systems) is crucial, and penalties for violations should be increased to act as effective deterrents.

4.2.6 Promote Inter-Municipal and Transboundary Cooperation

As rivers often flow through multiple administrative regions, coordinated water management is essential. The government should facilitate cooperation among municipalities through shared governance models, integrated water resource management (IWRM) platforms, and regular communication channels.

4.2.7 Public Engagement and Environmental Education

Governments should also support awareness campaigns and citizen science initiatives to educate the public on river protection. Empowering local communities to participate in water quality monitoring and decision-making can foster a shared sense of responsibility and improve long-term outcomes.

4.3 Limitations and Future Outlook

This study conducted six rounds of field measurements over a time span of only three months. Overall, the number of measurements remains insufficient, and some outliers may significantly affect the data analysis. In the future, more frequent field measurements should be conducted, and the analysis of water quality changes and influencing factors should be based on a larger dataset to eliminate the interference of abnormal values. Since the current time series only covers February to April, long-term field measurements should be carried out in the future to observe whether river water quality exhibits seasonal variation and to analyze long-term trends.

In addition to data limitations, there are also flaws in the placement of sampling points. Sites 9A and 9C are located at different positions along the same river but are in close proximity, resulting in nearly identical measurements — thus making one of them redundant. The same applies to Sites 8 and 8B. Site 9B is located in an inland lake with no surrounding peat industry, agriculture, or animal husbandry; its water quality is mainly affected by domestic sewage from residents living around the lake. Therefore, its relevance to this study is limited, and it could be excluded. Future site selection should consider adding points near locations where water quality parameters vary significantly to avoid sharp fluctuations in the data that could impact analysis.

This study only included field measurements and focused on a limited set of water quality parameters, mostly physical indicators, and did not include chemical parameters. Thus, it could only provide a general analysis of water quality trends and potential influencing factors. In the future, water samples should be collected for laboratory analysis in addition to fieldwork, to explore the water's chemical composition in depth and enable the identification of specific pollution processes and the quantitative assessment of peatland impacts on water quality.

Finally, all field measurements in this study were conducted near the shore, where water levels are shallow, making the results more susceptible to disturbances. For example, turbidity at some points was abnormally high. In future studies, tools such as fishing boats should be used to measure water quality in the center of lakes, thereby reducing measurement errors.

5 Conclusion

This study investigated the effects of peatland ecosystems and adjacent human activities—particularly agriculture and livestock—on river water quality between the Flyxen Lake and Kösen Lake. Through six field surveys conducted between February and April 2025, a total of 209 valid samples were collected across 15 sites, covering 10 key water quality parameters. The analysis revealed clear spatial and temporal patterns of water quality degradation associated with peat industrial discharge, agricultural runoff, and poor hydrological exchange in enclosed water bodies.

The study found that Flyxen Lake, as the headwater, exhibited relatively good water quality due to minimal human disturbance. In contrast, several downstream sites - particularly those near peat industrial zones or agriculturally intensive areas - showed significant declines in DO levels, along with marked increases in EC, TDS, and Salinity. Meanwhile, pH and ORP exhibited fluctuating changes. These patterns reflect a substantial increase in organic and mineral pollutant loads, which exceed the river's natural self-purification capacity and result in cumulative water quality deterioration.

Notably, even undisturbed natural peatlands may exert negative effects on water quality under certain hydrological conditions. For instance, in slow-flowing or enclosed water bodies, the release of reductive organic matter from peat soils can lead to hypoxia and disruption of aquatic ecosystems. Additionally, non-point source pollution from agricultural practices, such as fertilization, livestock waste, and surface runoff has further increased nutrient loading and turbidity, becoming one of the major driving forces of water quality degradation in the watershed.

It should be noted that this study has certain limitations, including a relatively short observation period, limited number of field surveys, and the absence of quantitative chemical composition analysis. Future research should extend the monitoring period, expand the sampling scope, and incorporate laboratory-based water sample analysis to explore the specific sources and components of pollutants. Such efforts are essential to better understand the long-term impacts on riverine ecosystems and to provide more scientifically grounded support for watershed water resource management.

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Appendix 1

Here follow some pictures of our study area and water sampling process.

The sampling sites (2025.04.23)

Site 1

Site 2

Site 3

Site 4

Site 5

Site 5B

Site 6

Site 7

Site 8

Site 8B

Site 9

Site 9A

Site 9B

Site 9C

Site 10

The water sampling process