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The Norwegian river monitoring programme 2019

– water quality status and trends

Photo: NIVA

Norwegian Institute for Water Research

REPORT

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Summary

In the Norwegian River Monitoring Programme (in Norwegian: Elveovervåkingsprogrammet) 20 rivers along the Norwegian coastline are monitored for chemical and hydrological parameters. It is a continuation of river monitoring with data from 1990. This report presents the current status (2019) and long-term (1990-2019) water quality trends.

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The Norwegian river monitoring programme 2019 – water quality status and trends

Preface

The Norwegian river monitoring programme is a main component of the Norwegian water authorities' surveillance monitoring in rivers, according to the requirements set by the EU Water Framework Directive (WFD). The monitoring also fulfils Norway's obligations under the Oslo-Paris Convention (OSPAR). Since 2017, the Norwegian Institute for Water Research (NIVA), in collaboration with consortium partners, has carried out the monitoring activities. Results from the 2019 monitoring activities are presented in four thematic reports, where this report includes results from the basic monitoring of 20 rivers across Norway. The 20 rivers are selected to represent the variability in river water quality and fluxes, and to cover a substantial fraction of the riverine flux from mainland Norway to the sea.

In 2019, the work presented in this report was a collaboration between NIVA, the Norwegian Water Resources and Energy Directorate (NVE), and Eurofins Environment Testing Norway AS.

Hans Fredrik Veiteberg Braaten (NIVA) was project leader for the river monitoring programme in 2019, together with Cathrine Brecke Gundersen. Other co-workers at NIVA responsible for the results in the present report include Øyvind Kaste (catchment modelling, evaluation of sensor data), James Sample (databases, calculation of riverine loads, TEOTIL modelling), José-Luis Calidonio (catchment and TEOTIL modelling), Luca Nizzetto (catchment modelling), Ian Allan (catchment modelling), Rolf Høgberget (sensor monitoring), Dag Ø. Hjermann (climate and hydrology data), Liv Bente Skancke (coordination of local field work personnel, quality assurance of sampling and chemical analyses), Jan Karud (development of maps), and Elisabeth Lie and Marit Villø (contact persons at the NIVA chemical laboratory). Quality assurance of the report has been carried out by François Clayer.

At NVE, Trine Fjeldstad has been responsible for the local sampling programmes, Stein Beldring has carried out the hydrological modelling, and Morten N. Due has been the administrative contact. In 2019, Eurofins carried out the total nitrogen and parts of the mercury analyses.

Contact persons at The Norwegian Environment Agency have been Gunn Lise Haugestøl, Preben Danielsen and Eivind Farmen. Thanks to all involved for a good collaboration.

Oslo, 30.11.2020

Hans Fredrik Veiteberg Braaten

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Summary

The **Norwegian River Monitoring Programme** features monitoring for various chemical, physical, and hydrological parameters in 20 rivers distributed along the Norwegian coastline. The monitoring programme is a main component of the Norwegian water authorities' surveillance of rivers, according to the requirements set by the EU Water Framework Directive (WFD), and it also forms the basis for the fulfilment of Norway's obligations under the Oslo-Paris Convention (OSPAR). This report presents 2019 water quality status and the up to 30-year trends (1990-2019) for the 20 rivers. Additionally, data from the National monitoring program for limed rivers, including 6 rivers in the south and south-western parts of Norway, were included.

Overall, 2019 was the 20th warmest year since the measurements started in 1900. **Air temperatures** were 1.2 °C above the 1961-1990 normal. The geographical differences were large, with southern parts of the country having a warmer year than normal and the northern parts a colder or more normal year. For 17 out of 20 monitoring stations, there is a significant increasing temperature trend since the early 1980s. There was 15 % more **precipitation** than normal in 2019, making it the 15th wettest year recorded the last 120 years.

The river catchments display large variation in elevation, vegetation and soils types, affecting the **water chemistry.** Generally, most variables follow a geographical pattern east-to-west and south-to-north, typically illustrated by **pH** and **calcium** (Ca) concentrations. In 2019, river pH ranged from weakly acidic (pH 6.2) to basic (pH 7.9). The most acidic rivers are found in the south and south-west due to historical acid deposition and slow weathering bedrock. Consequently, several of these rivers were low in Ca, and according to the Norwegian WFD typology fall into the categories very low (< 1 mg/L) and low (1-4 mg/L). In the south-east, where the catchments typically consist of boreal forests, pH was weakly acidic to neutral and in mid-to-northern Norway, the pH was generally close to neutral. Organic carbon, measured as **total organic carbon** (TOC), also fall into these categories based on catchment typography. Bjerkreimselva, Vikedalselva, Vosso, Vefsna, Driva, and Målselva have very clear water (TOC < 2mg/L) according to the Norwegian WFD typology, while Glomma, Alna, Drammenselva, Numedalslågen, Skienselva, Otra, Nausta, Orkla, Nidelva, Altaelva, Tana and Pasvikelva are clear (2 mg/L < TOC < 5 mg/L), and Storelva and Orreelva are humic (TOC > 5 mg/L). There are two clear exceptions from these patterns, Alna and Orreelva, both heavily influenced by human activities through urbanization and agriculture, respectively. These rivers typically have higher pH values and Orreelva also elevated TOC concentrations, likely due to effluent inputs and diffuse water discharge from agriculture.

Turbidity and **suspended particulate matter** (SPM) – typically influencing aqueous light penetration and transport of metals and/or nutrients – were much higher in Orreelva than in the other rivers, consistent with influence from agriculture and particles from erodible clays. Glomma and Alna are also rivers with typically high measurements of suspended matter, but both turbidity and SPM concentrations were lower in 2019 compared to the previous five years.

Concentrations of **total phosphorous** (tot-P) and **total nitrogen** (tot-N) are much higher in Alna and Orreelva compared to the other rivers in the monitoring programme, again due to urban and agricultural activities in the respective catchments. Both rivers have less than good ecological status according to the good/moderate boundary for both parameters for their respective water. Of the remaining rivers, only Glomma and Numedalslågen had elevated tot-P concentrations, but both were below the good/moderate boundary. Elevated levels of tot-N were also evident for some of the rivers in the south and south-western part of Norway, likely an effect of atmospheric deposition.

Total **metals** concentrations were generally high in the urban river Alna, including arsenic (As), lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), and mercury (Hg). But mean annual 2019 concentrations were lower than the five-year mean for all metals where historical data exists. Pasvikelva also shows elevated concentrations of selected metals, most noteworthy Ni and Cu, likely due to metallurgical activity on the Russian side of the border. Orkla (Cd, Cu, Zn, Ni), Storelva (As, Pb, Cd) and Orreelva (As, Pb, Ni) had moderately elevated concentrations of some metals, likely from runoff from old main tailings in the catchments (Orkla and Storelva) and from agricultural activities (Orreelva).

The statistical analysis of **trends of loads** of the different parameters for a sub-selection of rivers revealed a geographical pattern: there was a significant increase in the loads and concentrations of silica (SiO_2), PO_4, and tot-N for the south-eastern rivers Glomma, Drammenselva, and Numedalslågen. Additionally, significant trends in the loads, but not in the concentrations, were evident in Drammenselva for SPM, TOC, and tot-P, in Numedalslågen for tot-P and NH_4, and in Orreelva for SPM, SiO_2, and tot-P. In contrast, decreasing trends in loads and concentrations were evident in Vefsna for SPM, tot-P, PO_4, tot-N, NH_4, and NO_3. Parallel trends in loads and concentrations reflect a change in the sources of the considered parameters to the river in addition to possible changes in discharge. For **metal loads**, the general pattern is significantly declining trends in loads and concentrations. The only two exceptions are Vefsna and Alta, where Ni concentrations are significantly increasing. Although the reason for this is not known, the Ni concentrations are low and does not warrant major concern at this point. For the first time, Hg loads were calculated, revealing highest flux of Hg in 2019 in Glomma (46.4 kg). The Hg load from Glomma was nearly four times as high as in the other rivers: 13.5 kg in Pasvikelva, 12.7 kg in Tanaelva, 10.7 kg in Drammenselva, and 9.5 kg in Skienselva.

Generally, the long-term monitoring of river water in Norway (1990-2019) does not display a significant increase in TOC concentrations (Drammenselva is the only exception) and no river show significant trends in the **export of TOC**. Browning of surface waters across the northern hemisphere is a well-established phenomenon, consisting of an observed increase in both the concentration and colour of DOM, explained by a reduction of acid deposition and/or to climate change. The lack of expected TOC increase in the large Norwegian rivers included here are likely explained by 1) too short time series to capture any potential increase, and 2) regulation of rivers for hydropower. Point 2) is particularly important as studies have shown that water flow is the major factor governing interannual variation in organic matter (OM) concentration in rivers.

For Norway as a whole, the **mean seasonal TOC concentration** in 2019 was increasing from winter through summer, dropping in august before a continued increase during autumn. This reflects the typical seasonal events of increased production and transport of OM to the river during spring warming with snow melt. The drop in TOC concentration in august was likely caused by a combination of high biological uptake and low precipitation that reduced transport of new OM. During autumn, intensive rainfall ensured increased transport of TOC from the forest floors to the rivers. The rivers draining into the North Sea generally show the lowest TOC levels, high water discharge and relatively high **DOM aromaticity** and **molecular size**. The Skagerrak region rivers had the highest TOC levels, moderate water discharge, but also high DOM aromaticity and molecular size. The Barents Sea rivers generally had intermediate TOC levels, low water discharge and the lowest aromaticity and molecular size. These regional variations should be explored further in combination with data on land use, climate, and other catchment characteristics.

An **integrated catchment model for contaminants (INCA-Tox)** was applied to simulate fate and transport of two PCB congeners (PCB-101, PCB-153) and three PAH congeners (Phenanthrene, Fluoranthene, Benzo-a-Pyrene) in Alna. Hydrology (2006-2015), suspended sediments, carbon, and contaminants were calibrated based on measured data. The selected contaminants are largely hydrophobic with a large affinity to OM, implying that concentrations of contaminants in soil OM will determine the dissolved concentration in soil water, which again is the main driver for the river dissolved concentrations. By choosing initial concentrations in soil organic carbon (SOC) within the ranges given by data from forested areas around Oslo, we obtained river dissolved contaminant concentrations that matched the general magnitude of data measured during the period 2013-2016. Boreal forested catchments are currently in a transitory phase, where the system will shift from acting as a net sink of atmospheric PCBs to becoming a net source for air and water environments.

Short-term effects of climate variability on water chemistry were studied **using high-frequency (hourly) sensor data from Storelva and Målselva**, including water temperature, pH, conductivity, turbidity and fluorescent DOM (fDOM). Data from Storelva show that flood characteristics (i.e. type, magnitude, timing) largely influenced short-time variation in concentrations of dissolved ions (conductivity), suspended particles (turbidity) and DOM in 2019. Also in Målselva, turbidity values showed a strong response to repeated flood peaks during a high-flow period in late spring. Values were especially high (<300 NTU) during a major flood peak that occurred in early July. fDOM on the other hand were highest in the early phase of the snowmelt period and decreased during the major flood peak in early July.

Sammendrag

Tittel: Elveovervåkningsprogrammet 2019 – vannkvalitetsstatus og -trender
År: 2020
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Elveovervåkingsprogrammet omfatter månedlig overvåking av ulike kjemiske, fysiske og hydrologiske parametere i 20 elver fordelt geografisk langs norskekysten. Programmet er en viktig del av norske myndigheters basisovervåking av elver i henhold til vannforskriften, i tillegg til at programmet oppfyller Norges forpliktelser i henhold til Oslo-Paris konvensjonen (OSPAR). Denne rapporten presenterer status for 2019 og langtidstrender (opptil 30 år, 1990-2019) av vannkvalitet for de 20 elvene. I tillegg er data fra seks elver fra *Tiltaksovervåking av kalkede laksevassdrag i Norge* inkludert.

2019 var det 20. varmeste året siden målingene startet i 1900. Den gjennomsnittlige **lufttemperaturen** i Norge var 1,2° C over normalen for perioden 1961-1990. Den geografiske variasjonen var stor, der de sørlige delene av landet hadde et varmere år enn normalt, mens nordlige områder hadde kaldere eller mer normale temperaturer. For 17 av de 20 overvåkingsstasjonene i programmet viser data signifikant økende temperaturer siden tidlig 1980-tall. Det var også 15 % mer **nedbør** enn normalt i Norge i 2019, noe som tilsvarer det 15. våteste året de siste 120 årene.

De overvåkede nedbørfeltene har ulike karakteristika, som for eksempel stor variasjon i høyde over havet, vegetasjon og jordtyper, og dette påvirker vannkjemien i elvene. Generelt følger de fleste målte parametere et geografisk mønster (øst-til-vest og sør-til-nord), illustrert ved for eksempel **pH** og **kalsiumkonsentrasjoner**. I 2019 varierte pH i elvene fra svakt surt (pH 6,2) til basisk (pH 7,9). De sureste elvene var i sør- og sørvestlige deler av landet. Dette skyldes en kombinasjon av naturlig lav bufferkapasitet og det faktum at disse områdene er – og har vært – utsatt for sur nedbør. Som et resultat av dette har disse elvene lave kalsiumkonsentrasjoner og typifiseres som svært kalkfattig (< 1 mg Ca/L) og kalkfattig (1-4 mg Ca/L), i henhold til Vannforskriften. I sørøstlige, boreale områder, var elvene svakt sure eller nøytrale, mens elvene lenger nord (midt- til Nord-Norge) var typisk nøytrale. Et lignende geografisk mønster observeres for organisk karbon i vann, målt som **totalt organisk karbon (TOC)**. Bjerkreimselva, Vikedalselva, Vosso, Vefsna, Driva og Målselva kan typifiseres som veldig klare (TOC < 2 mg/L), Glomma, Alna, Drammenselva, Numedalslågen, Skienselva, Otra, Nausta, Orkla, Nidelva, Altaelva, Tana og Pasvikelva er klare (2 mg/L < TOC < 5 mg/L), mens Storelva og Orreelva er humøse (TOC > 5 mg/L). I denne sammenhengen skiller Alna og Orreelva seg tydelig ut, begge tungt påvirket av menneskelig aktivitet gjennom henholdsvis urbanisering/industri og landbruk. Alna og Orreelva har høyere pH-verdier og Orreelva også forhøyede TOC-konsentrasjoner, sannsynligvis pga. tilførsel av avløpsvann og utslipp fra jordbruk.

Turbiditet og **suspendert partikulært materiale** (SPM) – parametere som indikerer hvordan lysforhold og transport av metaller og næringsstoffer påvirkes i elvene – hadde mye høyere nivåer i Orreelva sammenlignet med de andre elvene. Dette er typisk der vannet påvirkes av landbruk og jorderosjon. Glomma og Alna har også tradisjonelt høye målinger av suspendert materiale, men både turbiditet og SPM var lavere i 2019 sammenlignet med gjennomsnittet for de fem foregående årene (2014-2018).

Næringsstoffene **fosfor** (P) og **nitrogen** (N) forekommer i mye høyere konsentrasjoner i Alna og Orreelva sammenlignet med de andre elvene i programmet. Dette er også en effekt av menneskelige aktiviteter og landbruksvirksomhet i respektive nedbørfelt. Begge elvene overskred Vannforskriftens grense for god tilstand for sine respektive vanntyper, basert på totale konsentrasjoner (tot-N og tot-P). Av de andre elvene var det bare Glomma og Numedalslågen som hadde forhøyede tot-P konsentrasjoner, men begge innenfor god tilstand. Forhøyede nivåer av tot-N ble dokumentert for enkelte elver i sør og sørøstlige deler av Norge, sannsynligvis en effekt av atmosfærisk deposisjon.

Som et resultat av nærliggende industriaktivitet hadde Alna høye konsentrasjoner av arsen, bly, kadmium, kobber, sink, krom, nikkel og kvikksølv, men nivåene i 2019 var lavere enn gjennomsnittet i perioden 2014-2018 for alle **metaller** der historiske data finnes. I Pasvikelva ble det observert høye konsentrasjoner av nikkel og kadmium, sannsynligvis pga. betydelig metallurgisk industriaktivitet i grensenære områder i Russland. Orkla (kadmium, kobber, sink, nikkel), Storelva (arsen, bly, kadmium) og Orreelva (arsen, bly, nikkel) hadde moderat forhøyede konsentrasjoner av enkelte metaller, der sannsynlige kilder inkluderer avrenning fra historisk gruvedrift i nedbørfeltet (Orkla og Storelva) og landbruksaktivitet (Orreelva).

Den statistiske analysen av **tilførselstrender** for et utvalg nedbørfelt i programmet avslørte et geografisk mønster: det var en signifikant økning i tilførsler og konsentrasjoner av silisiumdioksid (SiO_2), fosfat (PO_4) og tot-N for de sørøstlige elvene Glomma, Drammenselva og Numedalslågen. I tillegg var det signifikante trender i tilførsler, men ikke i konsentrasjoner, i Drammenselva av SPM, TOC og tot-P, i Numedalslågen av tot-P og ammonium (NH_4), og i Orreelva av SPM, SiO_2 og tot-P. Dette i contrast til Vefsna, der trendene i både tilførsler og konsentrasjoner av SPM, tot-P, PO_4, tot-N, NH_4 og NO_3 var signifikant nedadgående. Parallelle trender i tilførsler og konsentrasjoner reflekterer en endring i kilden for den aktuelle parameteren, i tillegg til en mulig endring i vanntilførsel. For metalltilførsler er det generelle mønsteret at trendene er nedadgående. Det er to unntak: Vefsna og Alta, der nikkelkonsentrasjonene øker signifikant. Årsaken til dette er ikke kjent, men konsentrasjonene er lave og det er ikke grunnlag for bekymring foreløpig. For første gang ble også kvikksølvtilførsler beregnet for elvene i programmet. Tilførslene var størst i Glomma (46,4 kg), nesten fire ganger mer enn i noen annen elv: 13,5 kg i Pasvikelva, 12,7 kg i Tanaelva, 10,7 kg i Drammenselva, og 9,5 kg i Skienselva.

Generelt er det ikke mulig å observere noen signifikant økning i **TOC-konsentrasjoner** (Drammenselva eneste unntaket) eller **TOC-tilførsler** i langtidsovervåkingen av elvevann i Norge (1990-2019). Brunere overflatevann i innsjøer og elver er en veletablert realitet over store deler av den nordlige halvkule, en effekt av redusert sur nedbør og økt nedbør som fører til økt utlekking av organisk materiale (OM) fra jordsmonnet i nedbørfeltene. Den manglende trenden i store norske elver skyldes sannsynligvis 1) for korte tidsserier, og 2) regulering av vassdragene. Reguleringen er særlig viktig ettersom studier har vist at vannføring er den viktigste faktoren for å forklare år-til-år variasjon av OM-konsentrasjoner.

For Norge samlet var det i 2019 en økning i gjennomsnittlig månedlig **TOC-konsentrasjon** fra vinteren og gjennom sommeren, med en nedgang i nivået i august, før konsentrasjonene økte igjen utover høsten. Dette reflekterer et typisk sesongmønster med økt produksjon og transport av OM til elvene ved varmere temperaturer og snøsmelting om våren. Lavere konsentrasjoner i august skyldes sannsynligvis høyt biologisk opptak og lite nedbør (som gir redusert transport). Gjennom høsten fører intense nedbørsperioder til økt transport av OM fra skogbunn til elv. Elvene som drenerer til Nordsjøen hadde lavest TOC-konsentrasjoner, høy vannføring og relativt høy DOM-aromatisitet og molekylstørrelse. Elvene i Skagerrak-regionen hadde høyest TOC-konsentrasjoner, moderat vannføring, men også høy DOM-aromatisitet og molekylstørrelse. I Barentsregionen hadde elvene generelt et middels TOC-innhold, lav vannføring og den laveste DOM-aromatisitet og molekylstørrelse. Disse regionale variasjonene i **OM-kvalitet** bør undersøkes nærmere i kombinasjon med data for arealutnyttelse, klima og andre nedbørfeltkarakteristika.

En **integrert nedbørfeltmodell for miljøgifter (INCA-Tox)** ble brukt for å simulere mobilisering og transport av to PCB-forbindelser (PCB-101, PCB-153) og tre PAH-forbindelser (fenantren, fluoranten, benzo-a-pyren) i Alna. Hydrologi (2006-2015), suspenderte sedimenter, organisk karbon og miljøgifter ble kalibrert i forhold til målte data. De valgte PCB- og PAH-forbindelsene er i stor grad hydrofobe med stor affinitet til organisk materiale. Dette innebærer at konsentrasjoner av miljøgifter i jorda vil styre hvor mye som kan løses i jordvannet og deretter i elvevannet. Ved å benytte jorddata fra skogkledde områder rundt Oslo var det mulig å simulere nivåer av løste miljøgiftforbindelser som samsvarte med konsentrasjonene som er målt i elva i perioden 2013-2016. Boreale nedbørfelt er i en overgangsfase der systemet om kort tid vil endre seg fra å være et sluk for atmosfærisk PCB til å bli en netto kilde for PBC til luft og vann.

Korttidseffekter av klimavariasjon på vannkjemi ble studert ved bruk av **høyoppløselige (timesverdier) sensordata fra Storelva og Målselva**, inkludert vanntemperatur, pH, konduktivitet, turbiditet og løst organisk materiale (fDOM). Data fra Storelva viste at flommer har stor innvirkning på vannkvaliteten i elva, men responsen på de ulike vannkvalitetsparameterne varierer med flomtype, flomstørrelse og tidspunkt på året flommene inntreffer. Også i Målselva viste dataene at turbiditeten responderte sterkt på gjentatte flomtopper som oppsto i løpet av snøsmeltingsperioden. Spesielt høy turbiditet ble målt under flomtoppen i begynnelsen av juli. fDOM var høyest tidlig i snøsmeltingsperioden, mens målingene i motsetning til turbiditeten avtok under den største flomtoppen i juli.

1. Introduction

The river monitoring programme (Elveovervåkingsprogrammet) was established in 2017, replacing the former RID programme (Riverine inputs and direct discharges to Norwegian coastal waters) that had been running since 1990. The programme includes monitoring of 20 rivers (Table 1 and Figure 1) for various chemical, physical, and hydrological parameters. The main features of the programme are: 1) relatively high sampling frequency (monthly at all sites and for all parameters, except for metals); 2) an extended list of chemical variables (including emerging contaminants and priority substances); 3) the use of catchment models for simulation of climate effects and contaminant discharges on water quality; and 4) sensor monitoring in selected rivers (determining water temperature, pH, conductivity, turbidity and fluorescent dissolved organic matter (FDOM)).

The 20 monitored rivers were all part of the RID programme, but the monitoring frequency has changed: minimum monthly since 1990 for 11 of the rivers (with two exceptions where monitoring started later); quarterly since 1990 for 8 of the rivers; and annually from 1990 to 2003 for 1 of the rivers (Braaten et al., 2017). For more information on the differences between the current and the past programme, see the report for the 2017 river monitoring results (Kaste et al., 2018).

1.1 Monitoring objectives

The Norwegian river monitoring programme is the basis for fulfilment of Norway's obligations under the Oslo-Paris Convention (OSPAR) and is also a main component of the Norwegian water authorities' surveillance monitoring in rivers, according to the requirements set by the EU Water Framework Directive (WFD).

The main objectives of the river monitoring programme, formulated by the Norwegian Environment Agency, are to:

1. document status and long-term trends for nutrient and contaminant concentrations in Norwegian rivers
2. obtain data for classification of Norwegian rivers according to the requirements of the WFD
3. reveal water quality changes that can be attributed to climate change or other human influences
4. increase the knowledge base on climate processes affecting water
5. increase current knowledge related to the fates of emerging contaminants in aquatic ecosystems
6. provide data that may explain changes in eutrophication and contaminant levels along the Norwegian coast
7. estimate riverine inputs and direct discharges of nutrients and contaminants to Norwegian coastal waters (for reporting under the OSPAR Convention)

Data collected as part of the river monitoring programme in 2019 are presented in four separate reports. The present report addresses objectives 1, 3, 4, and partly 6 and 7 by providing the current status (2019) and long-term water quality trends (1990-2019) for 20 rivers selected to represent most of the Norwegian drainage area. The other reports include: *i*) "Classification of ecological and chemical status of Norwegian rivers according to the requirements of the WFD – The river monitoring programme 2019" (In Norwegian), addressing objective 2; *ii*) "Source apportioned input of nutrients to Norwegian coastal areas in 2019 – tables, charts and maps" (In Norwegian), addressing partly objective 7, and *iii*) «Priority substances and emerging contaminants in selected

Norwegian rivers», addressing objectives 1, 5, 6 and 7. Additionally, the monitoring programme provides an information repository for the newly developed TEOTIL metals model, addressing partly objectives 6 and 7.

1.2 Main rivers

The 20 rivers sampled within this monitoring programme discharge to (from south to north) Skagerrak, the North Sea, the Norwegian Sea and the Barents Sea (Table 1). The rivers are selected based on geographical location (Table 1, Figure 1), availability of historical data, relevance in relation to land-use (Figure 2) and pollution pressure, and access to existing infrastructure for sampling.

Table 1. Rivers included in the programme.

River name	UTM (east)	UTM (north)	UTM zone	Catchment (km^2)	Waterbody code ID	Drainage basin
Glomma*	621600	6573156	32	41918	002-1519-R	Skagerrak
Alna*	600213	6642144	32	69	006-71-R	Skagerrak
Drammenselva*	556636	6624287	32	17034	012-2399-R	Skagerrak
Numedalslågen*	561346	6551822	32	5577	015-33-R	Skagerrak
Skienselva*	534726	6562938	32	10772	016-769-R	Skagerrak
Storelva**	498897	6503307	32	408	018-127-R	Skagerrak
Otra*	438737	6449755	32	3738	021-28-R	Skagerrak
Bjerkreimselva	325246	6487028	32	705	027-92-R	North Sea
Orreelva*	299152	6515475	32	105	028-16-R	North Sea
Vikedalselva	325319	6599745	32	118	038-11-R	North Sea
Vosso*	336048	6727293	32	1492	062-219-R	North Sea
Nausta	327402	6826450	32	277	084-218-R	North Sea
Driva	477383	6948637	32	2487	109-54-R	Norwegian Sea
Orkla*	237185	7018935	33	3053	121-56-R	Norwegian Sea
Nidelva	569352	7030201	32	3110	123-29-R	Norwegian Sea
Vefsna*	418710	7292351	33	4122	151-36-R	Norwegian Sea
Målselva	406570	7660047	34	3239	196-275-R	Barents Sea
Altaelva*	586586	7759686	34	7373	212-63-R	Barents Sea
Tana	543964	7791926	35	16389	234-124-R	Barents Sea
Pasvikelva	386937	7709634	36	18404	246-65242-L	Barents Sea

* "Main rivers" in the previous RID programme, monthly monitoring since 1990 (except Rivers Vosso and Alna, monthly from 2008 and 2013, respectively)

** Also denoted "Vegårdselva" in the RID database

Of the rivers included, Glomma, Drammenselva, Numedalslågen, Skienselva, Otra, Bjerkreimselva, Driva, Orkla, Nidelva, Vefsna, Målselva, Altaelva, and Pasvikelva are regulated.

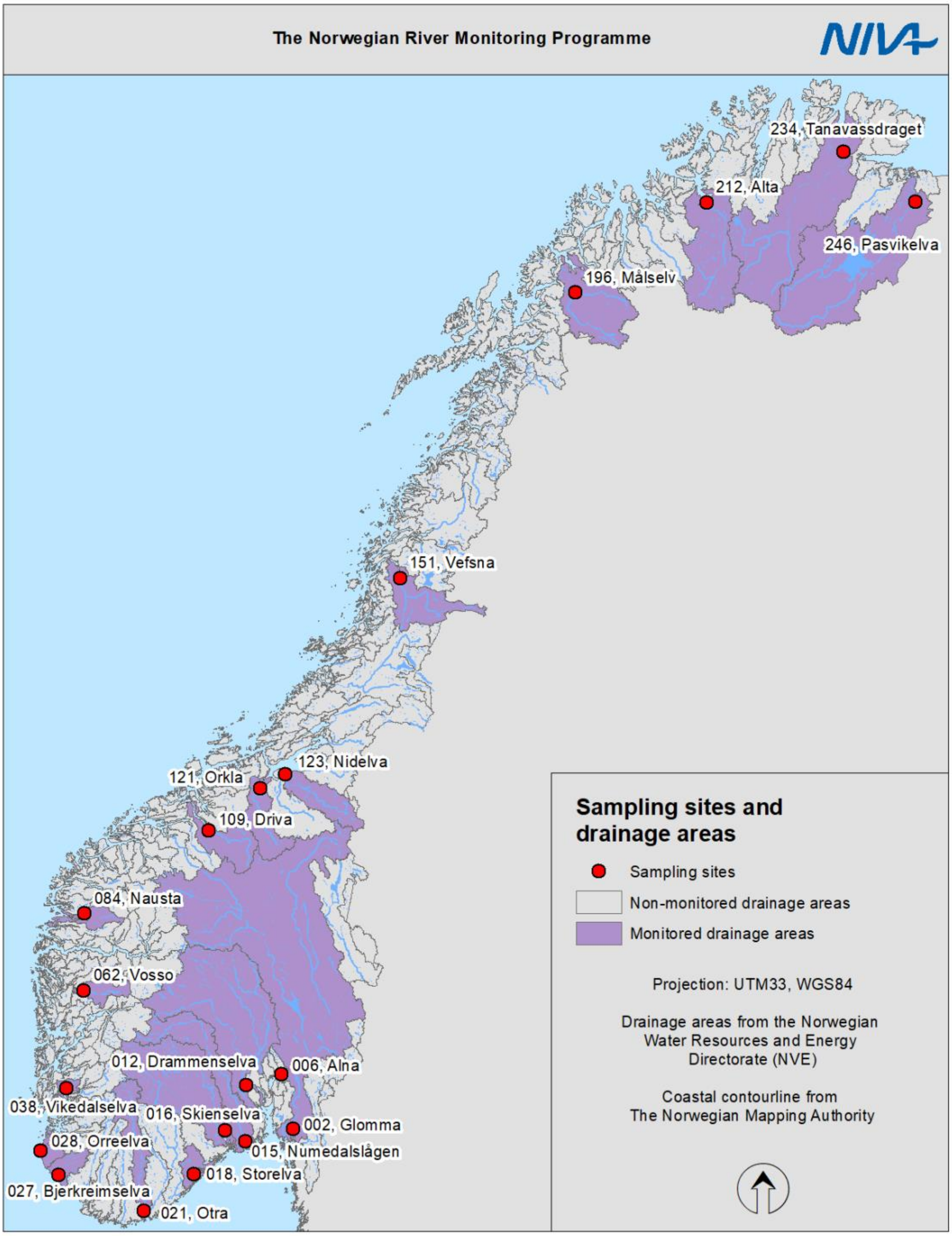

Figure 1: Map showing the location of the rivers in the Norwegian river monitoring programme, including drainage areas (purple) and the sampling sites (red dot).

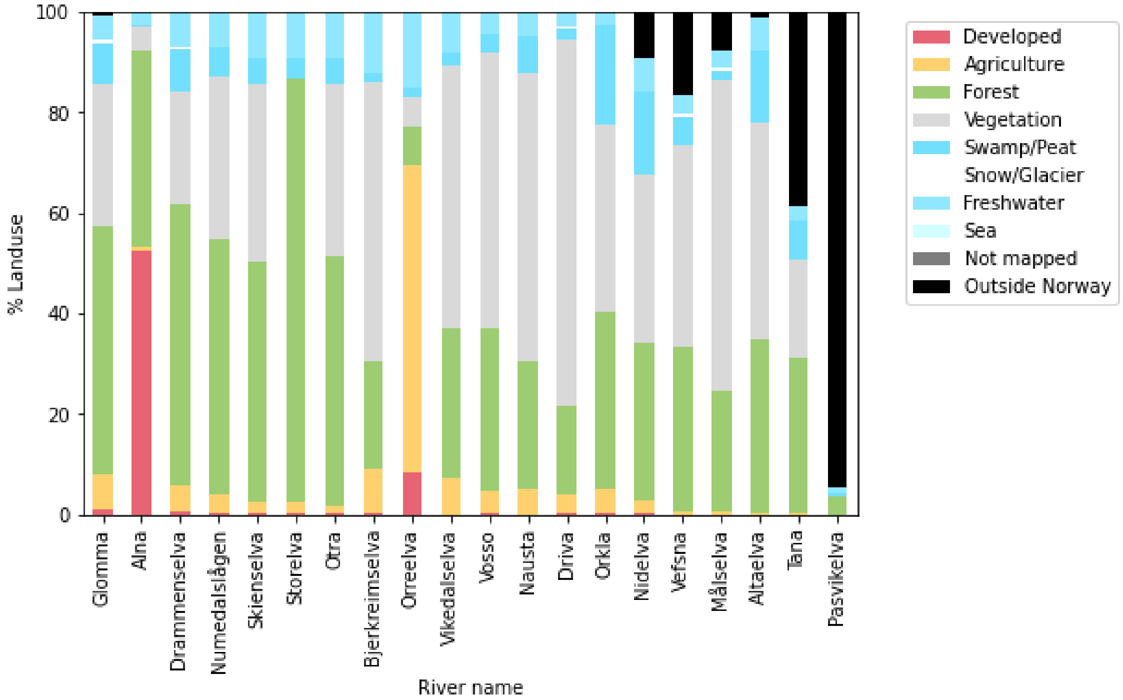

Figure 2: Land use for the 20 rivers included in the monitoring programme. Shown are % land-use, including developed (red), agriculture (yellow), forest (green), other vegetation (grey), swamp/peat (blue), snow/glacier (white), freshwater (light blue), sea (very light blue), not mapped (dark grey), and areas outside Norway without data available (black).

1.3 Additional Rivers

This year's report also covers the water chemistry for six additional rivers (Table 2 and Figure 3). These rivers were part of the National monitoring program for limed rivers (In Norwegian: Tiltaksovervåking av kalkede laksevassdrag i Norge). The National monitoring program for limed rivers covers rivers in the south and south-western Norway that are limed to counter the effects from acid deposition. Although acid deposition has decreased since the 1970s, the critical load for acid deposition (especially in the form of nitrogen) is still exceeded for these catchments.

Table 2. Additional rivers included in the report

River name	UTM (east)	UTM (north)	UTM zone	Catchment (km^2)	Waterbody ID
Nidelva	478798	6474111	32	4025	019-398-R
Tovdalselva	449503	6456437	32	1885	020-183-R
Mandalselva	413351	6453264	32	1809	022-654-R
Lygna	390778	6454254	32	663	024-412-R
Suldalslågen	344680	6596924	32	1463	036-92-R
Ekso	325747	6737576	32	414	063-181-R

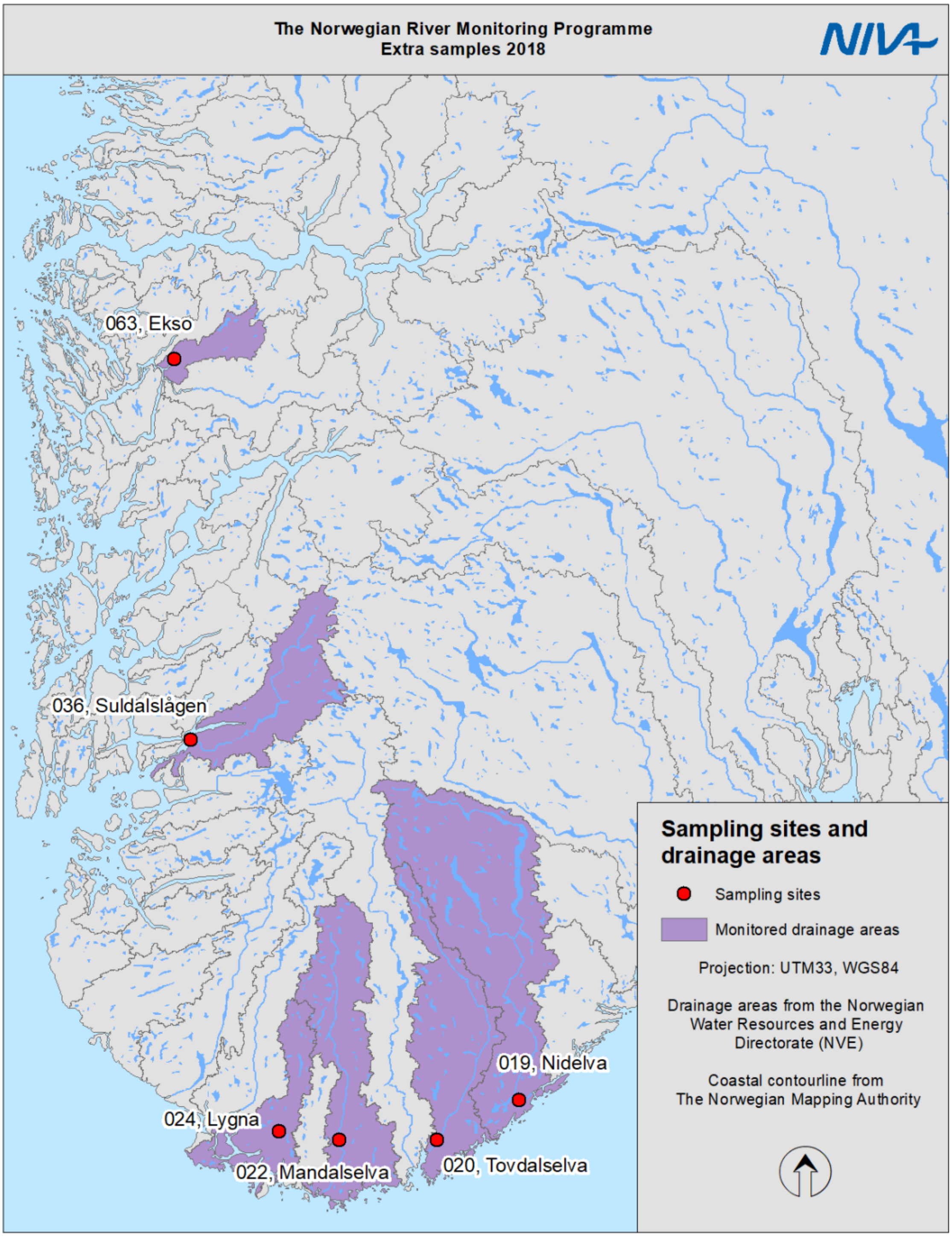

Figure 3: Map showing the location of the additional rivers included with water chemistry in this report. Drainage areas are illustrated with purple shading and the sampling sites from the liming programme status in red.

2. Methods

2.1 Water discharge

For 11 of the rivers (the “main rivers” of the previous RID programme plus Alna, Table 1) discharge data was downloaded from Norwegian Water Resources and Energy Directorate (NVE, Hydra-II database). Since the hydrological stations are usually not located exactly at the same site as where the water samples were collected, the water discharge has been calculated by up- or downscaling, proportional to the respective drainage area. For the remaining 9 rivers, water discharge has been simulated with a spatially distributed version of the HBV-model (Beldring et al., 2003). The use of this model was introduced in 2004, and Skarbøvik et al. (2017) gives more information on the methodology.

2.2 Water temperature

Data on water temperature is acquired from four different sources (Table 3): Sensor monitoring (hourly time-step, see section 2.7), TinyTag temperature loggers (hourly time-step), manual measurements with a thermometer in connection with the monthly water quality sampling, and NVE temperature logging (daily averages from bi-hourly measurements). For the former three the measurements were made at the water quality sampling sites, while the NVE loggers were at stations located in close vicinity to these sites. The TinyTag loggers were secured to land and deployed in the river at the water quality sampling site. They were routinely replaced each autumn to ensure enough battery capacity.

Since temperature measurements have only been part of the river monitoring programme since 2013, data from NVE has been used for long-term trend analysis. This includes data for rivers were other data sources are used for the current monitoring (to get data from the actual sampling sites). Details on the time series from the closest NVE station in each river are presented in Table 4. Long-term data series of water temperature typically contain some missing data. Prior to trend analysis, the data was filtered to remove years for which >90% of the daily observations were missing.

Table 3. Sources for water temperature data in monitored rivers

Data source	**Sites**
Sensor-based	Storelva
TinyTag loggers	Skienselva, Otra, Numedalslågen, Altaelva, Vefsna, Orreelva* and Vosso
NVE station	Orkla and Vikedalselva
Manual measurement	Drammenselva, Driva, Glomma, Alna, Bjerkreimselva, Nausta, Nidelva, Målselva, Tana, Pasvikelva

* The TinyTag logger in Orreelva was not found during field work in June 2020, and data from July to December 2019 were ignored. For more details we refer to result section 3.1.3.

Table 4. Stations with available long-term data on water temperature. The stations are operated by the Norwegian Water Resources and Energy Directorate (NVE).

St. ID	River name	Water temperature station	Start	End
29617	Glomma	2.1078.0.1003.1 Glomma ovf. Sarpefossen	2007	2019
36225	Alna	n.a.		
29612	Drammenselva	12.298.0.1003.4 Drammenselva v/Døvikfoss	1987	2019
29615	Numedalslågen	15.115.0.1003.1 Numedalslågen v/Brufoss	2005	2018*
29613	Skienselva	16.207.0.1003.2 Skienselva ndf. Norsjø	1991	2019
30019	Storelva	n.a.		
29614	Otra	21.79.0.1003.1 Otra v/Mosby	1988	2018*
29832	Bjerkreimselva	27.29.0.1003.1 Bjerkreimselvi v/Bjerkreim	1987	2018*
29783	Orreelva	n.a.		
29837	Vikedalselva	38.2.0.1003.1 Vikedalselva utløp	1987	2019
29821	Vosso	62.30.0.1003.3 Vosso ovf. Evangervatnet	1993	2017*
29842	Nausta	84.23.0.1003.3 Nausta v/Hovefossen	1999	2017*
29822	Driva	109.44.0.1003.2 Driva ndf. Grøa		
29778	Orkla	121.62.0 Orkla v/Merk Bru	1992	2019
29844	Nidelva	n.a.		
29782	Vefsna	151.32.0.1003.3 Vefsna v/Laksfors	2014	2015*
29848	Målselv	196.35.0.1003.1 Malangfoss		
29779	Altaelva	212.68.0.1003.1 Alta v/Gargia	1982	2018*
29820	Tanaelva	234.19.0.1003.1 Tana ovf. Polmakelva	2000	2018*
29819	Pasvikelva	246.11.0.1003.1 Pasvikelva v/Skogfoss kraftstasjon	1992	2018*

*Updated temperature was not available for 2019 in time for this report.

