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The Norwegian river monitoring programme- water quality status and trends 2017

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The Norwegian river monitoring programme – water quality status and trends 2017

Summary - sammendrag

From 2017, the Norwegian River Monitoring Programme (Elveovervåkingsprogrammet) replaced the former RID programme “Riverine inputs and direct discharges to Norwegian coastal waters” which had run continuously since 1990. The present report provides the current (2017) status and long-term (1990-2017) water quality trends in the 20 rivers included in the main programme.

Elveovervåkingsprogrammet avløste i 2017 det tidligere Elvetilførselsprogrammet (RID – Riverine inputs and direct discharges to Norwegian coastal waters) som har pågått kontinuerlig siden 1990. Denne rapporten gir en oversikt over vannkvalitetsstatus for de 20 elvene i 2017 og langtidsendringer (trender) i elvene som har vært overvåket siden 1990.

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Elver, overvåking, vannkvalitet, trender	Rivers, monitoring, water quality, trends

Front page photo

River Skienselva. Photo: Eskild H. Larsen

Content

Preface

The Norwegian Environment Agency (Miljødirektoratet) has commissioned the Norwegian Institute for Water Research (NIVA), in collaboration with consortium partners, to carry out the monitoring activities within the Norwegian River Monitoring Programme (Elveovervåkings-programmet). Results from the 2017 monitoring activities are presented in three thematic reports, of which this report presents results from the main programme consisting of 20 rivers distributed relatively evenly along the entire coast of Norway.

Besides NIVA, the programme involves the following collaborating partners: Norwegian Institute of Bioeconomy Research (NIBIO), the Norwegian Water Resources and Energy Directorate (NVE), Eurofins Environment Testing Norway AS, and UC Davis Stable Isotopes Facility (UC Davis SIF). Contact persons at The Norwegian Environment Agency has been Eivind Farmen and Malene Vågen Dimmen.

At NIVA, Øyvind Kaste co-ordinated the river monitoring programme in 2017. Other co-workers at NIVA include James Sample (databases, calculation of riverine loads), Cathrine Gundersen and Kari Austnes (interpretation of organic matter data), José-Luis Calidonio (hydrological modelling), Rolf Høgberget (sensor monitoring), Liv Bente Skancke (quality assurance of sampling and chemical analyses), Marit Villø and Trine Olsen (contact persons at NIVAlab).

At NIBIO, Eva Skarbøvik and Inga Greipsland has been the main responsible for the statistical trend analyses. 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. Eurofins has carried out the mercury analyses, whereas UC Davis Stable Isotopes Facility has analysed stable isotopes in nitrate. The sampling has been performed by our corps of local and highly conscientious fieldworkers.

Quality assurance of the report has been carried out by Kari Austnes, NIVA.

Summary

The programme

From 2017, the Norwegian River Monitoring Programme (Elveovervåkingsprogrammet) replaced the former RID programme "Riverine inputs and direct discharges to Norwegian coastal waters" which had run continuously since 1990. The new programme includes monthly monitoring in 20 rivers of which 11 are "main rivers" from the previous programme. New features include higher sampling frequency (monthly at all sites, except for metals), an extended list of chemical variables, and the use of catchment models for simulation of climate effects and contaminant discharges on water quality. The new programme marks a change in direction from mainly being the basis for the fulfillment of Norway's obligations under the Oslo-Paris Convention (OSPAR), to also become a main component of the Norwegian water authorities' surveillance monitoring in rivers, according to the requirements set by the EU Water Framework Directive (WFD). Results from 2017 are presented through three separate reports, of which the present report provides the current (2017) status and long-term (1990-2017) water quality trends in the 20 rivers included in the monitoring programme.

Weather in 2017

The average air temperature was 1.1°C above the 1961-1990 normal for the entire country, and the year was the 20th warmest since the measurements started in 1900. The highest deviation from the temperature normal (around +2°C) was found in the south-eastern parts of the country. Precipitation was 120% of the normal for the country as a whole, and the year was the 6th wettest since 1900. The highest deviation from the precipitation normal (125-175%) was found in the western parts of the country, especially in Rogaland county.

Trends in climate, water temperature and water flow

Trend analyses of air temperature and precipitation 1980-2017 at meteorological stations located in the near vicinity of the river monitoring stations show a significant increase in air temperature at nearly all stations. Only two stations showed a significant trend in precipitation during the same period: Blindern and Alta lufthavn (both had upward trends). The northern Rivers Altaelva and Pasvikelva and River Bjerkreimselva in the south-west have had a significant increase in water temperature over the last 20-25 years. Water flow has increased significantly since 1990 in Rivers Glomma, Drammenselva, Skienselva and Orreelva.

Water quality status 2017

Three rivers had annual mean calcium concentrations below 1 mg/l ("very low Ca concentrations" in the Norwegian WFD typology): Rivers Nausta, Otra and Vosso. Eight rivers had "low Ca concentrations" between 1-4 mg/l, whereas eight rivers (mainly in eastern and northern Norway) had "moderate Ca concentrations" (4-20 mg/l). The urban River Alna can be characterised as "calcareous" (> 20 mg/l) with an annual mean Ca concentration of 33 mg/l.

Rivers Vosso, Målselva, Driva, Vikedalselva, Vefsna, Bjerkreimselva, and Nausta had annual mean concentrations of total organic carbon (TOC) below 2 mg/l, which indicate "very clear waters" according to the Norwegian WFD typology. Eleven sites had TOC concentrations in the range 2-5 mg/l ("clear waters"), whereas two (Rivers Orreelva and Storelva) had annual mean TOC concentrations above 5 mg/l, which indicates "humic waters".

The urban River Alna and the agricultural River Orreelva had much higher total phosphorus (tot-P) concentrations than the other rivers, with annual mean concentrations far higher than the WFD good/moderate boundary for their respective water types. Among the other sites, Rivers Glomma and Numedalslågen had the highest annual mean tot-P concentrations in 2017 with 13 and 17 µg/l, respectively. This was below the WFD good/moderate boundary for both rivers. All the other rivers had tot-P concentrations below 10 µg/l, which is below the WFD good/moderate boundary for their water types. In the other end, Rivers Otra, Vosso, Nausta, Driva, Orkla, Nidelva and Vefsna had annual mean tot-P concentrations below 5 µg/l in 2017. Rivers Alna and Orreelva had the highest annual mean total nitrogen (tot-N) concentrations, around 1600 and 1400 µg/l, respectively. This was far beyond the WFD good/moderate boundary for their respective water types. Rivers in south-west Norway (Rivers Bjerkreimselva and Vikedalselva) that receives the highest amount of atmospheric N deposition in Norway also had relatively high tot-N values. In River Bjerkreim, the annual mean value was slightly above the WFD good/moderate boundary.

Samples analysed for metals in the main programme are unfiltered, which means that the results cannot be assessed directly against the WFD environmental quality standards for priority substances and river basin-specific pollutants in freshwater, which are based on dissolved concentrations (i.e., filtered samples). Metal concentrations will usually be higher in unfiltered samples. It implies that it is possible to state if annual mean concentrations are below – but not over - the threshold concentrations. Based on mean concentrations in the individual rivers in 2017, there was no exceedances of the threshold concentrations for arsenic, cadmium, copper, chromium and mercury.

River Alna had the highest annual concentrations of arsenic (0.48 µg/l), lead (1.9 µg/l), cadmium (0.07 µg/l), copper (6.0 µg/l), zinc (24.7 µg/l), chromium (1.2 µg/l) and mercury (1.75 ng/l). River Pasvikelva had clearly the highest nickel concentrations, with an annual mean of 6.9 µg/l. The contamination of nickel and copper in Pasvik is due to heavy influence from the Norilsk nickel plant, which is located a few kilometres away on the Russian side of the border. River Orkla also had elevated concentrations of e.g. copper (5.5 µg/l), zinc and cadmium. Here, the main source is runoff from mine tailings from the now abandoned copper mine Løkken Verk. River Storelva had surprisingly high values for e.g. arsenic, lead and cadmium, despite its sparsely populated and forest-dominated catchment. Heavy road traffic along the lower parts of the river and former mining activities within the catchment can be possible explanations. The annual mean zinc concentration in Glomma in 2017 was reduced to a more “normal” level (1.7 µg/l) compared to the last preceding years when the zinc concentrations suddenly increased without an obvious reason.

Trends in nutrients and metals

Statistical trend analyses were performed for two time periods: 1990-2017 and 2004-2017. Long-term trends show that water discharge has increased significantly in Rivers Glomma, Drammenselva, Skienselva and Orreelva. Most of these rivers also had increases in the loads of total organic carbon, total nitrogen and silicate. Phosphorus loads have increased significantly in Rivers Drammenselva and Numedalslågen. In River Vefsna, however, the loads of nitrogen and phosphorus have decreased significantly over the same period. Opposite trends for loads of inorganic nitrogen (nitrate and ammonium) and total nitrogen in many of the Skagerrak rivers, indicate that the fraction of organic nitrogen in river runoff is increasing.

In the rivers that were monitored quarterly before 2017, the trend tests were made only for 2004-2017 and for concentrations only. The concentrations of ammonium have decreased significantly in five rivers in the period 2004-2017. Rivers Bjerkreimselva and Vosso have statistically significant upward trends in concentrations of TOC, while Rivers Målselva and Pasvikelva have statistically significant upwards trends in the concentrations of silicate.

Metal loads and concentrations show mainly downward trends in all Norwegian rivers (1990-2017), but analyses of the short-term period (2004-2017) reveal statistically significant upward trends in zinc concentrations in River Glomma and nickel concentrations in River Altaelva.

Quality of dissolved organic matter
The quantity and quality of dissolved organic matter (DOM) can have large impacts on various catchment processes (e.g. transport of contaminants). Regional differences in DOM was found to be largest between rivers in the Skagerrak region (south-east) and the North Sea region (west) which is likely driven by differences in primary production and in precipitation patterns. On the other hand, seasonal variation in DOM displayed little regional dependence.

Overall, DOM levels were found to peak with the onset of hydrological events of spring snow melt and autumn intensive precipitation, both leading to flushing of the forest floor. With regards to DOM quality parameters, seasonal variation was hypothesized to be a result of changes in the dominating source of DOM; in spring, fresh organic matter becomes available for transport to the river (less aromatic and smaller size), while during summer and early autumn the organic matter is subject to more extensive humification (more aromatic and larger size) before reaching the river.

Variation in DOM along the river flow path was not generally detectable, except for River Vorma/Glomma, where River Vorma showed quite different characteristics compared to the larger River Glomma. More years of data may make it easier to disentangle the differences between the sampling sites.

Stable N- and O-isotopes in nitrate
Analysis of stable nitrogen and oxygen isotope ratios ($d^{15}N$ and $d^{18}O$) in nitrate (NO_3) can be a suitable tool for tracing sources for nitrate in surface water. To test the method in a Norwegian river, a one-day sampling campaign was carried out at three stations in River Alna. There were relatively small differences in the isotopic signatures between the stations, but the signals indicate that nitrate in the river might origin from soil N and septic waste. This is reasonable when knowing that the source areas are dominated by forest and the river is heavily affected by urban runoff as it discharges through the city of Oslo. Slightly higher $d^{15}N$ values at the stations closest to the outlet suggests an increasing influence of urban wastewater downstream the river. However, with the small number of samples and the small differences in the isotopic signatures, results should be interpreted with caution.

Sensor data from River Storelva
To study short-term effects of climate variability on water chemistry, high-frequency data are collected at the Storelva sensor station, which is located at the same site as the manual sampling site. The station is equipped with sensors that measure water temperature, pH, conductivity and turbidity. Data are recorded on an hourly basis, transferred to NIVA's server

and made available online at www.aquamonitor.no. Water flow data are obtained from the Norwegian Water Resources and Energy Directorates station, which is located right across the river from NIVA's station. The year 2017 was characterized by several floods, of which two floods that occurred in October were quite large, with water flows exceeding 100 and 130 m^3/s, respectively. The latter flow peak corresponded to a "10-year flood event". The sensor data nicely demonstrates the effects of flood events on water chemistry parameters, where especially conductivity and turbidity are highly responsive to increases in the water flow. Both parameters can therefore be interesting proxies for solute and particle-related export from rivers during flood events.

Samples from the 2017 autumn flood

In October 2017, the south-eastern part of the country was hit by two large flood events. During the last flood, a sampling campaign was carried out in selected rivers along the coast from Skien in the east to Åna Sira in the west, of which data from rivers that are part of the current monitoring programme (Rivers Skienselva, Storelva and Otra) are shown in this report. The most pronounced effects were on conductivity, suspended particulate matter, total organic carbon, phosphate and total phosphorus. Compared with the mean water chemistry in 2017, there were no dramatic changes in element concentrations, but when counting in the large water volumes, the element exports from river to fjords will be substantial during such flood events.

Sammendrag

Om programmet

Elveovervåkingsprogrammet avløste i 2017 det tidligere Elvetilførselsprogrammet (RID – Riverine inputs and direct discharges to Norwegian coastal waters) som har pågått kontinuerlig siden 1990. Det nye programmet inkluderer 20 elver, hvorav 11 er tidligere hovedelver fra RID-programmet. Nye elementer i Elveovervåkingsprogrammet er månedlig prøvetakingsfrekvens i alle elver (unntatt for metaller som analyseres 4 ganger per år), flere analysevariabler og et en tar i bruk nytt modelleringsverktøy for å simulere effekter av klimaendringer og utslipp av miljøgifter på vannkvaliteten i elvene. Det nye programmet markerer også en retningsendring fra å primært være en basis for oppfyllelse av Norges forpliktelser i forhold til Oslo-Paris konvensjonen (OSPAR), til også å bli en viktig del av norske myndigheters basisovervåking i henhold til vannforskriften. Resultatene fra det nye programmet blir formidlet i form at tre separate rapporter, hvorav den foreliggende rapporten gir en oversikt over vannkvalitetsstatus for de 20 elvene i 2017 og langtidsendringer (trender) i elvene som har vært overvåket siden 1990.