2.2 Water quality sampling and analyses

2.2.1 Sampling methodology

Monthly sampling was conducted by grab sampling, undertaken by local fieldworkers (Skarbøvik et al., 2017). In Rivers Glomma and Drammenselva, both receiving a substantial part of their water discharge from high-elevation areas, additional sampling was conducted during May and June to get a better representation of the high-flow period following snowmelt.

In 2019, the monitoring station at Målselva was moved approximately 17 km downstream (Table 1). Prior to 2017, two stations were monitored in this region: Målselva and Barduelva, the latter being a major tributary. Barduelva was removed from the monitoring programme in 2017 and the station at Målselva has now been shifted to a location downstream of the confluence, in order to integrate discharges from both river systems.

2.2.2 Chemical parameters – detection limits and analytical methods

The parameters monitored in 2019, including information on methodology and limits of detection (LOD) and quantification (LOQ) are given in Table 5. The metals, including silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) were analysed every three months (i.e. four times per year).

Mercury (Hg) was analysed for the first time this year with two different methods. The samples collected every three months were analysed by atomic absorption spectrometry (AAS) with a method limit of quantification (LOQ) 1.0 ng/L (hereafter: the AAS method). Additionally, separate samples were collected and analysed every month using USEPA method 1631, oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (CVAFS) with a LOQ 0.2 ng/L (hereafter: the CVAFS method) (Table 5).

Table 5. Analytical methods, limits of detection (LOD) and quantification (LOQ)

Parameter	LOD/LOQ	Analytical Method
pH	n.a.	NS-EN ISO 10523
Conductivity (mS/m)	0.03/0.1	NS-ISO 7888
Turbidity (FNU)	0.1/0.3	NS-EN ISO 7027
Suspended particulate matter (SPM) (mg/L)	0.1 mg/l when 1 L is filtered	NS 4733 modified
Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC) (mg C/L)	0.03/0.1	NS 1484 modified
Total phosphorus (tot-P) and total dissolved phosphorus (TDP) (µg P/L)	0.3/1	NS 4725 - Peroxodisulphate oxidation method modified (automated)
Orthophosphate (PO4-P) (µg P/L)	0.3/1	NS 4724 - Automated molybdate method modified (automated)
Total nitrogen (tot-N) (µg N/L)	3.3/10	NS 4743 - Peroxodisulphate oxidation method
Nitrate (NO_3-N) (µg N/L)	0.7/2	NS-EN ISO 10304-1
Ammonium (NH_4-N) (µg N/L)	0.7/2	NS-EN ISO 14911
Calcium (mg/L)	0.0017/0.005	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Particulate Organic Carbon (POC) and particulate Nitrogen (PN)	Dep. on blank & vol. filtered	NS-EN ISO/IEC 17025, Test 009
UV-visible absorbance spectrum	n.a.	Internal method (900 nm - 200 nm)
Silicone (Si) (Si/ICP; mg Si/L)	0.008/0.025	NS-EN ISO 16264 modified
Silver (Ag) (µg Ag/L)	0.0007/0.0020	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Arsenic (As) (µg As/L)	0.008/0.025	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Cadmium (Cd) (µg Cd/L)	0.0010/0.0030	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Chromium (Cr) (µg Cr/L)	0.008/0.025	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Copper (Cu) (µg Cu/L)	0.013/0.040	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Mercury (Hg) (ng Hg/L)	0.3/1.0	NS-EN ISO 12846 modified (AAS method)

	0.1/0.2	USEPA 1631 (CVAFS method)
Nickel (Ni) (µg Ni/L)	0.013/0.040	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Lead (Pb) (µg Pb/L)	0.0017/0.005	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified
Zinc (Zn) (µg Zn/L)	0.05/0.15	NS-EN ISO 17294-1 and NS EN ISO 17294-2 modified

2.2.3 Quality assurance and direct on-line access to data

Data from the chemical analyses were transferred to the NIVA database and quality checked against historical data by researchers with long experience in assessing water quality data. If any anomalies were found, the samples were re-analysed or data removed from the final dataset. The data are available on-line at www.aquamonitor.no/RID, where users can view values and graphs for each of the monitored rivers. In Table 6, information on the total number of samples analysed and the fraction of measurements below the LOQ for the various parameters are summarised.

Table 6. Proportion of analyses below limits of quantification (LOQ) in 2019

Parameter	Number of samples	Number below LOQ	% below LOQ
Conductivity	248	0	0
pH	259	0	0
Ca	248	0	0
SiO_2	248	0	0
SPM	248	32	13
TOC	248	0	0
TOT-P	248	1	0.4
PO_4-P	248	50	20
TOT-N	248	0	0
NO_3-N	248	6	2.4
NH_4-N	248	87	35
As	80	1	1.3
Pb	80	0	0
Cd	80	19	24
Cu	80	0	0
Zn	80	3	3.8
Cr	80	0	0
Ni	80	1	1.3
Hg (AAS method)	80	58	73
Hg (CVAFS method)	238	0	0
Ag	80	56	70

2.2.4 Sampling and analyses for additional rivers

The additional rivers from the National monitoring program for limed rivers programme were sampled in the same way as the regular rivers of the programme: monthly grab sampling. The samples were analysed at Vestfold laboratory. In Table 7, the number of samples analysed and the fraction of the samples being below the LOQ for the various parameters included in the report are summarised for the additional rivers. In addition to the parameters listed in Table 7, these samples were analysed for UV-Vis absorbance (200 – 800 nm by 0.5 nm) to describe the quality of the dissolved organic matter (DOM) in the samples (filtered through 0.45 µm pore size).

Table 7. Proportion of analyses below limits of quantification (LOQ) for the additional rivers in 2019

Parameter	Number of samples	Number below LOQ	% below LOQ
pH	71	0	0.0
Ca	71	0	0.0
SPM	71	0	0.0
Turbidity	71	0	0.0
SiO_2	71	0	0.0
TOC	71	0	0.0
DOC	71	0	0.0
POC	71	14	20
TOTN	71	0	0.0
NO3.N	71	0	0.0
NH4.N	71	21	30
PO4-P	71	49	69
As	71	0	0.0
Pb	71	34	48
Cd	71	44	62
Cu	71	5	7.0
Zn	71	0	0
Cr	71	24	34
Ni	71	49	69
Hg	71	71	100
Ag	71	70	98

2.3 Calculation of riverine loads

Estimates of annual riverine loads were done according to the formula below, which follows recommendations in OSPAR Agreement 2014:04; §6.13b. The method handles irregular sampling frequency and allows flood samples to be included in the annual load calculations.

$$Load = Q_r \frac{\sum_{1}^{n} Q_i \bullet C_i \bullet t_i}{\sum_{1}^{n} Q_i \bullet t_i}$$

where:

Q_i represents the water discharge at the day of sampling (day i);

C_i the concentration at day i;

t_i the time period from the midpoint between day i-1 and day i to the midpoint between day **i** and day i+1, i.e., half the number of days between the previous and next sampling; and

Q_r is the annual water volume.

When the results recorded were less than the limits of detection (LOD) the following estimate of the concentration has been used:

Estimated concentration = ((100%-A) • LOD)/100

Where A = percentage of samples below LOD. This procedure is in accordance with OSPAR Agreement 2014:04 (the updated RID Principles). According to these principles (http://www.ospar.org/documents?d=33689) no more than 30% of the samples should be below the LOQ). In 2019, Hg and Ag did not reach this requirement, which was also the case in 2017 (Kaste et al., 2018) and 2018 (Gundersen et al., 2019).

2.4 Trend analyses and data comparison

Trend analysis has been conducted both for weather data (air temperature, precipitation, and water temperature) and the water chemical parameters covered in the monitoring programme. Since stations can be different from what is described in chapter 1.2 for water sampling, trends in weather data are presented together with information on stations and time ranges used. Details for water chemistry and water discharge trend analysis are given below. The general trend analysis methodology described is applied also for the weather data.

When monitoring data collected in 2019 is presented, results are compared with the preceding five-year mean (2014-2019). 2019 data is presented as annual mean (based on monthly values) ± one standard deviation, while 2014-2018 data is presented as 5-year mean (based on annual values) ± one standard deviation.

2.4.1 Trend analysis methodology

Trend analyses in this report describe overall loads to the sea but are less suited to discuss changes in upstream sources, because inter-annual variability in water discharge strongly affects fluxes and might therefore mask changes in source emissions. The Mann-Kendall test (Hirsch and Slack, 1984) has been used to test for monotonic trends (including linear trends; Sen slope) in annual riverine inputs and concentrations. Trends are regarded as statistically significant at the 95% significance level ($p < 0.05$, double-sided test).

2.4.2 Selection of rivers

Trend analysis for water chemical parameters was conducted for nine of the former “main rivers” where monthly monitoring data was available since 1990 (Table 8). The remaining two rivers included as “main rivers” in the former RID programme, Alna and Vosso, did not have enough years with monthly monitoring. Alna also had a shift in monitoring methodology for water discharge. Storelva was not monitored at the current sampling site during 2004-2016, and only once a year from 1990-2003. The remaining rivers all had lower than monthly sampling frequency during 1990-2016. Trend analysis for water discharge was conducted for the nine rivers listed in Table 8, and for an additional nine rivers with discharge data (modelled) since 2004.

2.4.3 Selection of parameters and time-periods

The water chemical parameters included in the trend analyses were suspended particulate matter (SPM), silica (SiO_2), total organic carbon (TOC), total nitrogen (tot-N), ammonium (NH_4-N), nitrate (NO_3-N), total phosphorus (tot-P), orthophosphate (PO_4-P), Cu, Pb, Zn, Cd, and Ni. Trends for the remaining metals have not been calculated due to the combination of a large proportion of the samples having levels below LOQ and changes in the analytical methods during the time period; see Skarbøvik *et al.* (2010) for details.

Consistent with last year methodology (Gundersen et al., 2019), long-term (1990-2019) and short-term (2004-2019) trend analyses have been conducted for nutrients (SPM, SiO_2, TOC, Tot-N, NH_4, NO_3, tot-P, and PO_4), and metals (Cd, Cu, Ni, Pb, and Zn), respectively, depending on data availability. Trend analyses for metals was only short-term because there was a change in the analytical method, leading to better analytical sensitivity. Such a transition, making it possible to detect lower concentrations in the rivers, could result in a false declining trend. Note that the trend analysis for TOC started in 1999 (instead of 1990) for Numedalslågen, Orreelva, Altaelva, Vefsna, and Skienselva, due to infrequent measurement in the early years of the monitoring. The statistical power of the trend analysis decreases when applied to shorter time-series.

Hence, for 2019 the following trend analyses have been performed for the nine former “main rivers” (Glomma, Drammenselva, Numedalslågen, Skienselva, Otra, Orreelva, Orkla, Vefsna and Altaelva):

- Long-term trends in concentrations and loads for nutrients, SPM, TOC, and silica for the entire monitoring period (1990-2019), as well as water discharge. Long-term trend analysis for TOC for some of the rivers start in 1999.
- Short-term trends (2004-2019) in concentrations and loads for metals, as well as water discharge. Note that for metals, the rivers have only been monitored four times per year in 2017, 2018 and 2019.

Table 8. An overview over the rivers, parameters, and historical frequency of measurement for the nine rivers included in the trend analysis.

Short name	Rivers/parameters	Parameters***	Sampling frequency (times yr^{-1})		
			1990-2003	2004-2016	2017-2019
“Monthly monitored since 1990”	Glomma*, Drammenselva*, Numedalslågen, Skienselva, Otra, Orreelva, Orkla, Vefsna and Altaelva**	Nutrient fractions, SPM, TOC, silicate	12	12	12
-«-	-«-	Metals	12	12	4

* Rivers Glomma and Drammenselva have often been sampled 16 times per year, or even more frequently (e.g. during the 1995-flood).

** In River Altaelva, the sampling was less frequent during 1990-1998.

*** In 1999-2003 samples were analysed at a different laboratory, and for this reason, concentrations of total phosphorus and mercury data in 1999-2003 are excluded from the time series, whereas the loads are modelled. A more detailed overview of excluded data from historical records is given in Skarbøvik *et al.* (2010).

2.5 Comparison of metals data with EU WFD quality standards

Samples for metals determination were analysed unfiltered (section 2.2.2) and results cannot be compared directly with the EU WFD environmental quality standards for priority substances and river basin-specific pollutants in freshwater. This requires analyses of filtered samples (Direktoratsgruppen 2018, Table 9) and is a task undertaken in a subset of rivers in the river monitoring programme (results presented in different reports, e.g. Allan et al., 2018 and 2019). Given that unfiltered samples often have higher concentrations (dissolved + particulate fractions) it implies that it is possible to state if the annual mean concentrations are below – but not above - the threshold concentrations. Unfiltered samples were analysed to capture the total metal export to the oceans, in accordance with OSPAR RID. Moreover, by analysing unfiltered samples the recent data can be compared with the long trend series that have been obtained on unfiltered samples, to look for effects from climate change.

Table 9: Threshold concentrations for metals in Norwegian surface waters (annual averages, filtered samples) (Direktoratsgruppen 2018)

Metal	As	Pb	Cd	Cu	Zn	Cr	Ni	Hg
Limit (µg/L)	0.5	1.2	0.08[1]	7.8	11	3.4	4	0.047

Note that the annual mean values for 2019 (and 2017-2018) were based on quarterly samples, whereas the 5-year mean for eleven of the rivers ("main rivers" from the previous RID programme, Table 1) included years with monthly samples (2013-2016). In general, less frequent sampling is associated with higher uncertainty. An exception in the dataset for 2019 is the Hg data, where samples were collected monthly.

2.6 Modelling of contaminants in the Alna river

Coupled catchment-river models can be valuable tools to describe and to synthesize key processes that determine the temporal and spatial variation in hydrology and hydrochemistry in river systems. When successfully calibrated to historical (measured) data, the models can be applied to simulate possible effects of future changes in environmental or climatic factors as well as changes driven by pollution management and control actions.

Contaminants selected for modelling

We have applied an integrated catchment model for contaminants (INCA-Tox) to simulate fate and transport of two PCB congeners (PCB-101, PCB-153) and three PAH congeners (Phenanthrene, Fluoranthene, Benzo-a-Pyrene) in the Alna river. These compounds are chosen for their relevance as environmental contaminants and their inclusion in several national and international regulatory documents. The compounds can be present in the environment either as gases or adsorbed to particulate matter in the atmosphere or in soil and water. Environmental conditions and their specific physical-chemical properties determine how they partition across these media. While PAHs are unintentionally produced mostly during incomplete combustions of both biomasses and fossil fuels, PCBs are legacy pollutants banned by the UNEP Stockholm Convention on Persistent Organic Pollutants (POPs) and represent a group of compounds used in the past in several industrial

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[1] For water with calcium concentration < 16 mg/l. In more alkaline waters, the threshold value is higher (cf. Direktoratsgruppen 2018)

applications. Table 10 and 11 provide the relevant physical chemical properties of these compounds used as inputs for the model simulations.

Model description

The INCA-Tox model, formerly known as the INCA-Contaminants model (Nizzetto et al., 2016) solves mass balances of water, carbon, sediments and contaminants in the soil-stream-sediment system of catchments and their river networks as a function of climate, catchment characteristics and contaminant properties. When forced with realistic climate and contaminant input data, the model can predict contaminant concentrations in multiple segments of a river network.

The model integrates a hydrological, soil-stream carbon, sediment transport and a contaminant fate model. The underlying modules are derived from those developed within the Integrated Catchment models (INCA) family. These are one-dimensional dynamic catchment models designed for water quality assessment (Whitehead et al., 1998a; Whitehead et al., 1998b). In summary, the discretization of catchment and river structure is provided by determining the order of streams, their length and width between reach points, and by compiling dimensions and characteristics of individual sub-catchments – including soil properties and land use information.

Table 10: Compound-specific physical-chemical properties used in the model simulation.

Compound	MW (g mol^{-1})	V (cm^3 mol^{-1}) Source: 1	LogK$_{ow}$ Source: 1, 2	H (Pa m^3 mol^{-1}) Source: 2	ΔU$_{aw}$ (kJ mol^{-1}) Source: 2,3
PCB 101	326.4	289.1	5.33	24.1	59.7
PCB 153	360.9	310	6.87	19.8	62.8
Phenanthrene	202.3	199	4.57	3.24	47.3
Fluoranthene	166.2	217	5.22	1.037	38.7
Benzo-a-pyrene	252.3	263	5.91	0.046	50*

Sources: 1) Mackay et al. (1992), 2) Li et al. (2003), 3) Bamford et al. (1999). MW=molecular weight, V=molar volume, Know=octanol/water partition coefficient, H= Henry's law volatility constant, Uaw=enthalpy of phase transfer between air and water.

*Data not available. This value was chosen as default.

Table 11. Selected environmental half-lives used in model simulation.

Compound	Soil (days)	Water (days)	Sediment (days)
PCB 101	2200	2200	2200
PCB 153	2200	2200	2200
Phenanthrene	240	21	730
Fluoranthene	730	21	730
Benzo-a-pyrene	730	60	2200

Source: Mackay et al. (1991).

The new INCA-Tox model is implemented in the Mobius framework (Norling et al., in review) and is open source, available from https://github.com/NIVANorge/Mobius.

It consists of the following sub-modules:

- PERSiST - (the Precipitation, Evapotranspiration and Runoff Simulator for Solute Transport) is a hydrology model designed for working with the INCA family of water quality models. It computes water balance, and flow between compartments (Futter et al., 2014).
- INCA-Sed - a sediment mobilisation and transport model (Lazar et al., 2010).
- INCA water temperature - a very simple water temperature model used to compute temperatures in the river based on air temperatures.
- INCA soil temperature - a very simple soil temperature model using air temperature drivers. (Rankinen et al., 2004).
- INCA-Tox-C - a simple soil organic carbon (SOC) and dissolved organic carbon (DOC) model used to drive transport of contaminants bound in carbon through DOC that flows with the water and SOC that are mobilised in the sediment transport.
- INCA-Tox - The model that computes contaminant partitioning between compartments, degradation, and transport. The contaminant fate module uses temperature and compound physical chemical data to calculate the instantaneous contaminant distribution across the masses of water, carbon and sediments, and determine the fluxes of contaminants moving in the environment associated to these compartments.

While the model does not explicitly describe an atmospheric compartment, it accepts information on contaminants atmospheric concentrations and deposition fluxes. Atmosphere can serve both as a source of pollutants for the catchment environment, or as a recipient of volatilizing compounds from soil and water. A full description of the mathematical frame underpinning INCA-Contaminants is provided by Nizzetto et al. (2016). The same frame is utilized by the new version of the model (INCA-Tox), with some simplification introduced in the description of the environment.

Time series input data and boundary conditions for atmospheric and soil contamination. Temperature and precipitation data were derived from the Nordic Gridded Climate Dataset: https://thredds.met.no/thredds/catalog/ngcd/catalog.html which yields a 1 km grid that was then area-averaged to the Alna basin. Wind speeds were taken from the Blindern meteorological station. Temperature and precipitation are the drivers of the hydrological model, while temperature also drives changes in the partitioning of contaminants between compartments. Wind speed drives the air-water contaminant exchange in the river phase.

For atmospheric contaminant concentrations we used constant values based on averages of NILU time series data from the Birkenes station in southernmost Norway (data available at http://ebas.nilu.no/). Atmospheric deposition of the pollutants included wet, dry and litterfall-associated deposition. Litterfall-associated deposition was estimated by considering published yearly averaged deposition velocities (Horstmann and Mclachlan, 1998) multiplied by air concentrations extracted from the EBAS dataset. Daily wet deposition inputs were generated by assuming equilibrium between air and rain/snow combined with rainfall and snowfall measurements.

The boundary conditions were further refined by considering data of soil contamination available for forested areas surrounding Oslo generated by NIVA in 2015. To refine the atmospheric deposition scenario (which were based on data from the rural background station Birkenes) we computed realistic wet and dry depositions based on the atmospheric concentrations, then added in a third artificial deposition to maintain a constant PCB and PAH budget in the soil. Soil concentration data used to set the boundary condition of INCA-Tox are summarised in Table 12. The underlying assumption for setting atmospheric deposition to a level that maintain stationary soil contamination stems from the consideration that the level of PCBs and PAHs in soils vary slowly over time, due to the persistence to degradation and the high affinity for soil organic matter (Schuster et al., 2011).

Table 12. Boundary conditions for catchment soil contamination.

Compound	Concentration in soil (ng/g soil OC)	
	min	max
PCB 101	0.2	2.2
PCB 153	0.2	7.6
Phenanthrene	19.7	316.2
Fluoranthene	6.2	648.4
Benzo-a-Pyrene	5.2	350

Source: Soil contamination survey 2015 in forested areas surrounding Oslo.

Measured data used for calibration

Discharge data used for calibration of the hydrological model was obtained using NVE's Hyd API (https://hydapi.nve.no/UserDocumentation/). Measured data 2012-2018 on suspended sediments (SS), DOC and TOC were from the Norwegian River Monitoring programme. The contaminant data were collected by the same programme between 2011 and 2016 (Skarbøvik et al., 2014; 2015; 2016; 2017).

2.7 Sensor monitoring in Rivers Storelva and Målselva

The rivers Storelva and Målselva sensor stations are located at the same sites as the manual sampling sites (Table 1). Water from the river is pumped a few meters to an instrument container with flow cells equipped with sensors that measure water temperature, pH, conductivity, turbidity and fluorescent dissolved organic matter (FDOM). Data are recorded on an hourly basis, transferred to NIVA's server and made available online at www.aquamonitor.no/LandSjo/.

Water flow data are obtained from the Norwegian Water Resources and Energy Directorate (NVE) real-time stations 18.4.0. Lundevann, which is located close to the NIVA station in River Storelva, and 196.35.0 Målselvfossen, which is located 15 km upstream of the NIVA station in River Målselva.

A QA routine has been set up by flagging data that are obviously wrong, due to e.g. interrupted power supply, clogging, etc. Flagged data are not visible online or downloadable but are kept in the database. The sensors need repeated inspection during the year, and the stations are visited at regular intervals for service and maintenance. Temperature correction of the FDOM data for River Storelva was done in accordance with Ryder et al. (2012). The intercept constant was set to 100, and the slope intercept was chosen as to give the best correlation between temperature corrected FDOM and dissolved organic carbon (DOC) concentration for the time period 2015-2018. In River Målselva, temperature correction of FDOM was omitted as it did not improve the fit with DOC.

3. Results and Discussions

3.1 Climate and hydrology: status and trends

3.1.1 Air temperature and precipitation in 2019

The 2019 average air temperature for Norway (Figure 4, left) was 1.2 °C above the 1961-1990 normal and was the 20th warmest year since the measurements started in 1900. The average air temperature was above the normal during winter (+2.3 °C), spring (+1.4 °C), and summer (+1.2 °C), while in autumn, the temperature was slightly below (-0.6 °C) the normal. Overall geographical variation constituted temperatures above the normal (up to +2 °C above) at the Southern parts of the country, while temperatures were slightly below the normal furthest north. This was a result of a warmer-than normal winter in the south (up to +4 °C above the normal) and a colder than normal autumn in the north (- 1.5-3 °C). In 2019, a new national record was set for the highest minimum daily temperature, measured to 26.1 °C the 28th of July at Sømna – Kvaløyfjellet (Nordland). A total of 18 county temperature records were set: 5 cold and 13 warm (pre-2020 county division).

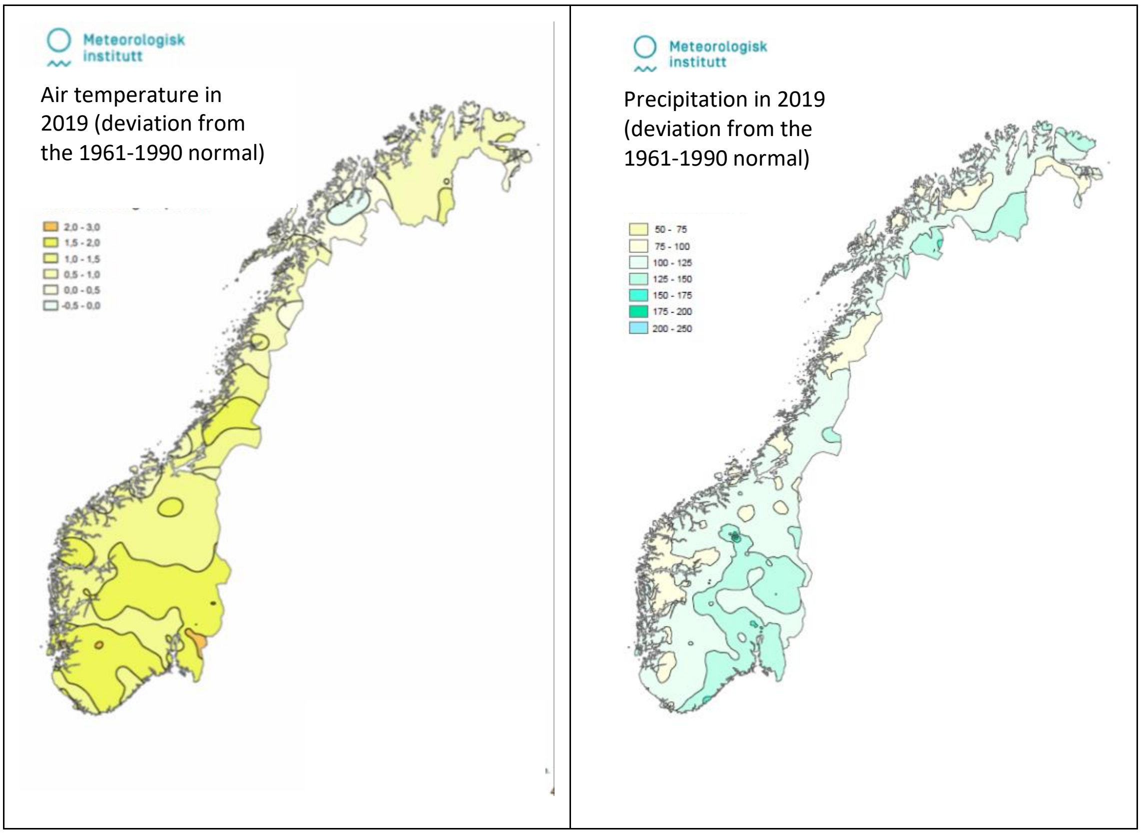

Figure 4: Air temperature (left) and precipitation (right) in Norway in 2019 as deviation from or percentage of the normal values (1961-1990). Maps edited from Grinde et al. (2020).

Precipitation in 2019 (Figure 4, right) was a little higher than the normal (115%) for the country, constituting the 15th wettest year since measurements started in 1900. Precipitation was higher than normal during winter (120%), spring (130%), and summer (110%), while in autumn, precipitation was slightly lower than normal (95%). Geographically, the western part of the country received less precipitation than normal most of the year (50-70%), except from during summer when the precipitation was higher than normal (150-200%). Eastern and northern parts of the country received higher than normal precipitation during most of the year. For more details on the weather in 2019, we refer to Grinde et al. (2020).

3.1.2 Trends in air temperature and precipitation 1980-2019

Table 13 shows trends in air temperature and precipitation since 1980 (1981 for Vosso and 1983 for Drammenselva) at meteorological stations located in the near vicinity of the river monitoring sites. The results show a significant increase in air temperature at nearly all the stations. For precipitation, only the station near Altaelva and Storelva showed a significant trend of increase. Large year-to-year variation in precipitation could potentially explain the lack of significant trends. These results were in accordance with the findings from 2018 (Gundersen et al., 2019).

Table 13. ***Trends in air temperature and precipitation 1980-2019. Data from the Norwegian Meteorological Office (met.no).***

River name	Temperature				Precipitation			
	St.no	Years	Temp. trend (p-value)	Temp change (°C)*	St. no	Years	Precip. trend (p-value)	Precip. change (mm)*
Glomma	SN700	1980-2019	0.008	+1.3	SN3780	1980-2019	0.139	+126
Alna	SN18700	1980-2019	0.000	+1.7	SN18700	1980-2019	0.067	+141
Drammenselva	SN19710	1983-2019	0.027	+1.0	SN19710	1983-2019	0.147	+122
Numedalslågen	SN27470	1980-2010	1.00	+1.9	SN30000	1980-2019	0.877	-8
Skienselva	SN27470	1980-2010	1.00	+1.9	SN30260	1980-2015	0.149	+133
Storelva	SN36560	1980-2018	0.000	+1.4	SN36560	1980-2019	0.024	+320
Otra	SN39040	1980-2019	0.001	+1.2	SN39040	1980-2019	0.147	+228
Bjerkreimselva	SN44560	1980-2019	0.000	+1.4	SN43360	1980-2017	0.365	+122
Orreelva	SN44560	1980-2019	0.000	+1.4	SN44190	1980-2019	0.712	+41
Vikedalselva	SN46910	1980-2011	0.003	+1.6	SN46850	1980-2019	0.099	+453
Vosso	SN52290	1981-2007	0.026	+1.4	SN51250	1980-2019	0.393	+295
Nausta	SN58070	1980-2017	0.004	+1.1	SN57480	1980-2019	0.507	+148
Driva	SN64550	1980-2007	0.003	+1.7	SN63530	1980-2019	0.477	-62
Orkla	SN69100	1980-2018	0.011	+1.1	SN66210	1980-2009	0.915	+46
Nidelva	SN69100	1980-2018	0.011	+1.1	SN68270	1980-2019	0.345	+91
Vefsna	SN85380	1980-2018	0.000	+1.5	SN78850	1980-2007	0.244	+316
Målselva	SN89350	1980-2019	0.091	+0.8	SN89350	1980-2019	0.301	+53
Altaelva	SN93140	1980-2019	0.000	+1.4	SN93140	1980-2017	0.024	+119
Tana	SN96800	1980-2012	0.008	+1.8	SN96970	1980-2018	0.798	+16
Pasvikelva	SN99370	1980-2019	0.000	+1.8	SN99500	1980-2018	0.406	+24

Red – significantly increasing trend, $p<0.05$. There were no significantly decreasing trends.
* Change in temperature and precipitation is the total change for the whole period.

3.1.3 Water temperature – status 2019 and trends

Generally, water temperatures show a strong seasonal pattern (Figure 5) and vary from the north to the south. Patterns for 2019 are very similar to those of 2018 (Gundersen et al., 2019). Unfortunately, the TinyTag logger was lost from Orreelva and data does not exist for the last 6 months of 2019 (Table 14).

The stations included in the long-term water temperature trend analysis are given in Table 15 and with details on the time series in Table 4. Note that eight of the rivers have not been included since they either do not have a temperature station nearby or the available long-term data series is incomplete. 2019 data had not been made available by the time of the data analysis (marked by "*" and text in grey) for eight of the stations (Table 15). For the remaining four rivers the inclusion of the 2019 water temperature did not lead to any major changes in the trends. Four rivers, including the two northern rivers Altaelva and Pasvikelva, displayed significantly increasing trends in water temperature, which agrees with the 2017 and 2018 results (Gundersen et al., 2019; Kaste et al., 2018).

Table 14. Monthly water temperature measured in the monitored rivers in 2019

River name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glomma	0.4	0	1.4	2.8	7.8	11.4	16.4	19.8	15.3	9.3	4.6	1.2
Alna	2.9	0.7	3.1	4.1	7.3	12.3	11.6	14.4	14.3	9.4	3.4	3.1
Drammenselva	1.4	0	1.5	2.7	7.5	10.7	16.9	20.7	16	9.2	6.1	2.4
Numedalslågen	0.0	0.1	0.9	4.7	8.6	13.8	18.8	17.8	12.7	7.0	1.9	0.3
Skienselva	3.3	1.9	2.4	3.6	5.9	10.5	15.7	16.8	14.8	10.4	6.7	4.4
Storelva	2.4	2.5	3.3	7.4	13.8	17.4	21.7	20.9	14.8	9.7	5.7	3.8
Otra	1.4	1.2	2.4	5.9	10.2	13.2	18.0	17.9	14.1	9.1	4.5	3.1
Bjerkreimselva	4.9	1.8	4.1	6	10.1	-	16.4	20	15.6	11.8	-	5.2
Orreelva	3.2	3.9	5.4	9.2	11.5	12.9	-	-	-	-	-	-
Vikedalselva	2.0	2.2	3.3	6.1	9.5	13.0	16.7	16.3	12.0	8.3	4.1	4.0
Vosso	2.1	1.7	2.1	3.0	-	10.4	14.3	15.8	11.2	8.3	5.2	3.5
Nausta	1.3	-0.2	1.5	2.2	6.4	9.1	11.9	14.7	13.1	2.9	0.0	2.1
Driva	4.0	1.6	2.6	3.0	3.0	3.5	8.0	16.5	14	6.0	1.0	2.0
Orkla	0.4	1.0	1.2	2.4	5.6	11.2	11.5	11.6	8.2	3.1	0.9	0.3
Nidelva	3.4	1.5	2.2	2.2	3.9	5.3	9.0	15.6	15.4	8.8	2.0	4.3
Vefsna	0.0	0.1	0.1	2.3	4.5	8.4	13.9	14.3	8.9	2.8	0.3	0.0
Målselva	0.0	0.0	0.0	0.1	4.4	7.5	11.9	13.1	8.5	1.7	0.1	0.1
Altaelva	0.0	0.1	0.1	0.3	3.4	5.8	9.5	11.3	10.1	4.3	0.8	0.4
Tana	0.1	0.0	0.1	0.3	3.8	4.1	12.6	4.0*	5.6		3.0	2.3
Pasvikelva	-0.1	0.0	0.0	0.0	0.4	6.7	12.8	11.6	15.3	5.9	3.0	3.6

*Average temperature measured in Tana in August is lower than expected. Previous year's data typically show higher temperature in August compared to September. The reason for the deviation is not known.

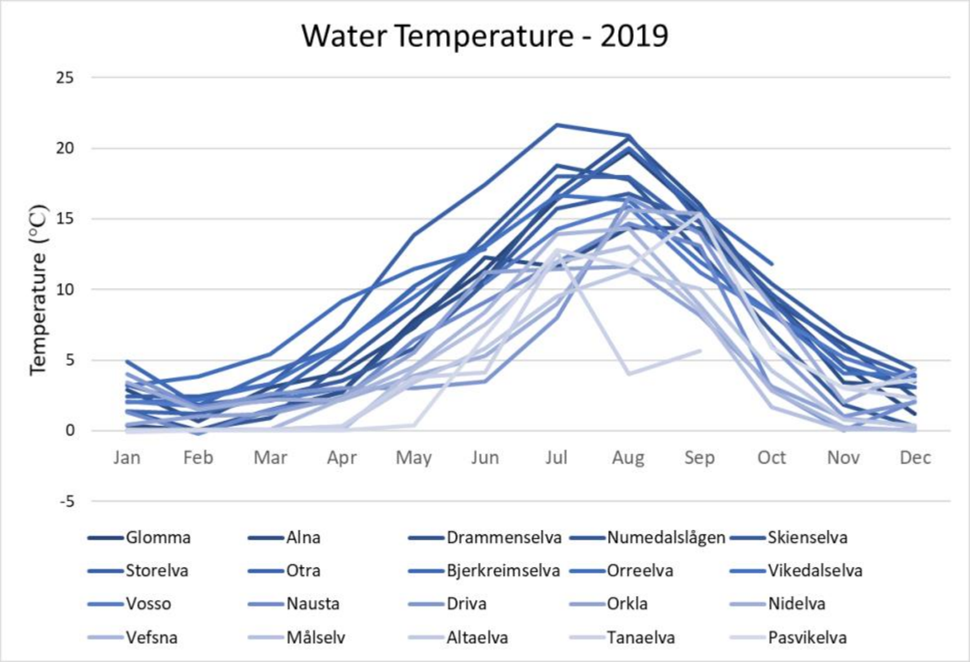

Figure 5: Monthly measured temperature in the rivers. Note that the shade of the lines indicates geographical location (South-eastern rivers are darker while the northern are the lightest). Data presented in Table 14.

Table 15. Trends in annual mean water temperature, in rivers with available long-term data.

River name	Years with data	Annual change**	p-value
Drammenselva	22	0.04	0.028
Numedalslågen	13*	0.03	0.760
Skienselva	23	0.01	0.091
Otra	24*	0.04	0.503
Bjerkreimselva	28*	0.06	0.019
Vikedalselva	30	0.06	0.080
Vosso	20*	0.04	0.496
Nausta	15*	<0.01	0.276
Orkla	23	<0.01	0.224
Altaelva	25*	0.04	0.001
Tana	16*	0.03	0.558
Pasvikelva	22*	0.05	0.018

Red – significantly upward p<0.05. There were no significantly decreasing trends.

*data from 2019 had not been made available at the time of analysis.
**annual change in °C calculated as [total temperature change]/[(last year of data)-(first year of data)]

3.1.4 Water discharge – status 2019 and trends

Comparing data from 2019 with the preceding five years (2014-2018, Figure 6), water discharge was lower in the southern and western rivers – from Otra to Nausta. This coincided with lower precipitation in 2019 for the western region of the country (50-70 % of 1961-1990 normal, Figure 4). For the eastern and northern rivers, 2019 data were within the range of the preceding five years (Figure 6), despite the fact that eastern and northern parts of Norway received higher than normal precipitation during most of the year (Figure 4).

In 2019, the geographical variation in water discharge followed the same patterns as for the previous five years: in southern Norway the water discharge increased when going from east to the west (from Glomma to Nausta), in middle Norway it decreased from south to north (from Driva to Vefsna), and in northern Norway it decreased from south-west to north-east (Målselva to Pasvikelva) (Figure 6).

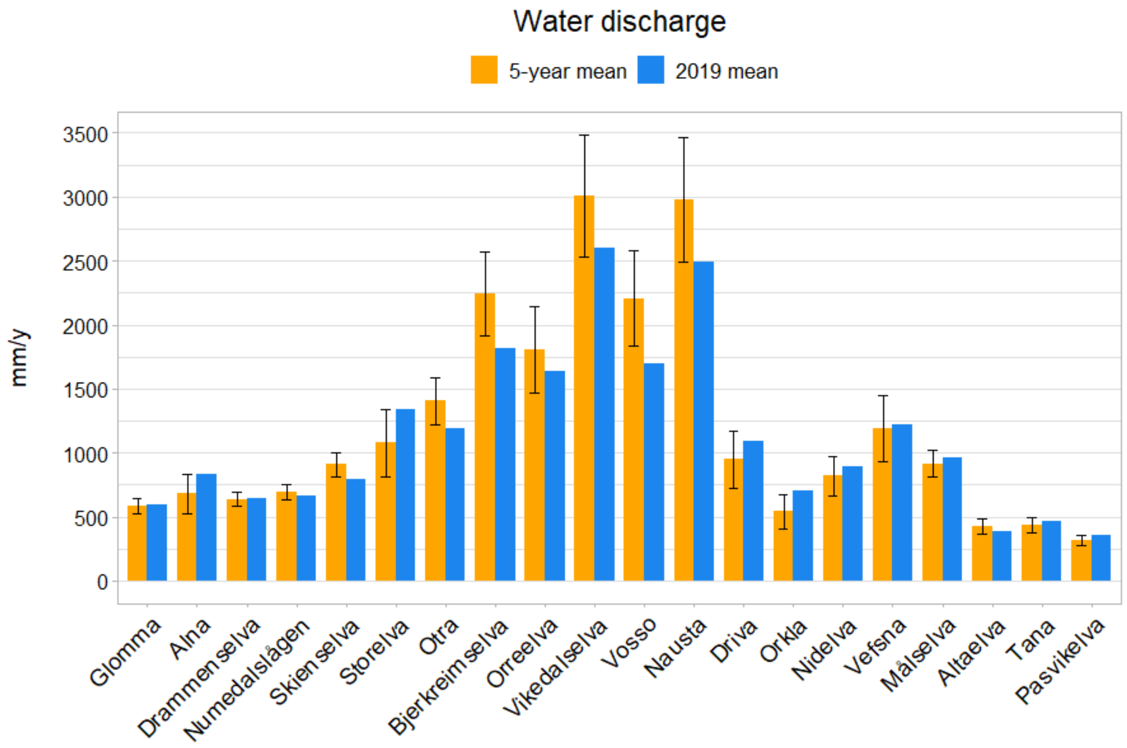

Figure 6: Average annual water discharge for the five preceding years (2014-2018, orange) and annual water discharge in 2019 (blue) for the monitored rivers. Error bars illustrate interannual variation in the five-year mean (± stdev).

Long-term trend analysis (1990-2019) of water discharge for the rivers with monthly monitoring since 1990 is presented in Table 16. Significant increasing trends were found for the south-eastern rivers Glomma and Drammenselva. Levels have increased by 5 and 16 %, for Glomma and Drammenselva, respectively, when comparing annual average in 1990 and 2019. Although the precipitation increases for Glomma (+126 mm) and Drammenselva (+ 122 mm) between 1980 and 2019 are not significant ($p > 0.05$, Table 9), other studies have found an annual national increase in precipitation of 18% since year 1900 (MET, 2015).

In last year's monitoring report, a significantly increasing trend in water discharge was also observed for Skienselva (Gundersen et al., 2019) which is not the case this year (Table 16). Among the rivers where water discharge data was available from 2004, only Tana showed a significantly increasing trend. This is in accordance with the findings in last year's report (Gundersen et al., 2019). It should be note that 13 rivers included in the program, Glomma, Drammenselva, Numedalslågen, Skienselva, Otra, Bjerkreimselva, Driva, Orkla, Nidelva, Vefsna, Målselva, Altaelva, and Pasvikelva are regulated. This will affect water discharge data and may clarify why discharge changes are not necessarily explained by precipitation data. Also, precipitation data does not cover the whole catchment, which complicates the comparison to discharge data.

Table 16. Trends in annual water discharge. Showing p-values

River	Long-term 1990-2019	Annual change (m^3/s)*	River	Short-term 2004-2019	Annual change (m^3/s)*
Glomma	0.030	4.5	Bjerkreimselva	0.344	0.2
Drammenselva	0.010	3.0	Vikedalselva	0.822	0.0
Numedalslågen	0.164	0.7	Vosso	0.753	0.2
Skienselva	0.116	1.8	Nausta	0.620	-0.1
Otra	0.392	0.4	Driva	0.300	-0.8
Orreelva	0.074	0.0	Nidelva	0.224	-1.1
Orkla	0.521	-0.2	Målselva	0.224	0.7
Vefsna	0.318	-0.9	Tana	0.003	4.8
Altaelva	0.335	0.2	Pasvikelva	0.053	2.9

Red – significantly increasing $p<0.05$. There were no significantly decreasing trends
*Change shown as m^3/second/year

3.2 Water quality status 2019

The Norwegian river monitoring programme is designed so that the results can be used for classification of ecological and chemical status according to the principles in the EU WFD. Thresholds for achieving good ecological status for individual quality elements (and underlying parameters) and good chemical status are given in the Norwegian classification guidance (Direktoratsgruppen 2018). Throughout this chapter the results will be evaluated with respect to these thresholds. The classification is only relevant for the water body where the monitoring site is located (Table 1).

3.2.1 pH and calcium

Levels of pH and calcium (Ca) typically covariates in the river water (i.e. elevated Ca concentration gives elevated pH). The 2019 levels of both pH and Ca were within the annual variation of the five and two preceding years, respectively, for all the rivers (Figures 7 and 8). For details on the geographical variation of pH and Ca concentrations and a classification based on the Norwegian typology for the WFD, we refer to last year's monitoring report (Gundersen et al., 2019).

Note that Ca is a relatively new parameter in the river monitoring programme, it was introduced in 2017.

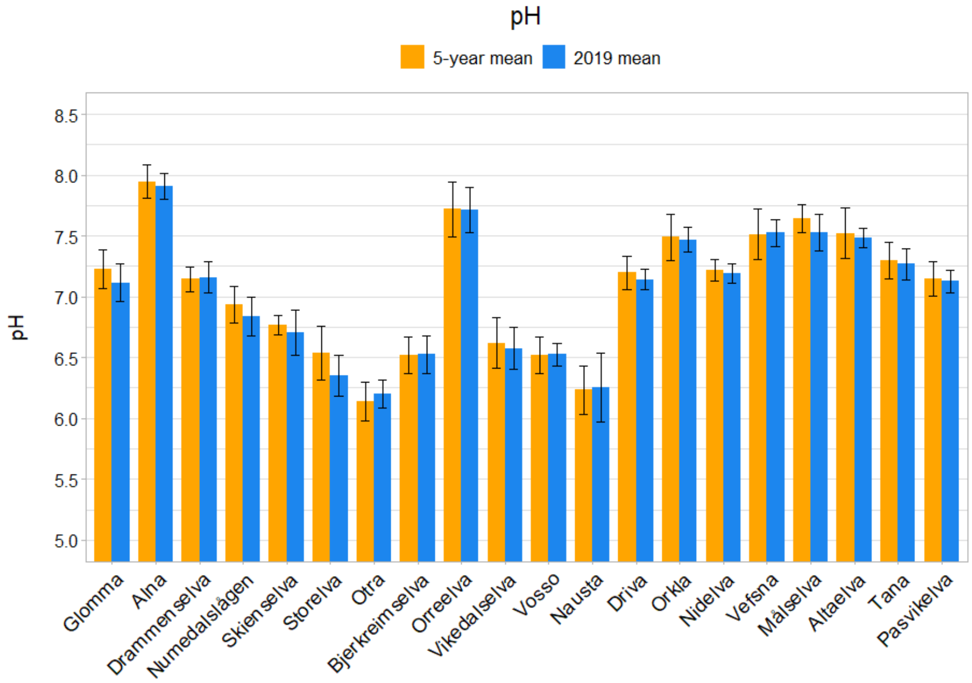

Figure 7: 5-year average for pH (2014-18, orange) and annual average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev). Mean values and standard deviation are based on pH values, not the H^+ concentration. This represents a negligible error when pH values are above 6.0.

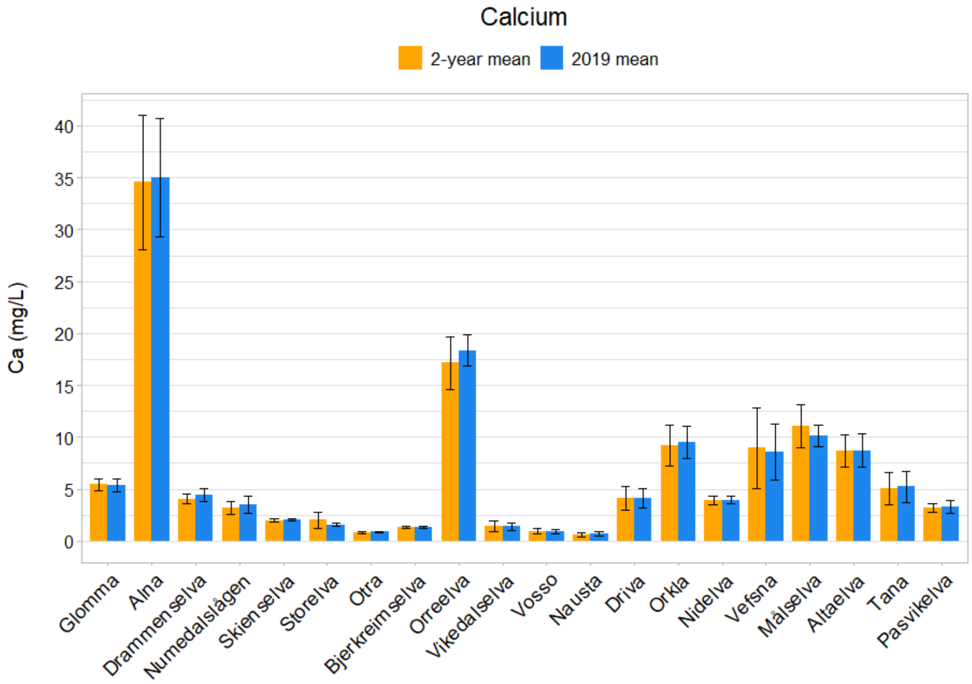

Figure 8: 2-year average annual calcium concentration (2017-18, orange) and annual average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 2-year mean and intra-annual variability for the 2019 mean (± stdev).)

3.2.2 Suspended matter (turbidity, SPM, and silica)

Turbidity is an optical measure of material in the water that can scatter light. Turbidity covers both SPM (0.4 µm < SPM < 2 µm) and colloidal material (<0.4 µm, e.g. SiO_2). These parameters are important for the water quality by influencing processes such as light penetration and transport of metals/nutrients.

The 2019 data shows that Orreelva has much higher turbidity and SPM concentrations than the other rivers included in the monitoring program (Figure 9 and 10). In addition to be a river influenced by agriculture (Table 2), it is also influenced by easily erodible clays. Glomma and Alna are also rivers with typically high levels of suspended matter, but both turbidity and SPM concentrations were lower in 2019 compared to the previous five years. For the other rivers with lower concentrations, levels were more similar to historical data (Figure 9 and 10).

It is worth noting that both SPM and turbidity are strongly influenced by seasonal precipitation events, providing highly variable data throughout the year.

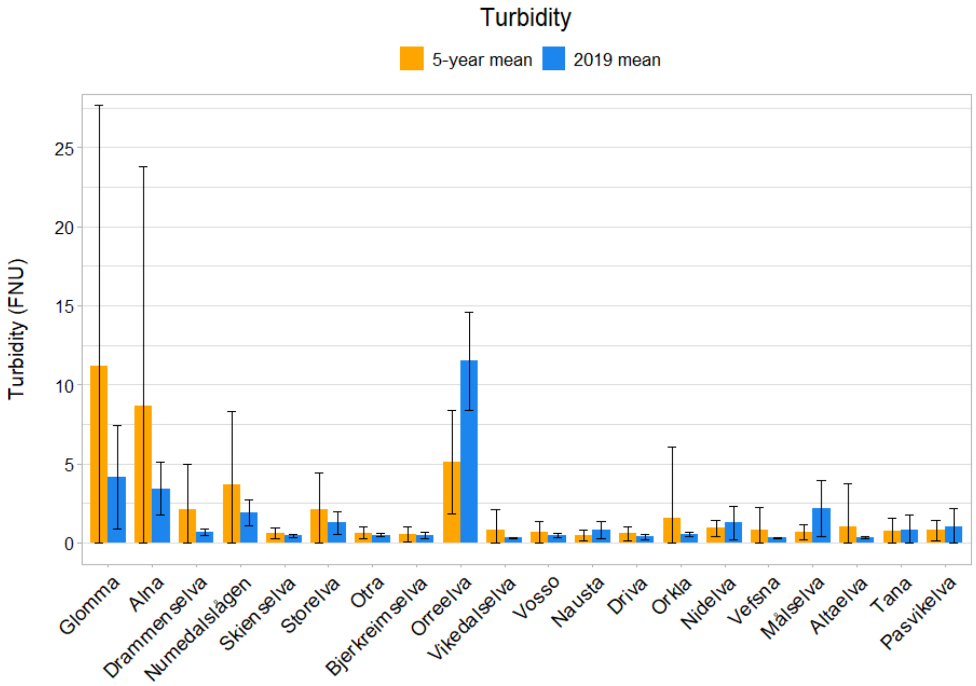

Figure 9: Average annual turbidity for the five preceding years (2014-18, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev).

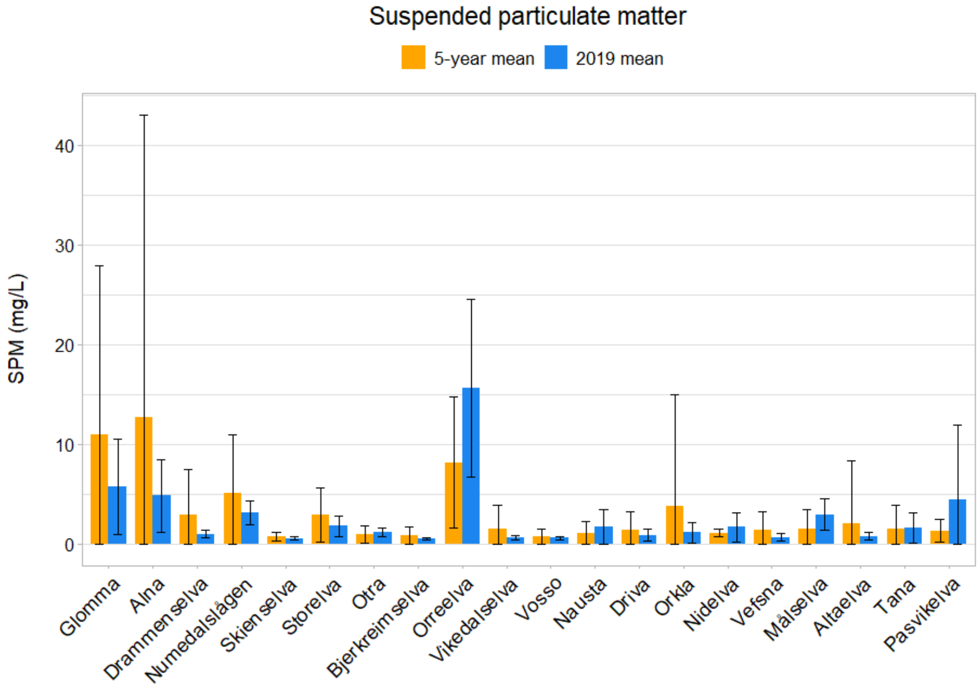

Figure 10: Average annual suspended particulate matter (SPM) concentration for the five preceding years (2014-18, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev).

SiO_2 is a major component of sand and clay and can therefore enter surface water through erosion. It is an essential nutrient for diatoms, which is an important phytoplankton group. Thus, changes in levels of SiO_2 can, together with nutrient information, provide an indication on potential eutrophication. Typically, low SiO_2 concentrations (Figure 11) are similar to Ca (Figure 8) and are found in areas with slow-weathering bedrock, which is typical for southern and western parts of Norway. The 2019 SiO_2 levels consistently followed those of the 5-years means.

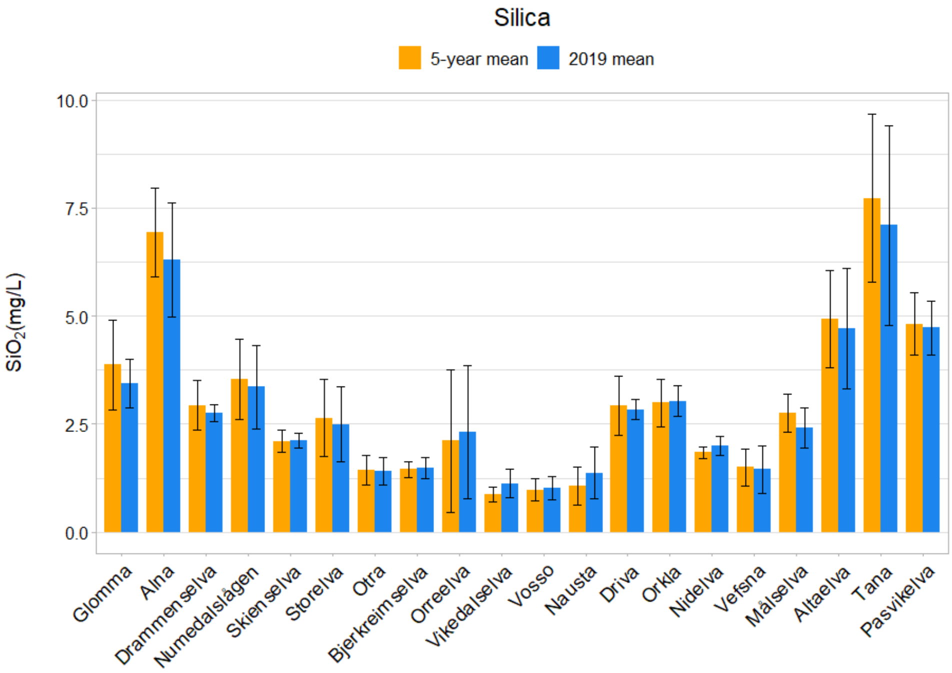

Figure 11: Average annual silica (SiO_2) concentration for the five preceding years (2014-18, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev).

3.2.3 Organic carbon

Overall, the 2019 levels of TOC were within the annual variation of the five preceding years (Figure 12) and followed the typical geographical pattern that was evident in last year's data (Gundersen et al., 2019). Briefly, the highest levels are found in the south-eastern rivers where catchments are dominated by forests (e.g. Glomma, Drammenselva, Numedalslågen) and the lowest levels in the western rivers where catchments typically have thin soils and exposed bedrock (e.g. Vikedalselva, Vosso, Driva) (Figure 2).

There was, like last year (Gundersen et al., 2019), one exception from this pattern: Orreelva. In Orreelva, concentrations were high compared to both geographical location and the five-year mean. As discussed by Gundersen et al. (2019), the river has effluent inputs and diffuse water discharge from agriculture that likely contribute to the elevated TOC concentrations. See also the discussion of data on particulate OM below.

According to the Norwegian WFD typology and data collected in 2019, Bjerkreimselva, Vikedalselva, Vosso, Vefsna, Driva and Målselva can be characterized as having very clear water (TOC < 2mg/L). Similarly, Glomma, Alna, Drammenselva, Numedalslågen, Skienselva, Otra, Nausta, Orkla, Nidelva, Altaelva, Tana and Pasvikelva were clear (2 mg/L < TOC < 5 mg/L), whereas Storelva and Orreelva were humic (TOC > 5 mg/L).

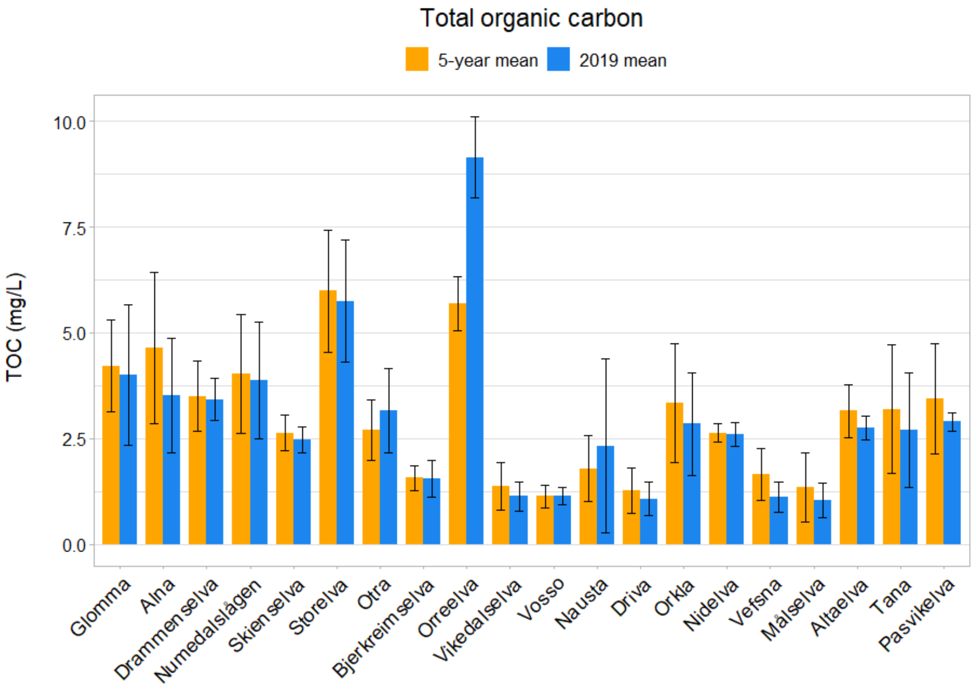

Figure 12: Average concentration of total organic carbon for the five preceding years (2014-18, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev).

Comparing the mean annual concentrations of dissolved and particulate organic carbon in the rivers (Figure 13), it is evident that TOC largely consists of the dissolved fraction (> 90% DOC). Again, Orreelva is the outlier compared to the remaining dataset of rivers, with the lowest dissolved fraction (74% DOC). This reflects the high turbidity and SPM levels recorded for Orreelva in 2019 (Figure 9 and 10).

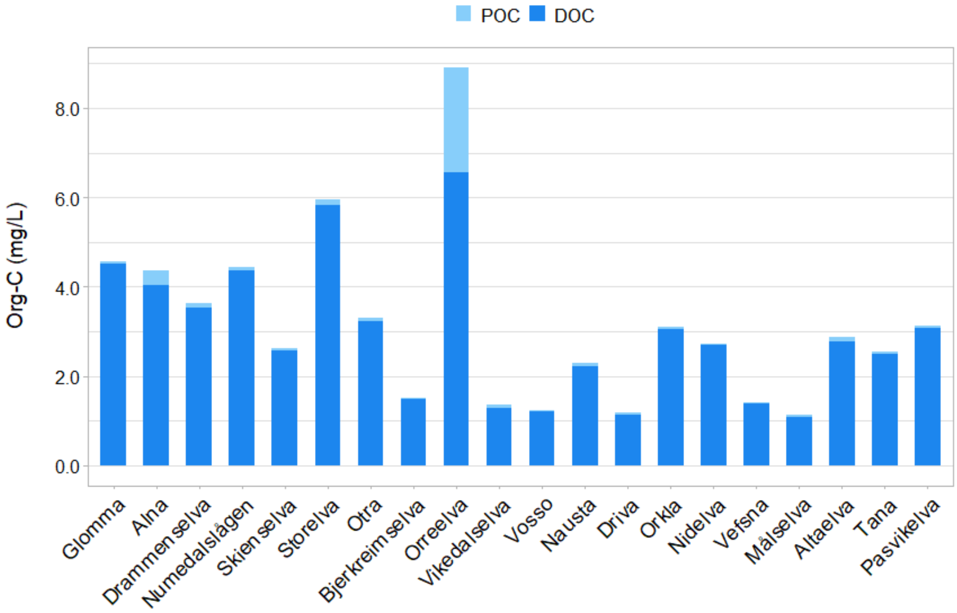

Figure 13: Average particulate (POC, light blue) and dissolved (DOC, dark blue) organic carbon concentration for 2019 in the monitored rivers. Note that the sum of POC and DOC equals to TOC.

Any deviation from the TOC in Figure 12 result from analytical uncertainties in the individual methods used to determine POC and DOC.

3.2.4 Nutrients

Phosphorus

Excess input of phosphorus (P) is regarded as the main driver for eutrophication in Norwegian water bodies. Major sources include agricultural activities, water discharge from urban areas, and weathering of P-containing minerals (e.g. apatite). In the river water, the bioavailability of P will mainly depend on its chemical form and whether it is bound to particles or freely dissolved in the water.

Similar to last year, concentrations of total P are much higher in Alna and Orreelva compared to the other rivers (Figure 14) which is consistent with the fact that they are highly affected by urban and agricultural activities, respectively. Annual mean 2019 tot-P concentrations are very similar to the 2018 concentrations (Gundersen et al., 2019) and both rivers have less than good ecological status according to the good/moderate boundary for tot-P (Direktoratsgruppen, 2018). Of the remaining rivers, only Glomma and Numedalslågen had elevated tot-P concentrations. Glomma and Numedalslågen were still below the good/moderate boundary.

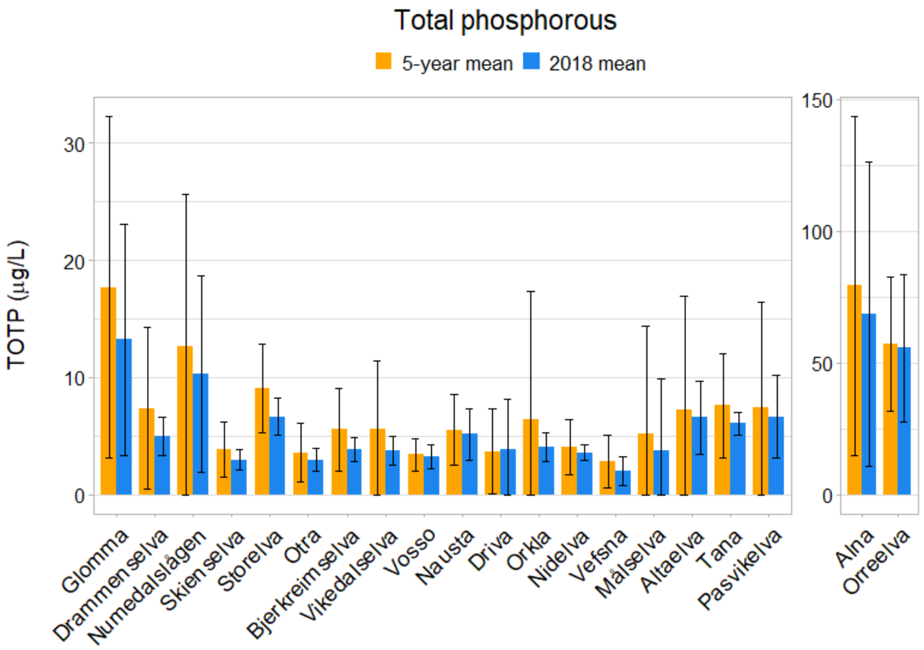

Figure 14: Average concentration of total phosphorous (tot-P/TOTP) for the five preceding years (2014-18, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev). Note the different y-scale range on the right-side panel.

It is reasonable to assume that the large variation in tot-P concentrations (Figure 14) was associated with particle bound phosphorus transported to the rivers in connection with seasonal discharge events. In fact, most rivers had a relatively high proportion of particulate-P (Figure 15), and especially for Glomma and Orreelva which had high SPM concentrations (Figure 10). When bound to particles, the bioavailability of P is reduced.

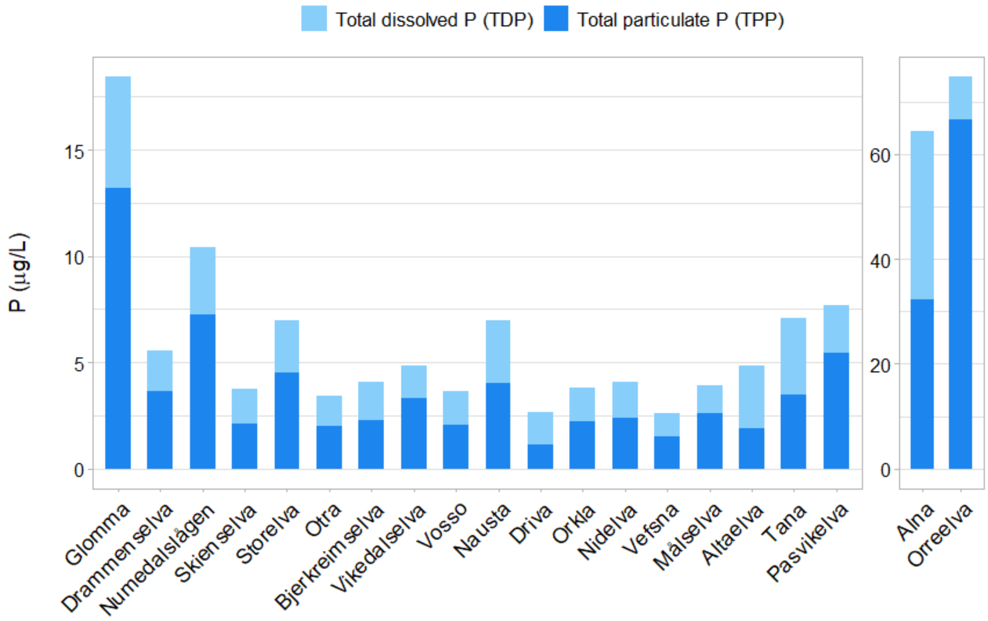

Figure 15: Distribution of the 2019 average concentration of total dissolved (TDP, light blue)- and total particulate phosphorus (TPP, dark blue) in the monitored rivers. Note that the sum of TDP and TPP equals to tot-P. The TPP was calculated as the difference between tot-P and the TDP. Note the different y-scale range on the right-side panel.

Phosphate (PO_4) is an inorganic form of tot-P which is easily available for algae and other primary producers. The highest annual mean PO_4 concentration was found in Alna (50 µg/L) and Orreelva (19 µg/L, Figure 16), likely resulting from the catchment activities previously mentioned.

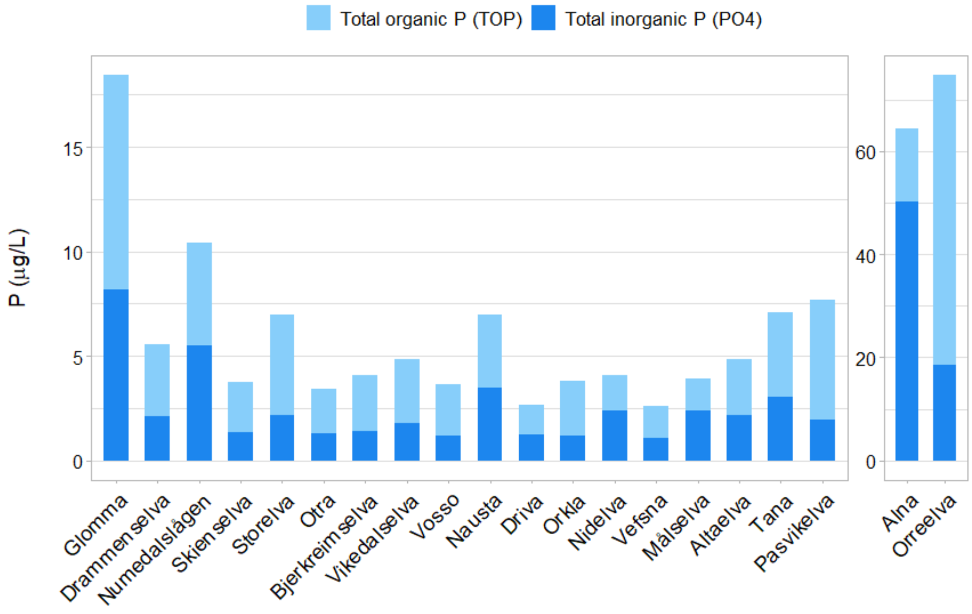

Figure 16: Distribution of the 2019 average concentration of inorganic (light blue)- and organic phosphorus (dark blue) in the monitored rivers. The organic P fraction has been calculated as the

difference between tot-P and phosphate and can also include tightly bound inorganic P. Note the different y-scale range on the right-side panel.

Nitrogen

The major sources for nitrogen (N) in river basins are water discharge from agriculture, atmospheric deposition, scattered dwellings, urban wastewater, and diffuse water discharge from upland areas. As for P, N can also exist in different chemical forms and be either freely dissolved or associated with particulate material.

The same two rivers, as for tot-P, stand out with higher total N (tot-N) concentrations (Alna 1500 and Orreelva 1480 µg/L, Figure 17). As for previous years, the concentrations exceeded the good/moderate boundary for tot-N for their respective water types (Direktoratsgruppen 2018). Relatively high levels of tot-N (> 300 µg/L) were also evident for several of the rivers in the south and south-western part of Norway (e.g. Bjerkreimselva, Vikedalselva, Storelva). This is likely an effect of atmospheric deposition (Garmo and Skancke 2018, Gundersen et al., 2019).

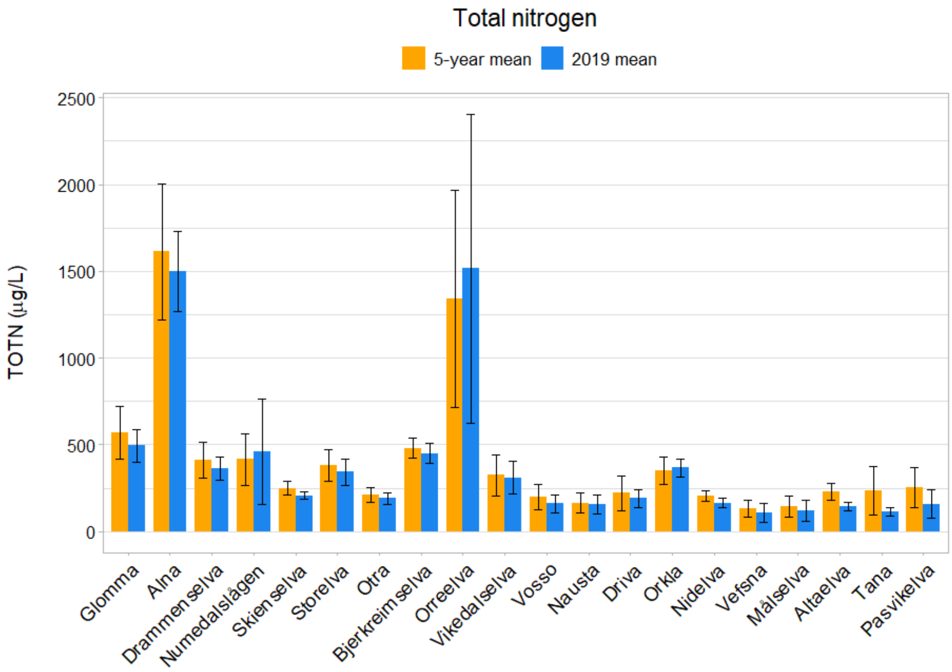

Figure 17: Average annual concentrations of total nitrogen (TOTN/tot-N) for the five preceding years (2014-2018, orange) and the 2019 average (blue) for the monitored rivers. Error bars illustrate interannual variability (± stdev) for the 5-year mean and intra-annual variability for the 2019 mean (± stdev).

Two forms of nitrogen are available for plant uptake, nitrate (NO_3) and ammonium (NH_4). NO_3 is the dominant fraction of tot-N in Norwegian surface waters, except in humic waters where the organically bound-N (total organic nitrogen, TON) can dominate. Similar to the findings in last year's report (Gundersen et al., 2019), the highest relative NO_3 content, i.e. 76% of tot-N, was found in Bjerkreimselva, whereas Tana and Pasvikelva had the lowest relative NO_3 contents: 28% and 24%, respectively (Figure 18). Ammonium (NH_4) concentrations are typially low in Norwegian surface waters, except if sites are highly polluted or have low oxygen content. Unsurprisingly, the highest NH_4 levels were found in Alna and Orreelva.

Figure 19 displays the concentrations of particulate and dissolved fractions of nitrogen in the rivers and highlights that nitrogen has less affinity to particles than phosphorus, as shown in Figure 15. The rivers with high particle content, Alna and Orreelva, had the highest concentrations of particulate N.

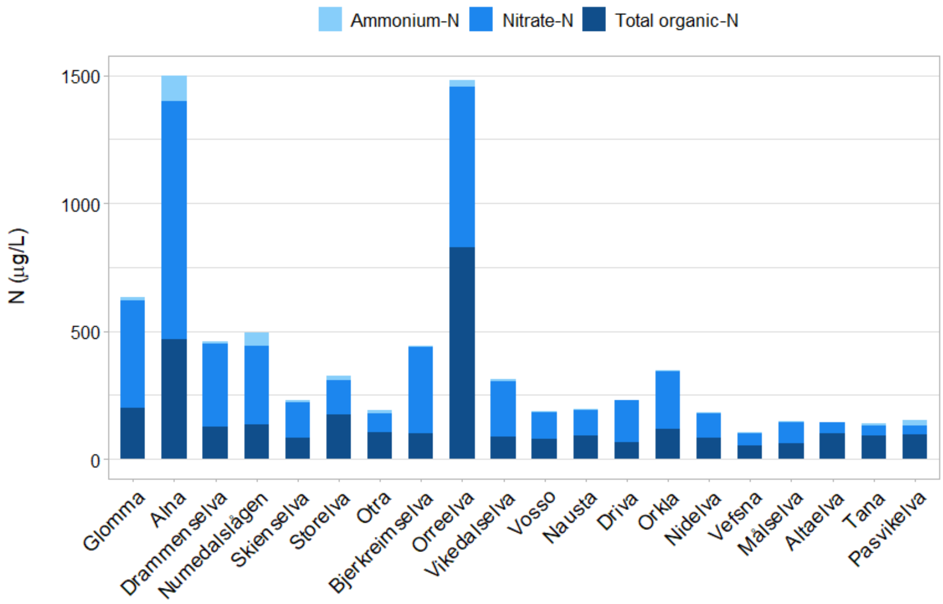

Figure 18: Distribution of the 2019 average concentration of ammonium-N (light blue), nitrate-N (blue), and organic-N in the monitored rivers. The organic-N fraction was calculated as the difference between tot-N and the two inorganic fractions (ammonium-N and nitrate-N).

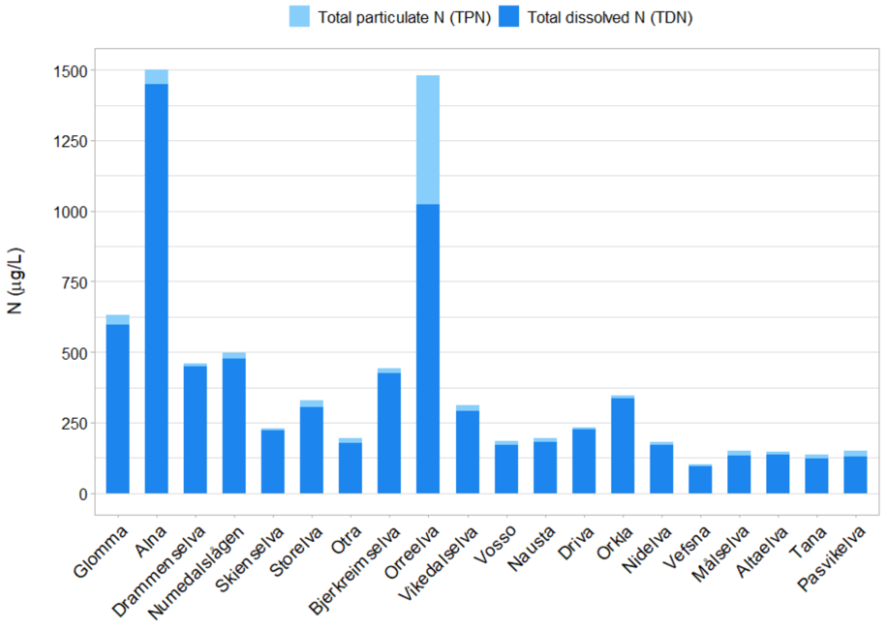

Figure 19: Distribution of the 2019 average concentration of total particulate-N (TPN, light blue) and dissolved-N (TDN, dark blue) in the monitored rivers. The TDN was calculated as the difference between tot-N and TPN.

3.2.5 Metals

Arsenic (As)

In 2019, all reported As concentrations were below the EU WFD environmental quality standard threshold level (Table 9). Alna (0.38 µg/L) and Orreelva (0.38 µg/L) had the highest annual mean As concentrations, followed by Storelva (0.26 µg/L) and Vikedalselva (0.26 µg/L). For Alna, Storelva and Vikedalselva mean annual concentrations were similar to the preceding fiver year mean, while Orreelva had elevated concentrations compared to the historical data (Figure 20). Pasvikelva had lower mean annual concentration (0.14 µg/L) than the 2014-2018 mean, while Numedalslågen were higher (0.20 µg/L). Of the remaining rivers, all annual means were below 0.2 µg/L (Figure 20). The elevated As levels in Alna and Orreelva can be explained by the high local anthropogenic influence on these rivers. Pasvikelva is likely influenced by pollution from the large metallurgical complex (Nornickel, Russia) located in close vicinity to the river. Higher metal concentrations in Storelva may be linked to former mining and smelting industries within the catchment. Transport of metals to the surface waters may also to a larger extent be facilitated by DOM in this river, given the relatively high content of OC (TOC: 6.0 mg C/L, DOC: 5.8 mg/L). Given the relatively high particle content in Alna (Figure 9-11), the dissolved fraction of As is likely to be low. For Pasvikelva, on the other hand, the content was low and thus the occasionally high As concentration gives more reason for concern.

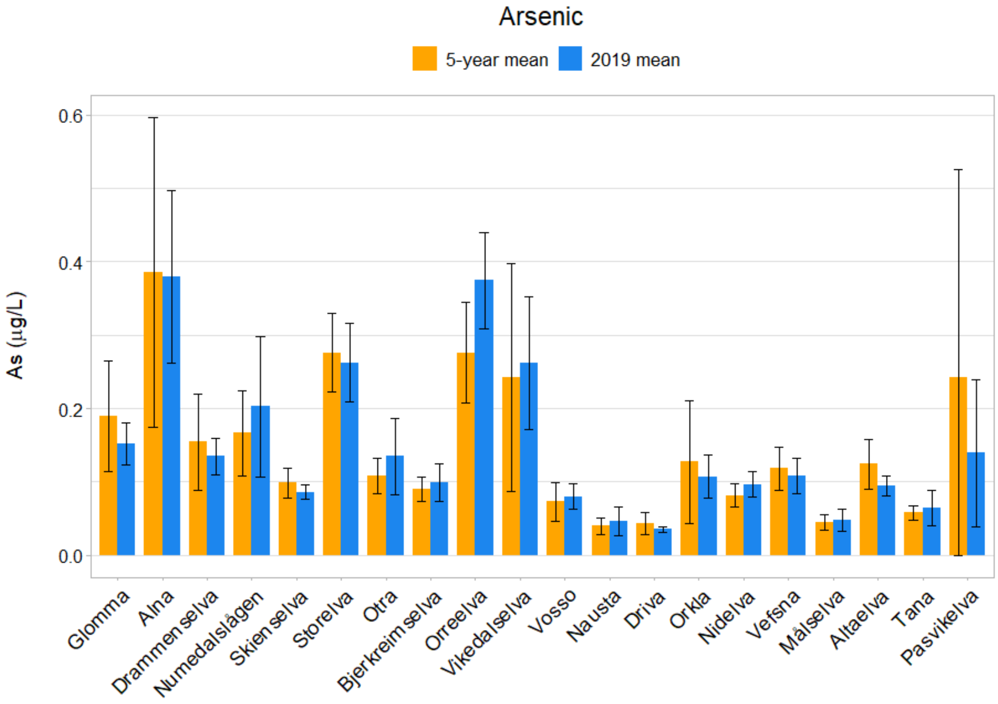

Figure 20: Average annual concentration of arsenic for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Lead (Pb)

Annual mean concentrations of Pb in 2019 (Figure 21), showed more or less the same pattern as the previous monitoring year (Gundersen et al., 2019). None of the rivers showed Pb levels exceeding the threshold concentration (1.2 µg/L, Table 9). Mean annual 2019 concentrations were generally lower than the 5-year means, and especially for the high-concentration rivers such as Alna (0.47 µg/L), Drammenselva (0.06 µg/L), and Storelva (0.37 µg/L). Two exceptions were Numedalslågen (0.45 µg/L) and Orreelva (0.35 µg/L), where levels were higher than the five-year mean.

It is worth mentioning that the apparent pattern of declining Pb concentrations could be an artefact from the less frequent measurements conducted between 2017 and 2019 compared to the previous years (from monthly to quarterly). With less frequent measurements, pulses of elevated Pb concentrations, caused by for example increased particle content, might have gone unnoticed.