Værforholdene i 2017

Temperaturen for hele landet var i gjennomsnitt 1,1 °C over normalen, og året var dermed det 20. varmeste siden målingene startet i 1900. Det høyeste avviket fra temperaturnormalen (rundt +2ºC) ble målt i de sørøstlige delene av landet. Samlet nedbør for hele landet var 120 % av normalen, og året var dermed det 6. våteste som er registrert siden målingene startet i 1900. Det største avviket fra nedbørnormalen (125-175%) forekom i de vestre delene av landet, spesielt i Rogaland.

Trender i klima, vanntemperatur og vannføring

Trendanalyser for lufttemperatur og nedbør i perioden 1980-2017, på meteorologiske målestasjoner lokalisert i nærheten av prøvetakingspunktene i elvene, viser en signifikant økning i lufttemperatur på nesten alle stasjoner. Bare to met.no stasjoner viste en signifikant trend i nedbør innenfor den samme perioden; Blindern og Alta lufthavn, som begge hadde økende trender. Altaelva og Pasvikelva i Finnmark, samt Bjerkreimselva i Rogaland viste en signifikant økning i vanntemperatur i løpet av de siste 20-25 år. Flere elver i Sør-Norge hadde en signifikant økning i vannføring; Glomma, Drammenselva, Skienselva og Orreelva.

Vannkvalitetsstatus 2017

Tre elver hadde middelkonsentrasjoner av kalsium som lå under 1 mg/l, noe som tilsvarer «svært kalkfattig» i typologien under Vannforskriften: Nausta, Otra og Vosso. I alt 8 elver kunne karakteriseres som «kalkfattige» (Ca 1-4 mg/l), mens ytterligere 8 elver kunne karakteriseres som «moderat kalkrike» (Ca 4-20 mg/l). Alna hadde en middelkonsentrasjon av kalsium på hele 33 mg/l, og kunne dermed karakteriseres som «kalkrik» (Ca >20 mg/l).

Når det gjelder humusinnhold, målt som totalt organisk karbon (TOC), hadde sju elver en årlig middelkonsentrasjon under 2 mg/l, noe som indikerer «svært klart vann» i norsk typologi for elver. Disse var: Vosso, Målselva, Driva, Vikedalselva, Vefsna, Bjerkreimselva og Nausta. Elleve elver hadde middelkonsentrasjoner i området 2-5 mg/l, noe som tilsvarer vanntypen «klar», mens to elver (Orreelva og Storelva) hadde midlere TOC-konsentrasjon over 5 mg/l og falt innenfor vanntypen «humøs».

Den urbane elva Alna og den landbrukspåvirkede elva Orreelva hadde mye høyere konsentrasjoner av totalt fosfor (tot-P) enn den andre elvene, med middelkonsentrasjoner som lå langt over vannforskriftens god/moderat-grense for vanntypene de tilhører. Blant de øvrige elvene hadde Glomma og Numedalslågen de høyeste middelkonsentrasjonene av tot-P, med hhv. 13 og 17 µg/l. Verdiene lå imidlertid under god/moderat-grensen for begge elvene. Alle de andre elvene hadde tot-P konsentrasjoner under 10 µg/l i snitt for 2017, noe som er under vannforskriftens god/moderat-grense for vanntypene de tilhører. Blant disse hadde Otra, Vosso, Nausta, Driva, Orkla, Nidelva og Vefsna de laveste middelkonsentrasjonene med under 5 µg/l.

Alna og Orreleva hadde også de høyeste konsentrasjonene av totalt nitrogen (tot-N) med hhv. 1608 og 1408 µg/l. Dette er langt over vannforskriftens god/moderat-grense for vanntypene de tilhører. Bjerkreimselva og Vikedalselva hadde også relativt høye konsentrasjoner av tot-N, og noe av forklaring til dette kan være at de ligger i den delen av landet som har det høyeste nedfallet av nitrogen fra langtransporterte luftforurensninger. For Bjerkreim lå den årlige middelverdien av tot-N rett over god/moderat-grensen.

Alle metallanalysene i grunnprogrammet er analysert på ufiltrerte prøver, mens Vannforskriftens grenseverdier for prioriterte og vannregionspesifikke stoffer er basert på løste konsentrasjoner i vann (dvs. filtrerte prøver). Metallkonsentrasjonen vil i de fleste tilfeller være høyere i ufiltrerte prøver. Det betyr at resultatene ikke kan brukes til klassifisering når de ligger over grenseverdiene, men kan derimot brukes til dokumentasjon på om konsentrasjonene ligger under en grenseverdi. Basert på middelverdiene for elvene i 2017 ble det ikke målt overskridelser av grenseverdiene for arsen, kadmium, kobber, krom og kvikksølv.

Alna var den av overvåkingselvene som hadde de høyeste middelkonsentrasjonene av arsen (0,48 µg/l), bly (1,9 µg/l), kadmium (0,07 µg/l), kobber (6,0 µg/l), sink (24,7 µg/l), krom (1,2 µg/l) og kvikksølv (1,75 ng/l). Pasvikelva hadde de klart høyeste konsentrasjonene av nikkel, med 6,9 µg/l. De forhøyede konsentrasjonene av både nikkel og kobber i Pasvikelva skyldes i stor grad forurensing fra smelteverket i Nikel, som ligger rett over grensen til Russland. Orkla hadde forhøyede konsentrasjoner av kobber (5,5 µg/l) samt også sink og kadmium. Her er hovedkilden avrenning fra den nedlagte kobbergruven ved Løkken Verk. Storelva i Aust-Agder hadde overraskende høye verdier av både arsen, bly og kadmium, på tross av at nedbørfeltet har relativt lite menneskelig aktivitet og stort sett er dominert av skog. Mulige påvirkninger kan være veitrafikk (E18) langs de nedre delene av elva og tidligere industriaktivitet (gruver og jernverk). Middelkonsentrasjonen av sink i Glomma sank i 2017 til et mer «normalt» nivå (1,7 µg/l) etter at verdiene for noen år siden plutselig økte uten at årsaken ble funnet.

Trender i næringssalter og metaller

De statistiske trendanalysene ble gjennomført for to tidsperioder: 1990-2017 (langtidstrender) og 2004-2017 (korttidstrender). Langtidstrendene viser at det har vært en signifikant økning i vannføringen i Glomma, Drammenselva, Skienselva og Orreelva. De fleste av disse elvene viste også en signifikant økning i transporten av totalt organisk karbon, totalt nitrogen og silikat. Det ble også registrert en signifikant økning i transporten av totalt fosfor i Drammenselva og Numedalslågen. I Vefsna er transporten av fosfor og nitrogen derimot signifikant redusert i løpet av den samme tidsperioden.

I elver som kun har kvartalsvise data før 2017 er trendanalysene kun gjennomført på konsentrasjoner og for perioden 2004-2017. I løpet av denne perioden viser Bjerkreimselva og Vosso en statistisk signifikant økning i TOC-konsentrasjoner, mens Målselva og Pasvikelva viste statistisk signifikante økninger i silikat-konsentrasjon.

Kvalitet av løst organisk materiale

Kvantiteten og kvaliteten av løst organisk materiale (DOM) kan ha stor betydning for ulike nedbørfeltprosesser, blant annet transport av miljøgifter. De regionale forskjellene i DOM ble funnet å være størst mellom Skagerrak-elvene i sør-øst til elvene som drenerer mot Nordsjøen i vest. Forholdet skyldes sannsynligvis forskjeller i primærproduksjon og nedbørmønster. Når det gjaldt sesongmessige variasjonsmønstre så regionale forskjeller ut til å spille en mindre rolle.

Generelt sett ble de høyeste DOM-nivåene funnet ved starten av flommer, slik som snøsmeltingsflommen om våren og høstflommer forårsaket av kraftige nedbørepisoder. I disse tilfellene foregår det en kraftig utvasking fra humussjiktet i jorda. Sesongvariasjon i DOM-kvalitet vil primært være styrt av hva som er kilden til det organiske materialet og graden av omdanning før det når elvene. F.eks. vil det om våren være god tilgang på ferskt organisk materiale (mindre aromatisk og mindre molekylstørrelse) som kan transporteres fra jord til vann, mens det organiske materialet som transporteres ut i elvene om sommeren og tidlig på høsten er mer preget av humifisering (mer aromatisk og større molekyler).

I noen av elvene ble det målt DOM kvalitet på inntil tre stasjoner med ulik avstand fra utløpet. Det var generelt lite variasjon i DOM-kvalitet fra stasjon til stasjon nedover langs elvene, med unntak av Glomma, hvor den øverste stasjonen i Vorma (grenen fra Mjøsa) skilte seg tydelig fra stasjonene som lå nedstrøms samløpet mellom Glomma og Vorma. Her vil flere år med data trolig gjøre det enklere å påvise forskjeller mellom de ulike prøvestedene.

Stabile N- og O-isotoper i nitrat

Analyse av stabile nitrogen- og oksygen-isotoper ($d^{15}N$ og $d^{18}O$) i nitrat (NO_3) kan være et egnet verktøy for å spore kilder til nitrat i vann. For å teste metodikken i en norsk elv, ble det tatt prøver for analyse av stabile isotoper på tre stasjoner i Alna. Resultatene viste at det var relativt små forskjeller i isotop-signaturen på de tre stasjonene, men signalene indikerte at hovedandelen av nitratet i vannet stammet dels fra jord/jordvann og dels fra kloakkpåvirkning. Dette virker rimelig da Alna har avrenning fra skogområdene i de øvre delene av nedbørfeltet, men er kraftig påvirket av urban avrenning i de midtre og nedre delene. Alle de tre prøvetakingsstasjonene lå innenfor den urbane delen av nedbørfeltet. Noe høyere $d^{15}N$ konsentrasjoner på stasjonene nærmest utløpet indikerer økt kloakkpåvirkning nedover mot utløpet. Med det lave antallet prøver (fire paralleller fra én stasjon og to paralleller fra de to andre) og relativt små forskjeller i isotop-signal er det imidlertid viktig å understreke at resultatene må tolkes med forsiktighet.

Sensor-overvåking i Storelva

For å studere korttidseffekter av klimavariasjon på vannkjemi er det registrert timesverdier for vanntemperatur, pH, konduktivitet og turbiditet i Storelva. Sensorstasjonen i Storelva har vært i drift siden 2015 og er lokalisert på samme sted som de manuelle prøvene tas i Elveovervåkingsprogrammet. Stasjonen har sensorer for overvåking av vanntemperatur, pH, konduktivitet og turbiditet. Data registreres hver time og overføres til NIVAs datasystemer hvor de gjøres tilgjengelig på nett på www.aquamonitor.no. Vannføring måles på NVEs stasjon

Lundevann, som er lokalisert tvers over elva for NIVAs stasjon. Det var forholdsvis mange flommer i 2017, hvorav to ganske store i oktober da vannføringen nådde henholdsvis 100 og 130 m^3/s. Den siste tilsvarte en såkalt «10-års flom». Sensordataene demonstrerte på en veldig god måte hvordan ulike vannkvalitetsparametere varierer gjennom flommer av ulik størrelse. Blant parameterne som overvåkes viste spesielt konduktiviteten og turbiditeten raske responser på vannføringsendringer. Begge disse parameterne kan være interessante som tilnærminger (proxies) for å beregne stofftransport fra elver under flomepisoder.

Prøver samlet inn under høstflommen på Sørlandet i 2017

Høsten 2017 ble de de sørøstlige delene av landet rammet av to store flommer, den første i begynnelsen av oktober og den andre mot slutten av den samme måneden. Under den andre flomepisoden ble det gjennomført en prøvetakingsrunde i elver fra Skien i øst til Åna Sira i vest. I denne rapporten er det vist resultater fra elvene som inngår i Elveovervåkings-programmet: Skienselva, Storelva og Otra. De største effektene av flommen var klart forhøyede verdier for parameterne konduktivitet, suspenderte partikler, totalt organisk karbon, fosfat og totalt fosfor. Sammenlignet med gjennomsnittsverdiene for hele året 2017, var det ikke snakk om dramatiske endringer i konsentrasjonene av de ulike stoffene, men gitt den store vannføringen i elvene vil stofftranporten i slike flomepisoder være svært stor.

1. Introduction

From 2017, the Norwegian River Monitoring Programme (Elveovervåkingsprogrammet) replaced the former RID programme “Riverine inputs and direct discharges to Norwegian coastal waters” which had run continuously since 1990. In the RID programme 11 “main rivers” were monitored monthly or more often, whereas another 36 rivers were monitored quarterly. Additionally, the programme included 109 rivers that were monitored once a year during the period 1990-2003. The new programme includes monthly monitoring in 20 rivers (Table 1, Figure 1) of which 11 are “main rivers” from the previous programme, 8 originate from the former 36 RID river population, and one (Storelva) originates from the former 109 RID river population). New features include (i) higher sampling frequency (monthly at all sites, except for metals), an extended list of chemical variables (including stable isotopes), and the use of catchment models for simulation of climate effects and contaminant discharges on water quality.