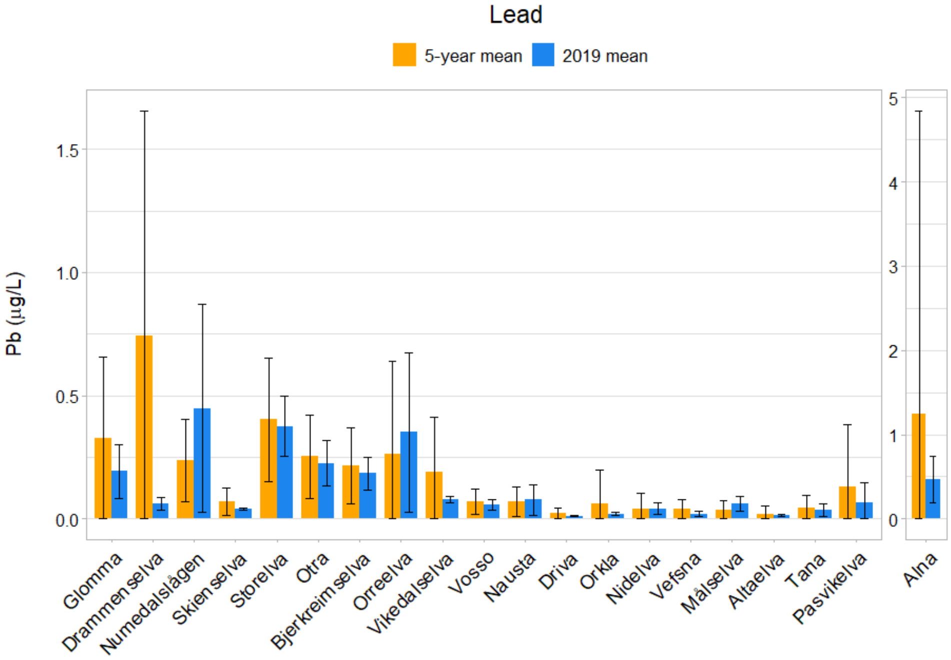

Figure 21: Average annual concentration of lead for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Cadmium (Cd)

Alna (0.03 µg/L), Storelva (0.04 µg/L), and Orkla (0.03 µg/L) had the highest annual mean cadmium (Cd) concentrations (Figure 22). In Orkla, this is likely resulting from water discharge from an abandoned Cu mine in the catchment (Gundersen et al., 2019). For Alna, the trend of annual mean Cd concentrations around 50% of the 5-year mean was continued (Gundersen et al., 2019). As has been observed in previous years, Pasvikelva was the only river with elevated concentrations in the northern parts of the country. Likely due to airborne pollution from the industry on the Russian side of the border. The remaining rivers had low Cd concentrations, and all measurements were below the threshold concentration (0.08 µg/L, Table 9).

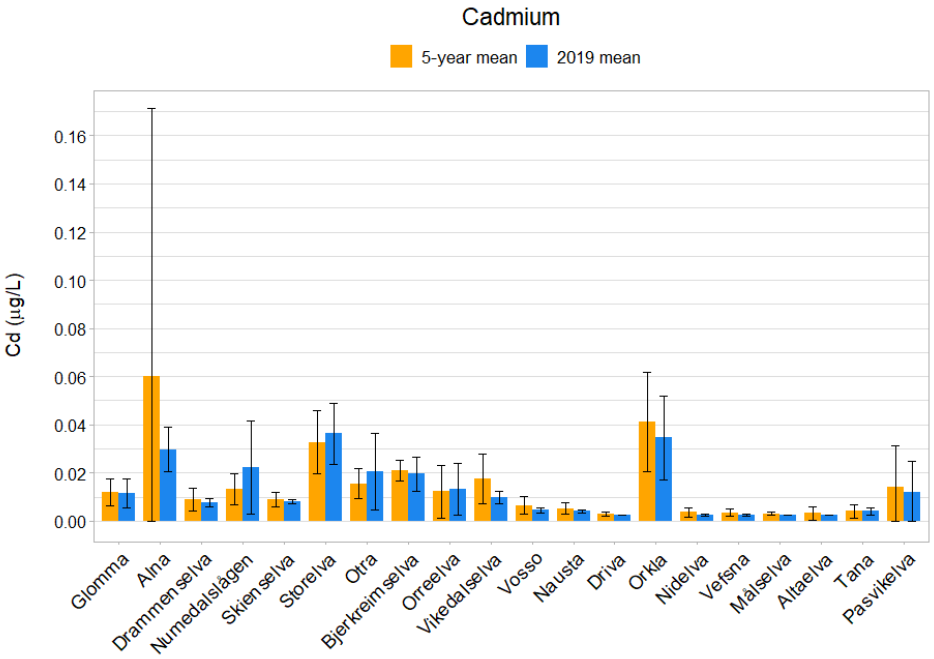

Figure 22: Average annual concentration of cadmium for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Copper (Cu)

In 2018, the highest annual mean Cu concentration was found in the northern river Pasvikelva (10.6 µg/L, Gundersen et al., 2019). Gundersen et al., 2019 argued that, based on low content of SPM and TOC in Pasvikelva, a large fraction of the Cu resides in the dissolved form, and it was likely that the threshold level (7.8 µg/L, Table 9) was exceeded. In 2019, the annual mean Cu concentrations in Pasvikelva is much lower (4.0 µg/L), also below the threshold level. The concentrations measured in 2019 is more in line with the 5-year mean (Figure 23). 2018 could represent an outlier in the dataset, but the river catchment does receive air-pollution from the metallurgical complex located in close vicinity on the Russian side of the border.

Orkla had the highest annual mean Cu concentration (4.8 µg/L) in 2019, but all remaining rivers had levels below the threshold concentration.

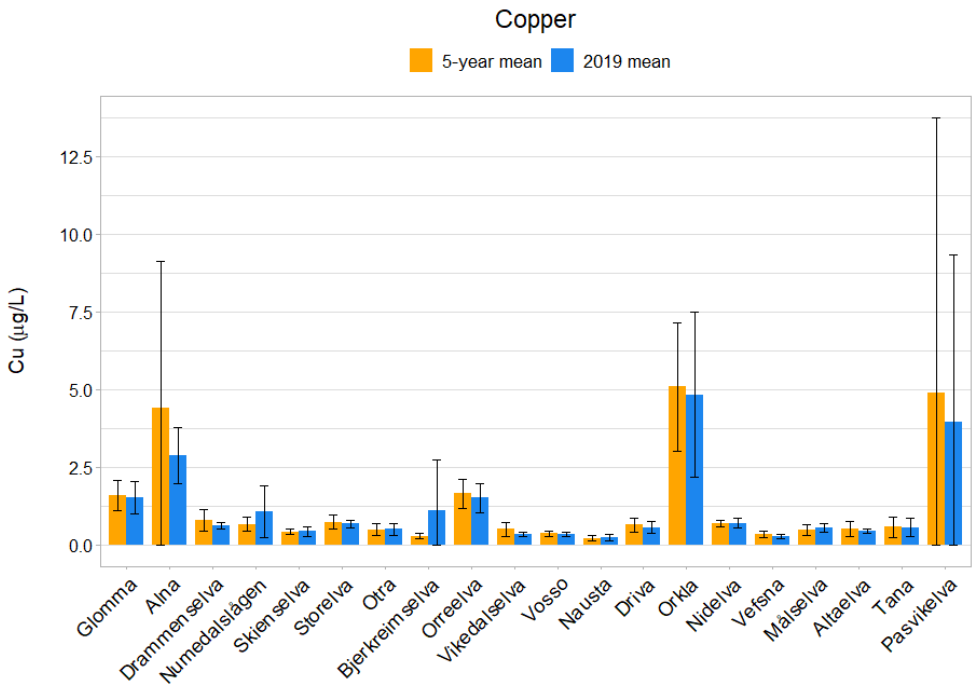

Figure 23: Average annual concentration of copper for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Zinc (Zn)

Like the previous year of monitoring, the highest annual mean Zn concentration was observed for Orkla (10 µg/L, Figure 24) and Alna (10 µg/L). Assuming parts of the Zn are particle bound, the dissolved concentration of Zn is likely to be below the threshold value (11 µg/L, Table 9). The three rivers with the highest 5-year mean, Alna, Orkla, and Glomma, had all much lower concentrations in 2019 compared to the historical data. This is a continuation of a pattern observed the last years and is likely due to the reduced sampling frequency since 2017. Metals are typically transported with particles, and particles generally show a high monthly variation.

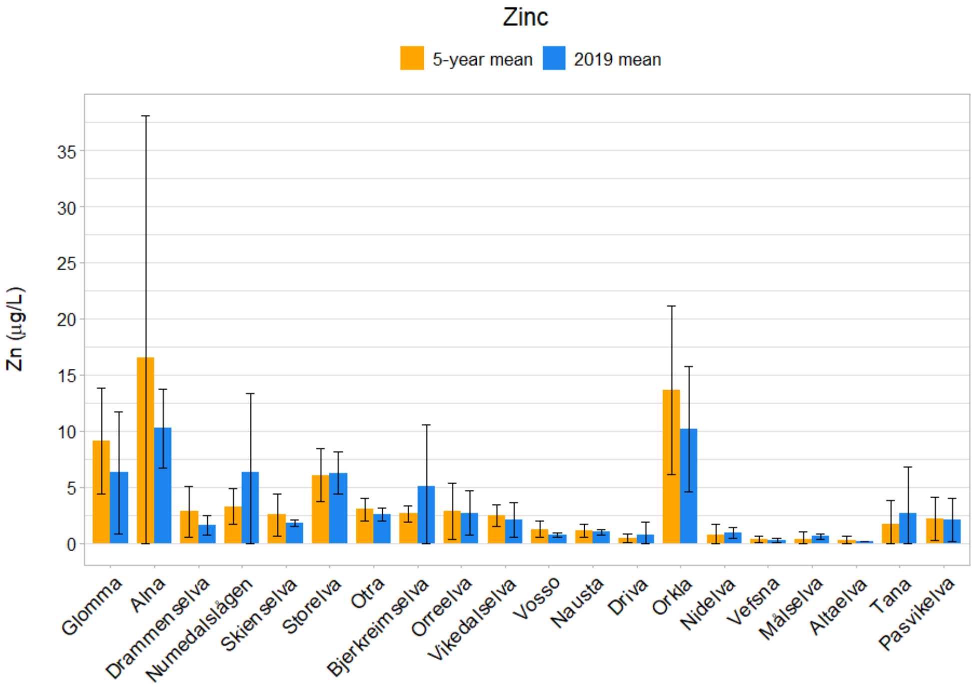

Figure 24: Average annual concentration of zinc for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Chromium (Cr)

Mean annual Cr concentrations were low (<0.5 µg/L, Figure 25) for all rivers and below the threshold concentration (3.4 µg/L, Table 9). For the rivers with the highest five-year mean concentrations, Glomma, Alna, and Orkla, the 2019 concentrations were lower than the historical data.

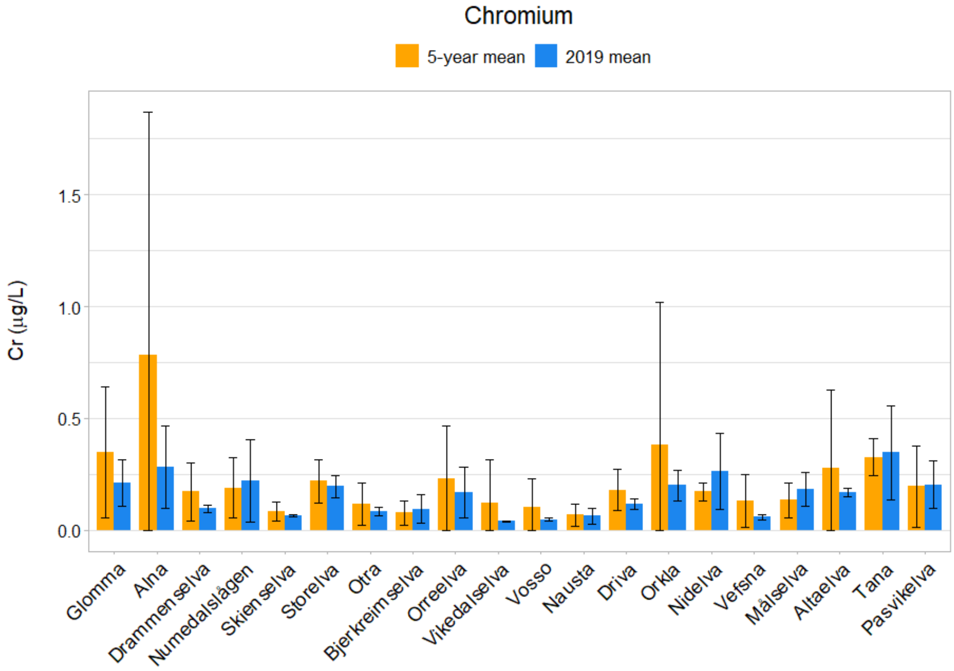

Figure 25: Average annual concentration of chromium for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev).

Nickel (Ni)

Mean annual Ni concentrations are clearly higher in Pasvikelva compared to the other monitored rivers (Figure 26). The annual mean in Pasvikelva was 9.3 µg/L in 2019, a concentration approximately 8 times higher than the second highest observed annual mean (1.2 µg/L for Orreelva). For all rivers, including Pasvikelva, the 2019 data were similar to the five-year mean (Figure 26).

Of the monitored rivers, it is only for Pasvikelva that the mean annual concentration is higher than the EU WFD threshold value (4 µg/L, Table 9). In Pasvikelva, SPM and TOC concentrations were low, and it is likely that the threshold concentration was exceeded. It is not surprising that the Ni levels are high in Pasvikelva. Contamination in Pasvikelva results from heavy influence from the Norilsk nickel plant, located a few kilometres away on the Russian side of the border.

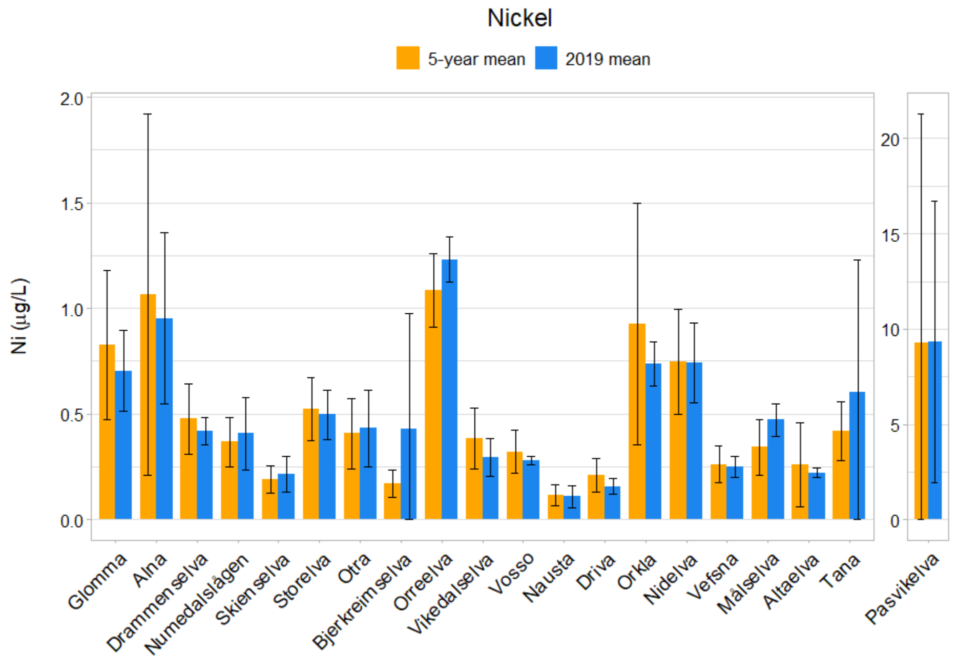

Figure 26: Average annual concentration of nickel for the five preceding years (2014-2018, orange) and average for 2019 (blue) for the monitored rivers. Error bars illustrate annual variation for the 5-year mean (± stdev) and monthly variation for the 2019 mean (± stdev). Note the different y-scale range on the right-side panel.

Mercury (Hg)

Previous activities of the Norwegian river monitoring programme have not been able to evaluate river Hg concentrations because a high number of samples had concentrations below analytical detection limits. Data from the past five years are correspondingly incomplete and associated with large uncertainties, see Braaten et al. (2018) for details. As an example, in 2018 70 of 70 samples had Hg concentrations below the LOQ (1 ng/L) (Gundersen et al., 2019). For samples collected in 2019, two methods were used for Hg determination (Section 2.2.2). The method previously used (i.e. the AAS method) resulted in 58 of 80 samples with Hg concentrations below the LOQ (1 ng/L). However, the CVAFS method used on samples collected monthly in 2019 provided 238 data entries of concentrations above the 0.2 ng/L LOQ (Table 6).

Hg, being very toxic and having a high potential for bioaccumulation, has the lowest threshold level among the metals (0.047 µg/L, Table 9). Here, Hg concentrations were very low for most of the rivers (< 2 ng/L, Figure 27). However, at several sites in the country, the Hg level in fish (both freshwater and marine) exceeds the recommended dietary intake. Hence, a continued effort to determine river Hg concentrations with lower detection limits is needed in order to provide an adequate time series for river water.

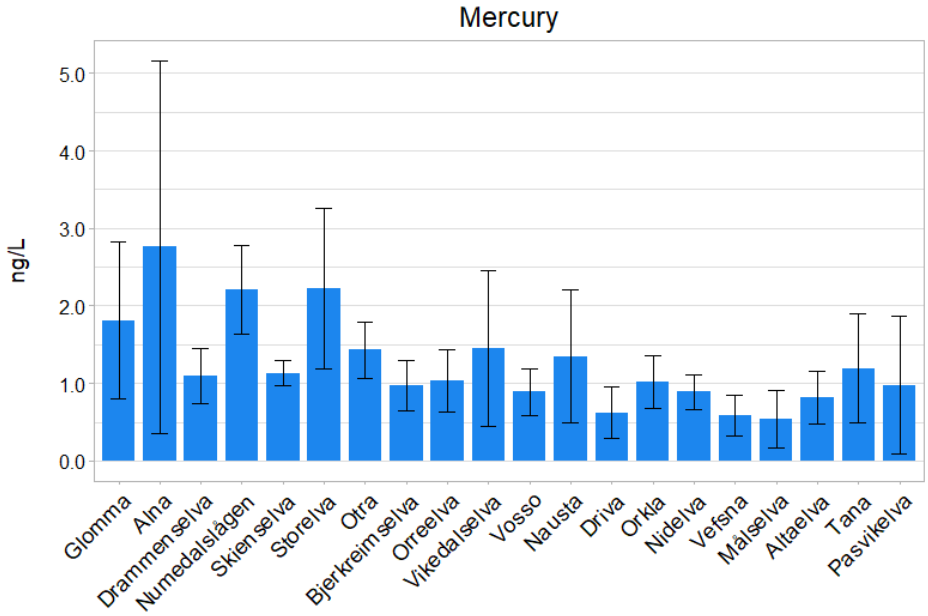

Figure 27: Average annual concentration of mercury for 2019 (blue) for the monitored rivers. Error bars illustrate monthly variation for the 2019 mean (± stdev).

3.3 Additional Rivers - Water quality status 2019

As in 2018 (Gundersen et al., 2019), water chemistry from a selection of rivers from the National monitoring program for limed rivers (Kalkningsovervåkningen) have been included to compliment the picture established by the 20 main river of the programme. Data for 2019 are included for six rivers, Nidelva, Tovdalselva, Mandalselva, Lygna, Suldalslågen, and Ekso (Table 2), compared to ten rivers in 2018 (additional rivers were Sira, Stryneelva, Namsen, and Saltdalselva, Gundersen et al., 2019). The rivers from the National monitoring program for limed rivers are from the south- and southwestern Norway (Figure 2).

The samples have been analysed at a different chemical laboratory (Vestfold lab) than the main river samples (NIVA lab). Since these rivers have not been routinely monitored with fully matched parameter lists, a complete 5-year mean does not exist for comparison. Data are only compared with results from 2018.

3.3.1 pH and calcium

Concentrations of pH and Ca showed very little difference compared with data from the previous year (Figure 28). As expected, given the acid-sensitive character of these rivers, levels are lower than what is reported for the main 20 rivers (Figures 7 and 8).

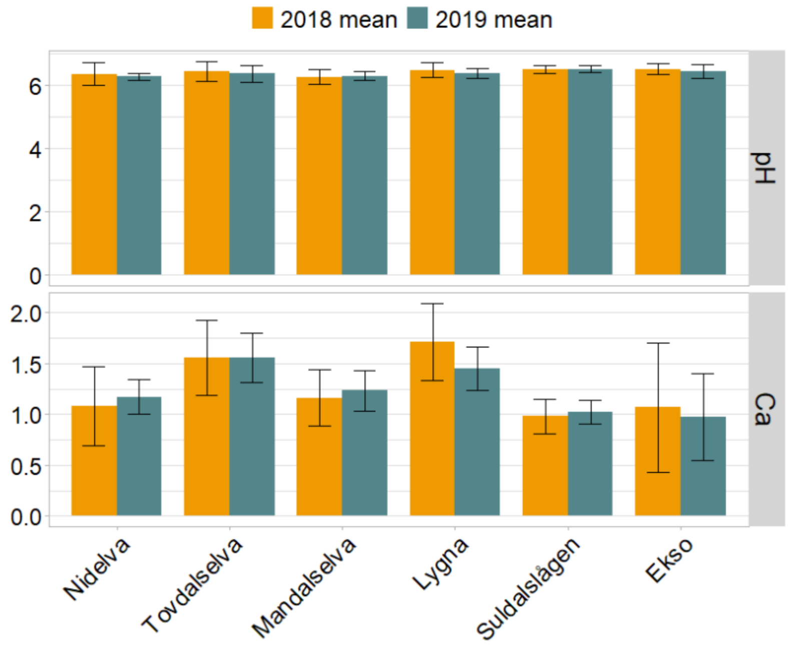

Figure 28: Average annual concentration of pH (above) and calcium in mg/L (below) for 2018 (orange) and for 2019 (dark blue) for the additional rivers included from the National monitoring program for limed rivers programme. Error bars illustrate interannual variability (± stdev). For pH, the average values and standard deviation are based on pH values, not the H^+ concentration. This represents a negligible error when pH values are above 6.0.

3.3.2 Suspended matter, (turbidity, SPM, and silica)

All rivers had low mean annual SPM concentrations (≤ 1 mg/L, Figurew 29), similar to what was reported last year (Gundersen et al., 20919). Correspondingly, turbidity measurements were also low (≤ 1 FNU). For silica, the geographical pattern was similar to that of the 20 rivers in the regular monitoring: lowest concentrations on the west coast (< 1 mg/L, Suldalslågen and Ekso), medium levels in the south (1 – 2 mg/L, Mandalselva and Lygna), and higher levels when moving northeast (approximately 2 mg/L, Tovdalselva and Nidelva).

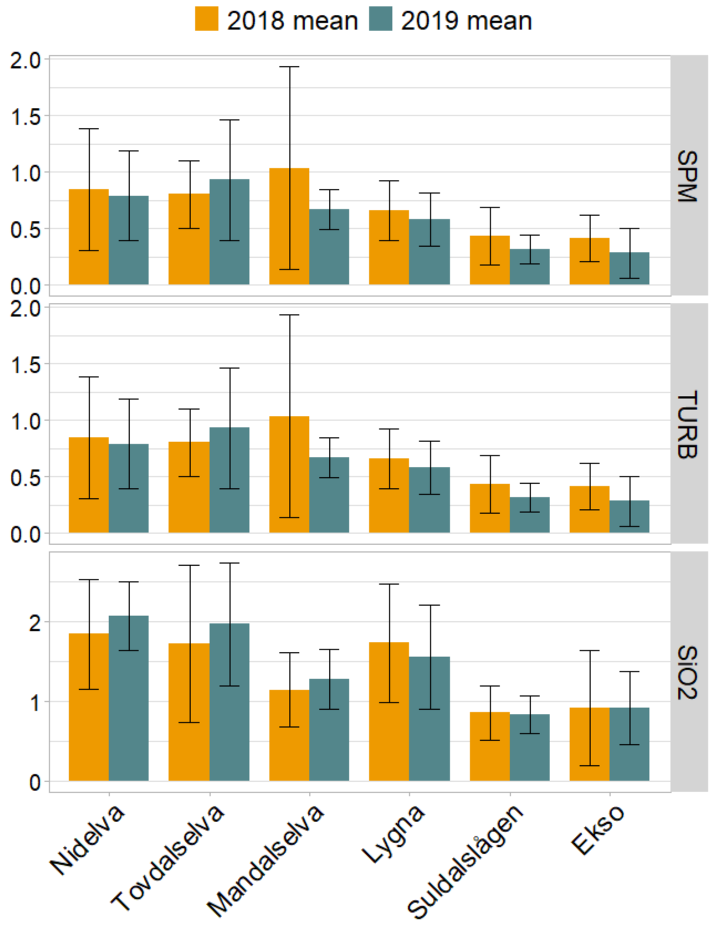

Figure 29: Average suspended particulate matter concentration (SPM, top), turbidity (middle), and silica concentration (bottom) for 2018 for the ten additional rivers included from the National monitoring program for limed rivers (dark turquoise) and the 2018 classification of ecological and chemical status (light turquoise). Error bars illustrate interannual variability (± stdev).

3.3.3 Organic carbon

Based on the mean annual concentration of TOC (Figure 30), Nidelva, Tovdalselva, Mandalselva, and Lygna were all categorized as humic in 2019 (> 5 mg/L), according to the Norwegian WFD typology. This was not the case in 2018, were both Nidelva and Lygna had lower concentrations (< 5 mg/L, Gundersen et al., 2019). Ekso and Suldalslågen are in 2019 categorised as clear (2 mg/L > TOC < 5 mg /L) and very clear (< 2 mg/L), respectively. In all rivers were POC and DOC were determined, the dissolved fraction was the dominant (Figure 31), but with a significant fraction of particulate in most rivers. This contrasted with the 20 rivers in the regular programme, where the particulate fraction was negligible in most cases (except for Orreelva). The reason for this is not known, but it mirrors the pattern observed in 2018 (Gundersen et al., 2019).

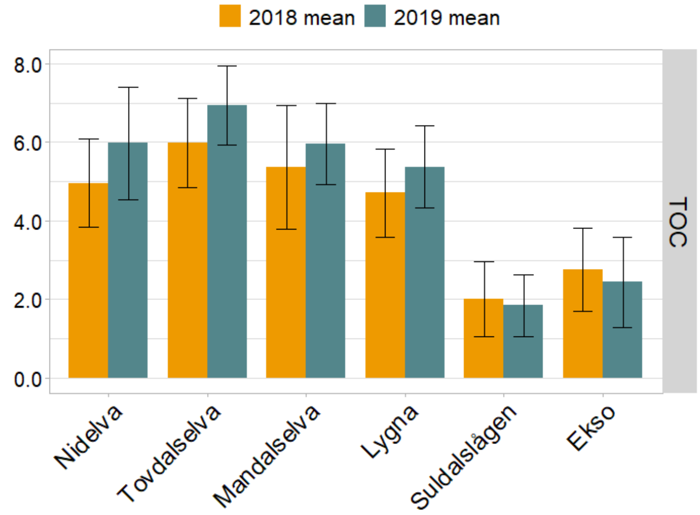

Figure 30: Average total organic carbon (TOC) concentration for 2018 for the ten additional rivers included from the National monitoring program for limed rivers (dark turquoise) and the 2018 classification of ecological and chemical status (light turquoise). Error bars illustrate interannual variability (± stdev).

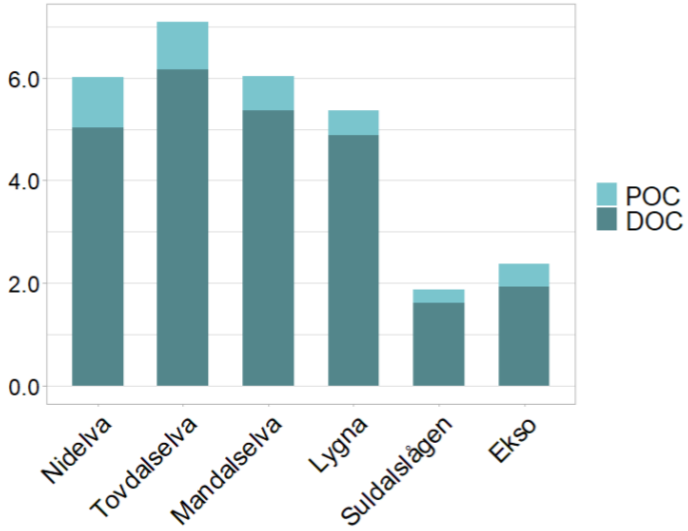

Figure 31: Average 2019 distribution of particulate (POC, light turquoise)- and dissolved (DOC, dark turquoise) organic carbon (mg/L) for the six additional rivers included from the National monitoring program for limed rivers (dark turquoise). Any deviation from the TOC in Figure 29 result from analytical uncertainties in the individual methods used to determine POC and DOC.

3.3.4 Nutrients

For the six rivers analysed in 2019, mean annual tot-P concentrations were relatively low (< 6 µg/L, Figure 32) and similar to last year (Gundersen et al., 2019). For tot-N there is more variation, with higher levels in the southern rivers (Nidelva, Tovdalselva, Mandalselva, and Lygna, Figure 32) compared to the rivers on the west coast (Suldalslågen and Ekso). This is likely a result of atmospheric deposition of nitrogen, from which the southern rivers have been and are most impacted.

The high variability in tot-N concentration observed in 2018 for Nidelva should be noted. This was due to a sudden increase during July; one measurement of tot-N about ten times higher than what was measured in the other months. As discussed in last year's report, the high tot-N value was caused by an increase in ammonium-N (2000 µg/L). Ammonium-N is typically low in Norwegian rivers, and the sudden increase could have resulted from manure application or a spill. For the remaining rivers, the distribution of the various N-fractions was in accordance with what was seen for the 20 rivers in the regular programme: dominated by nitrate-N, followed by organic-N, and with low levels of ammonium-N (Figure 33). One exception is Tovdalselva, where the ammonium-N fraction is higher.

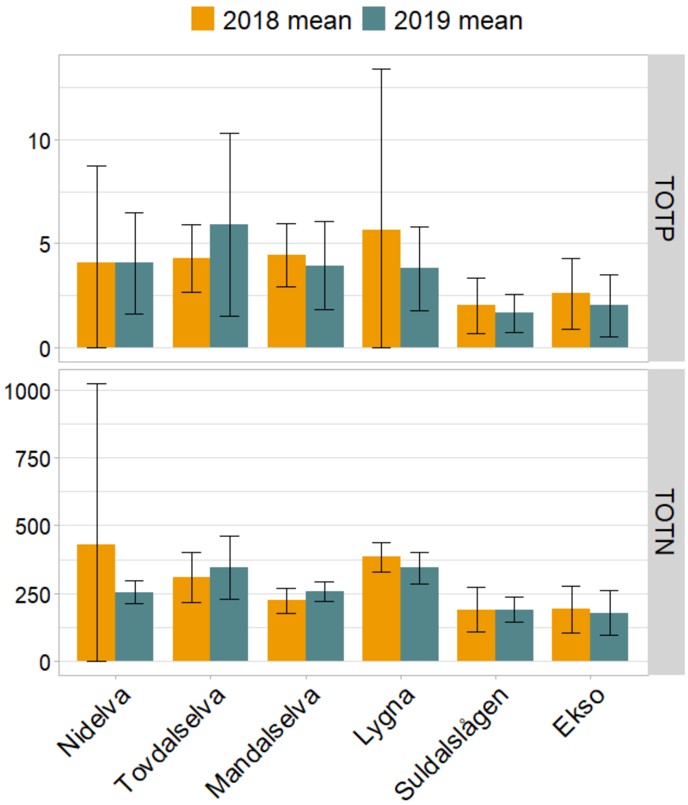

Figure 32: Average 2018 concentration of top: total phosphorus (TOTP/tot-P) and bottom: total nitrogen (TOTN/tot-N) for the ten additional rivers included from the National monitoring program for limed rivers (dark turquoise) and the 2018 classification of chemical and biological status (light turquoise). Error bars illustrate monthly variation (± stdev).

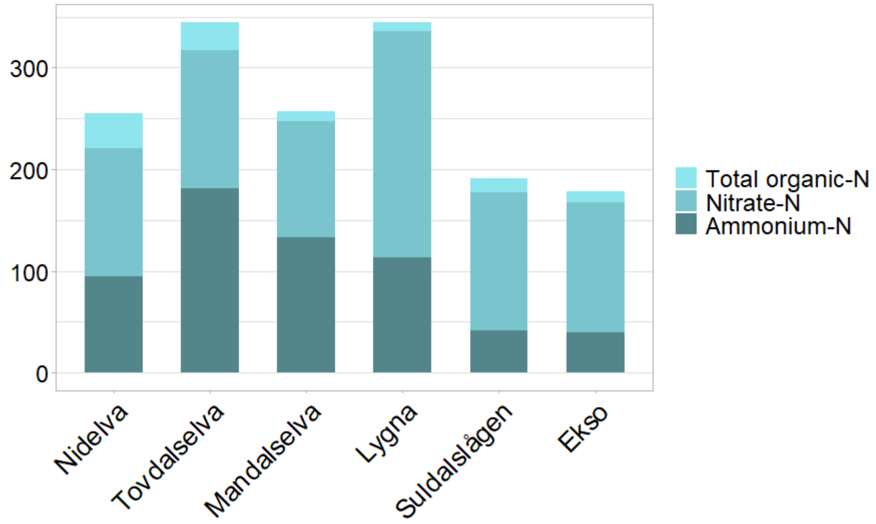

Figure 32: Average 2019 distribution of the following nitrogen fractions: ammonium- (dark turquoise), nitrate- (medium turquoise), and total organic- (light turquoise) nitrogen (N: µg/L) for the six additional rivers included from the National monitoring program for limed rivers.

3.3.5 Metals

Analytical determination of metals was conducted by a different laboratory (Vestfold lab) than the 20 main rivers discussed earlier in this report. At Vestfold lab, the LOQs of the methods were higher than at the NIVA lab and for several of the rivers, many of the metals were not detected. For this reason, Pb, Cd, Ni, Hg, and Ag – where 48 %, 62 %, 69 % and 100 % of the measurements were < LOQ – were not included in the discussion (Table 7).

Mean annual concentrations of As and Cu were below the EU WFD threshold value (0.5 µg/L and 7.8 µg/L, Table 9) for all six rivers (Table 17). Levels were similar to what was observed for most of the 20 main rivers (Figure 20 and 23).

Table 17. 2018 average metal concentrations ± stdev for additional rivers (all data in µg/L).

River	As	Cu	Zn	Cr
Nidelva	0.18 ± 0.03	1.0 ± 0.4	7 ± 2	0.2 ± 0.1
Tovdalselva	0.22 ± 0.04	0.3 ± 0.4	7 ± 4	0.2 ± 0.1
Mandalselva	0.18 ± 0.04	0.7 ± 0.3	7 ± 3	0.15 ± 0.08
Lygna	0.19 ± 0.04	0.4 ± 0.2	7 ± 3	0.13 ± 0.07
Suldalslågen	0.06 ± 0.01	0.8 ± 0.9	4 ± 2	0.12 ± 0.06
Ekso	0.06 ± 0.02	0.6 ± 0.2	5 ± 3	0.10 ± 0.07

In 2018, mean annual Zn concentrations were reported to be above or close to 10 µg/L in Tovdalselva, Mandalselva, and Lygna (Gundersen et al., 2019). These concentrations were similar to levels found in Alna and Orreelva, which are heavily influenced by human activities. In 2019, concentrations were much lower in Tovdalselva, Mandalselva, and Lygna (Table 17). All Zn concentrations were below the EU WFD threshold level (11 µg/L, Table 9).

Levels of Cr were generally low for all rivers (≤ 0.2 µg/L), much lower than the EU WFD threshold value (3.4 µg/L, Table 9).

3.4 Trends in riverine loads and concentrations

As in previous reports for the river monitoring programme, the trend analyses include an evaluation of both loads (riverine transport of dissolved and particulate matter per unit of time) and concentrations. Loads are important for assessing total transport to coastal waters, whereas concentrations will give an indication of the water quality. By evaluating trends in loads in combination with water discharge, it is possible to reveal whether potential trends are related to changes in the release of the chemical substance or in water flow.

3.4.1 Loads and concentrations of SPM, silica, TOC, and nutrients (1990-2019)

Trends in water discharge (Q) were discussed in Chapter 3.1.4 but are included also here in discussion of the dataset of long-term trend analysis (1990-2019) of loads (Table 18) and concentrations (Table 19) of SPM, silica, TOC, and nutrients. Note that for TOC, the trends for certain rivers represent a shorter time period (1999 – 2019), due to limited observations during the early 1990's. Only trends that are significant at a level of 95% ($p < 0.05$) will be discussed.

Spatial Patterns

A geographical pattern appeared when looking at the trend analysis of loads of the various parameters (Table 18). There was a significant increase for several of the parameters for the south-eastern rivers Glomma, Drammenselva, and Numedalslågen including SiO_2, PO_4, and tot-N. Additionally, Drammenselva had increasing SPM, TOC, and tot-P loads, while Numedalslågen increased in tot-P and NH_4. This can be seen in connection with the increased precipitation, temperature, and resulting discharge in this part of the country. For a few of the parameters (SiO_2, PO_4, and tot-N), the significant increase was also apparent in concentrations (Table 19). This indicates that discharge is not the only driving factor for the observed increase.

Table 18. P-values for long-term trends (1990-2019) in water discharge (Q) and loads (transport) of suspended particulate matter (SPM), silica (SiO_2), total organic carbon (TOC), total phosphorus (tot-P), and phosphate (PO_4), total nitrogen (Tot-N), ammonium (NH_4), nitrate (NO_3), in rivers.

River	Q	SPM	SiO_2	TOC*	Tot-P	PO_4	Tot-N	NH_4	NO_3
Glomma	0.030	0.544	0.032	0.094	0.568	0.038	0.010	0.000	0.059
Drammenselva	0.010	0.019	0.000	0.003	0.005	0.006	0.030	0.002	0.069
Numedalslågen	0.164	0.125	0.003	0.880*	0.027	0.009	0.003	0.022	0.108
Skienselva	0.116	0.721	0.007	0.786*	0.412	0.412	0.116	0.005	0.000
Otra	0.392	0.199	0.335	0.475	0.354	0.269	0.318	0.125	0.000
Orreelva	0.074	0.50	0.030	0.450	0.050	0.080	0.695	0.225	0.432
Orkla	0.521	0.669	0.943	0.412	0.669	0.568	0.830	0.000	0.803
Vefsna	0.318	0.002	0.116	0.608*	0.000	0.002	0.000	0.000	0.000
Altaelva	0.335	0.748	0.943	0.319	0.212	0.301	0.669	0.046	0.318

Red – significantly increasing p<0.05, green – significantly decreasing p<0.05

*Trend analysis started in 1999 due to limited data in the period from 1990

Increased transport of SPM, silica, TOC, and nutrients to the coastal system can have a negative impact on the ecology in these systems (McGovern et al., 2019). Particles can influence light penetration while SiO_2, OM, PO_4 and nitrogen species constitute the main nutrients for diatoms and heterotrophs and can thereby affect the foodweb structure.

Among the other rivers, the agricultural influenced Orreelva located on the west-coast displayed similar increase in the loads of SPM, silica, and tot-P (Table 18) while this was not evident in the trends of concentrations (Table 19). In contrast, decreasing trends was evident for Vefsna, covering loads of SPM, tot-P, PO_4, tot-N, NH_4, and NO_3. This picture was mirrored in the trends of concentrations, indicating that the sources of these parameters to the river had been reduced.

Table 19. Long-term trends (1990-2019) in concentrations of suspended particulate matter (SPM), silicate (SiO_2), total organic carbon (TOC), total nitrogen (Tot-N), ammonium (NH_4), nitrate (NO_3), total phosphorus (tot-P), and phosphate (PO_4) in rivers. p-values are shown.

River	SPM	SiO_2	TOC*	Tot-P	PO_4	Tot-N	NH_4	NO_3
Glomma	0.040	0.107	0.612	0.725	0.000	0.943	0.000	0.391
Drammenselva	0.108	0.012	0.137	0.942	0.090	0.858	0.001	0.029
Numedalslågen	0.077	0.003	0.650*	0.162	0.031	0.038	0.678	0.762
Skienselva	0.015	0.005	0.221*	0.616	0.223	0.000	0.001	0.000
Otra	0.008	0.963	0.624	0.002	0.578	0.003	0.068	0.000
Orreelva	0.254	0.559	0.251	0.387	0.093	0.326	0.079	0.042
Orkla	0.001	0.001	0.260	0.181	0.954	0.005	0.000	0.175
Vefsna	0.001	0.117	0.693*	0.001	0.036	0.006	0.000	0.000
Altaelva	0.031	0.779	0.625	0.104	0.048	0.775	0.009	0.592

Red – significantly increasing $p<0.05$, green – significantly decreasing $p<0.05$

*Trend analysis started in 1999 due to limited data in the period from 1990

Nitrogen related changes – some examples

For nitrogen, Glomma, Drammenselva and Numedalslågen all show a long-term increase in tot-N loads (Table 18). However, a concentration increase is only evident for Numedalslågen, indicating that there has been a long-term increase in water discharge for Glomma and Drammenselva. This pattern is supported by water discharge data discussed for the three rivers in chapter 3.1.4.

Skienselva shows decreasing trends of both NH_4 and NO_3 loads, but no change in tot-N loads (Table 18) suggesting that the organically bound nitrogen increases in Skienselva. The decrease in NH_4 and NO_3 is a positive development since these N species are normally quickly assimilated by plants or microbes. The reduced levels could result from increased biological activity, reduced atmospheric N-deposition, and/or, in some rivers, by increased water discharge (causing dilution). A similar pattern is evident for Vefsna.

2019 pending trends

Compared to the statistical analysis undertaken last year (Gundersen et al., 2019), some changes appeared in whether trends of loads and concentrations were significant or not. For Glomma there is no longer a significant increase in the load of SiO_2, Numedalslågen no longer displayed an increase in the load of NH_4, while the concentration of both PO_4 and tot-N was now increasing in the same river. In Orreelva, the load of tot-P is no longer increasing – likely explained by a corresponding loss of significantly increasing load of particles in the river. Moreover, NO_3 concentrations are now significantly decreasing in Orreelva. Finally, in River Altaelva, NH_4 loads are now significantly decreasing.