Table 1. Rivers included in the programme

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

* “Main rivers” in the previous RID programme

** Also denoted “Vegårdselva” in the RID database

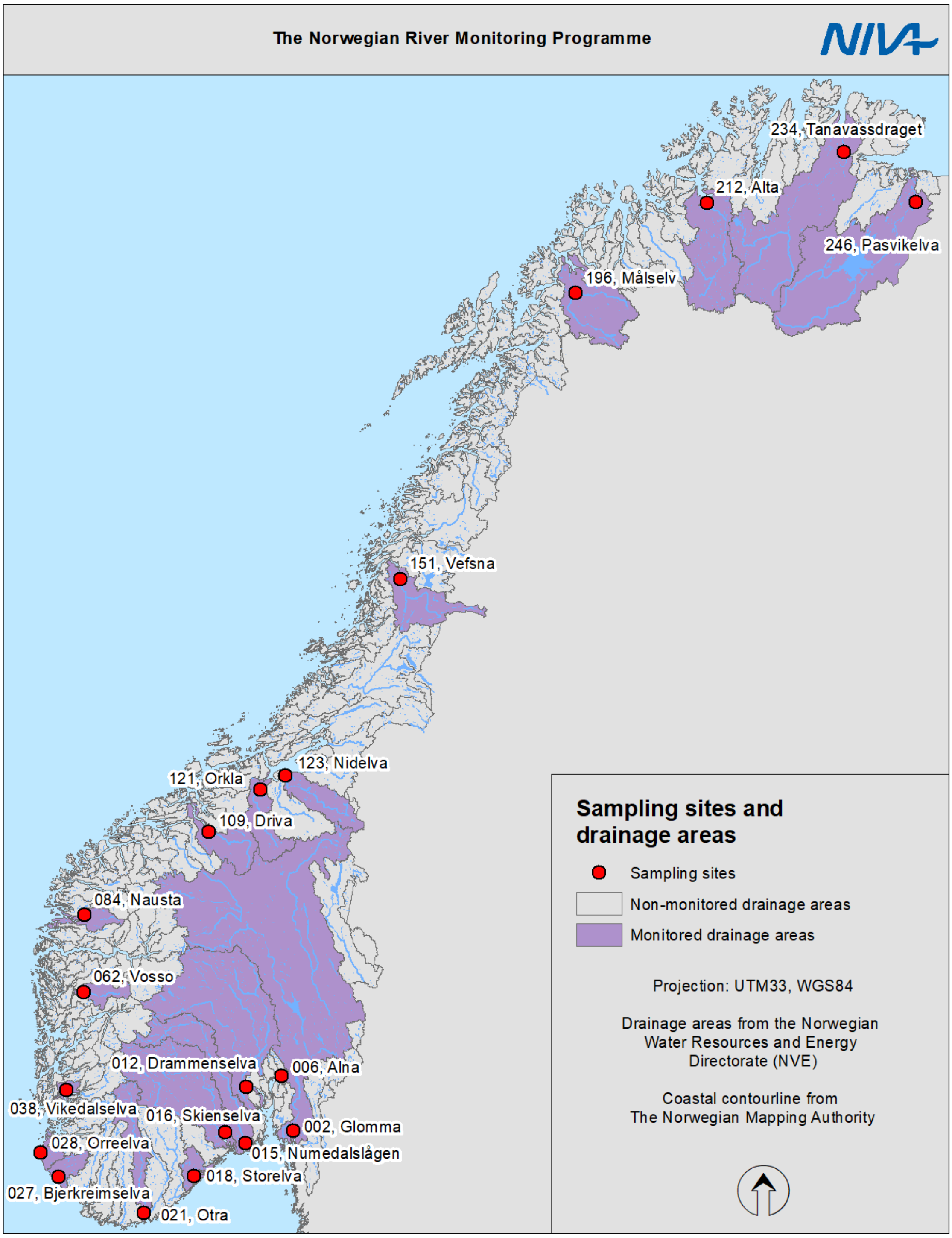


Figure 1. Rivers included in the Norwegian river monitoring programme. Map showing their drainage areas and the sampling sites.

The new programme marks a change in direction from mainly being the basis for fulfillment of Norway's obligations under the Oslo-Paris Convention (OSPAR), to also become 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, 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)

Results from the last year's monitoring activities are presented in three thematic reports, which collectively address the overall project objectives. The present report addresses objectives 1, 3, 4 and partly 6 by providing the current (2017) status and long-term (1990-2017) water quality trends in the 20 rivers included in the main programme.

2. Materials and methods

2.1 Water discharge

For the 11 “main rivers” of the previous RID programme (cf. Table 1), daily water discharge measurements have been used for the calculation of loads. Except for River Alna, where discharge data has been provided by Oslo Water and Sewerage Works, discharge data have been provided by the Norwegian Water Resources and Energy Directorate (NVE). Since the hydrological stations are usually not located at exactly the same sites as the water quality sampling, the water discharge at the water quality sampling sites have been calculated by up- or downscaling, proportional to the respective drainage areas. For the remaining 9 rivers, water discharge was 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

Water temperature data were acquired from four different sources: Sensor monitoring (hourly time-step), TinyTag temperature loggers (hourly time-step), NVE temperature logging (daily averages from bi-hourly measurements), or manual measurements with a thermometer in connection with the monthly water quality sampling (Table 2). In rivers where TinyTag loggers were deployed, the loggers were secured to land and deployed in the river at the water quality sampling locations. They are replaced each autumn, to ensure enough battery capacity.

Table 2. Sources for water temperature data in monitored rivers

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

For the long-term analysis of water temperatures, we have used time series from the closest NVE station in each river (Table 3).

Table 3. Stations with available long-term data on water temperatures. The stations are operated by the Norwegian Water Resources and Energy Directorate (NVE).

St.ID	Station Code	Station name	VANNTEMPERATURDATA	Start	End
29617	ØSTEGLO	Glomma ved Sarpsfoss	2.1087.0.1003.1 Glomma ovf. Sarpsfossen	Sept-2007	2017
36225	OSLEALN	Alna			
29612	BUSEDRA	Drammenselva	12.298.0.1003.4 Drammenselva v/Døvikfoss	Dec-1986	2017
29615	VESENUM	Numedalslågen	15.115.0.1003.1 Numedalslågen v/Brufoss	Nov-1984	2017
29613	TELESKI	Skienselva	16.207.0.1003.2 Skienselva ndf. Norsjø	Nov-1989	2017
30019	AAGEVEG	Vegårdselva			
29614	VAGEOTR	Otra	21.79.0.1003.1 Otra v/Mosby	Jan-1986	2017
29832	ROGEBJE	Bjerkreimselva	27.29.0.1003.1 Bjerkreimselvi v/Bjerkreim	Apr-1986	2017
29783	ROGEORR	Orreelva			
29837	ROGEVIK	Vikedalselva	38.2.0.1003.1 Vikedalselva utløp	Oct-1985	2017
29821	HOREVOS	Vosso(Bolstadelvi)	62.30.0.1003.3 Vosso ovf. Evangervatnet	Jun-1987	2017
29842	SFJENAU	Nausta	84.23.0.1003.3 Nausta v/Hovefossen	Dec-1989	2017
29822	MROEDRI	Driva	109.44.0.1003.2 Driva ndf. Grøa	Jul-2000	2015
29778	STREORK	Orkla	121.62.0 Orkla v/Merk Bru	Mar-1989	2017
29844	STRENID	Nidelva(Tr.heim)			
29782	NOREVEF	Vefsna	151.32.0.1003.3 Vefsna v/Laksfors	Sept-1993	2017
29848	TROEMÅL	Målselv	196.35.0.1003.1 Malangsfoss	May-1997	1997
29779	FINEALT	Altaelva	212.68.0.1003.1 Alta v/Gargia	Sept-1980	2016
29820	FINETAN	Tanaelva	234.19.0.1003.1 Tana ovf. Polmakelva	Jul-1990	2016
29819	FINEPAS	Pasvikelva	246.11.0.1003.1 Pasvikelva v/Skogfoss kraftstasjon	Mar-1991	2017

2.3 Water quality sampling and analyses

2.3.1 Sampling methodology

Sampling has been carried out in the same manner as in the former RID monitoring programme, with grab samples taken by local fieldworkers (Skarbøvik *et al.*, 2017). The samples are collected monthly. In Rivers Glomma and Drammenselva, both receiving a substantial part of their runoff from high-elevation areas, additional sampling is conducted during May and June to get a better representation of the high-flow period following snowmelt.

2.3.2 Chemical parameters - detection limits and analytical methods

The parameters monitored in 2017, including information on methodology and levels of detection (LOD) and levels of quantification (LOQ) is given in Table 4. All parameters are analysed monthly, except the metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) which is analysed quarterly.

Table 4. 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
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) (µg Hg/L)	0.0003/0.001	NS-EN ISO 12846 modified
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

2.3.3 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. The data are available on-line at www.aquamonitor.no/RID, where users can view values and graphs of each of the monitored rivers.

2.4 Calculation of riverine loads

Estimates of annual riverine loads are 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.

Table 5. Proportion of analyses below limits of quantification (LOQ) in 2017

Parameter	Number of samples	Number below LOQ	% below LOQ
pH	247	0	0.0
Conductivity	247	0	0.0
SPM	247	12	4.9
TOC	247	0	0.0
TOT-P	247	3	1.2
PO_4-P	248	61	24.6
TOT-N	248	0	0.0
NO_3-N	248	7	2.8
NH_4-N	248	95	38.3
SiO2	247	0	0.0
Pb	80	0	0.0
Cd	80	18	22.5
Cu	80	0	0.0
Zn	80	4	5.0
As	80	1	1.3
Hg	80	61	76.3
Cr	80	0	0.0
Ni	80	0	0.0
Ag	80	70	87.5

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), the analytical method should give at least 70% positive findings (i.e. no more than 30% of the samples below the detection limit). In 2017, mercury and silver did not reach this requirement (Table 5).

2.5 Trend analyses

2.5.1 Selection of rivers and notes on uncertainty

Due to the change in the Norwegian river monitoring programme from 2016 to 2017, there is also a change in the selection of rivers analysed for trends. In former RID reports, only rivers monitored monthly were included in the statistical trend analyses, whereas in this year's report also rivers that were monitored four times a year in the period 2004-2016 have been included (the "new monthly rivers"). Hence, this year the following trend analyses have been performed:

1. Long-term trends in both concentrations and loads for the entire monitoring period (1990-2017) for nine former "main rivers" monitored monthly (Rivers Glomma, Drammenselva, Numedalslågen, Skienselva, Otra, Orreelva, Orkla, Vefsna and Altaelva). Note that for metals, these rivers have only been monitored four times a year in 2017.
2. Shorter term trends (2004-2017) in concentrations and loads for metals for the above rivers[1], and in concentrations of nutrients and metals for nine rivers that have been monitored four times a year from 2004-2016, and monthly in 2017 (Rivers Bjerkreimselva, Vikedalselva, Vosso, Nausta, Driva, Nidelva, Målselva, Tana and Pasvikelva).

River Alna has been excluded from the trend analyses due to few water samples before 2013 and a shift in monitoring methodology for water discharge. Prior to 2006, area adjusted water discharge data from a near-by monitoring station in a neighbouring catchment was used, but since 2006 a monitoring station at Kværnerbyen (NVE's Hydra-II database) was used.
No trend analyses have been done for River Storelva, since this river was not monitored during 2004-2016 and only once a year from 1990-2003.

As noted in (2), only trends in concentrations have been performed for the "new monthly rivers". The statistical power of the trend analysis decreases when applied to shorter time-series, and when sampling frequencies are low or change over the years. Calculated loads introduce yet another uncertainty, and therefore we have chosen to assess trends only for concentrations for those nine "new" rivers. Table 6, below, shows how sampling frequencies have varied in the 18 rivers for which trend analyses have been performed.

[1] LOQs for metals changed quite much during the 1990s but less during the latest period 2004-2017

Table 6. Changes in sampling frequency in different rivers and for different parameters

Short name	Rivers/parameters	Parameters****	Sampling frequency (times/yr)		
			1990-2003	2004-2016	2017
"Monthly since 1990"	Glomma*, Drammenselva*, Numedalslågen, Skienselva, Otra, Orreelva, Orkla, Vefsna and Altaelva**	Nutrient fractions, SPM, TOC, silicate	12	12	12
-«-	-«-	Metals	12	12	4
"New monthly rivers"	Bjerkreimselva, Vikedalselva, Vosso***, Nausta, Driva, Nidelva, Målselva, Tana and Pasvikelva	Nutrient fractions, SPM, TOC, silicate	1	4	12
-«-	-«-	Metals	1	4	4

* Rivers Glomma and Drammen have often been sampled 16 times per year, or even more frequently (e.g. during the 1995-flood).
** In River Alta, the sampling was less frequent during 1990-1998.
*** River Vosso has been sampled monthly since 2008.
**** 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 series, whereas the loads are modelled. A more detailed overview of excluded data from historical records is given in Skarbøvik *et al.* (2010).

2.5.2 Parameters analysed for trends

The parameters analysed for trends include ammonium (NH_4-N), nitrate (NO_3-N), total nitrogen (tot-N), orthophosphate (PO_4-P), total phosphorus (tot-P), total organic carbon (TOC), silicate, suspended particulate matter (SPM), cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), and nickel (Ni). Out of these parameters, trend analyses for TOC and silicate are conducted for the first time this year. For certain metals included in the monitoring programme trends are not analysed, due to e.g. a large proportion of samples below LOQ and changes in analytical methods over time; see Skarbøvik *et al.* (2010) for details.

Trend analyses for air temperature, precipitation, water flow and water temperature are conducted with the same methodology (see next section) as for the chemical variables.

2.5.3 Trend analysis methodology

The trend analyses in this report have been conducted based on the actual riverine loads, and not on flow normalised loads. Thus, the analyses will reflect trends in loads to the sea but will be less suited to discuss changes in upstream sources (as the water discharge to a large extent affects the loads and might therefore mask changes in source emissions). Both the seasonal Mann-Kendall test (Hirsch and Slack, 1984) and the partial Mann-Kendall test (Libiseller and Grimvall, 2002) have been used to test for monotonic trends (including linear trends; Sen slope) in annual riverine inputs and monthly/quarterly concentrations. The partial Mann-Kendall test has its methodological basis in the seasonal Mann-Kendall-test with the difference that explanatory variables can be included. In this report, the seasonal Mann-

Kendall trends are presented, but partial Mann-Kendall tests have also been performed using water discharge as explanatory variable, to assess the reasons for the trends. These results are only presented in the text, and only when the water discharge could explain some of the trends. In addition to the formal statistical tests, visual inspections were performed. The trends were regarded as statistically significant at the 5%-level (double-sided test).