The missing TOC trends

Browning of surface waters across the northern hemisphere is a well-established phenomenon, consisting of an observed increase in both the concentration and colour of DOM. For example, Evans et al. (2006) described nearly a doubling in the median TOC concentration for several streams and lakes in the United Kingdom, during the period 1988-2003. The browning has been explained by a reduction of acid deposition occurring from the mid-1970s (de Wit et al., 2007; Evans et al., 2006; Monteith et al., 2007) and/or to climate change (de Wit et al., 2016; Worrall et al., 2003). The underlying mechanism constitutes either an increased leaching of DOM from the terrestrial compartment (e.g. increased DOM solubility from reduced sulphate deposition/increased flow from increased precipitation) or increased net DOC production (i.e. from increasing temperatures).

In Norway, the largest increase in browning has been observed for lakes and streams in the south-eastern Norway (de Wit et al., 2007; de Wit et al., 2016), which is the region that has been most severely impacted by acid deposition and that contains the largest terrestrial carbon stores. While browning of lakes and streams has been frequently documented, few studies have investigated the effect in larger rivers.

Among the rivers included in this monitoring programme, only Drammenselva displayed a significant increase in TOC concentration (Table 19 and Figure 33). None of the rivers showed significant trends in the export of TOC (Table 18). A few factors can help explain the lack of expected TOC increase in these rivers:

1) ***Time series***: the time series for five of the rivers (Numedalslågen, Skienselva, Orreelva, Vefsna, and Altaelva) are too short to capture any potential increase, starting from the year 1999.
2) ***Regulation of rivers***: An important difference between these larger rivers and smaller lakes and streams is the hydrological conditions and the fact that most of these rivers are regulated for hydropower (see section 1.2). Of the rivers included here, Glomma, Drammenselva, Numedalslågen, Skienselva, Otra, Bjerkreimselva, Driva, Orkla, Nidelva, Vefsna, Målselva, Altaelva, and Pasvikelva are all regulated.

Point 2) is particularly important. A Swedish study found water flow (together with sulphate deposition) to be the major factor governing interannual variation in OM concentration in rivers (Erlandsson et al., 2008). This was moreover supported by a Finnish study in which interannual variation in carbon export was driven mainly by hydrological conditions (Räike et al., 2012). Lakes and streams typically have smaller interannual variation in water flow, thereby making changes in the TOC concentration over time more apparent.

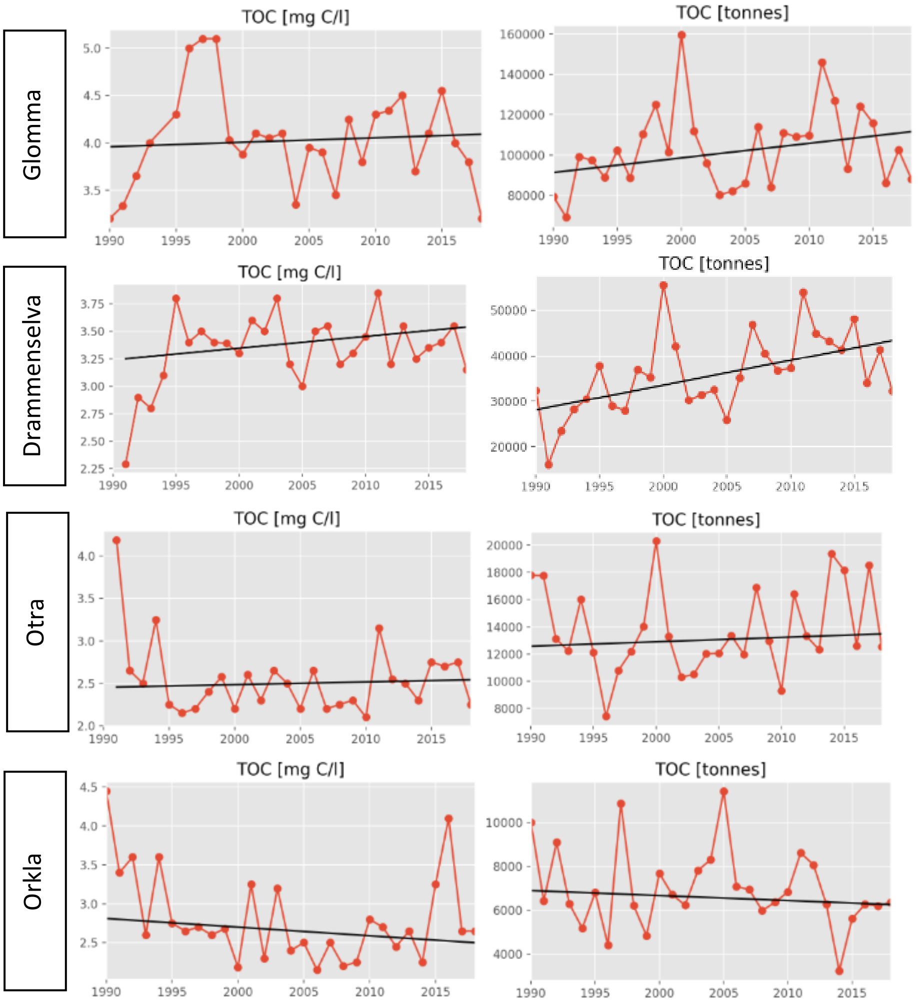

Figure 33: Annual average TOC concentration (mg C/L) to the left, and TOC export (tonnes C), to the right, for the rivers with time series starting in or close to 1990. From top: Glomma, Drammenselva, Otra and Orkla. Sen slope is illustrated in the plots.

3.4.2 Loads and concentrations of metals (2004-2019)

For metals, including Pb, Cd, Cu, Zn, and Ni, time series exist from 2004. The shorter time period was selected due to an increase in the sensitivity of the analytical methods (lower LOQ) over time, i.e. it has become possible to detect lower concentrations. As discussed in last year's report, if data prior to 2004 were not excluded, the trend analysis could potentially have showed false decreasing trends (Gundersen et al., 2019, Skarbøvik et al., 2007, Stålnacke et al., 2009). Additionally, caution should be paid when evaluating the data as the sampling frequency has been reduced from monthly to quarterly since 2017. This can introduce uncertainty to the trend analysis, especially for polluted rivers where the seasonal variability is expected to be substantial.

Generally, loads (Table 20) and concentrations (Table 21) of metals show a significant declining trend. The only two exceptions are Vefsna and Alta, where Ni concentrations are significantly increasing (Figure 34). The reason for this is not known. However, the Ni levels in these two rivers are low and the increasing trend does not warrant major concern at this point.

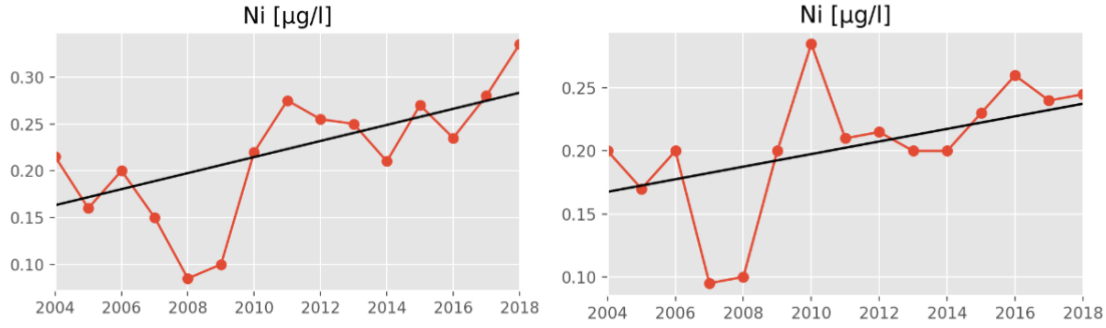

Figure 34: Concentrations of Ni in the Vefsna (left) and Alta (right). Sen slope is illustrated in the plots.

Table 20. Short-term trends (2004-2019) in metal loads in rivers monitored monthly since 1990. p-values are shown.

River	Pb	Cd	Cu	Zn	Ni
Glomma	0.753	0.260	0.043	0.224	0.558
Drammenselva	0.964	0.300	0.065	0.096	0.096
Numedalslågen	0.893	0.499	0.163	0.444	0.964
Skienselva	0.558	0.192	0.115	0.893	0.053
Otra	0.620	0.392	0.008	0.008	0.034
Orreelva	0.620	0.558	0.893	0.685	0.893
Orkla	0.006	0.053	0.013	0.022	0.444
Vefsna	0.065	0.471	0.096	0.001	0.822
Altaelva	0.260	0.516	0.065	0.096	0.753

Red – significantly upward p<0.05, green – significantly downward p<0.05.

Table 21. Short-term trends (2004-2019) in metal concentrations in rivers monitored monthly since 1990. P-values are shown.

River	Pb	Cd	Cu	Zn	Ni
Glomma	1.000	0.368	0.005	0.163	0.718
Drammenselva	0.241	0.007	0.000	0.001	0.071
Numedalslågen	0.620	0.715	0.043	0.022	0.498
Skienselva	0.058	0.000	0.006	0.009	0.000
Otra	0.685	0.120	0.005	0.000	0.031
Orreelva	1.000	0.961	0.240	0.964	0.085
Orkla	0.078	0.125	0.009	0.017	0.279
Vefsna	0.176	0.004	0.031	0.000	0.013
Altaelva	0.680	0.002	0.000	0.002	0.009

Red – significantly upward p<0.05, green – significantly downward p<0.05.

A few trends, now including data until 2019, are different from last year's report which only included data until 2018 (Gundersen et al., 2019). Skienselva do no longer have a decrease in Ni load (Table 20), Orkla no longer have a decreasing Cd load (table 20), and Vefsna have a significantly decreasing concentration of Cu (Table 21).

3.4.3 A comparison of methods for Hg flux calculations

Within the main monitoring programme, samples for metals are collected four times per year and analysed for Hg using the AAS method. More frequent sampling of the same rivers (one sample per month) is also undertaken specifically for Hg and analysed using the more sensitive CVAFS method (see sections 2.2.1 and 2.2.2 for more details). Results from both methods were extracted from the database for just the dates sampled in the main programme (i.e. four samples per year for both methods). LOQ values in results from the AAS method were linearly adjusted according to the proportion of LOQ values in the dataset (as is usual for the RID/OSPAR workflow; see section 2.3). No adjustment was necessary for the CVAFS dataset, since all values were above LOQ (Table 6). Annual Hg fluxes from both methods were then estimated using the standard OSPAR methodology.

Fluxes determined with the two different methods were in good agreement (Figure 35 and 36). Generally, fluxes are similar for the two methods. Nonetheless, the AAS method underestimates the loads, compared to CVAFS in some cases: for rivers Pasvikelva (13.5 kg Hg with CVAFS method, 5.0 kg Hg with AAS method) and Tanaelva (12.7 kg and 0 kg respectively), while their overestimates the loads in other cases: for rivers Drammenselva (10.7 kg and 32.0 kg respectively) and Skienselva (9.5 kg and 14.6 kg respectively).

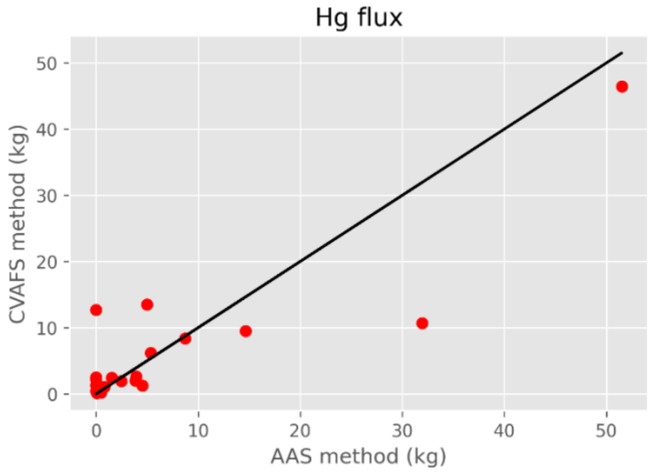

Figure 35: Fluxes of Hg in 16 rivers calculated based on analytical results from the CVAFS method (y-axis) and the AAS method (x-axis). The black line indicates the 1:1 ratio. Note that were no data available for Bjerkrheimselva, Vikedalselva, Nidelva, and Målselva (Figure 36) based on the AAS method due to all measurements being < LOD.

Based on the CVAFS method, the highest loads of Hg in 2019 were found in Glomma (46.4 kg), nearly four times as much as in the other rivers: 13.5 kg in Pasvikelva, 12.7 kg in Tanaelva, 10.7 kg in Drammenselva, and 9.5 kg in Skienselva. This is the first time that loads are calculated and reported for Hg in this cycle of the river monitoring programme.

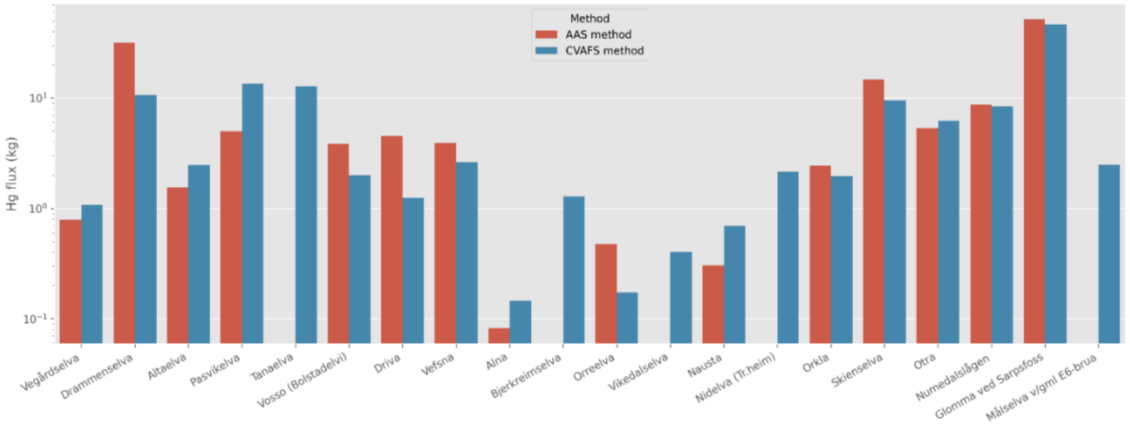

Figure 36: Fluxes of Hg in the main 20 rivers calculated based on analytical results from the CVAFS method (blue bars) and the AAS method (red bars). Note that were no data available for Bjerkrheimselva, Vikedalselva, Nidelva, and Målselva based on the AAS method due to all measurements being < LOD.

3.5 Quality of dissolved organic matter

Dissolved organic matter (DOM) is operationally defined as the fraction of organic carbon that can pass through a filter with 0.45 µm pore size. DOM is considered the most bioavailable and reactive fraction of the OM. The quality of DOM is governed by its source material, hydrological and climatic conditions, in addition to various local transformation processes (Harms et al., 2016; Mutschlecner et al., 2018; Shatilla and Carey, 2019). Light absorption at a certain wavelength can be attributed to specific molecular segments or functional groups in the DOM, and hence several spectral indices have been defined to describe characteristics such as the degree of aromaticity (sUVa) and molecular size (E2_E3) (Peuravuori and Pihlaja, 1997; Weishaar et al., 2003) (Table 22).

Table 22. Overview of the absorbance indices used to describe DOM quality

	Name	Definition	Characteristic
sUVa	Specific UV absorbance	(Abs 254nm / DOC[2])*100	Aromaticity (positive relationship)
E2_E3		250 nm /365nm	Aromaticity (negative relationship) Molecular size (negative relationship)

For this analysis, seasonal and regional patterns in DOM quantity (TOC) and quality (sUVa and E2_E3) have been investigated, in accordance with the two preceding years. The rivers have been grouped geographically according to the four major drainage basins in Norway (Barents Sea, Norwegian Sea, North Sea, and Skagerrak). The results for the main rivers will be discussed separately from the additional rivers since the analyses have been conducted by two different laboratories (NIVA lab and Vestfold lab).

3.5.1 Main Rivers

Seasonal variation

For Norway as a whole, the mean seasonal TOC concentration showed a steady increase from winter through summer, a drop in august followed by a continued increase during autumn (Figure 36). This reflects the typical seasonal events of increased production and transport of OM to the river during

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[2] TOC has been used instead of the DOC (< 0.45 µm) due to more extensive data availability.

spring warming with snow melt. The drop in TOC concentration in august was likely caused by a combination of high biological uptake and low precipitation that reduced transport of new OM. During autumn, intensive rainfall ensured increased transport of TOC from the forest floors to the rivers. Relatively large differences were apparent in the regional averages, likely reflecting differences in climatic and hydrological conditions (Harms et al., 2016; Mutschlecner et al., 2018). For example, in spring, a peak in TOC concentration can typically be associated with increased transport to the river with snow melt. While this peak appeared already in April for the rivers draining to Skagerrak, the effect from snow melt was not evident in the rivers draining to the Barents Sea until June.

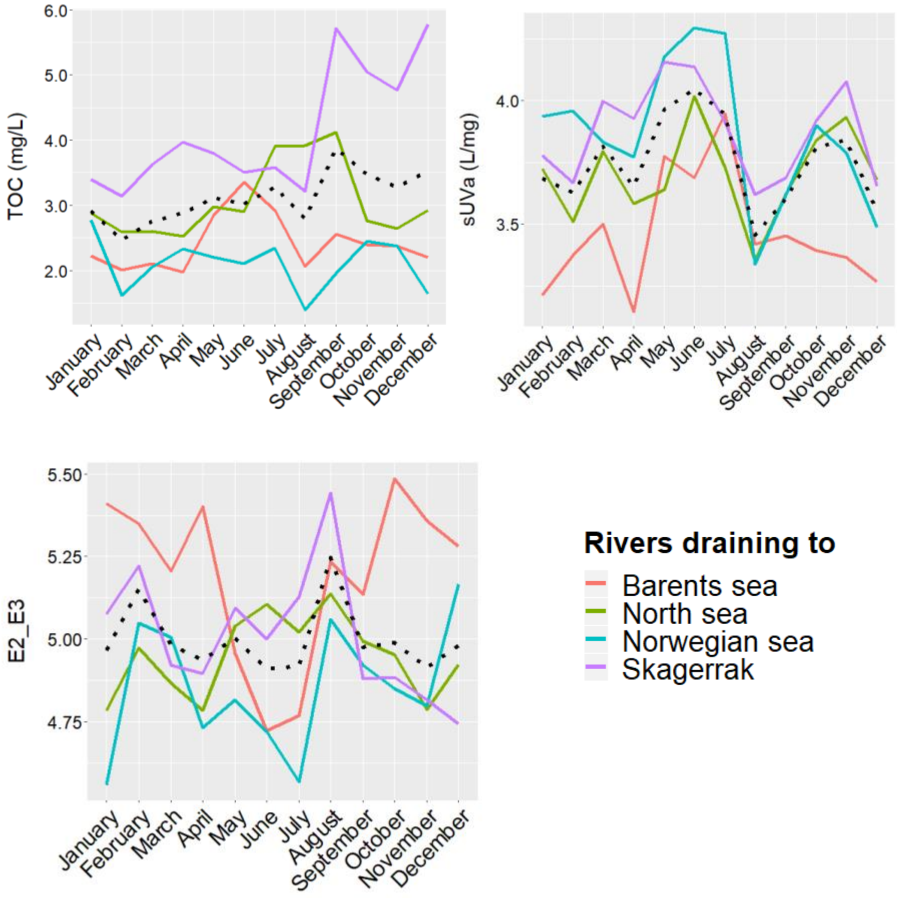

Figure 36: Monthly average values of TOC concentration, aromaticity (sUVa), and molecular size (E2_E3) for rivers in the four regions Barents Sea (red, n = 4), North Sea (green, n = 5), Norwegian Sea (blue, n = 4), and Skagerrak (purple, n = 7). The black dashed line shows monthly averages for all rivers (n = 20).

Interestingly, the regional averages appeared more uniform when looking at sUVa, except for the Barents Sea (Figure 36). During the summer months, the sUVa was overall higher than the rest of the year reflecting higher aromaticity before dropping in august at the same time as the TOC concentration dropped. This may be due to the production of new OM during summer, displaying a wide range in DOM qualitative parameters before transformation processes such as photodegradation.

The E2_E3 index shows contrasted seasonal variations in the south and in the north reflecting changes in molecular size (Figure 36). For the rivers draining to the Barents Sea and Norwegian sea the molecular size increased during summer, while it was the opposite for rivers draining to Skagerrak and the North Sea. The DOM in the rivers draining to the Barents Sea had the lowest molecular size at the beginning of the year and showed the largest relative increase during summer. The reason for these findings in DOM molecular size is not known.

A comparison of TOC concentrations, sUVa, and E2_E3 for the last three years revealed that the inter-river variation is the largest source of variability (Figure 37). However, the summer months in 2018 (June-Aug) display a distinct pattern with low TOC, low sUVa and high E2_E3 which could have been related to the unnormal warm and dry summer as hypothesized by Gundersen et al. (2019). Interestingly, August 2019, which was also drier and warmer than normal, show similar characteristics.

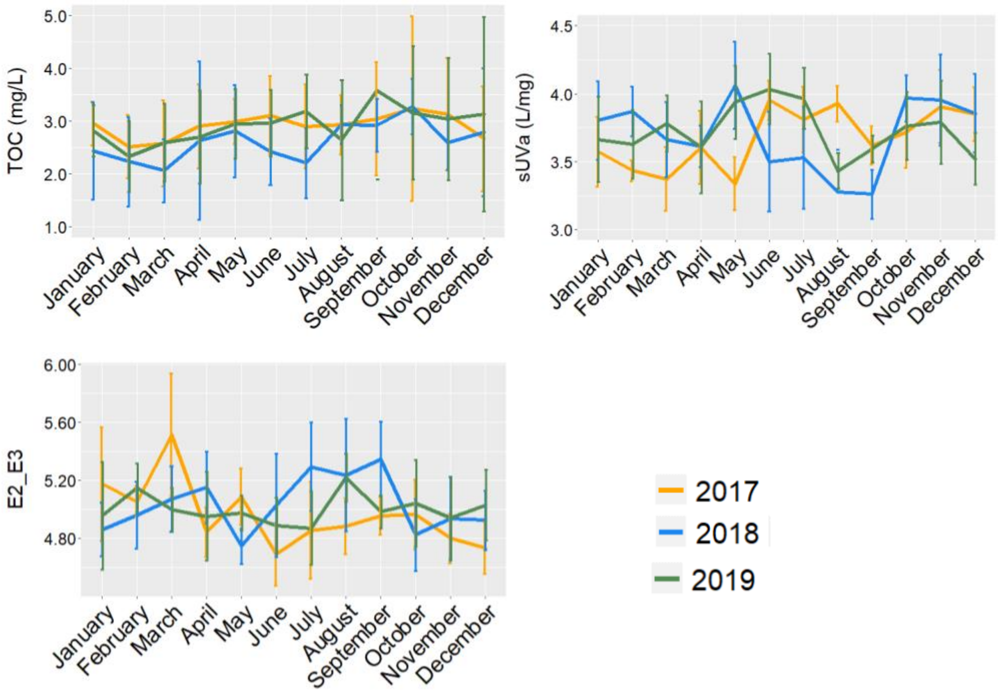

Figure 37: Monthly averages values of TOC concentration, aromaticity (sUVa), and molecular size (E2_E3) for 2017 (orange), 2018 (blue), and 2019 (green) for all 20 rivers in the monitoring programme. Error bars illustrate the variability in the data (± stdev).

Regional variation

Using monthly averages, the relationships between i) TOC concentration and water discharge, ii) DOM aromaticity (sUVa) and TOC concentration, and iii) DOM molecular size (E2_E3) and TOC concentration are explored (Figure 38). Note that Alna and Orreelva have been excluded from this analysis for being atypical of their regions (high particle load from human influence). Regional patterns in the quantity and quality of DOM were similar to the findings from 2018 (Gundersen et al., 2019). The DOM in the rivers draining to the North Sea (green) was most different from the other regions, being low in TOC despite a high water discharge, and relatively high in DOM aromaticity (sUVa) and molecular size (E2_E3). The Skagerrak region rivers were highest in TOC with a moderate water discharge, and the DOM was of comparable high aromaticity and molecular size to the rivers draining to the North Sea. The rivers draining to the Barents Sea were characterized by intermediate TOC levels and low water discharge, and the DOM was of the lowest aromaticity and molecular size. The Norwegian Sea rivers were intermediate for all parameters. These regional patterns are likely a reflection of differences in climate, hydrology, and other terrestrial conditions. To be able to explain these findings in more detail, the data should be analysed in combination with data on land use, climate, and other catchment characteristics.

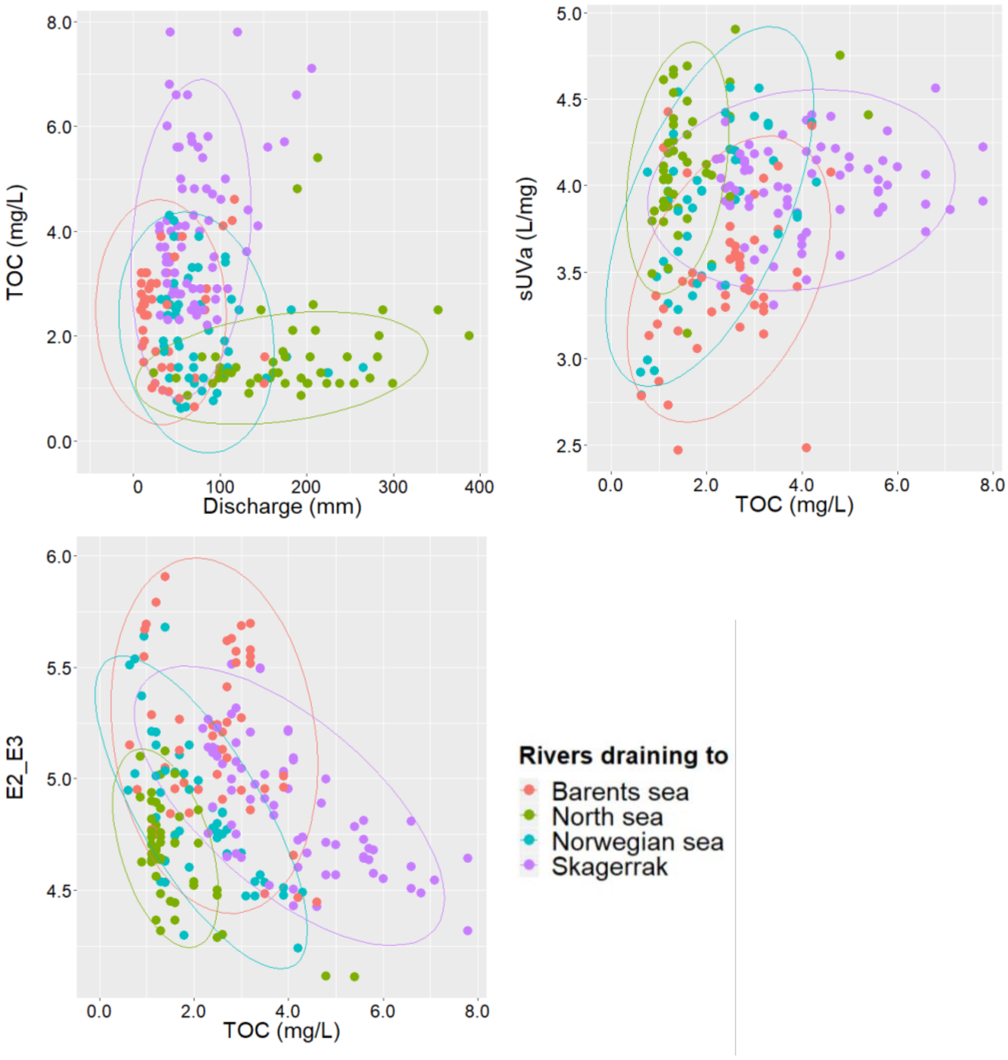

Figure 38: Relation between monthly TOC concentration and discharge (top left), aromaticity (sUVA) and TOC concentration (top right), and molecular size (E2_E3) and TOC concentration (bottom left) for rivers draining to the Barents Sea (red, n = 4), the North Sea (green, n = 4), the Norwegian Sea (blue, n = 4), and Skagerrak (purple, n = 6). Note that Rivers Alna (Skagerrak) and Orreelva (North Sea) have been excluded from the figures.

3.5.2 Additional Rivers

The six additional rivers included from the National monitoring program for limed rivers are divided into their representative drainage regions of Skagerrak (n=3) and the North Sea (n=3) for the evaluation of TOC concentrations, DOM aromaticity (sUVa) and molecular size (E2_E3) (Figure 39).

Seasonally, the rivers draining into both seas showed two peaks in TOC concentrations that corresponded to spring snow melt and autumn intensive rain. For the south-eastern region of Skagerrak, the onset of the spring peak was earlier than for the western North Sea region. The aromaticity of the DOM (sUVa) in the rivers from both regions were at its lowest during the spring and summer months. This contrasted with the findings from the main rivers of the monitoring programme (Figure 37). The reason for this is not known, but it may reflect local differences in climate and/or catchment characteristics. The DOM molecular size in the rivers draining to the North Sea appeared to have been very low during the beginning of the year. However, the high values are partly believed to result from high uncertainty in the data due to the low TOC concentrations.

The regional relationships between TOC concentration and DOM aromaticity, and between TOC concentration and DOM molecular size reported for these additional rivers appeared to be similar to those of the main monitoring programme. TOC concentrations in the North Sea rivers was lower than in the Skagerrak region rivers , but comparable DOM aromaticity and molecular size were reported in rivers from both regions.

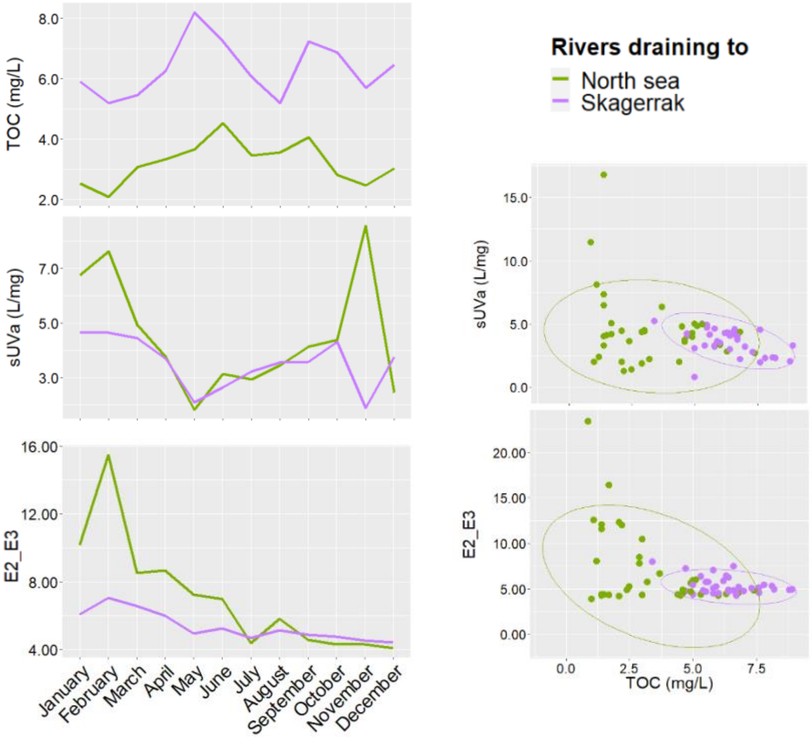

Figure 39: For the additional rivers draining to the regions of the North Sea (green, n = 3) and Skagerrak (purple, n=3), left panel: Monthly regional averages of TOC concentration, aromaticity (sUVa), and molecular size (E2_E3), and right panel: relation between monthly averages of aromaticity (sUVa) and TOC concentration, and molecular size (E2_E3) and TOC concentration.

3.6 Modelling of contaminants in the Alna river

3.6.1 Calibration results

Calibration of the hydrological model
The hydrological model PERSiST was calibrated on a time interval from 2006 to mid-2015. Later dates were excluded from the calibration due to an irregular flooding event in September 2015, when there was high uncertainty in the flow measurements as the river had a change in its regulation pattern. The hydrological model was calibrated against this discharge data using a combination of manual and automatic calibration with Python's LMFIT package. The calibration achieved a Nash-Sutcliffe coefficient of 0.53, which is a relatively good fit when considering that Alna is largely an urban catchment with complex subsurface drainage systems that are hard to simulate with a catchment model. Results of the calibration are displayed in Figure 40.

Calibration of INCA-Sed and INCA-Tox-C
INCA-Sed was calibrated against suspended particulate matter data collected in the Alna river by the River Monitoring Programme from 2012 until 2018. It was manually calibrated because the autocalibration had trouble to obtain stable levels of riverbed sediments with no trends over time. The calibration obtained a Nash-Sutcliffe coefficient of 0.24, and the results are displayed in Figure 41.

INCA-Tox-C was calibrated so that simulated DOC levels in the river matched measured DOC data from the River Monitoring Programme as close as possible. Since the DOC data was patchy, we also used TOC data (measured TOC and DOC were similar at dates when both were available). It is not critical to get an exact match of the model to the data since the contaminant module only relies on the general level being correct (Figure 42).

The soil assumed to contain about 20 kg of soil organic carbon (SOC) per m^2. This corresponds to a SOC content of about 4%. The final contaminant results were not too sensitive to this value unless it was changed by more than an order of magnitude, and so it is likely to be reliable. It was assumed that the proportion of SOC that engages in fast exchange with the soil water and air is 5% of the total, while the rest is a more slow-responding buffer.

Calibration of the main contaminant module in INCA-Tox
Data for contaminant concentrations in the river comprised both the dissolved and particulate phase. Dissolved contaminants were collected by passive samplers that were deployed in the river for about three months. Hence, each measurement corresponds to an average for the actual time span.

The selected contaminants all have high octanol-water partitioning coefficients, which mean that they are highly hydrophobic and have a large affinity to organic matter. Hence, most of the contaminants in the soil will be associated with SOC. This means that the modelled concentration of contaminants in SOC will govern the dissolved concentration in soil water, which again is the main driver for the river dissolved concentrations. The hydrologic residence time for Alna river is too short for the exchange between the river and atmosphere to have a large impact. This means that contaminant concentrations in the river are sensitive to contaminant concentrations in the SOC, highlighting the importance to work with realistic contaminant concentrations in the SOC.

By choosing initial concentrations in SOC within the ranges given by data from forested areas around Oslo (Table 12), we obtained some river dissolved contaminant concentrations that matched the general magnitude of observed data. However, the computed deposition of contaminants was not sufficient to sustain the level in the soil, even when dry deposition velocities were assumed to be the maximal theoretical value. We thus had to add in a superficial deposition of contaminants that was 10-100 times larger than the computed deposition from NILU's station at Birkenes (in Agder county) in order to sustain the levels in the soil. Dedicated measurements of atmospheric deposition from the Oslo urban area would have substantially constrained this uncertainty.

Monitoring of PCBs and PAHs concentrations in Norway is routinely performed at remote stations. In this case, the closest station was Birkenes in the extreme south of Norway. We would expect atmospheric concentrations of PCBs and PAHs in proximity to a large city like Oslo to be considerably larger than at a more remote station like Birkenes. Previous studies have shown PCB and PAH levels being 10-100 times higher in proximity of cities compared to rural sites (Liu et al., 2014; Menichini et al., 2007). In support to this explanation, we compared data of Benzo-a-Pyrene monitored in Oslo (through a programme run by Oslo municipality) with the levels at Birkenes, and the urban levels were typically 10-20 times higher.

Calibrating contaminant concentrations in suspended particulate matter turned out to be difficult because the measured concentrations are about 1000 times lower than what they would be if they were in equilibrium with the aqueous concentrations (based on the water-SOC partitioning coefficient, and assuming a carbon content of the suspended matter of 1%). Given that particle-bound contaminants account for less than 1% of the total contaminant transport in the river, getting these numbers right does not have a significant impact on the total fluxes.

The calibration results for PCB-101, PCB-153, Phenanthrene, Fluoranthene, and Benzo-a-Pyrene are showed in Figure 43 to Figure 47 on the next pages. The figures show that simulated concentrations were in the same range as the observed values.

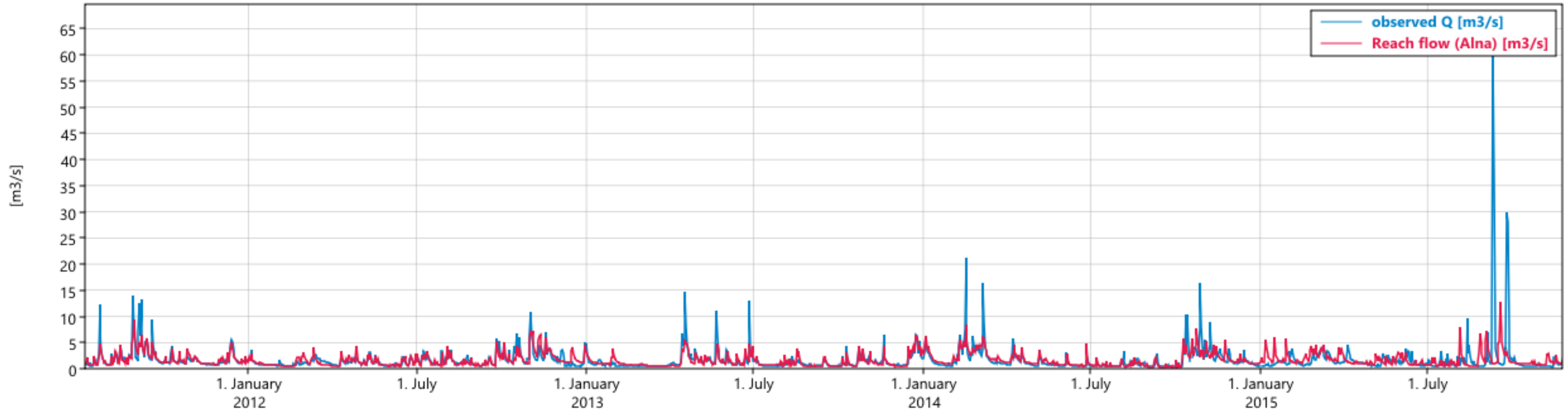

Figure 40. Modelled vs. observed river flow

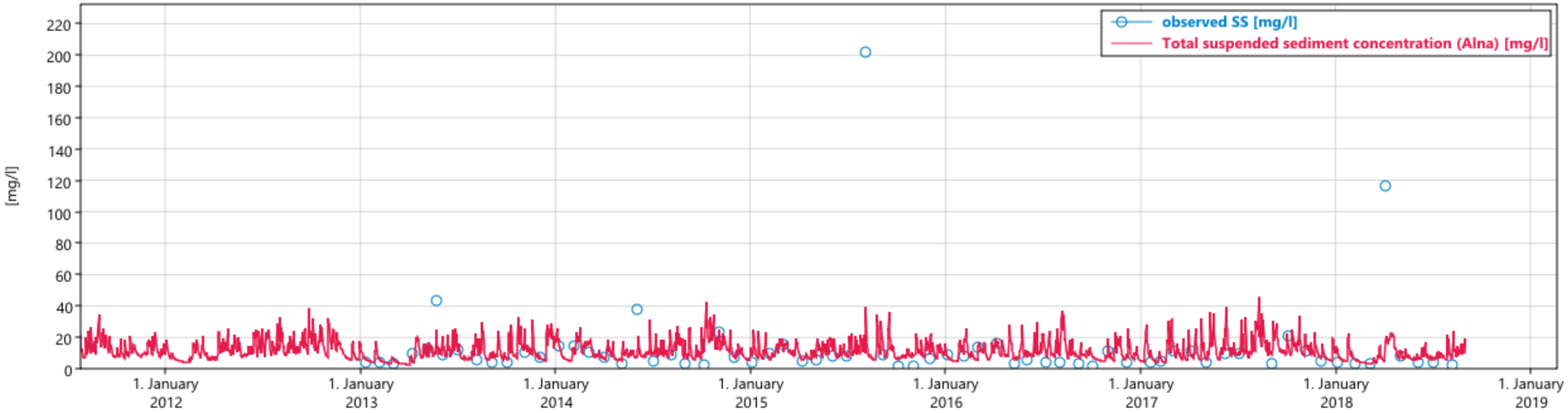

Figure 41. Modelled vs. observed suspended solids (SS)

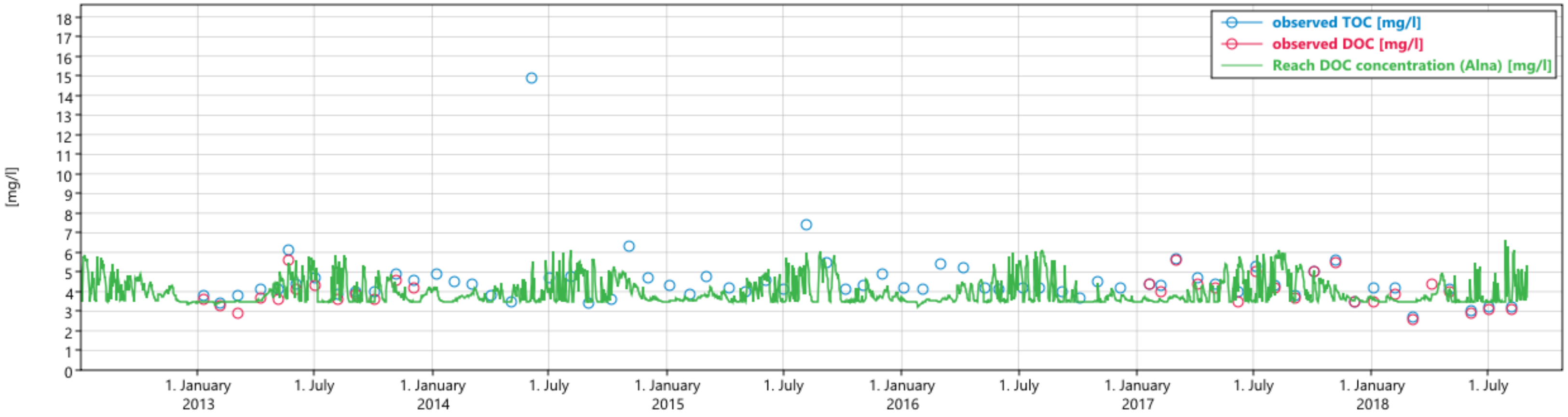

Figure 42. Modelled vs. observed dissolved organic carbon (DOC).