2.6 Stable N- and O-isotopes in nitrate

Samples for isotope analysis were collected at three stations in River Alna on 28 September 2017 (Figure 2):

1. Alna v/ Kvernerparken (UTM-east: 600213, UTM-north: 6642144, UTM-zone: 32)
2. Alna v/ Bryn (UTM-east: 601832, UTM-north: 6642664, UTM-zone: 32)
3. Alna v/ Alfaset (UTM-east: 603868, UTM-north: 6646002, UTM-zone: 32)

Station 1 is the same station as in the main programme (cf. Table 1). Two parallel samples were collected at station 1 and 2, whereas four parallel samples were collected at station 3. The samples were stored in 100 mL nitrate-free, freezable, wide-mouthed, screw-top containers. Short after arriving at NIVA's lab, the samples were filtered (<0.45 micropore) and a sub-sample taken for nitrate (NO_3^-) and nitrite (NO_2^-) analysis. Nitrate concentrations should be in the range 2-1500 µmol as NO_3^- (30 – 21000 µg N/l) to allow stable isotope analysis with the bacterial denitrifier method (Sigman *et al*. 2001). The method does not discriminate between nitrate (NO_3^-) and nitrite (NO_2^-), and for samples expected to contain nitrite, it should be removed with sulfamic acid (Granger and Sigman 2009). The remaining water sample (at least 20-30 ml) was stored frozen and shipped frozen to the UC Davis Stable Isotope Facility (SIF) in California.

At the UC Davis SIF the isotope ratios of ^{15}N and ^{18}O are measured using a trace gas concentration system linked to an isotope-ratio mass spectrometer (IRMS). Gas samples are purged from vials through a double-needle sampler into a helium carrier stream. The gas sample passes through a CO_2 scrubber and N_2O is trapped and concentrated in two liquid nitrogen cryo-traps operated in series such that the N_2O is held in the first trap until the non-condensing portion of the sample gas has been replaced by helium carrier, then passed to the second, smaller trap. Finally, the second trap is warmed to ambient temperature, and the N_2O is carried by helium to the IRMS via a capillary column that separates N_2O from residual CO_2. A reference N_2O peak is used to calculate provisional isotope ratios of the sample N_2O peak. Final $\delta^{15}N$ values are calculated by adjusting the provisional values such that correct $\delta^{15}N$ values for laboratory reference materials are obtained. The calibration standards are the nitrates USGS 32, USGS 34, and USGS 35, supplied by NIST (National Institute of Standards and Technology, Gaithersburg, MD). Additional laboratory reference materials are included in each batch to monitor and correct for instrumental drift and linearity. Limit of Quantitation and Long-term standard deviation for ^{15}N and ^{18}O of N_2O from NO_3 by bacterial denitrification: Accepted Precision: 0.4 ‰ for ^{15}N and 0.5 ‰ for ^{18}O.

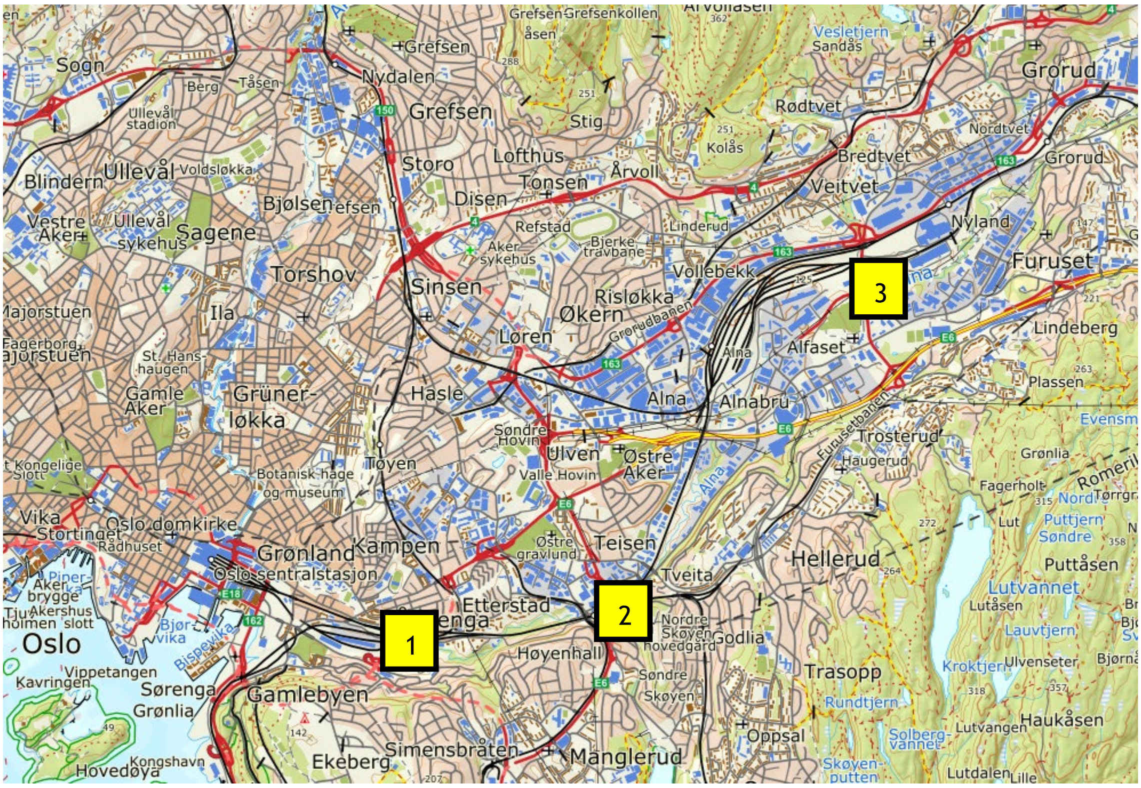


Figure 2. Map showing sampling sites for the isotope analysis.

2.7 Sensor monitoring in River Storelva

The Storelva sensor station is located at the same site as the manual sampling site (cf Table 1). Water from the river is pumped a few meters to an instrument container/cabin that is equipped with sensors that measure water temperature, pH, conductivity, turbidity and cDOM/fDOM (dissolved organic matter). 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 Directorates (NVE's) real-time station 18.4.0. Lundevann, which is located right across the river from NIVA's station.

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 station is visited monthly (or more often if required) for service and maintenance.

3. Results and discussion

3.1 Climate and hydrology: status and trends

3.1.1 Air temperature and precipitation in 2017

The average air temperature in 2017 was 1.1°C above the 1961-1990 normal for the entire country, and the year was the 20th warmest since the measurements started in 1900. The highest deviation from the temperature normal (around +2°C) was found in the south-eastern parts of the country (Figure 3). Precipitation in 2017 was 120% of the normal for the country as a whole, and the year was the 6th wettest since 1900. The highest deviation from the precipitation normal (125-175%) was found in the western parts of the country, especially in Rogaland county (Figure 3).

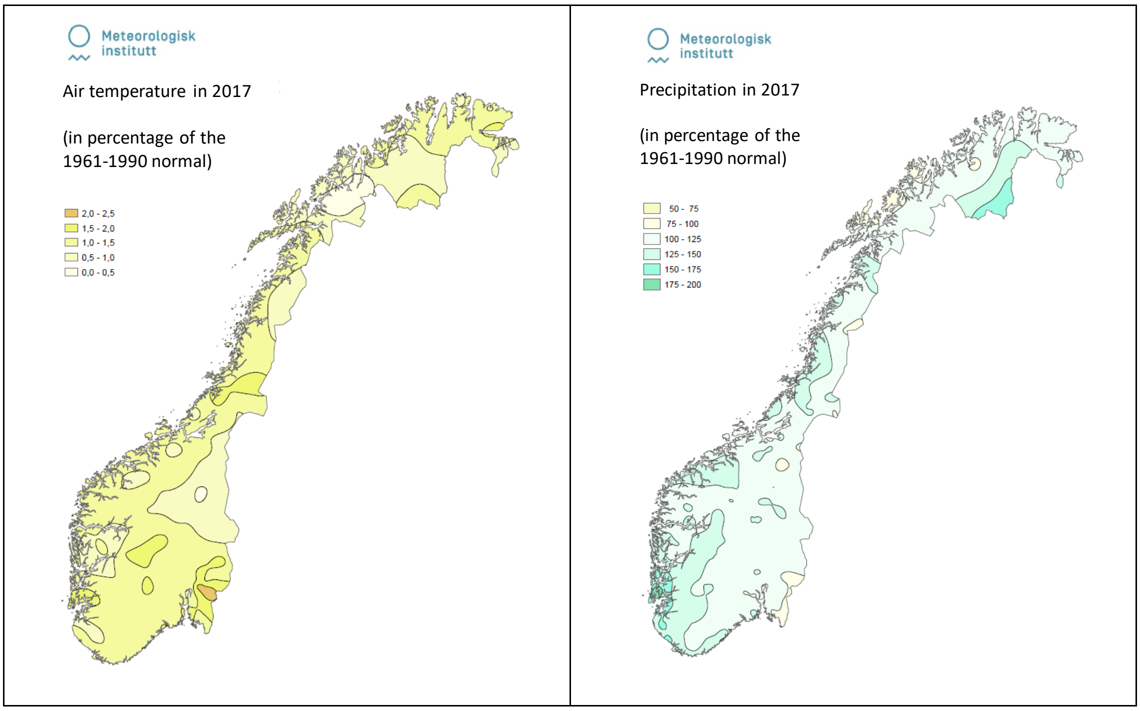


Figure 3. Air temperature and precipitation in Norway in 2017 as percentage of normal values (1961-1990). Maps derived from Grinde et al. (2018).

The air temperature during winter (December 2016 – February 2017) was 3.7°C above normal and by this the 6th warmest winter since 1900. Precipitation in winter was 140% of the normal, with the highest deviation in western and northern parts of the country. In northern Norway, the winter in 2017 was the wettest ever since 1900 (180% of normal).

In the spring (March-May), the air temperature was 0.8°C higher than normal, whereas the precipitation was 130% of the normal. There were relatively large regional differences in precipitation this spring, varying from 200% of normal at stations in Sogn og Fjordane to 75% in parts of Eastern Norway.

In summer (June-August), the air temperature in Norway was close to the normal. Precipitation during summer was 130% of the normal for the season, ant by this the 3rd wettest since 1900. Stations in Western Norway, Trøndelag and Finnmark had precipitation rates that were 170-200% of the seasonal normal.

The autumn was relatively warm, with air temperatures 1.2ºC above the normal. Despite precipitation being close to the normal (105%) for the country as a whole, there were considerable regional differences: 150-200% of the seasonal normal in Agder, Rogaland and Telemark, whereas Nordland and Troms received only 50% of the normal precipitation.

3.1.2 Trends in air temperature and precipitation 1980-2017

Table 7 shows trends in air temperature and precipitation since 1980 at meteorological stations located in the near vicinity of the river monitoring stations. The results show a significant increase in air temperature at nearly all the stations. Regarding precipitation, there were only two stations showing a significant trend: Blindern and Alta (both upward). Large year-to-year variation in precipitation amounts probably explains the lack of significant trends at more stations.

Table 7. Trends in air temperature and precipitation 1980-2017. Data from the Norwegian Meteorological Office (met.no).

River	St.no	Station name	Temperature trend (p value)	St.no	Station name	Precipitation trend (p value)
Glomma	27450	Melsom	0.003	3780	Igsi i Hobøl	0.105
Alna	18700	Oslo, Blindern	0.004	18700	Oslo, Blindern	0.048
Drammenselva	19710	Asker	0.091	19710	Asker	0.115
Numedalslågen	27470	Torp	n.a.	30000	Larvik	0.960
Skienselva	27470	Torp	n.a.	30260	Porsgrunn Brannst	0.624
Vegårdselva	36560	Nelaug	0.023	36560	Nelaug	0.054
Otra	39040	Kjevik	0.009	39040	Kjevik	0.158
Bjerkreimselva	44560	Sola	0.001	43360	Egersund	0.359
Orreelva	44560	Sola	0.001		Time-Lye	0.084
Vikedalselva	46910	Nedre Vats	0.006	46850	Hundseid i Vikedal	0.065
Vosso	52290	Modalen II	0.024	51250	Øvstedal	0.179
Nausta	58070	Sandane	0.021	57480	Botnen i Førde	0.321
Driva	64550	Tingvoll – Hanem	0.001	63530	Hafsås	0.606
Orkla	69100	Værnes	0.013	66210	Hoston (Orkdal)	0.678
Nidelva	69100	Værnes	0.013	68270	Løksmyr	0.274
Vefsna	85380	Skrova	0.001	78850	Røssvatn – Heggmo	0.105
Målselv	89350	Bardufoss	0.004	89350	Bardufoss	0.301
Alta	93140	Alta lufthavn	0.001	93140	Alta lufthavn	0.023
Tanavassdraget	96800	Rustefjelbma	0.004	96970	Sirbma	0.734
Pasvikelva	99370	Kirkenes lufthavn	0.000	99500	Skogfoss	0.243

Red - significantly upward $p<0.05$, orange - upward but not statistically significant $0.1>p>0.05$, green - significantly downward $p<0.05$, pale green - downward but not statistically significant $0.1>p>0.05$

3.1.3 Water temperature - status 2017 and trends

Table 8 shows the monthly mean water temperature measured in the monitored rivers in 2017. Water temperatures typically vary from the north to the south and according to whether the river catchments range from mountain to fjord (e.g., River Vosso) or mainly consist of lowland areas (e.g., River Orreelva and River Alna). Water temperatures have only been recorded in the river monitoring programme since 2014, and to our knowledge, no analysis of long-term temperature trends in Norwegian rivers has so far been conducted.

Table 8. Monthly mean water temperatures in monitored rivers, 2017

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glomma	0.3	0.2	0.7	3.9	8.9	12.1	15.9	16.0	15.5	12.2	8.5	0.5
Alna	2.3	1.3	2.8	4.6	7.5	11.8	12.5	13.4	12.0	10.5	5.4	1.7
Drammenselva	1.2	0.9	1.7	3.7	7.6	12.2	17.7	16.9	14.1	9.5	5.0	2.0
Numedalslågen	0.3	0.4	1.5	5.0	9.9	14.4	18.1	16.5	12.9	7.9	2.4	0.2
Skienselva	3.0	1.8	2.2	3.5	5.5	11.5	16.0	16.3	14.1	10.4	6.9	4.4
Storelva	1.5	2.9	4.3	8.1	14.6	17.9	20.9	19.1	15.3	11.0	6.5	3.2
Otra	1.8	0.8	1.9	4.9	8.3	13.8	17.1	16.2	13.5	9.1	5.2	2.5
Bjerkreimselva	3.7	2.3	3.2	4.7	8.0	11.8	14.3	14.2	13.3	9.8	6.9	4.5
Orreelva	3.0	2.0	4.8	8.3	13.3	15.8	16.9	16.4	14.3	10.5	7.4	5.9
Vikedalselva	2.5	1.5	2.6	4.3	9.3	12.7	14.8	13.8	12.9	9.2	5.6	3.0
Vosso	1.6	0.9	1.3	2.9	5.6	8.0	11.4	13.4	13.0	9.0	5.7	2.4
Nausta	0.9	0.5	1.0	3.5	6.5	9.5	13.4	13.1	11.4	7.5	2.6	0.5
Driva	4.0	4.0	4.0	5.0	4.5	8.1	10.0	13.0	11.0	8.6	-	1.0
Orkla	0.1	0.3	0.7	1.7	4.2	9.1	10.6	10.5	9.4	-	-	-
Nidelva	3.0	1.2	0.8	2.2	3.0	4.8	10.0	15.2	12.9	8.2	5.7	2.9
Vefsna	0.3	-0.1	-0.3	2.8	4.6	6.6	11.1	12.1	9.5	4.9	1.2	0.1
Målselva	0.1	0.3	-0.1	0.5	0.0	5.8	7.5	12.9	8.8	5.9	0.3	0.0
Altaelva	0.0	0.0	0.0	0.1	2.4	4.7	8.2	11.6	9.2	5.1	0.7	0.0
Tana	0.0	1.0	0.1	0.5	0.4	9.0	14.3	11.7	10.8	5.8	0.1	0.0
Pasvikelva	2.0	2.0	0.2	2.5	0.6	7.6	16.1	14.2	10.3	6.4	0.3	0.0

Long-term data series on water temperature are often less complete (have more gaps) than those on water flow. Hence, before performing a trend analysis, the data were filtered to remove years with many missing observations. A criterion of >90% daily observations per year was applied before the analysis was carried out (Table 9). The results show significant upward temperature trends for the northern Rivers Altaelva and Pasvikelva. This coincides well with the increasing trends in air temperature shown in Table 7. Also, River Bjerkreimselva in SW Norway shows a significant increase in water temperature.

Table 9. Trends in annual mean water temperature, in rivers with available long-term data.

River	Station no.	Years with data*	p-value
Drammenselva	12-298	20	0.0556
Numedalslågen	15-115	11	0.8763
Skienselva	16-207	21	0.1742
Otra	21-79	23	0.8327
Bjerkreimselva	27-29	27	0.0454
Vikedalselva	38-2	28	0.2951
Vosso	62-30	20	0.4957
Nausta	84-23	15	0.2763
Orkla	121-62	20	0.2300
Altaelva	212-68	22	0.0040
Tana	234-19	15	1.0000
Pasvikelva	246-11	20	0.0071

Red - significantly upward $p<0.05$, orange - upward but not statistically significant $0.1>p>0.05$, green - significantly downward $p<0.05$, pale green - downward but not statistically significant $0.1>p>0.05$

3.1.4 Water flow - status 2017 and trends

The annual water runoff (in millimetres per unit surface area) varies substantially between different regions of Norway (Figure 4). In southern Norway, it increases from east to the west. In middle and northern Norway, it decreases from south to north and to the north-east. Rivers Orreelva, Vikedalselva Driva, Orkla, and Nidelva had 20-40% higher runoff in 2017 compared with the latest five-year period means. This implies that the mean annual water discharge in 2017 will be correspondingly higher than in the latest five-year period. For other parts of the country the variation was low. An exception was Vefsna, where runoff in 2017 was about 30% less than the latest five-year mean.

When looking at long-term data (1990-2017) from rivers that have been monitored monthly since 1990, there are significant upward trends in water flow in Rivers Glomma, Drammenselva, Skienselva and Orreelva (Table 10). If looking at the last 13-yer period (2004-2017) in the “new rivers” with monthly monitoring since 2017, water flow increases significantly in River Tana.

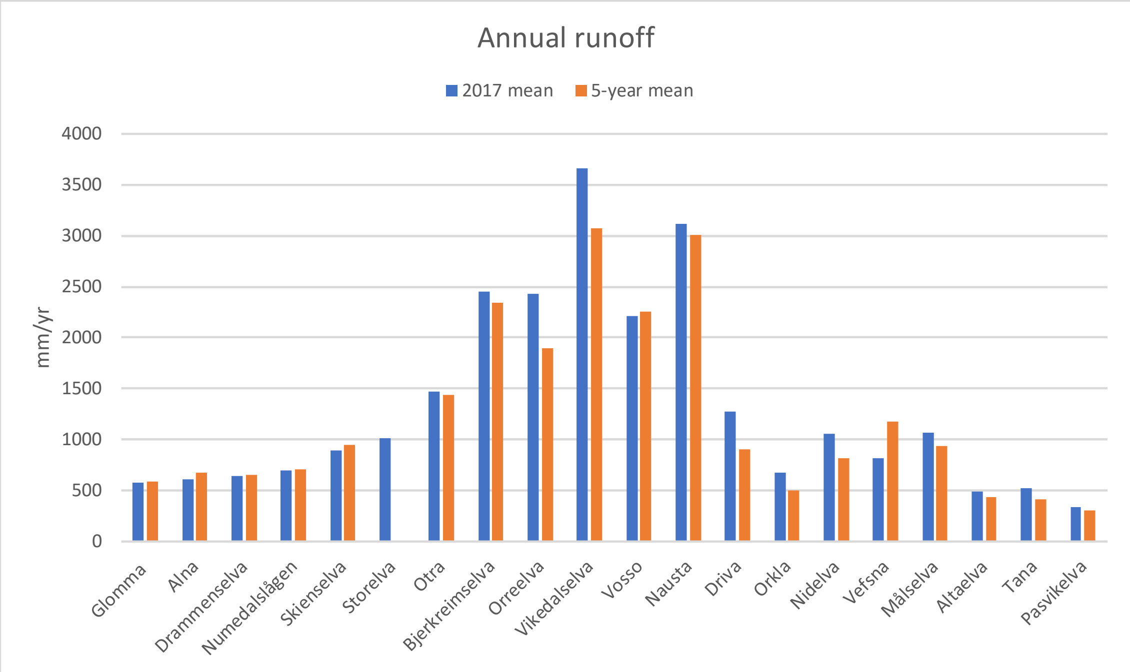


Figure 4. Annual (2017) and five-year mean (2013-17) annual runoff in the monitored rivers.

Table 10. Trends in annual water discharge. Showing p-values

River	Long-term 1990-2017	River	Short-term 2004-2017
Glomma	0.024	Bjerkreimselva	0.956
Drammenselva	0.007	Vikedalselva	0.622
Numedalslågen	0.058	Vosso	0.412
Skienselva	0.033	Nausta	0.956
Otra	0.286	Driva	0.208
Orreelva	0.036	Nidelva	0.412
Orkla	0.477	Målselva	0.171
Vefsna	0.269	Tana	0.033
Altaelva	0.206	Pasvikelva	0.208

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

3.2 Water quality status 2017

3.2.1 pH, calcium and silicate

The acidity of the river water shows a clear regional pattern with the highest pH values (> 7.0) in south-eastern Norway and northwards from Trøndelag (Figure 5). Correspondingly, the lowest pH values are found in the southern and western parts of the country. Large parts of this area are dominated by slow-weathering bedrock and surface waters with low buffering capacity. This is also the region of Norway that has received and still receives the highest levels of acid deposition, and many of the largest rivers are limed to protect brown trout and Atlantic salmon populations. Rivers Storelva, Bjerkreimselva, and Vikedalselva are fully limed with dozers placed in the main river. Other rivers in eastern, southern and western Norway can be affected by local liming (mainly in lakes), but the effects of this on the overall water chemistry are usually small. An exception in the south-western region is River Orreelva, which is a lowland river characterised by intensive agriculture and alkaline waters. In general, the annual mean pH-levels in 2017 were close to the five-year mean in all rivers. Only Rivers Otra and Nausta occasionally had pH values below 6.0 in 2017, with minimum values of 5.8 and 5.6, respectively. There are some local liming activities in River Otra, but with relatively little effect on water chemistry. In River Nausta, there are no significant liming activities within the catchment.

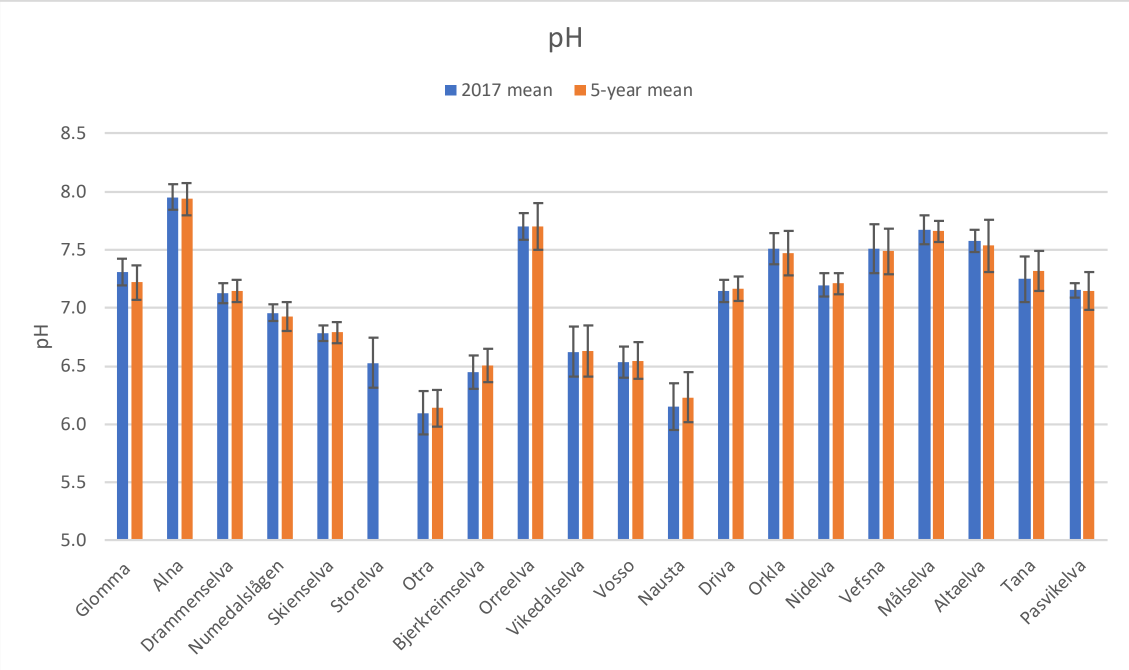


Figure 5. pH. Annual mean (2017) and five-year mean (2013-17) in the monitored rivers. Vertical bars show standard deviation of the mean. Mean values and standard deviation are based on pH-values, not the H^+ concentration. This represents a negligible error when pH-values are above 6.0.

Calcium was introduced for the first time in the monitoring programme in 2017 (Figure 6). pH and calcium concentrations in water are closely related, and the regional patterns of the two parameters are nearly identical in the monitored rivers. Three rivers had annual mean Ca concentrations below 1 mg/l (very low Ca concentrations in the Norwegian WFD typology):

Rivers Nausta, Otra and Vosso. Eight rivers had low Ca concentrations between 1-4 mg/l (some of these are limed), whereas eight rivers (mainly in eastern and northern Norway) had moderate Ca concentrations (4-20 mg/l). The urban River Alna can be characterised as calcareous (> 20 mg/l) with an annual mean Ca concentration of 33 mg/l.