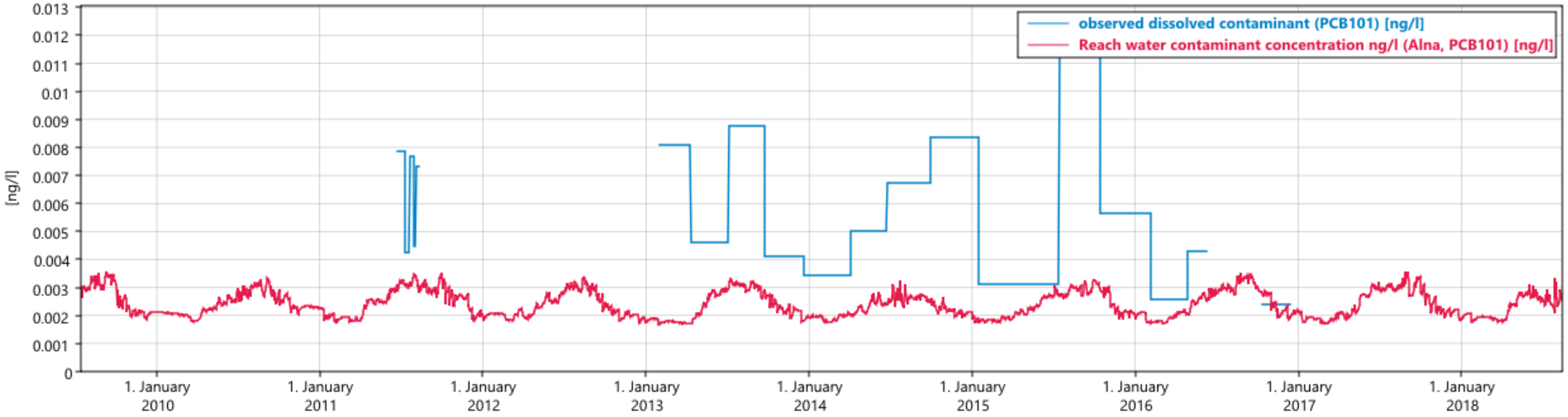

Figure 43. Modelled vs. observed PCB-101. Note that data displayed in 2011 are not from different points in time, but from 4 different locations in the river.

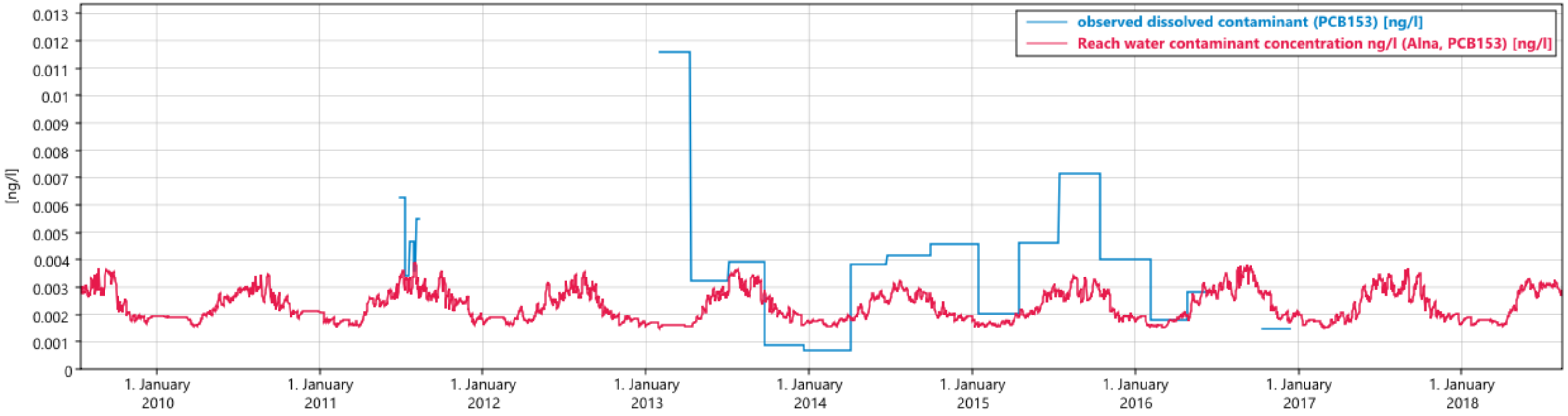

Figure 44. Modelled vs. observed PCB-153. Note that data displayed in 2011 are not from different points in time, but from 4 different locations in the river.

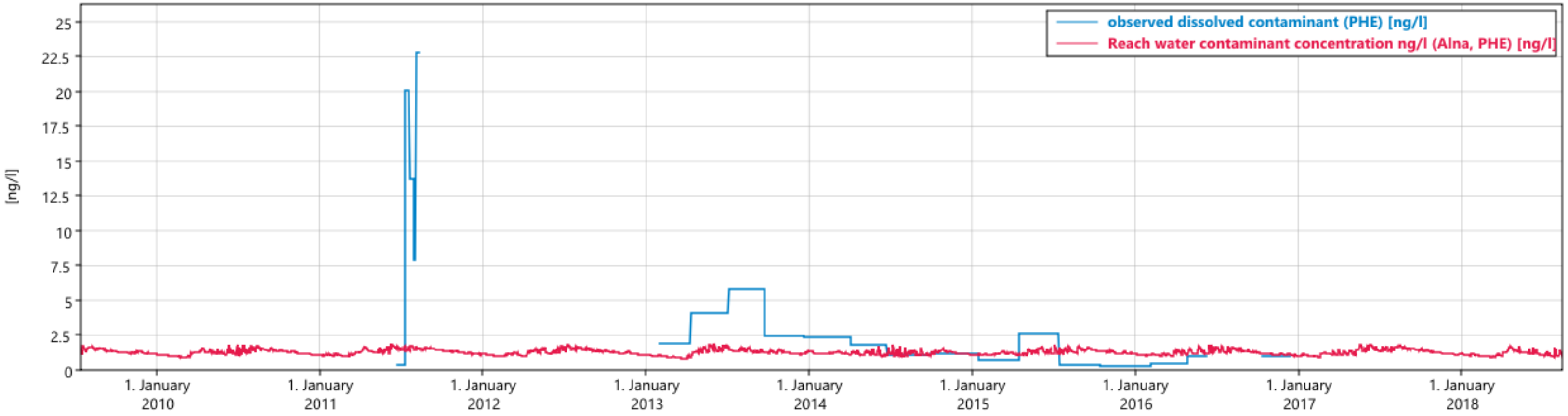

Figure 45. Modelled vs. observed Phenanthrene. Note that data displayed in 2011 are not from different points in time, but from 4 different locations in the river.

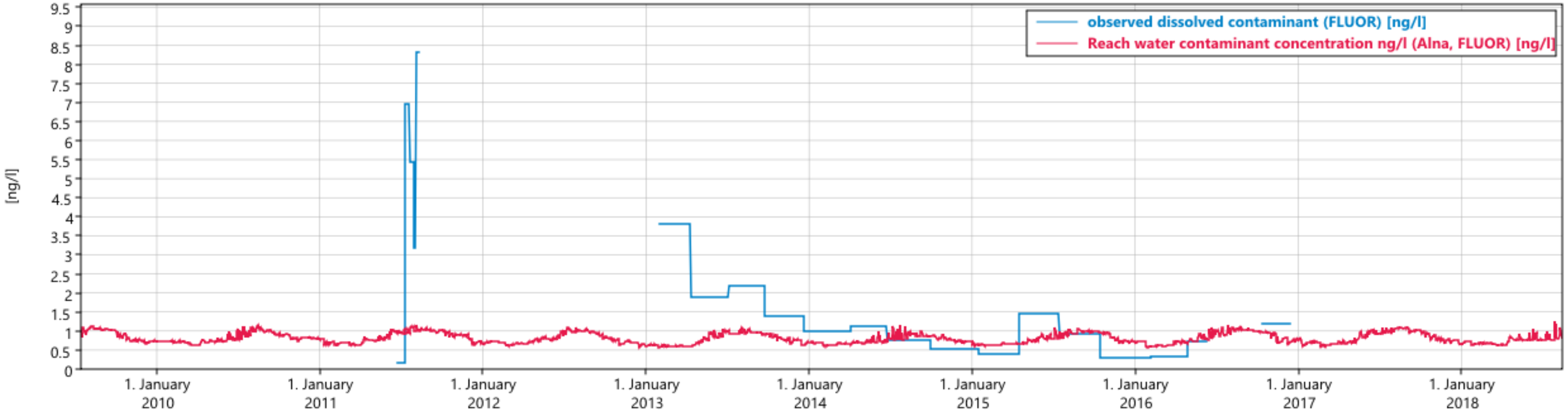

Figure 46. Modelled vs. observed Fluoranthene. Note that data displayed in 2011 are not from different points in time, but from 4 different locations in the river.

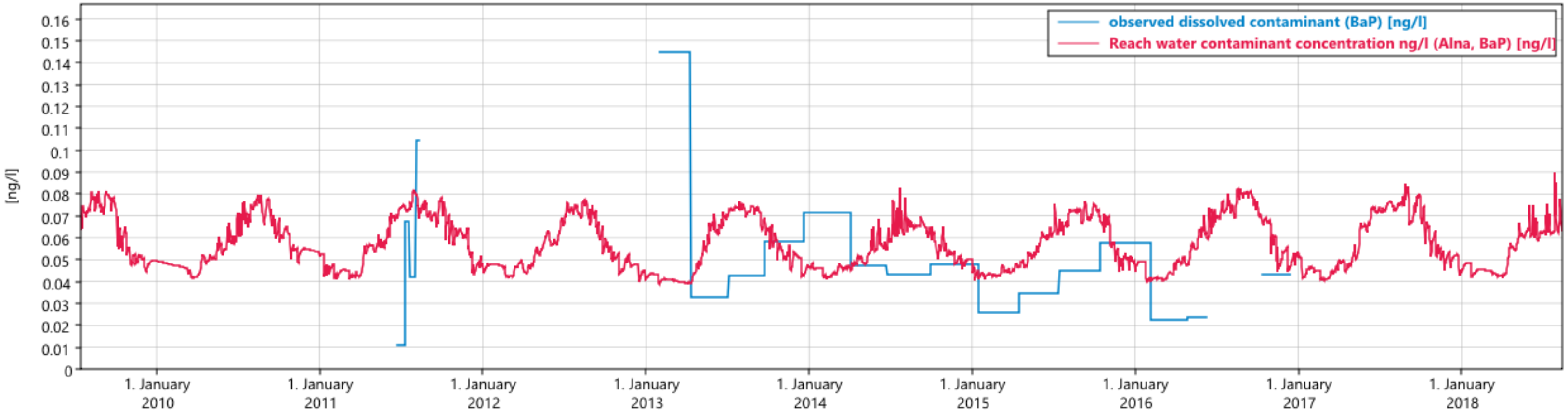

Figure 47. Modelled vs. observed Benzo-a-Pyrene. Note that data displayed in 2011 are not from different points in time, but from 4 different locations in the river.

3.6.2 Discussion of climate drivers affecting contaminant transport

Model sensitivity to climate-dependent biogeochemical parameters

An earlier application of the original INCA-Contaminant model provides useful insights on the expected influence of climate on mobilization of hydrophobic contaminants in boreal catchments (Nizzetto et al., 2016). The key premise to introduce this analysis is that climate drivers (i.e. mainly changes in mean temperature and precipitation patterns) not only have a direct effect on temperature-controlled contaminant partitioning and on the water-driven contaminant runoff, but it also affects turnover of organic matter in soils. This organic matter is the main pool of PCBs and PAHs in the catchment, and even a small change in the size of this capacitor may result in substantial changes in mobilisation and fluxes of contaminants in the catchment.

Nizzetto et al. (2016) analysed model output sensitivity to a number of hydro-biogeochemical parameters at Sandvikselva (Bærum municipality) which has similar characteristics as Alna. Model outputs were particularly sensitive to climate-dependent biogeochemical parameters. Rate coefficients for SOC production and consumption were very influential parameters with the mineralization rate of SOC being the most sensitive. Also, the rate of DOC production from SOC also ranked among the most influential parameters. Hydrologic time constants and temperature-related parameters all influenced model performance significantly. As expected, model outputs were also highly sensitive to varying K_{ow} value for compounds with LogK_{ow} > 6.2, suggesting that climate influences on contaminant outflow will be more pronounced for more hydrophobic substances such as PCB 153 or benzo-a-pyrene. The results highlight the need for credible hydro-chemical simulations when modelling the fate and transport of environmental contaminants that may be bound to SOC and suspended sediments.

Simulation of future climate influence on contaminant fate

Climate influence on the long-term fate of PCB101 has previously been evaluated using INCA-Contaminants on a boreal forest sub-catchment (70 km^2) in Sandvikselva, close to Oslo and with largely the same contaminant exposure as the Alna river (Nizzetto et al., 2016). As the soil OM hosts most of the PCBs and PAHs in the catchment, and considering the sensitivities elucidated in the previous section, the assessment of climate controls over contaminant fate and transport is performed considering the forested part of the catchment. Contaminants inputs in the urban part of the catchment will be instead prevalently sensitive to anthropogenic drivers, such as changes in technology, chemical management and pollution control. Simulations were carried out for the period 2006-2050 considering two climate scenarios: Scenario 1 "as-today" which considers future climate consistent with present conditions and Scenario 2 "RCP8.5" which projects a mean temperature increase of 2.5°C and total rainfall increasing with 20% by 2050 (IPCC 2013).

The simulation suggests that this typical boreal forested catchment is currently in a transitory phase in which yearly integrated re-emission of PCB to the atmosphere and to surface waters will exceed the total atmospheric inputs during the next decade. In other words, the system will shift from acting as a net sink of atmospheric PCBs to becoming a net source for air and water environments. Riverine discharge is the major contribution to the total physical output of contaminants, representing over 95% of the total PCB 101 re-emission from the catchment during the current decade. This output is predicted to decline by one order of magnitude by 2050 while net volatilization will still be in the same range as that calculated for the present time period. Climate change is projected to have very little influence on this trend which is largely governed by the steady decline in atmospheric concentrations of PCBs observed during the last two decades in boreal environments (Schuster et al., 2010).

These results support the rising importance of environmental reservoirs such as boreal soils as secondary atmospheric sources of POPs in a regime with declining atmospheric concentrations and are central for understanding future distribution of POPs and effectiveness of international regulation on these contaminants (Nizzetto et al., 2010).

3.7 High-frequency monitoring in Rivers Storelva and Målselva

Rivers Storelva and Målselva are selected for more detailed studies on the effects of climate variability and climate change on rivers. To study short-term effects of climate variability on water chemistry, sensors that measure water temperature, pH, conductivity, turbidity and FDOM are deployed in both rivers. The sensor stations are located at the same location as the manual sampling stations, and the data is collected on an hourly basis.

3.7.1 River Storelva

Water flow

The flow dynamics in River Storelva are characterized by rapid responses to precipitation events with a relatively quick return to the baseline level after the flood peak. There is no distinct seasonal pattern, and flood events can occur in all seasons, also during winter. In 2019, there was an early snowmelt flood lasting from the second week of February until the end of March (Figure 48). This is supported by data from the met.no station Nelaug (lat: 58.6582, lon: 8.63) where snow started to accumulate in late January and reached a maximum of 100 cm in mid-February, whereafter it largely melted away during the last part of February. There were smaller rainwater floods before and after summer, and much shorter period with summer low-flow than in 2019. From late September there were four distinct rainfall floods, with the largest reaching 115 m^3/s in late November.

Water temperature

The water temperature in 2019 exceeded 10^{o}C on April 20th, which was nearly 3 weeks earlier than in 2018 (Figure 48). On the other hand, the period with water temperatures above 20^{o}C was much shorter than in 2018, lasting from late June until early August. The temperature fell below 10^{o}C on October 8th, which was nearly three weeks earlier than in 2017 and 2018.

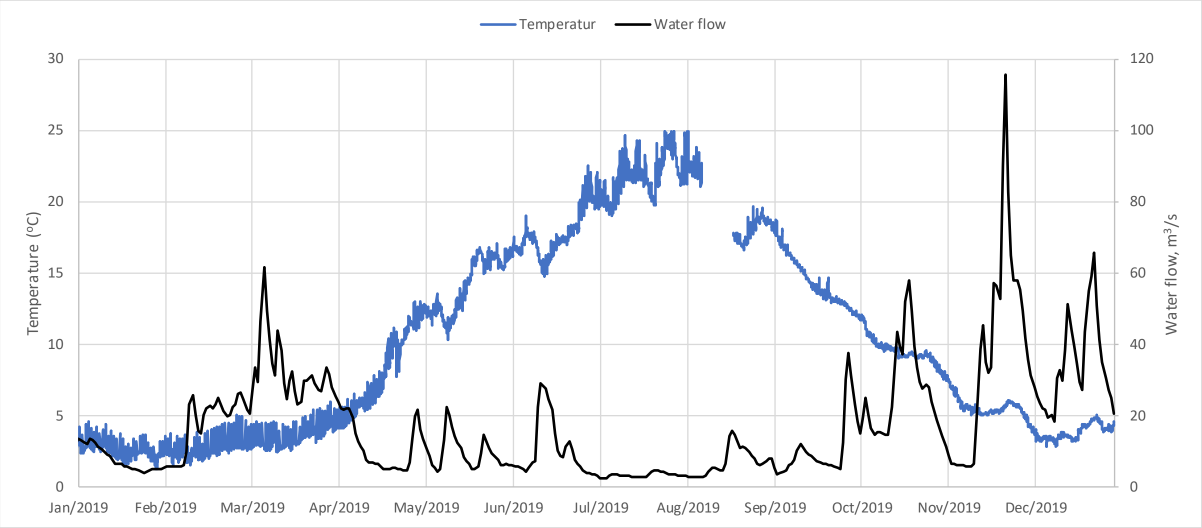

Figure 48. Water temperature and water flow at the outlet of River Storelva in 2019. The water flow data are from NVE's station 18.4.0. Lundevann.

pH

River Storelva has been heavily affected by acidification due to long-range transported air pollution and since the 1990s the river has been limed to protect the salmon and sea trout populations from toxic waters. The target pH value for the liming varies throughout the year and is highest (6.4) during the smolt migration period in the spring (usually set to the period from April 1st to June 15th). In other parts of the year the pH should be kept above 6.0. The continuous pH monitoring in 2019 shows that the pH was kept above 6.0 most of the time and that there was relatively good accordance between the sensor data and pH measured in grab samples (Figure 49). Since the lime addition is automatically regulated by water flow and pH downstream the lime dozer, pH values in the river rarely drop significantly during flood events. However, smaller pH drops were measured during the flood peak in early March (pH 6.0) and in late September (pH 6.2).

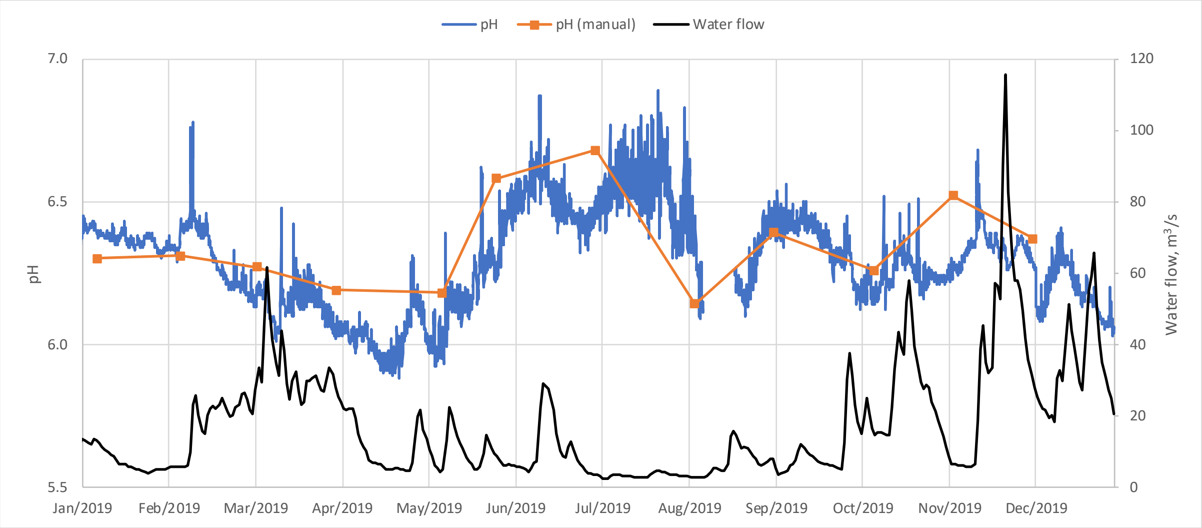

Figure 49. pH and water flow at the outlet of River Storelva in 2019. The water flow data are from NVE.

Conductivity

The conductivity, which is a measure of the ionic concentration in water, was relatively stable throughout the year with values around 3-6 mS/m (Figure 50). The conductivity shows different responses to flood dynamics during the year. At the very start of the snowmelt flood early February, the conductivity peaked to the year's highest level at 8 mS/m. This phenomenon is seen in other studies with high-frequency monitoring and is explained by elution of ions from the seasonal snowpack and sub-surface lateral flow in an early stage of the melting process. As the snowmelt proceeds the runoff is diluted by low-ionic water from the remaining snowpack. During most rainfall floods later in the year, conductivity peaked right before or simultaneously with the flood peak. One exception was the large flood in November, which led to ionic dilution and falling conductivity.

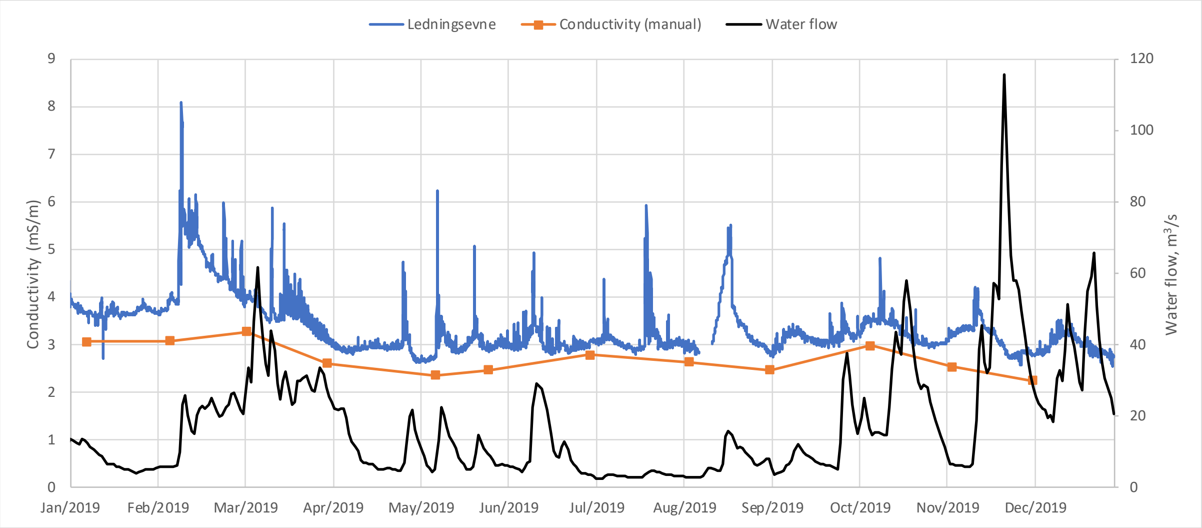

Figure 50. Conductivity and water flow at the outlet of River Storelva in 2019. The water flow data are from NVE.

Turbidity

Turbidity is related to suspended particulate matter that affect the clarity of water. In River Storelva, with clay soils in the lower parts of the catchment, the turbidity increases quickly during flood episodes (Figure 51). In 2019, this was especially the case in May, June and in the early autumn. Later in the autumn, floods did not seem to mobilise particles to such an extent and in some cases (as in mid-October) particle concentrations decreased during a flood event. Also, during the snowmelt flood in February and March turbidity in the river was relatively low, suggesting that soil particles are largely protected from erosion under the melting snow. As in 2018, the turbidity was relatively high during the low-flow period in summer. It can be related to increased concentrations of phytoplankton in the upstream Lake Lundevann, or possibly resuspension of bottom sediments close to the sensor station at low lake water levels. The sensor data were in most instances higher than turbidity values measured in grab samples. One reason is that monthly grab samples tend to miss flood events and usually underestimate the total particle load throughout the year.

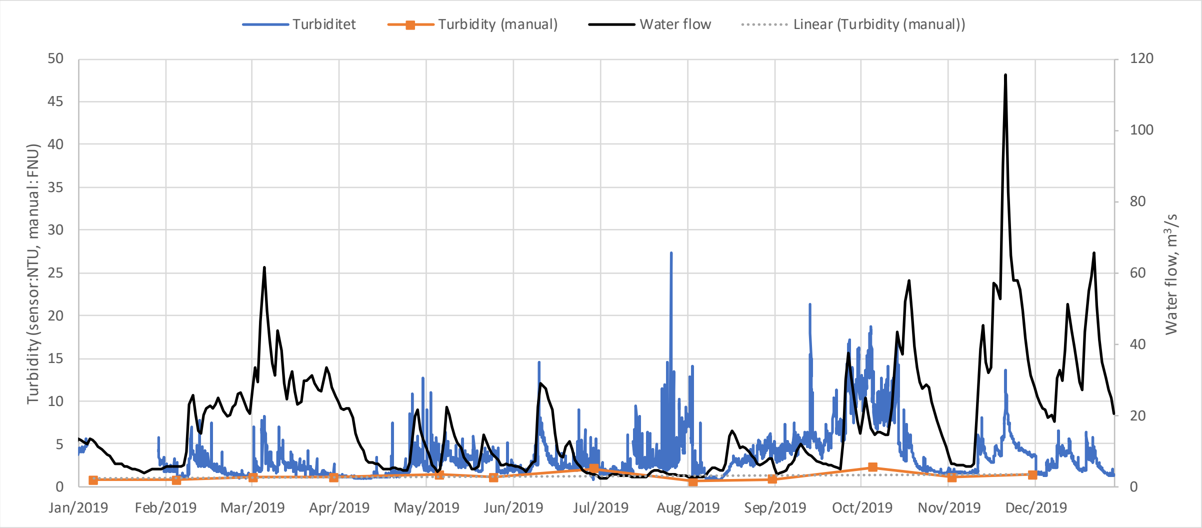

Figure 51. Turbidity and water flow at the outlet of Storelva in 2019. The water flow data are from NVE.

fDOM

Fluorescent dissolved organic matter (the fraction of CDOM that fluoresces) can be used as proxy for dissolved organic carbon (DOC) in water. As can be seen in Figure 52, DOC measured in grab samples largely follows the seasonal pattern emerging from the high-frequency data. In general, fDOM in River Storelva follow a seasonal pattern with the highest concentrations during the autumn and winter period and declining concentrations throughout the summer period. The largest fDOM peaks in 2019 were recorded during a small flood in June and during the first flood after summer. The post-summer fDOM peak was almost identical to the pattern in 2018, when concentrations suddenly increased from 30-40 to 70-80 quinine sulphate units (QSU) as a response to the increased water flow.

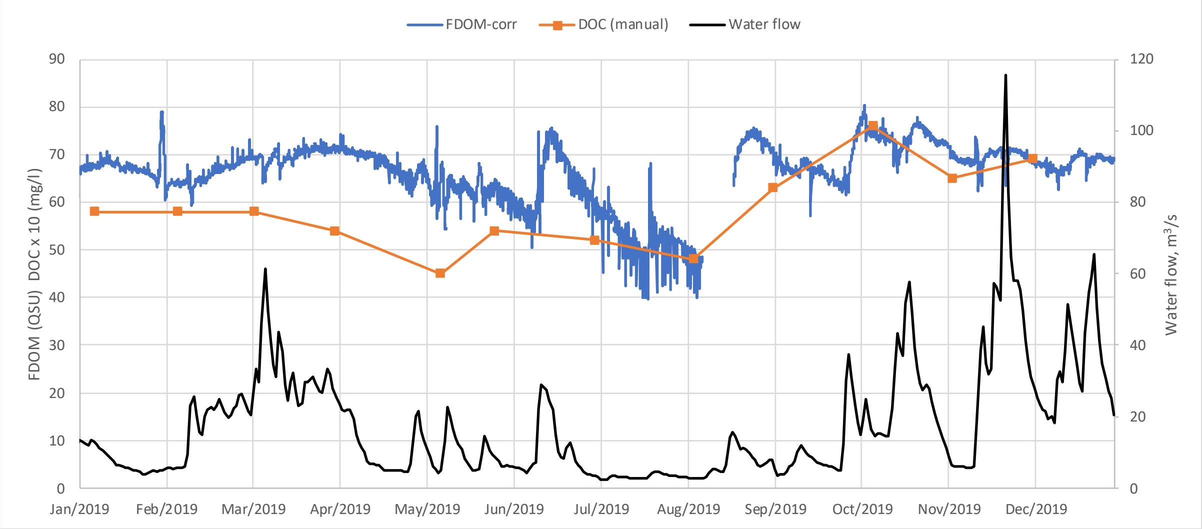

Figure 52. fDOM and water flow at the outlet of Storelva in 2019. The water flow data are from NVE.

3.7.2 River Målselva

Water flow

The flow pattern in River Målselva is dominated by strong seasonal signals (Figure 53). During winter, practically all precipitation accumulates as snow and the small water discharges are mainly supplied by groundwater. The highest water discharges are usually associated with snowmelt, first in the lower parts of the catchment and later in the upper, mountainous parts. In 2019, there was a small flood in February, whereas the major snowmelt flood lasted from late April until the maximum flow level (nearly 500 m^3/s) was reached in the beginning of July. After that time the water flow decreased gradually, without any significant flood peaks, during rest of the year.

Water temperature

The water temperature was around zero during all the wither months from late November to end of April (Figure 53). The water temperature crossed the 10°C limit on July 8th and reached a maximum of 16°C on July 28th. After that, the temperature fell below 10°C on September 6th.

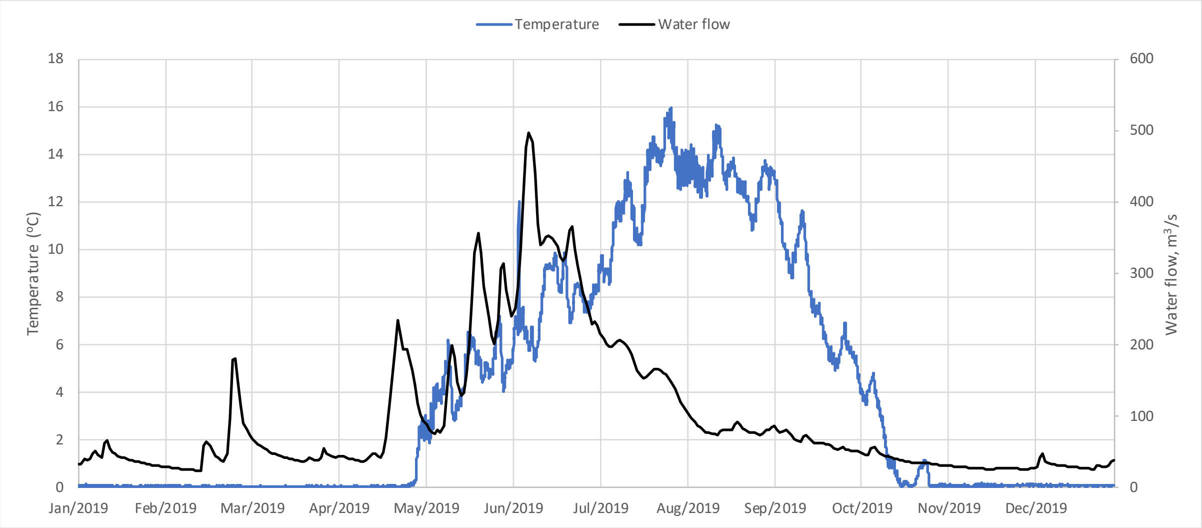

Figure 53. Water temperature and water flow at the outlet of River Målselva in 2019. The water flow data are from NVE's station 196.35.0 Målselvfossen.

pH

River Målselva is well-buffered and little affected by long-range transported air pollution. The pH-values are relatively stable around 7.5 with small seasonal variations (Figure 54). River ice can cause challenges with maintaining the calibration routines during the cold season, and in 2019 this led to large gaps in the time series. As can be seen from the manual samples, the pH values were relatively stable around 7.5, except at one occasion in August when pH was 7.1.

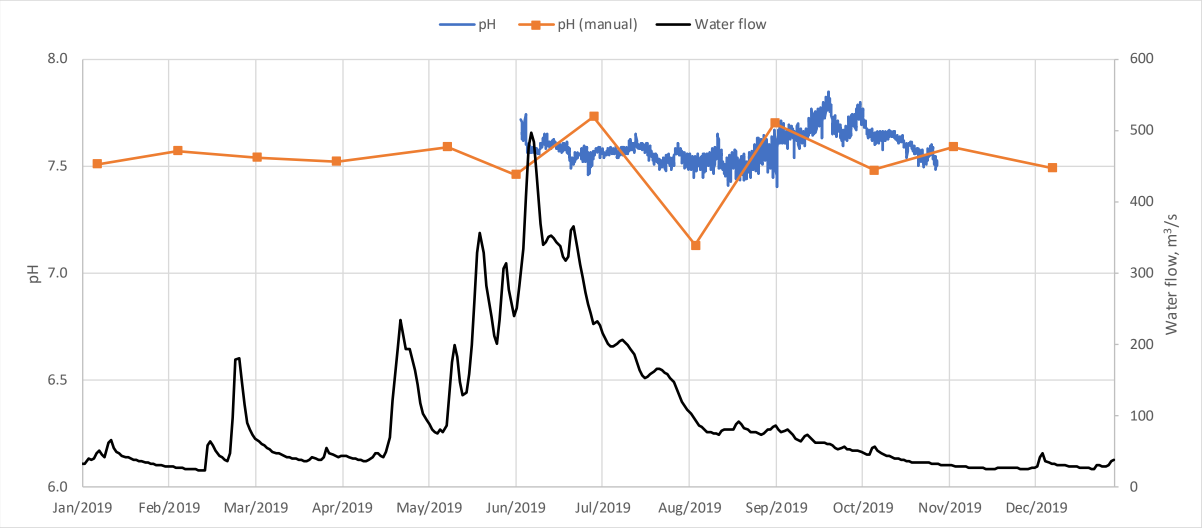

Figure 54. pH and water flow at the outlet of River Målselva in 2019. The water flow data are from NVE.

Conductivity

The conductivity in River Målselva usually shows a weak seasonal signal with the lowest values (around 4-5 mS/m) during winter and spring (Figure 55). In 2019, values during spring were a bit higher than in 2018, possible due to somewhat higher water flow in late winter/early spring compared to the previous year. During the snowmelt period, peaks in water flow was accompanied by drops in conductivity due to dilution by meltwater with low ionic strength. Ionic dilution is less common during rainfall floods when high-flow events can promote erosion and increased solute concentrations in water. There was generally good accordance between the sensor data and conductivity measured in grab samples.

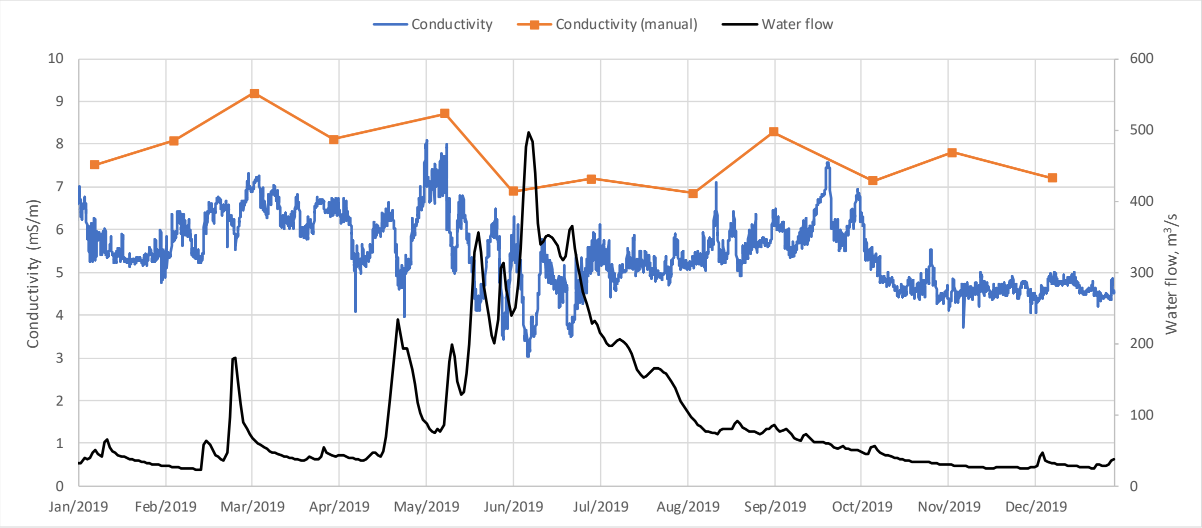

Figure 55. Conductivity and water flow at the outlet of River Målselva in 2019. The water flow data are from NVE.

Turbidity

As the lower parts of the river are relatively flat with several meander bends, sediment is easily resuspended during high-flow events. Flood peaks are therefore usually accompanied by significant turbidity peaks in this river. In 2019, turbidity values showed a strong response to flood peaks in the high-flow period in May and June (Figure 56). Values were especially high (<300 NTU) during the major flood peak that occurred in early July. None of the turbidity peaks were captured by the manual sampling, which demonstrates that monthly sampling often misses short-term episodes in rivers. The remaining parts of the year were characterised by low turbidity, mostly values below 5 NTU.

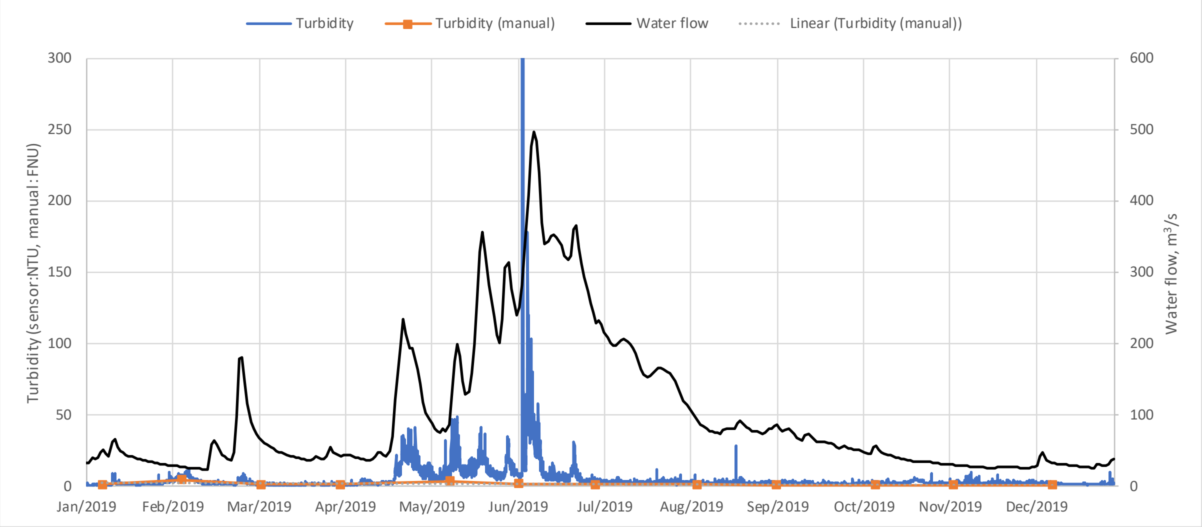

Figure 56. Turbidity and water flow at the outlet of Målselva in 2019. The water flow data are from NVE.

fDOM

The fluorescent dissolved organic matter (fDOM) signal is also closely connected to water flow in River Målselva (Figure 57). Even the small flood in late February resulted in a distinct fDOM peak. The same pattern occurred during the floods in late April and May, but interestingly, the largest flood peak in early July was not accompanied by a corresponding peak in fDOM. This might be explained by snowmelt and delivery of low-DOC water from the upper, mountainous parts of the catchment.

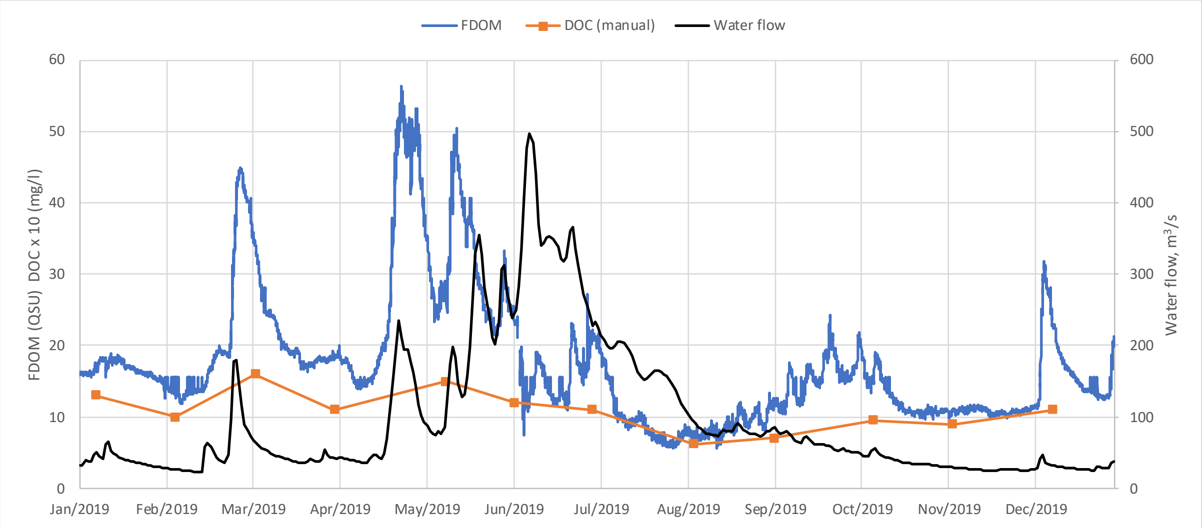

Figure 57. FDOM and water flow at the outlet of Målselva in 2019. The water flow data are from NVE.