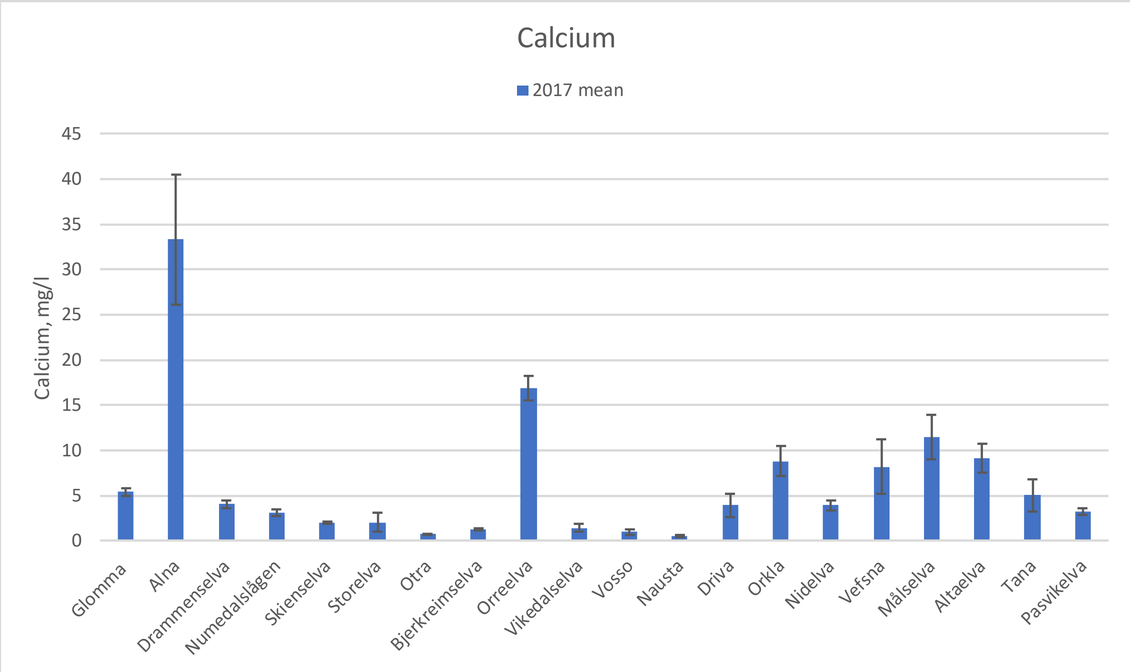


Figure 6. Calcium. Annual mean (2017) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

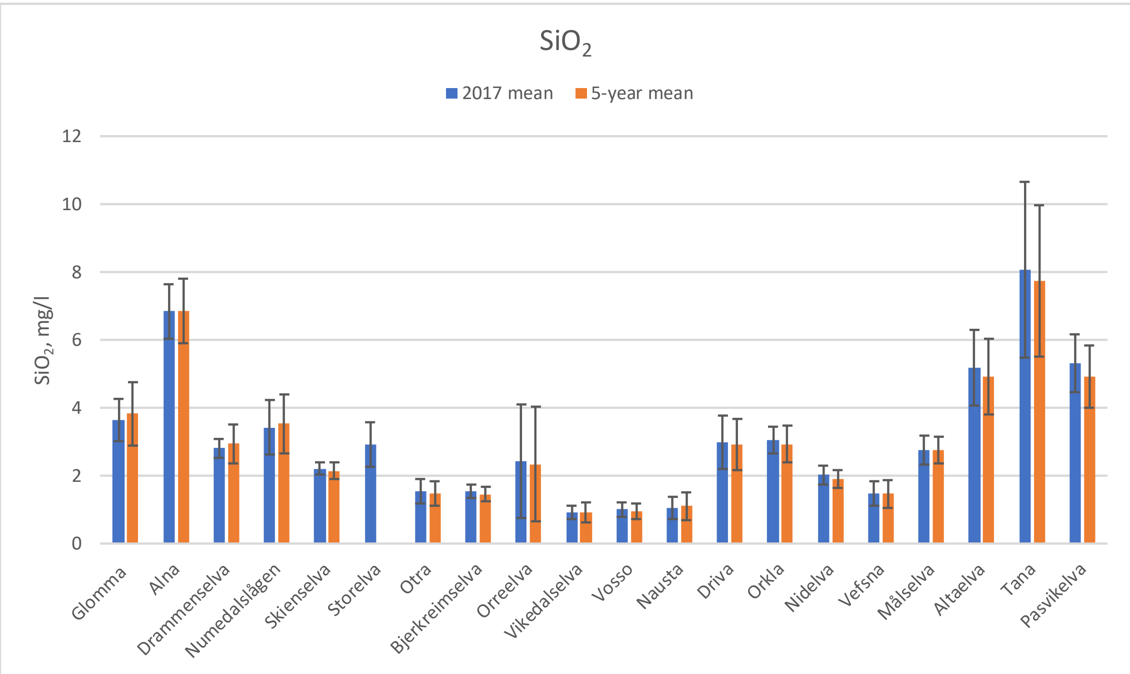


Figure 7. Silicate. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

Silicate concentrations in freshwater are mainly determined by weathering and erosion of sand, silt or clay particles. It is an essential nutrient for diatoms, which is an important phytoplankton group, especially in marine waters. As with calcium, the lowest silicate concentrations are found in areas with slow-weathering bedrock, typical for southern and western parts of Norway (Figure 7). The highest concentrations (above 5 mg/l) were recorded in River Alna and in the three northernmost Rivers Altaelva, Tana and Pasvikelva. The concentration differences between 2017 and the five-year mean (2013-17) were negligible, although fluxes from land to sea can vary from year to year depending on the annual flow and the frequency of flood- and erosion events.

3.2.2 Suspended particulate matter

The concentrations of suspended particulate matter (SPM) were highest in lowland rivers influenced by easily erodible clay soils. Examples on such rivers are Rivers Glomma, Alna, Numedalslågen, Orreelva, and to some extent also Orkla. The latter site is also affected by tailings from an abandoned copper mine. The highest mean SPM concentrations in 2017 (7-8 mg/l) were obtained in Rivers Glomma, Alna, and Orreelva. At the first two sites, both the annual means and the standard deviation of the means were clearly lower in 2017 compared to the previous 5-year period. In individual samples from 2017 the maximum recorded levels were in the 20-30 mg/l range (Rivers Numedalslågen, Glomma, Målselva and Alna), which is moderate compared to previous measurements during flood events.

Turbidity shows very similar patterns (Figure 9) and to a large extent confirms the general picture which is described for SPM.

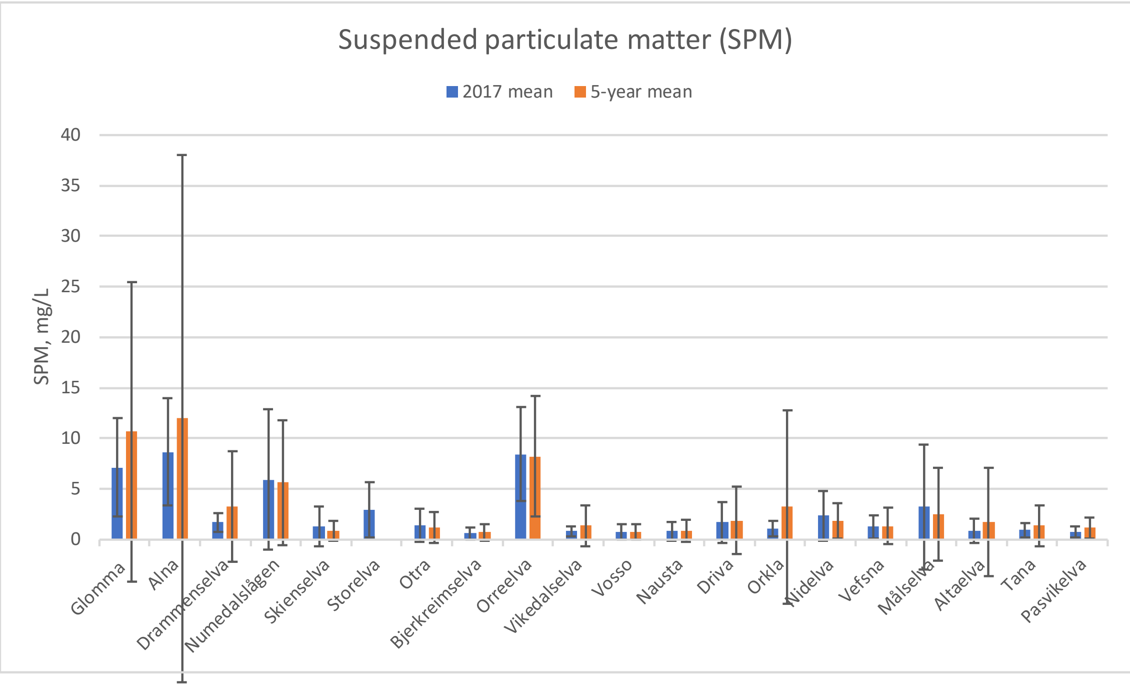


Figure 8. Suspended particulate matter (SPM). Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

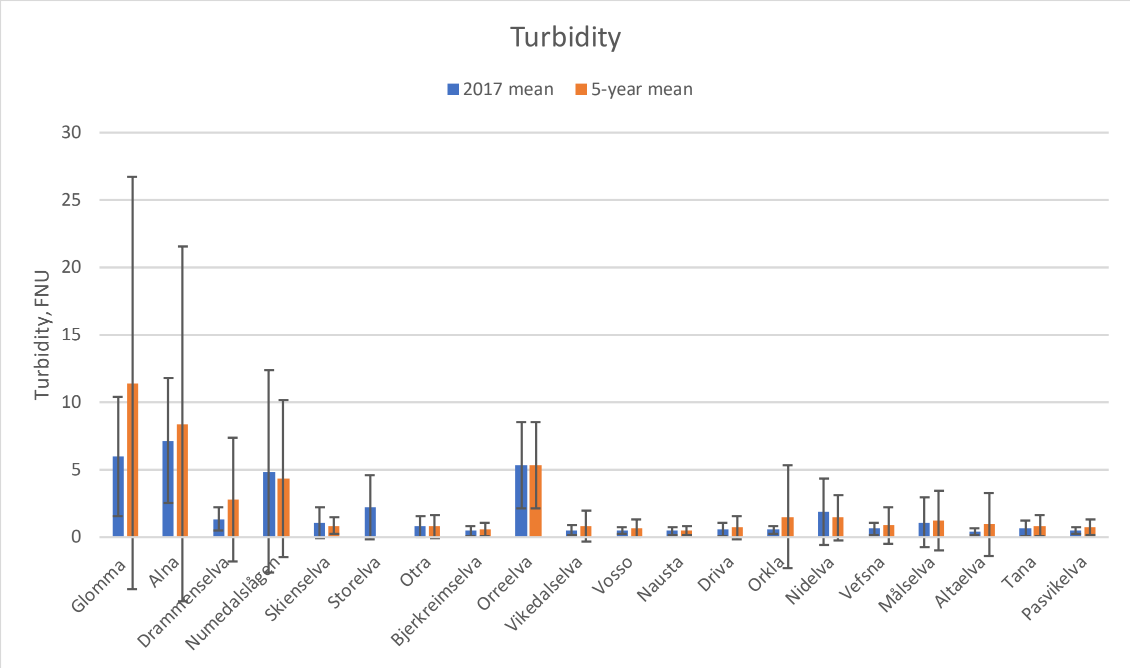


Figure 9. Turbidity. Annual mean (2017) and five-year mean (2013-17) in the monitored rivers. Vertical bars show standard deviation of the mean.

3.2.3 Organic matter

There has been a widespread increase in surface water concentrations of dissolved and total organic matter (DOC and TOC) over the last three decades, both in North America and in northern and central Europe (Monteith *et al*. 2007). The increase in DOC and colour in many Scandinavian surface waters has been explained as an effect of climate change and reduced acid precipitation (de Wit *et al*. 2007, de Wit *et al*. 2016). In Norway, the trends have been strongest in lakes and rivers in the south-eastern parts of the country, where large areas are covered by boreal forest (Garmo and Skancke 2018). In this report, organic matter content and characteristics are expressed by the following variables: total organic carbon (TOC), dissolved organic carbon (DOC), particulate organic carbon (POC), and UV-visible absorbance spectra (section 3.5).

The monitored rivers show largely the same regional pattern as sites in the Monitoring programme on long-range transboundary air pollution (Garmo and Skancke 2018) with highest TOC concentrations in SE Norway, low concentrations in SW and W, and moderate levels in middle and northern Norway (Figure 10). The highest annual mean concentrations in 2017 were found in Rivers Storelva (6.6 mg/l) and Orreelva (5.8 mg/l). At the latter site, it is assumed that a major fraction of the TOC is originating from effluent inputs and diffuse runoff from the agricultural area. In general, the annual mean concentrations in 2017 show small deviations from the five-year mean (2013-2017).

With reference to the Norwegian WFD typology, seven rivers had annual mean TOC concentrations below 2 mg/l, which indicates <u>very clear waters</u> (Rivers Vosso, Målselva, Driva, Vikedalselva, Vefsna, Bjerkreimselva, Nausta). Eleven rivers had concentrations between 2 and 5 mg/l (<u>clear waters</u>), whereas two rivers (Rivers Orre and Storelva) had annual mean TOC concentrations above 5 mg/l, which indicates humic waters. Given that a significant fraction of the TOC in River Orreelva might be due to anthropogenic inputs, water colour should also be measured before the water type can be confirmed (humic water in the WFD typology corresponds to a water colour range of 30-90 mg Pt/l).

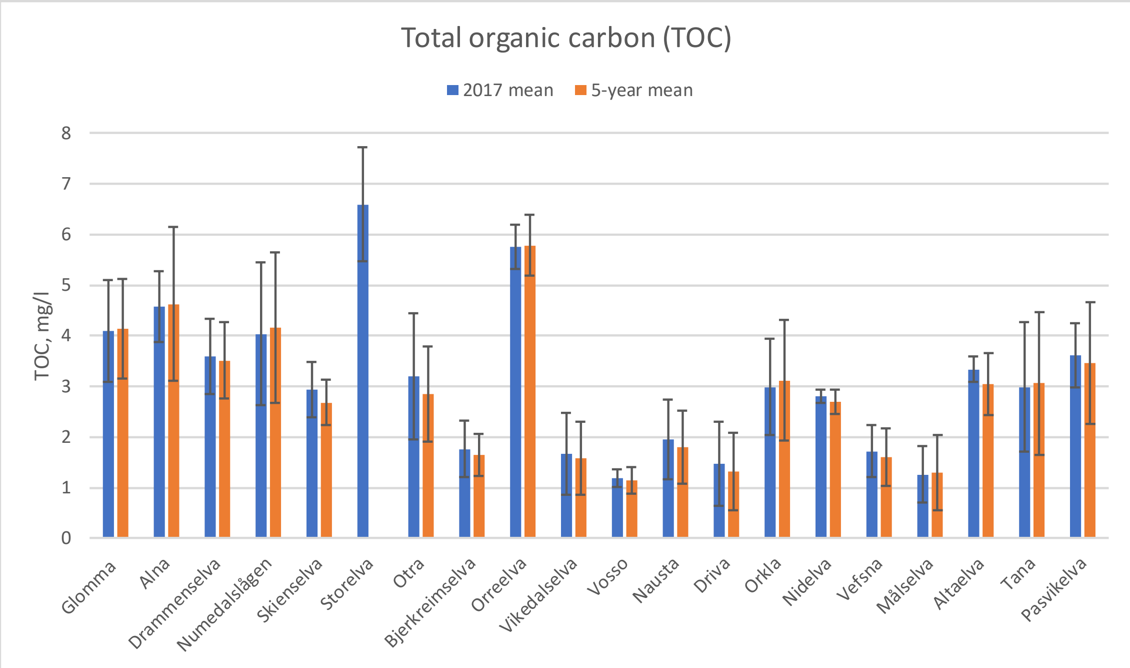


Figure 10. Total organic carbon. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

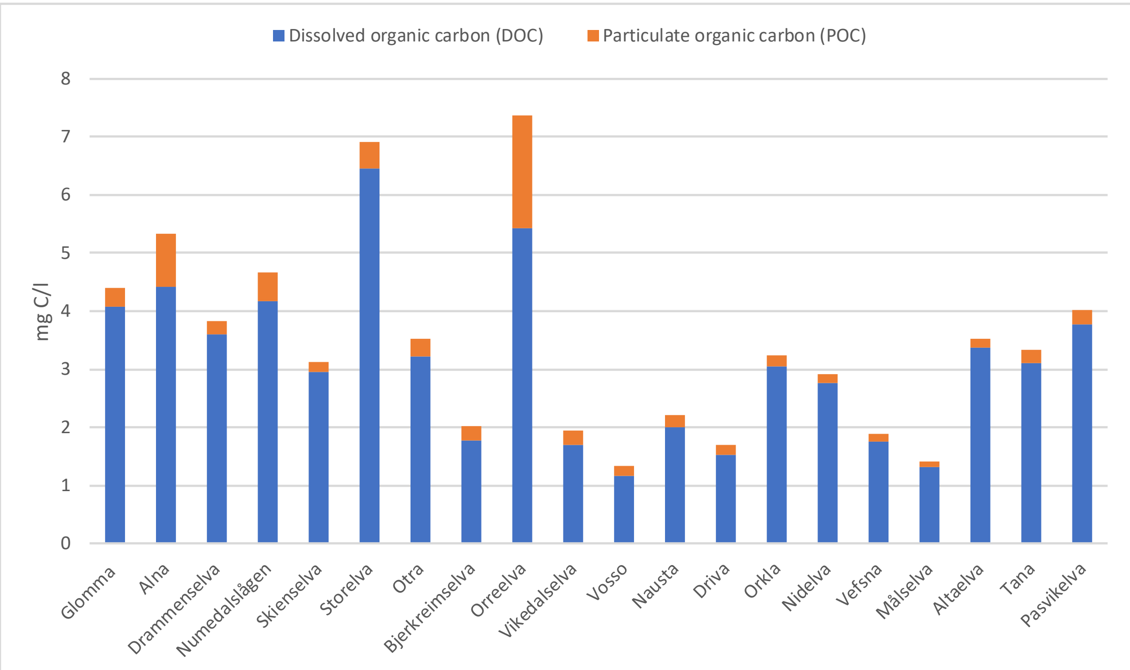


Figure 11. Dissolved organic carbon (DOC) and particulate organic carbon (POC). Annual mean (2017) concentrations in the monitored rivers.

Annual mean concentrations of dissolved organic carbon (DOC) in 2017 were close to- and sometimes above (94-105%) the annual mean TOC concentrations in the monitored rivers (Figure 11). This implied that the sum of DOC and POC exceeded the annual mean TOC-concentrations in all rivers (Figure 11)[2]. The results suggest that TOC largely consists of dissolved organic compounds, and that higher particulate carbon concentrations mainly occur in rivers that receive high particle loads. The highest annual mean POC concentrations were found in Rivers Alna and Orreelva, which also had the highest SPM concentrations.

3.2.4 Nutrients

Phosphorus

Phosphorus (P) is generally regarded as the major driver for eutrophication in lowland waterbodies in Norway. The urban River Alna and the agricultural River Orreelva stand out with clearly higher total phosphorus concentrations than the other rivers (Figure 12, right panel). The annual mean concentrations are also far higher than the WFD good/moderate boundary for their respective water types (Direktoratsgruppen 2018). Among the other sites, Rivers Glomma and Numedalslågen had the highest annual mean tot-P concentrations in 2017 with 13 and 17 µg/l, respectively. This was below the WFD good/moderate boundary for both rivers. All the other rivers had tot-P concentrations below 10 µg/l. In the other end, Rivers Otra, Vosso, Nausta, Driva, Orkla, Nidelva and Vefsna had annual mean tot-P concentrations below 5 µg/l in 2017.

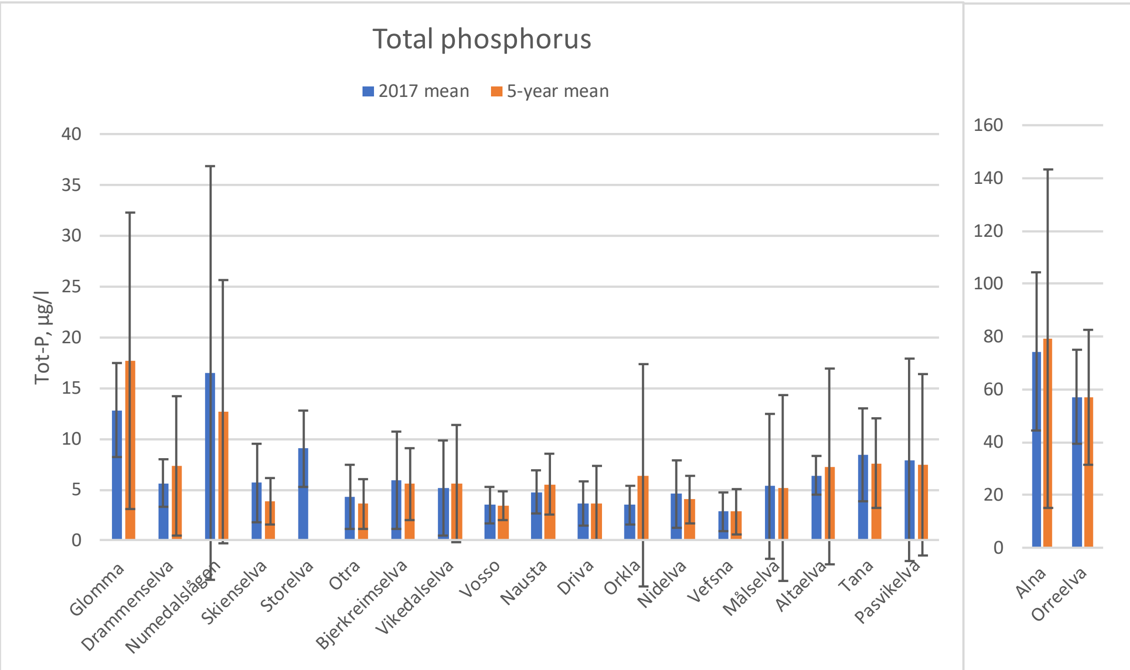


Figure 12. Total phosphorus. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean. Note different scales in left vs. right panel.

[2] Can be due to sedimentation of large particles during the TOC analysis. Hence, to quantify the POC it should be measured directly (as done in this programme) and not estimated from the difference between TOC and DOC.

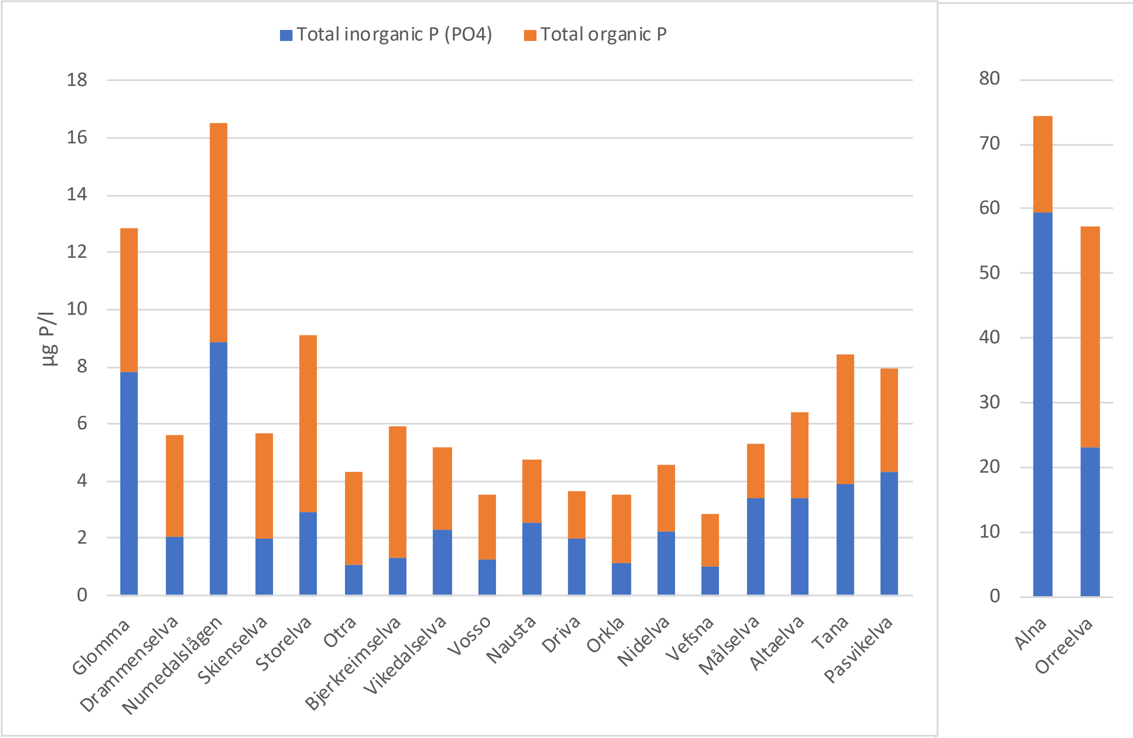


Figure 13. Total inorganic (PO_4) and organic P. Annual mean (2017) concentrations in the monitored rivers. Note different scales in left vs. right panel. The organic P fraction is calculated as the difference between tot-P and PO_4, and can also include tightly bound inorganic P.

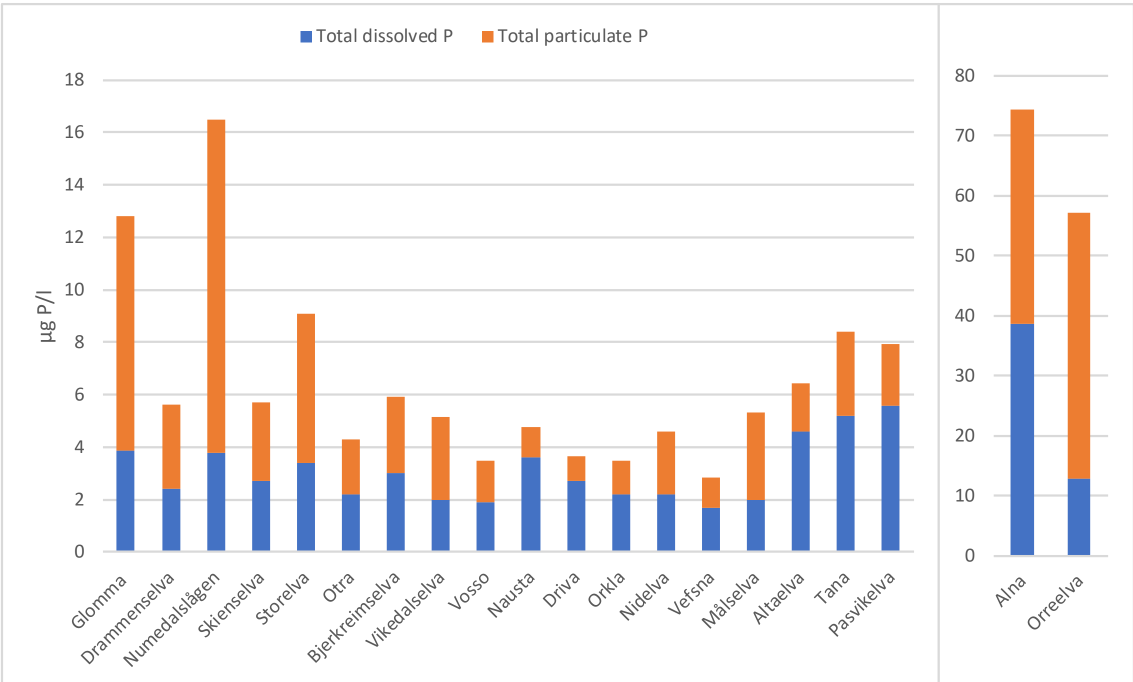


Figure 14. Total dissolved and particulate P. Annual mean (2017) concentrations in the monitored rivers. Note different scales in left vs. right panel.

There were quite small deviations between the 2017 mean values compared to the latest five-year mean (2013-2017). Exceptions were River Glomma, where the 2017-mean was 25% lower and River Numedalslågen, where the 2017-mean was 30% higher than the five-year mean, respectively. The increase in River Numedalslågen is probably due the massive flood in October 2017, where phosphate (PO_4) and tot-P concentrations reached 56 and 76 µg/l, respectively.

All the phosphorus will not be readily available for algae, however. As shown in Figure 14, a relatively large P fraction is associated with- or tightly bound to particles, in such a way that the bioavailability is relatively low. In rivers susceptible to erosion, like Rivers Glomma, Numedalslågen and Orreelva, particulate P constitutes a substantial fraction of the total P, and hence, not all analysed tot-P will be easily available for algal growth. In River Alna, however, more than 50% of the phosphorus is present on a soluble form.

Phosphate, which is the inorganic fraction, is easily available for algae and other primary producers if present on a soluble form. The highest annual mean PO_4 concentrations were found in Rivers Alna and Orreelva (>20 µg P/l). Concentrations were high also in Rivers Glomma and Numedalslågen (8-9 µg P/l) (Figure 13).