4. Conclusion

Monitoring for various chemical, physical, and hydrological parameters in 20 rivers distributed along the Norwegian coastline was undertaken in 2019 as part of the Norwegian River Monitoring Programme. 2019 was a relatively warm and wet year, with air temperatures 1.2 ^{o}C above the 1961-1990 normal and 15 % more precipitation.

The monitored river catchments displayed water chemistry patterns in relation to their respective variation in land-use, elevation, vegetation and soils types. Typically, acidic rivers are found in the south and south-west, weakly acidic to neutral in the south-east, and close to neutral in mid-to-northern Norway. Bjerkreimselva, Vikedalselva, Vosso, Vefsna, Driva, and Målselva have very clear water (TOC < 2mg/L) according to the Norwegian WFD typology; Glomma, Alna, Drammenselva, Numedalslågen, Skienselva, Otra, Nausta, Orkla, Nidelva, Altaelva, Tana and Pasvikelva are clear (2 mg/L < TOC < 5 mg/L); while Storelva and Orreelva are humic (TOC > 5 mg/L). For nutrients, concentrations of tot-P and tot-N are generally below the good/moderate boundary.

There are two clear exceptions from the general water chemistry patterns among the 20 investigated rivers – Alna and Orreelva – both heavily influenced by human activities through urbanization and agriculture, respectively. These rivers typically have higher pH values and Orreelva also elevated TOC concentrations, likely due to effluent inputs and diffuse water discharge from agriculture. Alna and Orreelva are also high in turbidity, SPM and they display less than good ecological status according to the good/moderate boundary for tot-P and tot-N for their respective waters. Alna also has high metals concentrations, including As, Pb, Cd, Cu, Zn, Cr, Ni, and Hg. But mean annual 2019 concentrations were lower than the five-year (2014-2018) mean for all metals where historical data exists.

Pasvikelva also shows elevated concentrations of selected metals, most noteworthy Ni and Cu, likely due to metallurgical activity on the Russian side of the border. However, for metals, most rivers show significantly declining trends in loads and concentrations. The only two exceptions are Vefsna and Alta, where Ni concentrations are significantly increasing. However, concentrations are low and does not warrant major concern at this point.

The long-term monitoring of river water in Norway does not display a significant increase in export of TOC. Browning of surface waters across the northern hemisphere is a well-established phenomenon, consisting of an observed increase in both the concentration and colour of DOM. The lack of expected TOC increase in the large Norwegian rivers are likely explained by the fact that time series are too short, and that rivers are regulated for hydropower.

Simulations of the fate and transport of PCB and PAH in Alna using the INCA-Tox model provided dissolved contaminant concentrations that matched the general magnitude of data measured during the period 2013-2016. Boreal forested catchments are currently in a transitory phase, where the system will shift from acting as a net sink of atmospheric PCBs to becoming a net source for air and water environments. High-frequency (hourly) sensor data from Storelva and Målselva, including water temperature, pH, conductivity, turbidity and fDOM gave new insights into how flood characteristics (i.e. type, magnitude, timing) influenced short-time variation in concentrations of dissolved ions (conductivity), suspended particles (turbidity) and DOM in 2019.

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6. Appendix A

6.1 Riverine concentrations in 2019

Glomma ved Sarpsfoss

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	442.25	7.11	4.89	1.30	1.21	3.70	3.70	152.00	2.00	6.00	4.00	420.00	33.00	500.00	14.20	3.75									
05.02.2019	573.10	7.20	4.92	1.00	0.93	2.40	2.40	140.00	2.00	5.00	2.00	340.00	31.00	470.00	10.90	3.56	0.00	0.11	0.09	0.01	1.09	13.80	0.55	0.12	4.00
05.03.2019	511.98	7.02	7.21	24.00	21.50	4.10	4.10	625.00	22.00	36.00	9.00	1100.00	<2.0	1600.00	68.60	4.63									
01.04.2019	527.63	7.07	5.74	6.20	5.23	4.20	4.30	137.00	7.00	10.00	6.00	670.00	<2.0	830.00	<1.0	4.05									
06.05.2019	1384.92	7.03	4.06	7.50	11.60	5.80	5.40	515.00	9.00	17.00	6.00	280.00	10.00	500.00	44.10	4.07	0.01	0.17	0.33	0.02	2.26	6.60	0.85	0.27	3.00
14.05.2019	1251.63	6.87	4.07	3.00	5.38	4.10	4.10	332.00	7.00	12.00	4.00	220.00	<2.0	410.00	27.90	3.26									
20.05.2019	1208.82	6.95	3.91	3.70	5.03	5.30	5.20	297.00	9.00	11.00	3.00	260.00	20.00	520.00	<1.0	3.41									
03.06.2019	1506.51	7.05	4.00	3.10	7.33	3.70	3.70	312.00	7.00	14.00	3.00	290.00	13.00	450.00	36.10	3.15									
17.06.2019	1976.86	7.24	4.83	15.00	14.00	4.60	4.70	445.00	2.00	62.00	5.00	500.00	<2.0	770.00	79.80	4.07									
24.06.2019	1564.87	7.26	4.46	6.50	7.40	4.40	4.30	337.00	8.00	15.00	3.00	350.00	4.00	510.00	38.00	3.64									
08.07.2019	703.66	7.36	4.58	2.50	3.65	3.50	3.50	302.00	5.00	10.00	5.00	270.00	17.00	440.00	44.30	2.81									
05.08.2019	519.01	7.45	5.02	1.70	2.88	2.80	2.70	286.00	4.00	8.00	2.00	240.00	7.00	390.00	30.80	2.70	0.00	0.16	0.12	0.01	1.23	1.50	0.53	0.13	<1.0
02.09.2019	877.79	7.13	5.18	16.00	17.30	4.80	4.80	454.00	16.00	30.00	10.00	490.00	11.00	700.00	62.10	2.81									
07.10.2019	799.60	7.09	5.02	6.40	7.40	5.00	5.00	341.00	7.00	14.00	5.00	390.00	2.00	620.00	35.80	3.43	<0.002	0.17	0.24	0.01	1.46	3.30	0.89	0.33	<1.0
06.11.2019	634.57	7.08	4.92	10.00	8.66	6.80	6.90	338.00	9.00	19.00	7.00	410.00	<2.0	630.00	36.20	4.16									
02.12.2019	649.63	6.92	5.30	17.00	12.80	7.80	7.30	487.00	15.00	26.00	10.00	550.00	4.00	770.00	21.20	5.46									
Lower avg.	945.80	7.11	4.88	7.81	8.27	4.56	4.51	343.75	8.19	18.44	5.25	423.75	9.50	631.88	34.38	3.68	0.00	0.15	0.19	0.01	1.51	6.30	0.70	0.21	1.75
Upper avg..	945.80	7.11	4.88	7.81	8.27	4.56	4.51	343.75	8.19	18.44	5.25	423.75	10.12	631.88	34.50	3.68	0.01	0.15	0.19	0.01	1.51	6.30	0.70	0.21	2.25
Minimum	442.25	6.87	3.91	1.00	0.93	2.40	2.40	137.00	2.00	5.00	2.00	220.00	2.00	390.00	1.00	2.70	0.00	0.11	0.09	0.01	1.09	1.50	0.53	0.12	1.00
Maximum	1976.86	7.45	7.21	24.00	21.50	7.80	7.30	625.00	22.00	62.00	10.00	1100.00	33.00	1600.00	79.80	5.46	0.01	0.17	0.33	0.02	2.26	13.80	0.89	0.33	4.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
n	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	470.68	0.16	0.81	6.80	5.81	1.39	1.31	136.84	5.47	14.45	2.62	219.42	10.31	292.74	22.56	0.72	0.01	0.03	0.11	0.01	0.52	5.43	0.19	0.10	1.50

Alna

Date DD.MM.YYYY	Qs [m3/s]	pH []	KOND [mS/m]	TURB860 [FNU]	SPM [mg/l]	TOC [mgC/l]	DOC [mgC/l]	Part. C [µgC/l]	PO4-P [µgP/l]	TOTP [µgP/l]	TDP [µgP/l]	NO3-N [µgN/l]	NH4-N [µgN/l]	TOTN [µgN/l]	Tot. Part. N [µgN/l]	SiO2 [mgSiO2/l]	Ag [µg/l]	As [µg/l]	Pb [µg/l]	Cd [µg/l]	Cu [µg/l]	Zn [µg/l]	Ni [µg/l]	Cr [µg/l]	Hg [ng/l]
07.01.2019	0.49	7.78	48.60	2.30	2.68	3.00	3.00	381.00	58.00	67.00	51.00	1150.00	460.00	1700.00	43.40	6.79									
05.02.2019	0.39	7.88	51.60	2.00	2.09	3.00	2.80	405.00	48.00	65.00	41.00	820.00	230.00	1700.00	36.50	6.56	0.02	0.26	0.17	0.02	1.90	6.50	0.59	0.15	<1.0
05.03.2019	2.54	7.84	80.00	6.70	9.94	3.70	3.60	556.00	32.00	35.00	17.00	1200.00	6.00	2000.00	50.20	7.50									
02.04.2019	2.02	7.86	41.60	5.50	7.53	3.80	3.80	790.00	24.00	34.00	12.00	990.00	71.00	1300.00	43.50	6.47									
09.05.2019	0.75	7.93	45.90	2.70	4.21	2.40	2.10	423.00	36.00	54.00	25.00	780.00	95.00	1300.00	<1.0	4.46	0.01	0.31	0.32	0.03	2.65	8.50	0.68	0.19	<1.0
04.06.2019	0.99	7.93	46.90	2.40	3.70	2.60	2.60	456.00	28.00	46.00	26.00	800.00	35.00	1100.00	47.50	5.72									
03.07.2019	0.53	8.11	48.40	5.60	5.63	2.70	2.50	452.00	45.00	59.00	34.00	1130.00	59.00	1600.00	25.60	6.71									
06.08.2019	0.46	8.09	47.60	3.20	2.85	3.20	3.10	334.00	77.00	93.00	58.00	1150.00	<2.0	1700.00	22.30	6.56	0.01	0.52	0.68	0.03	2.91	14.60	1.48	0.24	<1.0
05.09.2019	52.59	7.75	27.10	61.00	104.00	11.10	8.50	2114.00	140.00	170.00	36.00	780.00	<2.0	1300.00	190.00	5.87									
01.10.2019	2.30	7.86	32.00	5.80	10.10	5.50	5.30	680.00	40.00	48.00	27.00	660.00	<2.0	1300.00	51.30	7.61	<0.002	0.43	0.73	0.04	4.06	11.40	1.06	0.55	2.00
05.11.2019	0.69	7.95	39.70	2.80	3.90	3.30	3.30	330.00	42.00	52.00	32.00	900.00	53.00	1600.00	34.70	7.69									
04.12.2019	1.04	7.90	109.00	4.00	5.16	8.00	7.70	646.00	34.00	51.00	28.00	830.00	200.00	1400.00	74.00	7.31									
Lower avg.	5.40	7.91	51.53	8.67	13.48	4.36	4.02	630.58	50.33	64.50	32.25	932.50	100.75	1500.00	51.58	6.60	0.01	0.38	0.47	0.03	2.88	10.25	0.95	0.28	0.50
Upper avg..	5.40	7.91	51.53	8.67	13.48	4.36	4.02	630.58	50.33	64.50	32.25	932.50	101.25	1500.00	51.67	6.60	0.01	0.38	0.47	0.03	2.88	10.25	0.95	0.28	1.25
Minimum	0.39	7.75	27.10	2.00	2.09	2.40	2.10	330.00	24.00	34.00	12.00	660.00	2.00	1100.00	1.00	4.46	0.00	0.26	0.17	0.02	1.90	6.50	0.59	0.15	1.00
Maximum	52.59	8.11	109.00	61.00	104.00	11.10	8.50	2114.00	140.00	170.00	58.00	1200.00	460.00	2000.00	190.00	7.69	0.02	0.52	0.73	0.04	4.06	14.60	1.48	0.55	2.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	14.88	0.11	22.19	16.56	28.63	2.64	2.08	489.07	31.65	36.73	13.10	183.66	135.88	255.84	47.11	0.93	0.01	0.12	0.28	0.01	0.90	3.53	0.41	0.18	0.50

Drammenselva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	309.32	7.03	3.59	0.58	0.75	3.20	3.20	105.00	<1.0	4.00	3.00	290.00	9.00	380.00	4.87	2.91									
04.02.2019	311.30	7.11	3.58	0.75	0.77	2.90	2.80	133.00	2.00	5.00	2.00	220.00	14.00	350.00	8.63	2.76	<0.002	0.11	0.04	0.01	0.47	1.40	0.39	0.09	5.00
04.03.2019	332.83	7.10	4.45	0.94	1.05	2.80	2.80	124.00	1.00	4.00	2.00	350.00	10.00	490.00	9.34	3.00									
02.04.2019	245.13	7.23	5.90	2.80	4.19	3.90	3.90	261.00	4.00	8.00	3.00	900.00	3.00	1000.00	24.00	3.77									
06.05.2019	410.45	7.32	4.66	0.38	1.55	3.30	3.30	179.00	1.00	5.00	2.00	240.00	2.00	360.00	1.00	3.00	0.00	0.13	0.10	0.01	0.73	2.80	0.43	0.11	<1.0
15.05.2019	470.08	7.21	4.01	0.80	1.07	3.50	3.40	97.90	3.00	5.00	<1.0	360.00	4.00	440.00	<1.0	3.04									
22.05.2019	690.61	7.15	4.20	3.30	3.59	3.60	3.50	372.00	5.00	9.00	1.00	520.00	9.00	730.00	<1.0	3.02									
03.06.2019	553.30	7.18	3.70	1.10	1.36	3.40	3.30	155.00	3.00	6.00	1.00	260.00	2.00	380.00	13.50	2.89									
12.06.2019	591.18	7.11	3.91	3.10	3.94	4.00	3.90	329.00	3.00	10.00	2.00	380.00	<2.0	510.00	<1.0	3.00									
24.06.2019	413.30	7.52	5.20	0.59	1.25	3.90	3.90	256.00	<1.0	6.00	2.00	260.00	5.00	380.00	25.40	2.96									
01.07.2019	245.46	6.99	3.98	0.67	1.47	4.00	3.90	220.00	2.00	5.00	3.00	240.00	14.00	370.00	<1.0	2.68									
05.08.2019	191.90	7.21	3.54	0.64	0.73	3.40	3.20	193.00	2.00	4.00	1.00	150.00	19.00	290.00	21.90	2.53	<0.002	0.17	0.05	0.01	0.63	0.80	0.35	0.07	<1.0
02.09.2019	311.90	7.09	3.72	1.30	1.04	4.00	3.90	171.00	1.00	6.00	3.00	200.00	10.00	340.00	9.82	2.55									
07.10.2019	303.22	7.03	3.91	0.82	0.96	4.10	4.00	138.00	2.00	4.00	2.00	270.00	21.00	450.00	16.50	2.72	<0.002	0.13	0.06	0.01	0.65	1.40	0.50	0.11	5.00
04.11.2019	366.83	7.15	4.05	0.94	1.18	3.90	3.70	151.00	1.00	4.00	<1.0	260.00	13.00	420.00	10.90	2.89									
03.12.2019	313.94	7.13	4.35	0.74	0.80	4.10	4.00	127.00	2.00	4.00	2.00	320.00	8.00	480.00	8.31	3.15									
Lower avg.	378.80	7.16	4.17	1.22	1.61	3.62	3.54	188.24	2.00	5.56	1.81	326.25	8.94	460.62	9.64	2.93	0.00	0.14	0.06	0.01	0.62	1.60	0.42	0.10	2.50
Upper avg..	378.80	7.16	4.17	1.22	1.61	3.62	3.54	188.24	2.12	5.56	1.94	326.25	9.06	460.62	9.89	2.93	0.00	0.14	0.06	0.01	0.62	1.60	0.42	0.10	3.00
Minimum	191.90	6.99	3.54	0.38	0.73	2.80	2.80	97.90	1.00	4.00	1.00	150.00	2.00	290.00	1.00	2.53	0.00	0.11	0.04	0.01	0.47	0.80	0.35	0.07	1.00
Maximum	690.61	7.52	5.90	3.30	4.19	4.10	4.00	372.00	5.00	10.00	3.00	900.00	21.00	1000.00	25.40	3.77	0.00	0.17	0.10	0.01	0.73	2.80	0.50	0.11	5.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	136.61	0.13	0.64	0.95	1.17	0.43	0.41	79.96	1.20	1.90	0.77	175.53	5.98	175.71	8.43	0.29	0.00	0.03	0.03	0.00	0.11	0.85	0.06	0.02	2.31

Numedalslågen

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	86.09	6.88	3.33	4.50	4.93	3.00	2.90	471.00	10.00	14.00	3.00	250.00	61.00	380.00	<1.0	3.56									
04.02.2019	65.74	6.84	4.71	2.70	4.37	3.40	3.30	711.00	4.00	10.00	2.00	620.00	290.00	860.00	61.40	4.50	0.01	0.34	1.07	0.05	2.28	16.70	0.65	0.49	1.00
04.03.2019	105.05	6.82	4.71	2.90	3.21	3.70	3.80	231.00	5.00	9.00	3.00	470.00	21.00	660.00	16.20	4.16									
01.04.2019	215.73	6.85	3.79	6.20	8.32	4.80	4.80	500.00	10.00	15.00	3.00	460.00	2.00	630.00	<1.0	4.16									
06.05.2019	144.90	6.64	2.35	1.50	3.79	4.20	4.10	312.00	2.00	7.00	3.00	130.00	6.00	280.00	20.80	3.06	0.01	0.16	0.34	0.02	0.67	3.60	0.33	0.15	4.00
03.06.2019	105.58	6.83	2.80	1.40	1.92	4.30	4.10	247.00	3.00	7.00	2.00	150.00	20.00	300.00	16.90	3.06									
01.07.2019	85.16	7.02	2.94	1.30	3.48	3.70	3.60	215.00	3.00	6.00	2.00	130.00	22.00	250.00	16.00	2.64									
05.08.2019	91.15	6.44	2.39	0.99	1.59	2.30	2.30	163.00	3.00	6.00	2.00	58.00	26.00	170.00	12.60	2.21	0.01	0.12	0.15	0.01	0.47	1.20	0.25	0.07	<1.0
02.09.2019	71.52	6.93	3.87	2.10	2.08	5.60	5.80	323.00	3.00	10.00	6.00	200.00	44.00	390.00	20.80	2.94									
07.10.2019	86.23	6.88	3.88	2.50	2.80	5.60	5.50	218.00	4.00	9.00	3.00	260.00	30.00	530.00	1.00	3.66	0.00	0.19	0.23	0.01	0.85	3.70	0.40	0.18	2.00
04.11.2019	46.35	7.01	4.80	2.40	2.97	6.00	5.80	219.00	5.00	10.00	3.00	370.00	100.00	630.00	26.00	4.44									
02.12.2019	60.20	6.92	5.35	4.80	8.12	6.60	6.30	575.00	14.00	22.00	6.00	600.00	3.00	870.00	40.40	5.38									
Lower avg.	96.97	6.84	3.74	2.77	3.96	4.43	4.36	348.75	5.50	10.42	3.17	308.17	52.08	495.83	19.34	3.65	0.01	0.20	0.45	0.02	1.07	6.30	0.41	0.22	1.75
Upper avg..	96.97	6.84	3.74	2.77	3.96	4.43	4.36	348.75	5.50	10.42	3.17	308.17	52.08	495.83	19.51	3.65	0.01	0.20	0.45	0.02	1.07	6.30	0.41	0.22	2.00
Minimum	46.35	6.44	2.35	0.99	1.59	2.30	2.30	163.00	2.00	6.00	2.00	58.00	2.00	170.00	1.00	2.21	0.00	0.12	0.15	0.01	0.47	1.20	0.25	0.07	1.00
Maximum	215.73	7.02	5.35	6.20	8.32	6.60	6.30	711.00	14.00	22.00	6.00	620.00	290.00	870.00	61.40	5.38	0.01	0.34	1.07	0.05	2.28	16.70	0.65	0.49	4.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	45.21	0.16	1.00	1.61	2.21	1.31	1.28	173.94	3.75	4.62	1.40	191.63	79.86	236.05	17.43	0.91	0.00	0.10	0.42	0.02	0.82	7.03	0.17	0.18	1.41

Skienselva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
14.01.2019	305.70	6.73	1.94	0.35	0.37	2.40	2.40	80.70	<1.0	3.00	2.00	170.00	8.00	230.00	4.18	2.21									
05.02.2019	306.45	6.68	1.87	0.44	<0.67	2.30	2.30	98.70	1.00	3.00	2.00	130.00	6.00	220.00	5.05	2.23	<0.002	0.08	0.04	0.01	0.33	1.70	0.19	0.06	<1.0
11.03.2019	269.46	6.78	2.09	0.66	0.83	2.50	2.40	153.00	1.00	3.00	2.00	160.00	<2.0	260.00	11.80	2.40									
01.04.2019	328.18	6.78	2.09	0.98	1.93	2.50	2.40	166.00	3.00	5.00	2.00	170.00	<2.0	250.00	<1.0	2.40									
06.05.2019	301.62	6.74	1.95	0.41	0.42	2.20	2.20	79.40	<1.0	3.00	2.00	140.00	<2.0	210.00	<1.0	2.25	<0.002	0.08	0.04	0.01	0.34	2.10	0.15	0.07	<1.0
03.06.2019	280.15	6.90	2.13	0.47	0.73	2.60	2.50	155.00	2.00	4.00	<1.0	150.00	14.00	240.00	11.70	2.23									
01.07.2019	192.34	6.87	1.99	0.54	0.53	2.80	2.70	162.00	<1.0	7.00	4.00	130.00	4.00	230.00	8.74	2.06									
06.08.2019	306.84	6.19	1.88	0.31	<0.4	2.50	2.50	111.00	1.00	3.00	<1.0	97.00	20.00	180.00	12.30	1.87	<0.002	0.10	0.04	0.01	0.41	1.50	0.18	0.06	<1.0
03.09.2019	213.26	6.75	1.95	1.60	0.61	2.90	2.90	149.00	2.00	4.00	1.00	96.00	26.00	200.00	15.10	1.95									
14.10.2019	428.71	6.70	1.95	0.58	0.77	2.90	2.90	151.00	2.00	3.00	<1.0	120.00	16.00	220.00	10.70	2.12	<0.002	0.09	0.05	0.01	0.67	1.90	0.34	0.07	4.00
04.11.2019	120.90	6.78	2.04	0.75	0.79	3.20	3.00	114.00	<1.0	4.00	<1.0	130.00	17.00	250.00	14.40	2.23									
09.12.2019	167.97	6.54	2.02	0.66	0.59	2.80	2.80	110.00	<1.0	3.00	1.00	150.00	9.00	270.00	8.50	2.42									
Lower avg.	268.46	6.70	1.99	0.65	0.63	2.63	2.58	127.48	1.00	3.75	1.33	136.92	10.00	230.00	8.54	2.20	0.00	0.09	0.04	0.01	0.44	1.80	0.22	0.06	1.00
Upper avg..	268.46	6.70	1.99	0.65	0.72	2.63	2.58	127.48	1.42	3.75	1.67	136.92	10.50	230.00	8.71	2.20	0.00	0.09	0.04	0.01	0.44	1.80	0.22	0.06	1.75
Minimum	120.90	6.19	1.87	0.31	0.37	2.20	2.20	79.40	1.00	3.00	1.00	96.00	2.00	180.00	1.00	1.87	0.00	0.08	0.04	0.01	0.33	1.50	0.15	0.06	1.00
Maximum	428.71	6.90	2.13	1.60	1.93	3.20	3.00	166.00	3.00	7.00	4.00	170.00	26.00	270.00	15.10	2.42	0.00	0.10	0.05	0.01	0.67	2.10	0.34	0.07	4.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	82.85	0.19	0.08	0.35	0.41	0.29	0.27	31.89	0.67	1.22	0.89	24.81	7.99	25.94	4.87	0.17	0.00	0.01	0.00	0.00	0.16	0.26	0.09	0.01	1.50

Otra

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	144.01	6.14	1.51	0.40	<0.5	2.70	2.60	173.00	<1.0	3.00	2.00	100.00	19.00	180.00	9.27	1.79									
04.02.2019	137.64	6.21	1.49	0.34	0.62	2.30	2.30	130.00	1.00	3.00	1.00	76.00	17.00	160.00	6.96	1.68	<0.002	0.08	0.13	0.01	0.29	2.00	0.23	0.06	4.00
04.03.2019	138.74	6.28	1.73	0.68	0.79	2.90	2.80	4.96	1.00	2.00	2.00	96.00	26.00	230.00	1.00	1.90									
01.04.2019	138.07	6.24	1.69	0.47	0.87	3.00	3.00	175.00	3.00	3.00	1.00	92.00	3.00	180.00	10.30	1.64									
06.05.2019	74.65	6.39	1.56	0.60	1.26	2.40	2.20	295.00	<1.0	4.00	2.00	69.00	<2.0	170.00	<1.0	1.10	0.00	0.11	0.19	0.01	0.43	2.30	0.42	0.08	<1.0
03.06.2019	83.32	6.34	1.49	0.43	0.96	2.90	2.80	313.00	<1.0	4.00	1.00	84.00	7.00	180.00	24.30	1.27									
01.07.2019	63.20	6.30	1.44	0.50	1.29	2.80	2.70	244.00	<1.0	3.00	2.00	61.00	<2.0	150.00	17.20	1.07									
05.08.2019	78.89	6.05	1.42	0.47	1.69	3.50	3.40	175.00	2.00	5.00	1.00	57.00	24.00	190.00	11.30	1.15	0.01	0.15	0.23	0.02	0.54	2.60	0.41	0.09	<1.0
02.09.2019	115.76	6.02	1.45	0.56	1.24	5.00	5.00	311.00	<1.0	4.00	2.00	56.00	5.00	240.00	13.00	1.50									
07.10.2019	166.51	6.09	1.48	0.56	1.27	4.40	4.40	316.00	2.00	4.00	<1.0	56.00	18.00	240.00	27.30	1.67	0.01	0.20	0.35	0.04	0.75	3.40	0.67	0.11	<1.0
04.11.2019	164.63	6.20	1.42	0.70	0.79	3.60	3.50	212.00	<1.0	3.00	<1.0	65.00	14.00	190.00	34.60	1.88									
02.12.2019	220.62	6.13	1.42	0.57	0.69	4.10	4.10	219.00	2.00	3.00	1.00	76.00	17.00	210.00	12.60	1.96									
Lower avg.	127.17	6.20	1.51	0.52	0.96	3.30	3.23	214.00	0.92	3.42	1.25	74.00	12.50	193.33	13.99	1.55	0.00	0.14	0.23	0.02	0.50	2.58	0.43	0.09	1.00
Upper avg..	127.17	6.20	1.51	0.52	1.00	3.30	3.23	214.00	1.42	3.42	1.42	74.00	12.83	193.33	14.07	1.55	0.00	0.14	0.23	0.02	0.50	2.58	0.43	0.09	1.75
Minimum	63.20	6.02	1.42	0.34	0.50	2.30	2.20	4.96	1.00	2.00	1.00	56.00	2.00	150.00	1.00	1.07	0.00	0.08	0.13	0.01	0.29	2.00	0.23	0.06	1.00
Maximum	220.62	6.39	1.73	0.70	1.69	5.00	5.00	316.00	3.00	5.00	2.00	100.00	26.00	240.00	34.60	1.96	0.01	0.20	0.35	0.04	0.75	3.40	0.67	0.11	4.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	46.28	0.12	0.10	0.11	0.35	0.84	0.87	91.74	0.67	0.79	0.51	15.97	8.66	30.25	10.23	0.33	0.00	0.05	0.09	0.02	0.19	0.60	0.18	0.02	1.50

Orreelva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	10.00	7.67	19.60	13.00	24.90	9.50	5.20	2618.00	43.00	130.00	10.00	1300.00	5.00	2300.00	308.00	2.11									
05.02.2019	8.92	7.57	19.90	10.00	27.40	8.90	5.50	3732.00	52.00	97.00	12.00	1500.00	4.00	2800.00	388.00	3.28	0.00	0.35	0.70	0.03	1.98	5.20	1.38	0.32	5.00
04.03.2019	2.96	7.59	19.50	6.00	7.77	7.90	5.29	1444.00	10.00	41.00	9.00	1500.00	<2.0	2400.00	206.00	1.64									
01.04.2019	3.82	7.78	18.90	4.70	8.58	7.70	6.30	1760.00	12.00	42.00	5.00	1400.00	61.00	2000.00	201.00	0.10									
06.05.2019	0.86	7.63	20.90	11.00	17.50	10.40	5.60	3360.00	17.00	63.00	8.00	430.00	24.00	1200.00	448.00	0.25	0.00	0.36	0.55	0.02	1.74	3.20	1.23	0.18	<1.0
03.06.2019	1.74	7.81	21.20	8.70	5.14	7.90	6.40	1860.00	9.00	54.00	6.00	<2.0	<2.0	550.00	515.00	0.24									
01.07.2019	0.90	8.23	21.60	17.00	10.90	9.50	7.60	4414.00	6.00	82.00	7.00	<2.0	<2.0	890.00	663.00	0.77									
05.08.2019	3.03	7.51	21.20	9.00	7.31	9.20	7.20	3041.00	12.00	64.00	7.00	<2.0	160.00	760.00	488.00	2.04	<0.002	0.47	0.06	0.00	0.89	0.72	1.17	0.04	<1.0
02.09.2019	7.78	7.77	21.90	14.00	15.80	12.00	10.70	4269.00	22.00	100.00	11.00	35.00	36.00	960.00	336.00	2.98									
07.10.2019	2.78	7.63	18.70	16.00	10.40	8.10	6.80	2477.00	18.00	55.00	8.00	400.00	21.00	1300.00	520.00	3.66	0.00	0.32	0.09	0.00	1.46	1.60	1.14	0.13	<1.0
04.11.2019	3.25	7.67	19.30	19.00	8.25	7.50	6.20	3581.00	13.00	74.00	7.00	550.00	<2.0	1500.00	699.00	3.99									
02.12.2019	2.09	7.73	20.40	25.00	10.80	8.30	5.90	4032.00	9.00	95.00	7.00	370.00	<2.0	1100.00	692.00	4.82									
Lower avg.	4.01	7.72	20.26	12.78	12.90	8.91	6.56	3049.00	18.58	74.75	8.08	623.75	25.92	1480.00	455.33	2.16	0.00	0.38	0.35	0.01	1.52	2.68	1.23	0.17	1.25
Upper avg..	4.01	7.72	20.26	12.78	12.90	8.91	6.56	3049.00	18.58	74.75	8.08	624.25	26.75	1480.00	455.33	2.16	0.00	0.38	0.35	0.01	1.52	2.68	1.23	0.17	2.00
Minimum	0.86	7.51	18.70	4.70	5.14	7.50	5.20	1444.00	6.00	41.00	5.00	2.00	2.00	550.00	201.00	0.10	0.00	0.32	0.06	0.00	0.89	0.72	1.14	0.04	1.00
Maximum	10.00	8.23	21.90	25.00	27.40	12.00	10.70	4414.00	52.00	130.00	12.00	1500.00	160.00	2800.00	699.00	4.82	0.00	0.47	0.70	0.03	1.98	5.20	1.38	0.32	5.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	3.11	0.19	1.09	5.81	7.11	1.32	1.50	1014.82	14.34	26.86	2.07	622.26	45.83	725.45	174.44	1.61	0.00	0.07	0.33	0.01	0.47	1.97	0.11	0.12	2.00

Vosso (Bolstadelvi)

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	40.11	6.55	1.45	1.30	2.65	1.20	1.10	422.00	1.00	7.00	2.00	120.00	5.00	380.00	27.70	1.06									
04.02.2019	6.69	6.50	1.42	<0.3	0.40	0.86	0.85	105.00	1.00	3.00	2.00	100.00	5.00	150.00	10.80	1.02	<0.002	0.06	0.03	0.00	0.26	0.66	0.25	0.04	<1.0
05.03.2019	28.88	6.55	1.83	0.41	0.56	1.10	1.10	103.00	1.00	2.00	2.00	160.00	<2.0	230.00	2.00	1.26									
01.04.2019	95.88	6.46	1.85	0.59	0.51	1.10	1.10	106.00	1.00	3.00	<1.0	160.00	<2.0	220.00	8.04	1.17									
06.05.2019	52.94	6.74	1.92	0.58	0.76	1.10	0.98	114.00	<1.0	4.00	2.00	160.00	7.00	220.00	24.40	1.30	0.00	0.07	0.06	0.01	0.35	0.98	0.28	0.04	3.00
03.06.2019	248.34	6.54	1.33	0.33	0.44	1.10	1.10	158.00	1.00	3.00	<1.0	81.00	<2.0	140.00	20.90	1.02									
01.07.2019	95.35	6.50	1.08	0.32	0.96	1.30	1.20	119.00	<1.0	3.00	2.00	50.00	2.00	110.00	9.53	0.81									
12.08.2019	69.37	6.65	1.15	0.52	0.64	1.30	1.40	184.00	2.00	4.00	<1.0	38.00	3.00	100.00	25.30	0.66	<0.002	0.10	0.08	0.00	0.37	0.58	0.29	0.06	<1.0
02.09.2019	275.19	6.40	1.21	0.70	1.03	2.00	1.90	226.00	<1.0	5.00	4.00	75.00	<2.0	160.00	21.00	1.08									
07.10.2019	18.36	6.51	1.37	0.56	0.66	1.30	1.30	148.00	2.00	3.00	1.00	90.00	5.00	170.00	<1.0	1.08	<0.002	0.09	0.06	0.00	0.40	0.85	0.30	0.05	1.00
04.11.2019	22.73	6.47	1.41	0.49	1.29	1.30	1.30	213.00	2.00	4.00	<1.0	97.00	5.00	170.00	22.30	1.17									
02.12.2019	7.91	6.45	1.52	<0.3	0.25	1.10	1.10	78.70	1.00	3.00	<1.0	130.00	7.00	180.00	2.02	1.08									
Lower avg.	80.15	6.53	1.46	0.48	0.85	1.23	1.20	164.72	1.00	3.67	1.25	105.08	3.25	185.83	14.50	1.06	0.00	0.08	0.06	0.00	0.34	0.77	0.28	0.05	1.00
Upper avg..	80.15	6.53	1.46	0.53	0.85	1.23	1.20	164.72	1.25	3.67	1.67	105.08	3.92	185.83	14.58	1.06	0.00	0.08	0.06	0.00	0.34	0.77	0.28	0.05	1.50
Minimum	6.69	6.40	1.08	0.30	0.25	0.86	0.85	78.70	1.00	2.00	1.00	38.00	2.00	100.00	1.00	0.66	0.00	0.06	0.03	0.00	0.26	0.58	0.25	0.04	1.00
Maximum	275.19	6.74	1.92	1.30	2.65	2.00	1.90	422.00	2.00	7.00	4.00	160.00	7.00	380.00	27.70	1.30	0.00	0.10	0.08	0.01	0.40	0.98	0.30	0.06	3.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	90.26	0.09	0.28	0.28	0.64	0.28	0.26	93.35	0.45	1.30	0.89	41.81	1.98	73.66	10.03	0.18	0.00	0.02	0.02	0.00	0.06	0.18	0.02	0.01	1.00

Orkla

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
09.01.2019	43.99	7.36	7.58	0.65	0.96	3.90	3.80	197.00	<1.0	5.00	3.00	360.00	4.00	440.00	<1.0	3.30									
11.02.2019	44.16	7.47	6.65	0.56	2.64	1.90	1.90	214.00	2.00	5.00	1.00	230.00	7.00	340.00	<1.0	3.26	<0.002	0.07	0.03	0.03	3.09	7.40	0.68	0.22	<1.0
04.03.2019	63.07	7.49	7.29	0.64	0.63	2.60	2.70	350.00	1.00	3.00	2.00	220.00	<2.0	350.00	37.40	3.30									
01.04.2019	42.04	7.46	8.93	1.10	1.13	3.50	3.40	216.00	2.00	4.00	2.00	320.00	<2.0	470.00	5.95	3.60									
06.05.2019	62.27	7.43	6.84	0.69	0.74	3.40	3.30	150.00	<1.0	4.00	2.00	250.00	<2.0	400.00	<1.0	3.15	<0.002	0.12	0.02	0.04	7.02	12.90	0.83	0.24	2.00
02.06.2019	58.70	7.37	5.45	0.32	0.62	3.30	3.30	146.00	1.00	3.00	<1.0	150.00	<2.0	250.00	8.59	2.64									
01.07.2019	88.52	7.46	4.97	0.82	1.73	4.20	4.20	182.00	1.00	7.00	2.00	97.00	<2.0	230.00	27.10	2.16									
05.08.2019	30.80	7.72	7.35	0.35	<0.5	1.80	1.70	140.00	1.00	3.00	<1.0	190.00	<2.0	310.00	14.00	2.51	<0.002	0.10	0.01	0.01	2.03	3.90	0.62	0.10	<1.0
02.09.2019	23.88	7.58	7.00	0.39	1.02	2.40	2.30	177.00	<1.0	4.00	2.00	130.00	<2.0	230.00	1.48	2.27									
07.10.2019	50.50	7.34	7.48	0.49	0.62	4.30	4.40	183.00	<1.0	3.00	2.00	250.00	2.00	420.00	<1.0	3.21	<0.002	0.14	0.02	0.05	7.17	16.50	0.82	0.24	1.00
04.11.2019	27.90	7.48	8.78	0.36	<0.29	3.90	3.80	130.00	2.00	3.00	1.00	290.00	5.00	440.00	12.20	3.64									
02.12.2019	45.15	7.45	6.89	<0.3	0.47	1.90	1.80	89.20	1.00	2.00	<1.0	190.00	11.00	270.00	8.35	2.85									
Lower avg.	48.42	7.47	7.10	0.53	0.88	3.09	3.05	181.18	0.92	3.83	1.42	223.08	2.42	345.83	9.59	2.99	0.00	0.11	0.02	0.03	4.83	10.18	0.74	0.20	0.75
Upper avg..	48.42	7.47	7.10	0.56	0.95	3.09	3.05	181.18	1.25	3.83	1.67	223.08	3.58	345.83	9.92	2.99	0.00	0.11	0.02	0.03	4.83	10.18	0.74	0.20	1.25
Minimum	23.88	7.34	4.97	0.30	0.29	1.80	1.70	89.20	1.00	2.00	1.00	97.00	2.00	230.00	1.00	2.16	0.00	0.07	0.01	0.01	2.03	3.90	0.62	0.10	1.00
Maximum	88.52	7.72	8.93	1.10	2.64	4.30	4.40	350.00	2.00	7.00	3.00	360.00	11.00	470.00	37.40	3.64	0.00	0.14	0.03	0.05	7.17	16.50	0.83	0.24	2.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	no	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	17.96	0.10	1.14	0.24	0.66	0.93	0.95	64.70	0.45	1.34	0.65	77.59	2.84	87.75	11.61	0.50	0.00	0.03	0.01	0.02	2.65	5.61	0.10	0.07	0.50

Vefsna

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	123.41	7.41	5.21	0.45	0.88	1.80	1.70	288.00	1.00	3.00	2.00	47.00	3.00	97.00	33.40	1.37									
05.02.2019	45.72	7.73	8.97	<0.3	<0.67	1.20	1.20	31.50	<1.0	2.00	2.00	110.00	<2.0	180.00	<1.0	2.14	<0.002	0.14	0.01	<0.003	0.27	0.18	0.23	0.06	<1.0
04.03.2019	94.72	7.56	8.90	0.39	0.46	1.60	1.60	142.00	<1.0	2.00	1.00	66.00	<2.0	130.00	8.75	1.81									
01.04.2019	136.34	7.46	8.21	0.74	1.96	1.40	1.30	119.00	2.00	3.00	<1.0	43.00	<2.0	95.00	8.77	1.46									
06.05.2019	150.35	7.61	7.00	0.36	1.19	1.30	1.30	7.29	<1.0	2.00	1.00	33.00	<2.0	100.00	<1.0	1.46	<0.002	0.08	0.03	0.00	0.34	0.50	0.32	0.07	<1.0
03.06.2019	259.76	7.50	5.31	<0.3	0.65	1.40	1.40	85.90	1.00	2.00	<1.0	24.00	<2.0	69.00	6.82	1.35									
03.07.2019	258.21	7.38	3.74	0.59	1.30	1.30	1.20	58.00	2.00	10.00	1.00	12.00	<2.0	51.00	4.59	0.98									
06.08.2019	57.66	7.39	4.68	<0.3	<0.5	0.61	0.58	52.40	1.00	2.00	<1.0	22.00	3.00	55.00	3.52	0.81	<0.002	0.11	0.02	<0.003	0.20	<0.15	0.20	0.04	<1.0
09.09.2019	117.23	7.47	5.14	<0.3	0.65	1.90	1.90	141.00	1.00	2.00	1.00	12.00	<2.0	64.00	12.90	1.22									
02.10.2019	78.48	7.54	6.39	<0.3	<0.36	1.40	1.30	69.00	1.00	1.00	<1.0	30.00	3.00	94.00	<1.0	1.41	<0.002	0.10	0.01	<0.003	0.27	0.20	0.25	0.07	2.00
04.11.2019	72.23	7.61	7.94	<0.3	<0.38	1.70	1.70	44.10	<1.0	1.00	<1.0	50.00	4.00	120.00	5.87	1.70									
03.12.2019	48.36	7.63	9.55	<0.3	<0.4	1.20	1.30	29.50	<1.0	<1.0	<1.0	110.00	4.00	180.00	4.56	2.10									
Lower avg.	120.21	7.52	6.75	0.21	0.59	1.40	1.37	88.97	0.75	2.50	0.67	46.58	1.42	102.92	7.43	1.48	0.00	0.11	0.02	0.00	0.27	0.22	0.25	0.06	0.50
Upper avg..	120.21	7.52	6.75	0.39	0.78	1.40	1.37	88.97	1.17	2.58	1.17	46.58	2.58	102.92	7.68	1.48	0.00	0.11	0.02	0.00	0.27	0.26	0.25	0.06	1.25
Minimum	45.72	7.38	3.74	0.30	0.36	0.61	0.58	7.29	1.00	1.00	1.00	12.00	2.00	51.00	1.00	0.81	0.00	0.08	0.01	0.00	0.20	0.15	0.20	0.04	1.00
Maximum	259.76	7.73	9.55	0.74	1.96	1.90	1.90	288.00	2.00	10.00	2.00	110.00	4.00	180.00	33.40	2.14	0.00	0.14	0.03	0.00	0.34	0.50	0.32	0.07	2.00
More than 70% >LOD	yes	yes	yes	no	no	yes	yes	yes	no	yes	no	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	73.25	0.11	1.94	0.14	0.48	0.34	0.34	76.43	0.39	2.43	0.39	33.59	0.79	43.43	8.87	0.40	0.00	0.02	0.01	0.00	0.06	0.16	0.05	0.01	0.50

Altaelva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	32.98	7.47	7.48	0.76	1.61	2.60	2.60	70.50	2.00	5.00	3.00	69.00	<2.0	150.00	<1.0	5.19									
03.02.2019	28.10	7.53	7.57	0.39	0.53	2.50	2.60	65.00	2.00	4.00	3.00	55.00	<2.0	150.00	4.78	5.70	<0.002	0.08	0.01	<0.003	0.38	<0.15	0.21	0.16	<1.0
04.03.2019	26.24	7.43	7.95	<0.3	0.41	2.50	2.50	102.00	3.00	5.00	4.00	46.00	<2.0	170.00	8.52	5.94									
01.04.2019	26.11	7.61	8.28	0.69	0.64	2.40	2.30	121.00	2.00	4.00	2.00	62.00	<2.0	150.00	<1.0	6.21									
06.05.2019	132.83	7.61	9.04	<0.3	1.36	2.50	2.40	128.00	<1.0	5.00	2.00	61.00	<2.0	170.00	19.10	6.11	<0.002	0.11	0.01	<0.003	0.40	0.18	0.20	0.19	<1.0
03.06.2019	460.12	7.44	10.80	1.90	7.93	4.10	3.10	240.00	2.00	8.00	6.00	13.00	<2.0	100.00	<1.0	4.39									
09.07.2019	149.06	7.46	5.38	<0.3	0.88	3.20	3.20	209.00	2.00	3.00	2.00	18.00	<2.0	110.00	12.90	3.51									
06.08.2019	43.51	7.48	6.13	<0.3	0.57	3.00	3.00	85.70	2.00	5.00	2.00	21.00	<2.0	140.00	<1.0	3.45	<0.002	0.09	0.02	<0.003	0.53	0.18	0.23	0.18	<1.0
03.09.2019	94.97	7.35	5.60	0.61	7.21	3.50	3.50	226.00	3.00	5.00	2.00	25.00	<2.0	130.00	30.40	3.15									
06.10.2019	94.50	7.53	6.39	<0.3	0.59	3.00	3.20	111.00	1.00	3.00	1.00	18.00	6.00	110.00	12.10	3.56	0.01	0.10	0.01	<0.003	0.42	<0.15	0.25	0.15	1.00
04.11.2019	45.22	7.53	8.42	0.30	0.30	2.70	2.60	35.20	2.00	4.00	2.00	60.00	<2.0	160.00	12.70	3.86									
03.12.2019	37.24	7.37	11.10	<0.3	7.17	2.40	2.40	70.40	4.00	7.00	6.00	66.00	5.00	210.00	8.02	4.80									
Lower avg.	97.57	7.48	7.84	0.39	2.43	2.87	2.78	121.98	2.08	4.83	2.92	42.83	0.92	145.83	9.04	4.66	0.00	0.09	0.01	0.00	0.43	0.09	0.22	0.17	0.25
Upper avg..	97.57	7.48	7.84	0.54	2.43	2.87	2.78	121.98	2.17	4.83	2.92	42.83	2.58	145.83	9.38	4.66	0.00	0.09	0.01	0.00	0.43	0.17	0.22	0.17	1.00
Minimum	26.11	7.35	5.38	0.30	0.30	2.40	2.30	35.20	1.00	3.00	1.00	13.00	2.00	100.00	1.00	3.15	0.00	0.08	0.01	0.00	0.38	0.15	0.20	0.15	1.00
Maximum	460.12	7.61	11.10	1.90	7.93	4.10	3.50	240.00	4.00	8.00	6.00	69.00	6.00	210.00	30.40	6.21	0.01	0.11	0.02	0.00	0.53	0.18	0.25	0.19	1.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	no	yes	yes	no	yes	no	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	122.05	0.08	1.85	0.46	3.05	0.52	0.40	67.61	0.83	1.47	1.62	21.93	1.38	30.88	8.90	1.15	0.00	0.01	0.00	0.00	0.07	0.02	0.02	0.02	0.00

Bjerkreimselva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
09.01.2019	60.18	6.39	3.18	0.42	0.55	1.30	1.30	117.00	<1.0	3.00	2.00	380.00	5.00	420.00	9.28	1.53									
04.02.2019	21.83	6.52	3.58	0.34	0.59	1.20	1.20	152.00	2.00	5.00	1.00	410.00	<2.0	500.00	12.40	1.83	<0.002	0.09	0.17	0.02	0.27	2.50	0.18	0.07	<1.0
06.03.2019	34.32	6.45	3.47	0.41	0.57	1.30	1.30	196.00	<1.0	3.00	2.00	340.00	5.00	470.00	17.20	1.63									
09.04.2019	39.74	6.61	3.67	0.30	0.64	1.40	1.50	273.00	<1.0	4.00	2.00	360.00	7.00	450.00	29.00	1.49									
08.05.2019	24.27	6.54	3.40	<0.3	<0.53	1.20	1.10	85.80	<1.0	3.00	2.00	260.00	<2.0	370.00	11.60	1.38	<0.002	0.07	0.12	0.01	0.20	1.90	0.08	0.05	<1.0
19.06.2019	32.26	6.57	3.30	<0.3	<0.29	1.30	1.30	294.00	<1.0	5.00	3.00	330.00	10.00	420.00	55.40	1.36									
02.07.2019	26.84	6.74	3.38	<0.3	<0.38	1.40	1.30	118.00	2.00	4.00	2.00	290.00	<2.0	380.00	<1.0	1.22									
06.08.2019	29.89	6.15	3.48	0.66	0.70	2.10	2.10	310.00	3.00	7.00	2.00	340.00	8.00	480.00	23.40	1.26	<0.002	0.12	0.17	0.01	0.37	2.60	0.20	0.07	<1.0
04.09.2019	47.91	6.45	3.06	0.42	0.83	2.10	2.00	236.00	1.00	5.00	3.00	300.00	3.00	420.00	18.10	1.39									
02.10.2019	39.94	6.62	3.39	0.64	0.47	1.70	1.60	189.00	2.00	4.00	1.00	300.00	9.00	450.00	12.10	1.47	0.00	0.12	0.28	0.03	3.56	13.30	1.25	0.19	<1.0
05.11.2019	25.68	6.60	3.54	0.35	0.24	1.60	1.60	73.70	2.00	3.00	1.00	370.00	<2.0	480.00	11.50	1.78									
04.12.2019	22.85	6.68	3.56	<0.3	<0.33	1.60	1.50	101.00	<1.0	3.00	<1.0	360.00	<2.0	480.00	10.50	1.88									
Lower avg.	33.81	6.53	3.42	0.29	0.38	1.52	1.48	178.79	1.00	4.08	1.75	336.67	3.92	443.33	17.54	1.52	0.00	0.10	0.18	0.02	1.10	5.08	0.43	0.10	0.00
Upper avg..	33.81	6.53	3.42	0.39	0.51	1.52	1.48	178.79	1.50	4.08	1.83	336.67	4.75	443.33	17.62	1.52	0.00	0.10	0.18	0.02	1.10	5.08	0.43	0.10	1.00
Minimum	21.83	6.15	3.06	0.30	0.24	1.20	1.10	73.70	1.00	3.00	1.00	260.00	2.00	370.00	1.00	1.22	0.00	0.07	0.12	0.01	0.20	1.90	0.08	0.05	1.00
Maximum	60.18	6.74	3.67	0.66	0.83	2.10	2.10	310.00	3.00	7.00	3.00	410.00	10.00	500.00	55.40	1.88	0.00	0.12	0.28	0.03	3.56	13.30	1.25	0.19	1.00
More than 70% >LOD	yes	yes	yes	no	no	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	11.50	0.16	0.17	0.13	0.18	0.32	0.31	83.67	0.67	1.24	0.72	42.92	3.05	41.63	13.88	0.22	0.00	0.03	0.07	0.01	1.64	5.49	0.55	0.06	0.00

Vikedalselva

Date DD.MM.YYYY	Qs [m3/s]	pH []	KOND [mS/m]	TURB860 [FNU]	SPM [mg/l]	TOC [mgC/l]	DOC [mgC/l]	Part. C [µgC/l]	PO4-P [µgP/l]	TOTP [µgP/l]	TDP [µgP/l]	NO3-N [µgN/l]	NH4-N [µgN/l]	TOTN [µgN/l]	Tot. Part. N [µgN/l]	SiO2 [mgSiO2/l]	Ag [µg/l]	As [µg/l]	Pb [µg/l]	Cd [µg/l]	Cu [µg/l]	Zn [µg/l]	Ni [µg/l]	Cr [µg/l]	Hg [ng/l]
07.01.2019	8.22	6.43	2.48	0.33	<0.5	1.10	1.10	103.00	<1.0	3.00	2.00	220.00	10.00	430.00	8.54	0.96									
04.02.2019	4.81	6.72	3.47	0.35	<0.67	0.86	0.82	110.00	1.00	4.00	2.00	350.00	9.00	430.00	6.98	1.57	<0.002	0.25	0.07	0.01	0.31	1.80	0.32	0.04	<1.0
04.03.2019	8.30	6.43	2.78	0.44	0.89	1.10	1.00	139.00	2.00	3.00	1.00	200.00	3.00	290.00	10.70	0.85									
01.04.2019	12.03	6.39	2.44	0.38	1.43	1.20	1.10	305.00	2.00	4.00	1.00	180.00	6.00	260.00	25.40	0.95									
06.05.2019	4.70	6.64	2.48	0.33	0.44	0.90	0.81	132.00	<1.0	2.00	1.00	140.00	<2.0	200.00	<1.0	0.86	<0.002	0.14	0.07	0.01	0.25	1.40	0.21	0.04	<1.0
03.06.2019	11.31	6.69	2.32	0.38	0.77	1.60	1.50	239.00	2.00	5.00	<1.0	180.00	4.00	150.00	42.70	0.78									
01.07.2019	6.80	6.69	2.73	5.60	7.27	2.50	2.30	628.00	6.00	21.00	5.00	280.00	53.00	470.00	57.30	0.82									
05.08.2019	5.36	6.75	2.48	<0.3	<0.5	1.60	1.50	159.00	2.00	4.00	<1.0	210.00	<2.0	310.00	10.90	0.91	<0.002	0.32	0.10	0.01	0.40	0.89	0.24	0.04	<1.0
02.09.2019	22.63	6.24	1.79	0.54	0.72	2.00	2.00	225.00	1.00	4.00	2.00	140.00	<2.0	260.00	19.80	0.78									
07.10.2019	5.71	6.48	2.75	0.30	0.95	1.20	1.10	211.00	2.00	3.00	<1.0	210.00	7.00	300.00	23.10	1.19	<0.002	0.34	0.08	0.01	0.41	4.30	0.41	0.04	<1.0
04.11.2019	6.18	6.69	2.87	0.49	1.28	1.20	1.10	274.00	<1.0	3.00	<1.0	190.00	18.00	310.00	22.80	1.36									
02.12.2019	3.58	6.77	3.06	0.32	0.40	1.10	1.10	110.00	1.00	2.00	1.00	280.00	9.00	340.00	13.10	1.45									
Lower avg.	8.30	6.58	2.64	0.79	1.18	1.36	1.29	219.58	1.58	4.83	1.25	215.00	9.92	312.50	20.11	1.04	0.00	0.26	0.08	0.01	0.34	2.10	0.29	0.04	0.00
Upper avg..	8.30	6.58	2.64	0.81	1.32	1.36	1.29	219.58	1.83	4.83	1.58	215.00	10.42	312.50	20.19	1.04	0.00	0.26	0.08	0.01	0.34	2.10	0.29	0.04	1.00
Minimum	3.58	6.24	1.79	0.30	0.40	0.86	0.81	103.00	1.00	2.00	1.00	140.00	2.00	150.00	1.00	0.78	0.00	0.14	0.07	0.01	0.25	0.89	0.21	0.04	1.00
Maximum	22.63	6.77	3.47	5.60	7.27	2.50	2.30	628.00	6.00	21.00	5.00	350.00	53.00	470.00	57.30	1.57	0.00	0.34	0.10	0.01	0.41	4.30	0.41	0.04	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	5.21	0.17	0.42	1.51	1.90	0.48	0.46	145.54	1.40	5.17	1.16	61.27	14.19	94.59	16.04	0.28	0.00	0.09	0.01	0.00	0.08	1.51	0.09	0.00	0.00

Nausta

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	30.44	6.10	1.74	<0.3	1.04	1.30	1.30	143.00	<1.0	3.00	2.00	100.00	3.00	150.00	11.40	1.23									
05.02.2019	10.04	6.40	2.13	0.46	<0.67	1.10	1.00	63.50	1.00	3.00	2.00	160.00	<2.0	220.00	<1.0	2.23	<0.002	<0.025	0.02	0.00	0.17	1.10	0.11	0.03	<1.0
04.03.2019	18.41	6.48	2.12	0.58	<0.5	1.60	1.60	93.80	1.00	2.00	2.00	93.00	<2.0	170.00	5.81	1.44									
03.04.2019	23.23	6.35	2.05	0.36	<0.3	1.20	1.10	129.00	1.00	3.00	<1.0	110.00	<2.0	150.00	<1.0	1.20									
13.05.2019	13.24	6.48	1.74	0.47	0.36	1.30	1.20	86.30	2.00	2.00	<1.0	50.00	7.00	98.00	<1.0	0.85	<0.002	0.04	0.04	0.00	0.14	0.66	<0.04	0.04	<1.0
04.06.2019	22.77	6.23	1.29	0.76	2.51	2.60	2.60	331.00	3.00	8.00	1.00	55.00	<2.0	140.00	24.70	0.90									
01.07.2019	26.04	6.18	1.43	1.30	3.68	4.80	4.70	777.00	18.00	28.00	13.00	180.00	41.00	380.00	66.70	1.04									
29.08.2019	25.33	5.53	1.09	0.73	1.41	5.40	5.10	358.00	4.00	12.00	5.00	5.00	<2.0	180.00	8.85	1.08	<0.002	0.07	0.15	0.01	0.37	1.20	0.16	0.10	<1.0
10.09.2019	19.44	6.44	1.63	<0.3	0.71	2.50	2.50	112.00	2.00	6.00	2.00	110.00	<2.0	210.00	13.80	1.22									
07.10.2019	13.79	6.28	1.52	1.60	4.26	1.50	1.40	293.00	5.00	7.00	2.00	50.00	<2.0	130.00	9.65	1.34	<0.002	0.06	0.10	0.00	0.24	1.10	0.13	0.09	1.00
05.11.2019	12.15	6.56	2.18	<0.3	0.52	1.60	1.60	88.30	2.00	5.00	2.00	180.00	2.00	280.00	<1.0	1.99									
09.12.2019	37.82	6.02	1.83	<0.3	<0.5	2.50	2.50	127.00	2.00	5.00	3.00	110.00	3.00	240.00	11.30	1.82									
Lower avg.	21.06	6.25	1.73	0.52	1.21	2.28	2.22	216.83	3.42	7.00	2.83	100.25	4.67	195.67	12.68	1.36	0.00	0.04	0.08	0.00	0.23	1.02	0.10	0.06	0.25
Upper avg..	21.06	6.25	1.73	0.62	1.37	2.28	2.22	216.83	3.50	7.00	3.00	100.25	5.83	195.67	13.02	1.36	0.00	0.05	0.08	0.00	0.23	1.02	0.11	0.06	1.00
Minimum	10.04	5.53	1.09	0.30	0.30	1.10	1.00	63.50	1.00	2.00	1.00	5.00	2.00	98.00	1.00	0.85	0.00	0.03	0.02	0.00	0.14	0.66	0.04	0.03	1.00
Maximum	37.82	6.56	2.18	1.60	4.26	5.40	5.10	777.00	18.00	28.00	13.00	180.00	41.00	380.00	66.70	2.23	0.00	0.07	0.15	0.01	0.37	1.20	0.16	0.10	1.00
More than 70% >LOD	yes	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	8.22	0.28	0.35	0.42	1.36	1.42	1.38	203.82	4.74	7.22	3.33	54.60	11.17	77.39	18.30	0.44	0.00	0.02	0.06	0.00	0.10	0.24	0.05	0.03	0.00

Driva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	127.45	7.03	4.22	0.40	0.77	2.10	2.10	117.00	2.00	4.00	4.00	300.00	<2.0	370.00	9.38	3.43									
08.02.2019	32.72	7.05	3.66	<0.3	<1.0	0.95	0.97	56.40	<1.0	2.00	<1.0	170.00	<2.0	230.00	<1.0	2.96	<0.002	0.04	0.01	<0.003	0.44	0.17	0.15	0.10	<1.0
03.03.2019	102.09	7.17	4.74	0.73	<0.65	1.40	1.30	67.30	1.00	2.00	2.00	230.00	<2.0	330.00	5.37	3.36									
01.04.2019	90.88	7.14	4.25	0.50	1.25	1.70	1.50	156.00	2.00	4.00	1.00	190.00	<2.0	280.00	15.80	2.96									
06.05.2019	142.43	7.24	4.12	0.61	1.71	1.60	1.50	89.90	<1.0	3.00	1.00	150.00	<2.0	230.00	11.20	3.02	<0.002	0.03	0.01	<0.003	0.81	2.40	0.20	0.12	2.00
03.06.2019	120.67	7.13	3.62	<0.3	0.60	1.20	1.10	63.50	1.00	1.00	<1.0	110.00	<2.0	170.00	5.35	3.13									
01.07.2019	103.87	7.13	2.18	0.48	1.96	0.76	0.69	118.00	2.00	3.00	1.00	37.00	<2.0	73.00	6.03	2.03									
05.08.2019	56.35	7.23	3.58	<0.3	<0.33	0.64	0.65	77.50	1.00	2.00	<1.0	77.00	<2.0	120.00	4.06	2.49	<0.002	0.04	0.01	<0.003	0.39	0.18	0.11	0.10	<1.0
02.09.2019	52.59	7.15	3.35	<0.3	<0.4	0.90	0.80	68.50	<1.0	2.00	3.00	58.00	<2.0	100.00	<1.0	2.74									
02.10.2019	130.94	7.02	3.21	<0.3	0.60	1.10	1.10	116.00	1.00	2.00	<1.0	110.00	3.00	190.00	15.50	2.89	<0.002	0.03	0.02	<0.003	0.60	0.37	0.17	0.15	2.00
04.11.2019	49.57	7.28	5.28	<0.3	0.42	1.20	1.20	121.00	<1.0	2.00	<1.0	250.00	7.00	350.00	16.20	4.18									
02.12.2019	33.31	7.15	5.14	<0.3	<0.26	0.76	0.78	56.70	2.00	5.00	2.00	290.00	4.00	340.00	<1.0	5.42									
Lower avg.	86.91	7.14	3.95	0.23	0.61	1.19	1.14	92.32	1.00	2.67	1.17	164.33	1.17	231.92	7.41	3.22	0.00	0.04	0.01	0.00	0.56	0.78	0.16	0.12	1.00
Upper avg..	86.91	7.14	3.95	0.40	0.83	1.19	1.14	92.32	1.33	2.67	1.58	164.33	2.67	231.92	7.66	3.22	0.00	0.04	0.01	0.00	0.56	0.78	0.16	0.12	1.50
Minimum	32.72	7.02	2.18	0.30	0.26	0.64	0.65	56.40	1.00	1.00	1.00	37.00	2.00	73.00	1.00	2.03	0.00	0.03	0.01	0.00	0.39	0.17	0.11	0.10	1.00
Maximum	142.43	7.28	5.28	0.73	1.96	2.10	2.10	156.00	2.00	5.00	4.00	300.00	7.00	370.00	16.20	5.42	0.00	0.04	0.02	0.00	0.81	2.40	0.20	0.15	2.00
More than 70% >LOD	yes	yes	yes	no	no	yes	yes	yes	no	yes	no	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	40.06	0.08	0.87	0.15	0.55	0.44	0.42	32.36	0.49	1.15	1.00	89.34	1.50	103.31	5.84	0.87	0.00	0.00	0.00	0.00	0.19	1.08	0.04	0.02	0.58

Nidelva (Tr.heim)

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	162.39	7.16	4.03	2.90	3.23	3.30	3.30	131.00	3.00	6.00	3.00	160.00	6.00	250.00	8.49	2.31									
06.02.2019	39.30	7.14	3.20	0.76	1.19	2.40	2.40	101.00	2.00	4.00	2.00	87.00	3.00	170.00	4.62	2.01	<0.002	0.08	0.03	<0.003	0.61	1.50	0.71	0.19	<1.0
04.03.2019	69.45	7.23	3.86	0.96	0.83	2.60	2.60	79.40	2.00	3.00	1.00	110.00	<2.0	210.00	<1.0	2.10									
01.04.2019	68.36	7.19	3.90	1.30	1.55	2.70	2.60	140.00	3.00	4.00	<1.0	120.00	<2.0	210.00	13.50	2.16									
13.05.2019	134.00	7.12	3.42	1.10	1.22	2.50	2.50	105.00	2.00	3.00	2.00	110.00	2.00	170.00	<1.0	1.98	<0.002	0.08	0.03	<0.003	0.60	0.49	0.60	0.19	<1.0
03.06.2019	175.04	7.20	3.23	0.30	0.85	2.50	2.50	113.00	1.00	3.00	1.00	87.00	<2.0	160.00	15.20	2.01									
01.07.2019	115.92	7.32	3.88	4.40	5.39	3.10	3.10	190.00	6.00	9.00	4.00	110.00	2.00	230.00	<1.0	2.10									
05.08.2019	34.28	7.33	3.38	0.37	<0.5	2.50	2.50	119.00	2.00	3.00	<1.0	50.00	3.00	130.00	11.30	1.72	<0.002	0.10	0.03	<0.003	0.67	0.54	0.64	0.16	<1.0
02.09.2019	54.48	7.20	3.23	0.41	0.69	2.60	2.60	142.00	<1.0	3.00	3.00	50.00	3.00	140.00	19.50	1.61									
02.10.2019	79.26	7.23	3.62	2.80	3.84	3.00	3.00	200.00	4.00	5.00	1.00	79.00	7.00	190.00	15.50	2.27	<0.002	0.12	0.07	0.00	0.92	1.10	1.02	0.52	<1.0
04.11.2019	48.86	7.07	3.20	0.34	0.59	2.70	2.70	70.90	<1.0	3.00	<1.0	77.00	8.00	160.00	7.58	1.96									
02.12.2019	31.04	7.11	3.27	0.33	1.07	2.70	2.70	58.20	2.00	3.00	<1.0	92.00	12.00	170.00	23.30	1.91									
Lower avg.	84.36	7.19	3.52	1.33	1.70	2.72	2.71	120.79	2.25	4.08	1.42	94.33	3.83	182.50	9.92	2.01	0.00	0.10	0.04	0.00	0.70	0.91	0.74	0.27	0.00
Upper avg..	84.36	7.19	3.52	1.33	1.75	2.72	2.71	120.79	2.42	4.08	1.75	94.33	4.33	182.50	10.17	2.01	0.00	0.10	0.04	0.00	0.70	0.91	0.74	0.27	1.00
Minimum	31.04	7.07	3.20	0.30	0.50	2.40	2.40	58.20	1.00	3.00	1.00	50.00	2.00	130.00	1.00	1.61	0.00	0.08	0.03	0.00	0.60	0.49	0.60	0.16	1.00
Maximum	175.04	7.33	4.03	4.40	5.39	3.30	3.30	200.00	6.00	9.00	4.00	160.00	12.00	250.00	23.30	2.31	0.00	0.12	0.07	0.00	0.92	1.50	1.02	0.52	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	50.28	0.08	0.32	1.33	1.55	0.28	0.28	43.50	1.44	1.83	1.06	30.58	3.23	36.21	7.50	0.20	0.00	0.02	0.02	0.00	0.15	0.48	0.19	0.17	0.00

Målselva v/gml E6-brua

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	81.83	7.51	7.52	0.72	1.50	1.40	1.30	465.00	<1.0	5.00	2.00	98.00	42.00	290.00	76.50	2.57									
04.02.2019	47.70	7.57	8.08	4.10	3.44	0.94	1.00	101.00	4.00	5.00	2.00	78.00	6.00	140.00	6.74	2.66	<0.002	0.06	0.09	<0.003	0.69	0.93	0.48	0.22	<1.0
04.03.2019	120.56	7.54	9.19	0.89	1.14	1.70	1.60	213.00	1.00	5.00	2.00	130.00	3.00	240.00	19.00	3.00									
01.04.2019	76.17	7.52	8.12	0.70	0.90	1.20	1.10	160.00	2.00	5.00	2.00	240.00	2.00	240.00	20.70	2.61									
10.05.2019	152.98	7.59	8.72	3.20	4.91	1.60	1.50	140.00	6.00	7.00	<1.0	110.00	<2.0	200.00	<1.0	2.89	<0.002	0.06	0.09	<0.003	0.67	0.72	0.53	0.27	<1.0
03.06.2019	424.73	7.46	6.90	1.50	2.48	1.20	1.20	104.00	3.00	4.00	<1.0	55.00	<2.0	120.00	12.50	2.25									
01.07.2019	406.79	7.73	7.19	0.84	2.48	1.10	1.10	87.20	3.00	3.00	1.00	39.00	<2.0	91.00	9.41	2.06									
05.08.2019	172.37	7.13	6.85	0.74	1.53	0.64	0.62	80.20	2.00	2.00	<1.0	27.00	<2.0	73.00	<1.0	1.86	<0.002	0.04	0.04	<0.003	0.42	0.30	0.36	0.12	<1.0
02.09.2019	149.53	7.70	8.29	0.60	0.86	0.80	0.70	90.40	<1.0	3.00	2.00	25.00	<2.0	60.00	7.20	1.90									
07.10.2019	94.79	7.48	7.15	0.65	1.91	0.97	0.95	94.20	2.00	2.00	<1.0	30.00	4.00	75.00	<1.0	2.23	<0.002	0.03	0.04	<0.003	0.44	0.50	0.52	0.12	<1.0
04.11.2019	52.41	7.59	7.81	0.66	2.81	1.00	0.90	139.00	3.00	3.00	<1.0	63.00	16.00	150.00	15.90	2.44									
09.12.2019	58.38	7.49	7.20	<0.3	0.76	1.10	1.10	150.00	<1.0	3.00	<1.0	62.00	11.00	120.00	14.80	2.49									
Lower avg.	153.19	7.53	7.75	1.22	2.06	1.14	1.09	152.00	2.17	3.92	0.92	79.75	7.00	149.92	15.23	2.41	0.00	0.05	0.06	0.00	0.55	0.61	0.47	0.18	0.00
Upper avg..	153.19	7.53	7.75	1.24	2.06	1.14	1.09	152.00	2.42	3.92	1.42	79.75	7.83	149.92	15.48	2.41	0.00	0.05	0.06	0.00	0.55	0.61	0.47	0.18	1.00
Minimum	47.70	7.13	6.85	0.30	0.76	0.64	0.62	80.20	1.00	2.00	1.00	25.00	2.00	60.00	1.00	1.86	0.00	0.03	0.04	0.00	0.42	0.30	0.36	0.12	1.00
Maximum	424.73	7.73	9.19	4.10	4.91	1.70	1.60	465.00	6.00	7.00	2.00	240.00	42.00	290.00	76.50	3.00	0.00	0.06	0.09	0.00	0.69	0.93	0.53	0.27	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	129.41	0.15	0.75	1.17	1.24	0.31	0.29	105.94	1.51	1.51	0.51	60.74	11.64	75.88	20.41	0.37	0.00	0.02	0.03	0.00	0.14	0.27	0.08	0.08	0.00

Tanaelva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	84.62	7.26	7.03	0.48	0.45	1.90	1.80	107.00	2.00	6.00	3.00	94.00	11.00	170.00	12.70	9.79									
04.02.2019	66.31	7.41	7.35	0.57	1.63	1.80	1.70	111.00	5.00	6.00	6.00	69.00	<2.0	130.00	1.00	10.54	<0.002	0.10	0.03	0.01	0.35	0.43	0.27	0.28	<1.0
04.03.2019	73.21	7.20	7.45	0.39	<0.33	1.50	1.50	106.00	5.00	5.00	7.00	35.00	<2.0	170.00	<1.0	10.05									
01.04.2019	66.28	7.19	8.20	0.57	1.67	1.40	1.50	368.00	10.00	17.00	10.00	90.00	<2.0	220.00	31.20	10.35									
06.05.2019	317.72	7.00	3.69	2.20	3.82	4.60	4.30	373.00	2.00	11.00	3.00	34.00	4.00	140.00	40.40	5.68	<0.002	0.05	0.07	0.00	0.99	8.90	1.54	0.66	<1.0
03.06.2019	925.93	7.09	2.78	0.80	2.23	4.20	4.20	294.00	2.00	11.00	4.00	6.00	<2.0	110.00	<1.0	4.52									
01.07.2019	446.30	7.30	4.04	<0.3	1.52	3.50	3.50	232.00	3.00	6.00	3.00	6.00	11.00	100.00	12.40	5.12									
05.08.2019	135.86	7.43	6.15	<0.3	0.41	1.70	1.70	66.80	2.00	4.00	1.00	13.00	<2.0	85.00	<1.0	6.02	<0.002	0.07	0.03	0.00	0.53	0.48	0.29	0.22	<1.0
02.09.2019	195.70	7.34	5.48	0.40	1.18	2.60	2.60	273.00	2.00	8.00	2.00	2.00	5.00	91.00	40.30	5.70									
30.09.2019	180.25	7.27	5.07	<0.3	0.57	2.70	2.60	172.00	2.00	4.00	1.00	17.00	6.00	110.00	15.60	6.15	<0.002	0.04	0.01	<0.003	0.38	1.00	0.31	0.23	<1.0
04.11.2019	86.85	7.36	5.53	0.59	0.74	2.60	2.60	163.00	<1.0	4.00	2.00	34.00	5.00	130.00	20.20	8.81									
02.12.2019	66.72	7.36	6.58	0.34	<0.33	2.10	2.00	130.00	<1.0	3.00	1.00	67.00	39.00	200.00	20.80	9.15									
Lower avg.	220.48	7.27	5.78	0.53	1.19	2.55	2.50	199.65	2.92	7.08	3.58	38.92	6.75	138.00	16.22	7.66	0.00	0.06	0.04	0.00	0.56	2.70	0.60	0.35	0.00
Upper avg..	220.48	7.27	5.78	0.60	1.24	2.55	2.50	199.65	3.08	7.08	3.58	38.92	7.58	138.00	16.47	7.66	0.00	0.06	0.04	0.00	0.56	2.70	0.60	0.35	1.00
Minimum	66.28	7.00	2.78	0.30	0.33	1.40	1.50	66.80	1.00	3.00	1.00	2.00	2.00	85.00	1.00	4.52	0.00	0.04	0.01	0.00	0.35	0.43	0.27	0.22	1.00
Maximum	925.93	7.43	8.20	2.20	3.82	4.60	4.30	373.00	10.00	17.00	10.00	94.00	39.00	220.00	40.40	10.54	0.00	0.10	0.07	0.01	0.99	8.90	1.54	0.66	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	251.67	0.13	1.67	0.53	1.03	1.05	1.01	105.98	2.54	4.08	2.78	33.14	10.42	43.46	14.71	2.30	0.00	0.02	0.03	0.00	0.30	4.14	0.63	0.21	0.00

Pasvikelva

Date	Qs	pH	KOND	TURB860	SPM	TOC	DOC	Part. C	PO4-P	TOTP	TDP	NO3-N	NH4-N	TOTN	Tot. Part. N	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
DD.MM.YYYY	[m3/s]	[]	[mS/m]	[FNU]	[mg/l]	[mgC/l]	[mgC/l]	[µgC/l]	[µgP/l]	[µgP/l]	[µgP/l]	[µgN/l]	[µgN/l]	[µgN/l]	[µgN/l]	[mgSiO2/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[ng/l]
07.01.2019	68.73	7.17	3.45	<0.3	0.47	3.00	3.00	169.00	<1.0	4.00	2.00	42.00	73.00	180.00	18.00	5.25									
10.02.2019	59.86	6.98	3.23	0.37	<0.38	2.80	2.80	63.70	1.00	12.00	2.00	170.00	<2.0	270.00	<1.0	5.64	0.00	0.07	0.02	0.00	0.94	1.00	1.13	0.13	<1.0
04.03.2019	101.32	7.05	3.44	0.45	1.16	2.70	2.70	400.00	1.00	3.00	2.00	64.00	29.00	260.00	27.30	5.70									
01.04.2019	72.47	7.09	3.41	<0.3	0.48	2.90	2.90	180.00	1.00	4.00	2.00	57.00	<2.0	150.00	15.70	5.91									
05.05.2019	535.56	6.94	2.90	2.70	15.70	2.70	2.40	1396.00	5.00	28.00	5.00	25.00	82.00	170.00	106.00	4.52	0.01	0.28	0.18	0.03	12.00	4.90	16.40	0.36	<1.0
02.06.2019	420.78	7.14	4.65	1.80	4.77	3.90	3.70	650.00	3.00	12.00	5.00	23.00	<2.0	130.00	<1.0	4.95									
01.07.2019	310.38	7.21	3.18	0.31	1.02	3.90	3.90	224.00	4.00	6.00	2.00	<2.0	12.00	110.00	<1.0	4.26									
05.08.2019	122.83	7.20	3.37	0.50	0.92	2.90	2.90	205.00	2.00	4.00	1.00	<2.0	4.00	83.00	<1.0	4.44	<0.002	0.07	0.02	0.00	1.21	0.74	5.10	0.16	<1.0
03.09.2019	109.05	7.19	3.36	0.56	0.91	3.20	3.20	212.00	2.00	4.00	2.00	<2.0	4.00	96.00	<1.0	3.86									
07.10.2019	120.63	7.18	4.07	0.51	0.85	3.20	3.20	193.00	1.00	6.00	2.00	6.00	6.00	110.00	23.00	4.31	0.00	0.14	0.03	0.01	1.71	1.80	14.70	0.16	3.00
04.11.2019	73.93	7.14	3.44	0.39	<0.41	3.20	3.00	259.00	2.00	6.00	<1.0	22.00	4.00	130.00	37.50	5.16									
01.12.2019	56.64	7.22	3.44	<0.3	<0.38	3.20	3.10	146.00	<1.0	3.00	<1.0	32.00	12.00	130.00	16.40	5.51									
Lower avg.	171.02	7.13	3.49	0.63	2.19	3.13	3.07	341.47	1.83	7.67	2.08	36.75	18.83	151.58	20.32	4.96	0.01	0.14	0.07	0.01	3.96	2.11	9.33	0.20	0.75
Upper avg..	171.02	7.13	3.49	0.71	2.29	3.13	3.07	341.47	2.00	7.67	2.25	37.25	19.33	151.58	20.74	4.96	0.01	0.14	0.07	0.01	3.96	2.11	9.33	0.20	1.50
Minimum	56.64	6.94	2.90	0.30	0.38	2.70	2.40	63.70	1.00	3.00	1.00	2.00	2.00	83.00	1.00	3.86	0.00	0.07	0.02	0.00	0.94	0.74	1.13	0.13	1.00
Maximum	535.56	7.22	4.65	2.70	15.70	3.90	3.90	1396.00	5.00	28.00	5.00	170.00	82.00	270.00	106.00	5.91	0.01	0.28	0.18	0.03	12.00	4.90	16.40	0.36	3.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	160.48	0.09	0.45	0.75	4.39	0.41	0.41	364.30	1.35	7.11	1.36	46.78	28.27	59.98	29.54	0.67	0.01	0.10	0.08	0.01	5.37	1.91	7.39	0.11	1.00

6.2 Riverine loads in 2019

River	Estimate	Flow rate	SPM	TOC	PO4-P	TOTP	NO3-N	NH4-N	TOTN	SiO2	Ag	As	Pb	Cd	Cu	Zn	Ni	Cr	Hg
		1000 m3/d	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[kg]
Glomma ved Sarpsfoss	avg.	68724.28	231900.82	120633.42	219.28	505.23	10707.40	223.21	16007.19	93974.33	0.17	4.00	5.92	0.34	42.72	150.61	19.44	6.21	51.56
Alna	avg.	157.44	4841.36	557.96	6.83	8.33	46.57	0.90	77.03	349.32	0.00	0.02	0.04	0.00	0.20	0.62	0.06	0.02	0.08
Drammenselva	avg.	30040.03	16797.21	39925.22	21.98	58.82	3554.80	104.50	5080.43	32190.31	0.01	1.43	0.72	0.09	6.95	19.58	4.74	1.11	31.96
Numedalslågen	avg.	10191.47	16540.46	16477.72	21.40	39.52	1143.44	132.34	1814.00	13477.48	0.03	0.70	1.41	0.07	3.42	18.94	1.42	0.72	8.73
Skienselva	avg.	23520.99	6129.18	22347.84	11.52	31.22	1166.48	89.05	1948.08	18786.42	0.00	0.75	0.36	0.07	4.12	15.67	2.04	0.57	14.61
Otra	avg.	12232.63	4153.88	15583.92	6.08	14.78	331.33	62.22	891.05	7410.25	0.02	0.66	1.12	0.12	2.47	12.32	2.15	0.40	5.37
Orreelva	avg.	470.05	2741.08	1582.42	4.42	14.64	134.27	4.54	294.36	435.79	0.00	0.06	0.07	0.00	0.28	0.59	0.22	0.04	0.47
Vosso (Bolstadelvi)	avg.	6827.16	1977.47	3476.21	2.51	9.45	224.32	5.57	407.18	2569.10	0.01	0.21	0.17	0.01	0.90	1.95	0.71	0.12	3.85
Orkla	avg.	5917.46	2116.51	6892.11	2.35	8.67	456.02	6.21	723.95	6328.97	0.00	0.25	0.04	0.09	12.01	25.35	1.66	0.47	2.46
Vefsna	avg.	13823.15	4429.22	7107.55	5.88	17.86	180.85	7.52	446.39	6947.07	0.00	0.50	0.12	0.01	1.47	1.60	1.37	0.32	3.92
Altaelva	avg.	7844.14	12836.29	9656.52	5.68	16.59	81.31	2.84	358.55	12569.73	0.01	0.29	0.03	0.00	1.21	0.38	0.64	0.49	1.54
Bjerkreimselva	avg.	3507.88	634.09	1977.17	1.50	5.20	429.91	6.10	566.94	1935.28	0.00	0.13	0.26	0.03	2.18	9.07	0.80	0.15	0.00
Vikedalselva	avg.	832.40	384.71	455.99	0.53	1.48	59.68	2.63	88.80	291.35	0.00	0.08	0.02	0.00	0.11	0.73	0.09	0.01	0.00
Nausta	avg.	1863.29	919.65	1815.40	3.01	5.87	68.83	5.09	143.98	911.89	0.00	0.03	0.06	0.00	0.17	0.70	0.08	0.05	0.30
Driva	avg.	7282.59	2369.66	3377.20	3.32	7.06	415.01	3.50	600.69	8227.34	0.00	0.09	0.03	0.00	1.70	2.83	0.46	0.34	4.54
Nidelva (Tr.heim)	avg.	7588.16	5712.60	7642.28	7.22	12.21	282.18	10.17	525.36	5692.27	0.00	0.27	0.13	0.00	1.99	2.30	2.11	0.84	0.00
Målselva v/gml E6-brua	avg.	15100.26	12136.52	6222.93	14.36	20.53	358.34	20.45	702.83	12621.10	0.00	0.26	0.32	0.00	2.94	3.04	2.59	0.99	0.00
Tanaelva	avg.	20199.89	13053.15	24965.88	18.10	60.83	147.89	41.59	881.89	43729.35	0.00	0.40	0.32	0.03	4.92	31.97	6.21	3.10	0.00
Pasvikelva	avg.	17903.23	36221.82	21209.53	20.08	82.30	158.25	187.92	931.40	30814.40	0.07	1.39	0.82	0.14	52.28	23.16	89.30	1.85	4.99
Vegårdselva	avg.	1572.04	912.26	3492.02	1.30	3.92	81.32	12.30	192.52	1560.15	0.00	0.16	0.24	0.02	0.41	3.72	0.30	0.12	0.78

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