Nitrogen

The major sources for nitrogen (N) in river basins are atmospheric deposition, runoff from agriculture, scattered dwellings, urban wastewater and diffuse runoff from upland areas. Again, Rivers Alna and Orreelva stand out with the highest annual mean concentrations, around 1600 and 1400 µg/l, respectively (Figure 15). This was much higher the WFD good/moderate boundary for their respective water types (Direktoratsgruppen 2018). Worth noticing is also that rivers in SW Norway (Rivers Bjerkreimselva and Vikedalselva) that receive the highest amount of atmospheric N deposition in Norway (Garmo and Skancke 2018), had relatively high tot-N values and also a high tot-N/tot-P ratio of more than 80 (data not shown). In Bjerkreim, the annual mean value was slightly above the WFD good/moderate boundary. In northern Norway, on the other hand, both N deposition and riverine N concentrations are low. There were quite small deviations between the 2017 mean values for tot-N compared to the latest five-year mean (2013-2017).

Nitrate (NO_3) is usually the dominant fraction of tot-N, except in humic waters and during the growing season when the plant uptake of inorganic N is high. The highest NO_3:tot-N ratio (0.75) was found in River Bjerkreimselva, whereas Rivers Tana and Pasvikelva were at the other end with ratios of 0.17 and 0.15, respectively (Figure 16). Ammonium (NH_4) concentrations are usually low in Norwegian surface waters, except for highly pollutes sites or in waters with low oxygen content. It is therefore not surprising that the highest NH_4 concentrations among the monitored rivers were found in Rivers Alna and Orreelva. In some of the rivers, especially in western-, middle- and northern Norway (except eastern parts of Finnmark) NH_4 were close to zero. The fraction of organic nitrogen (TON) is usually highest in low N-deposition areas and in water with high TOC concentrations. The highest TON:tot-N ratios (>0.7) were found in Rivers Tana and Pasvikelva in eastern Finnmark (Figure 16). Nitrogen has less affinity to particles than phosphorus, and as illustrated in Figure 17 the dissolved N fraction is dominant vs. the particulate fraction. It was the “particle-rich” Rivers Alna and Orreelva that had the highest concentrations of particulate N.

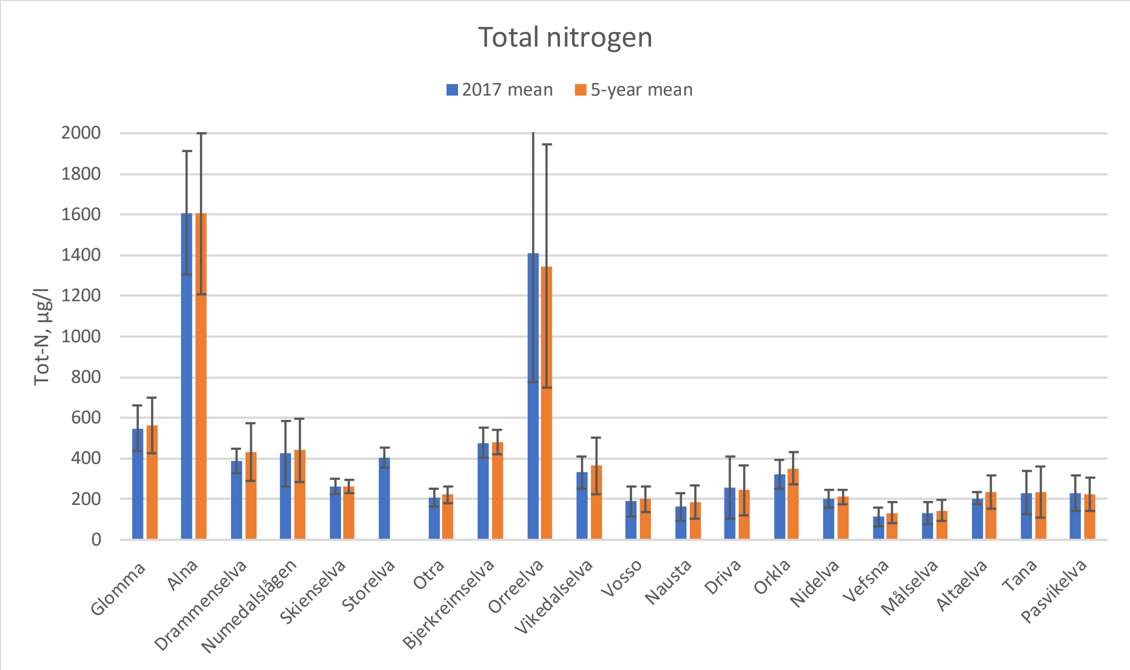


Figure 15. Total nitrogen. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

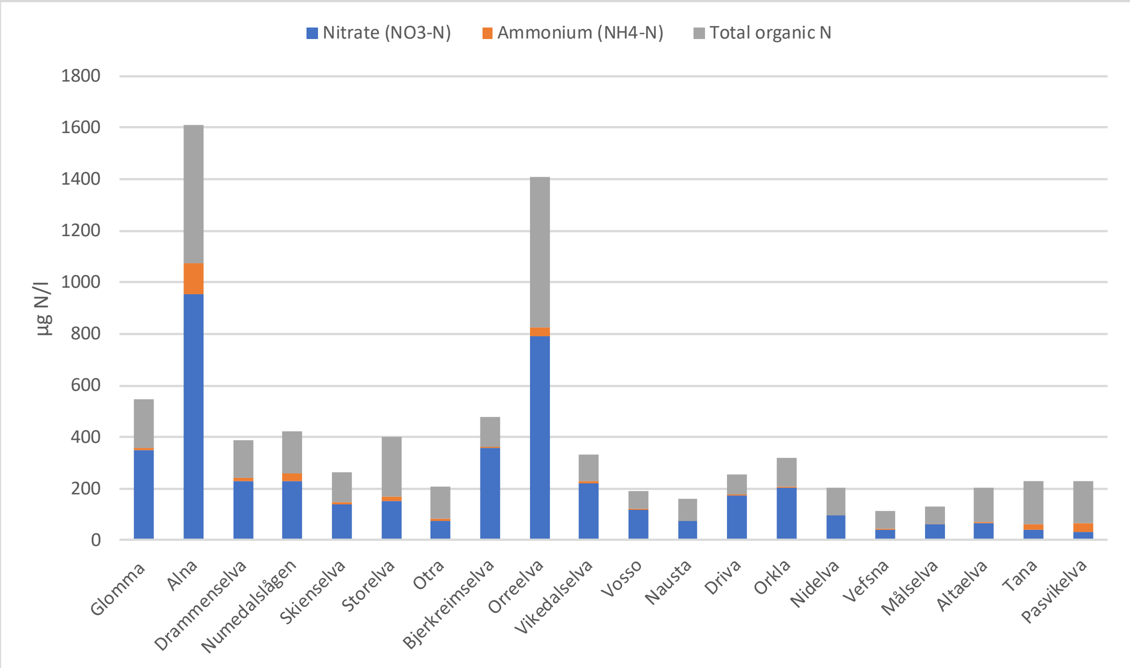


Figure 16. Nitrogen fractions. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers.

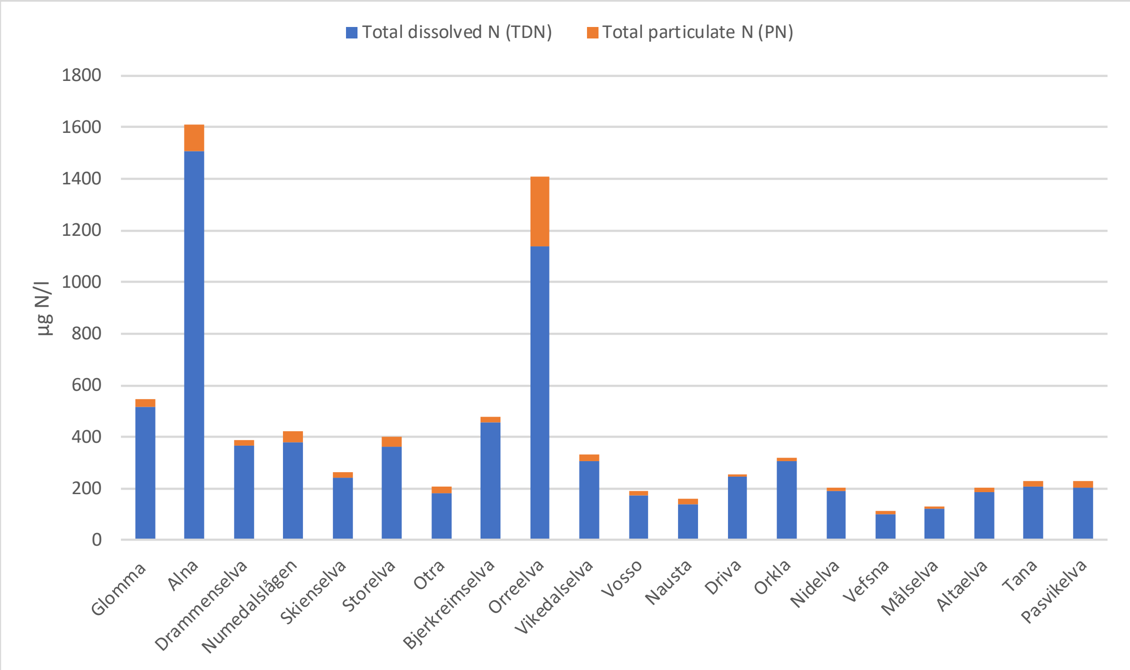


Figure 17. Total dissolved and particulate N. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Total dissolved N is calculated as the difference between tot-N and particulate N.

3.2.5 Metals

The major sources for metal concentrations in surface waters are local point sources (industry, urban areas, agriculture, transport, etc.) and diffuse runoff from the catchment (e.g., determined by long-range transported air pollution and bedrock geology).

Samples analysed for metals in the main programme (the 20 rivers) are unfiltered, which means that the results cannot be assessed directly against the WFD environmental quality standards for priority substances and river basin-specific pollutants in freshwater, which requires analyses of filtered samples (Direktoratsgruppen 2018). Given that unfiltered samples often contain higher concentrations (dissolved + particulate fractions) it implies that it is possible to state if the annual mean concentrations are below – but not over - the threshold concentrations. As an illustration of acceptable and non-acceptable metal concentrations in Norwegian surface waters, the threshold concentrations are: Arsenic – 0.5 µg/l, lead – 1.2 µg/l, cadmium – 0.08 µg/l[3], copper – 7.8 µg/l, zinc – 11 µg/l, chromium – 3.4 µg/l, nickel – 4 µg/l and mercury – 0.047 µg/l (Direktoratsgruppen 2018).

It should be noted that the annual mean values for 2017 are based on quarterly samples (4 per year), whereas the 11 “main rivers” from the previous RID programme (cf. Table 1) had monthly metal data until 2016.

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

Arsenic

River Alna had the highest annual mean arsenic concentration in 2017 (0.48 µg/l), followed by Rivers Storelva and Orreelva, both with an annual mean concentration of 0.30 µg/l (Figure 18). The lowest concentrations (<0.05 µg/l) were found in Rivers Nausta, Driva and Målselva. Compared with the latest five-year mean (2013-2017), the 2017 mean values were about 30% higher in River Alna and 30% lower in River Pasvikelva. The deviation might well be due to fewer samples in 2017 (4/yr) than in 2013-2016 (12/yr).

Lead

The highest annual mean lead concentrations in 2017 were found in rivers draining the eastern, southern and southwestern parts of the country (Figure 19) whereas rivers in the west and in the north had low values (<0.1 µg/l). River Pasvikelva in the north-east, which receives airborne pollution and effluent discharges from the Norilsk nickel plant on the Russian side of the border, had slightly higher concentrations than the other northern rivers. River Alna had the highest annual mean concentration in 2017 (1.9 µg/l), followed by River Storelva (0.5 µg/l). The latter had surprisingly high concentrations despite its sparsely populated and forest-dominated catchment, but possible explanations can be heavy road traffic along the lower parts of the river and former mining activities and smelting industries in the catchment. It is also worth noticing that lead concentrations in Rivers Glomma and Drammenselva were much lower in 2017 compared with the latest five-year mean (2013-2017). Fewer samples in 2017 gives a higher uncertainty, so further monitoring will show if this is a trend.

Cadmium

River Alna had the highest mean cadmium concentration in 2017 (0.07 µg/l), followed by Rivers Storelva and Orkla with annual means of 0.03 µg/l (Figure 20). The elevated concentrations in River Orkla can be due to runoff from mine tailings from the abandoned copper mine. All other rivers had cadmium concentrations ≤ 0.02 µg/l, and of these 12 rivers had concentrations below 0.01 µg/l. There were relatively small deviations between the 2017 mean values for cadmium compared to the latest five-year mean (2013-2017). The largest differences were found in Rivers Alna and Orkla, but this can to a large extent be explained by high variability between the samples, both in 2017 and in the latest five-year period.

Copper

The highest annual mean copper concentration in 2017 was found in River Alna (6.0 µg/l), followed by Rivers Orkla with 5.5 µg/l and Pasvikelva with 3.2 µg/l (Figure 21). In River Orkla, the main source is runoff from mine tailings, whereas in River Pasvikelva, the main source is atmospheric deposition from the Russian side. Besides Rivers Alna, Orkla and Pasvikelva, only Rivers Glomma and Orreelva had mean copper concentrations exceeding 1 µg/l in 2017. With only four samples per year, large uncertainties in the annual mean estimates make it difficult to assess short-term changes in metal concentrations. This is especially the case in contaminated rivers, where the variability between individual samples can be substantial (cf. standard deviation bars in Figure 21).

Zinc

River Alna had the highest annual mean zinc concentration in 2017 (24.7 µg/l), and it was substantially higher than in the latest five-year period (Figure 22). It is difficult to say whether this is a result of changed inputs to the stream, or a result of reduced sampling frequency (from 12 to 4 times/yr) leading to higher uncertainties in the annual estimates. It is also interesting to note that the annual mean zinc concentration in Glomma in 2017 was reduced to a more “normal” level (1.7 µg/l) compared to the preceding years when the zinc concentrations suddenly increased with no obvious reason. Besides River Alna, River Orkla also stands out with relatively high zinc concentrations (9.7 µg/l), which mainly are caused by runoff from old mine tailings. Slightly elevated metal concentrations in River Storelva might also be linked to the former mining and smelting industries within the catchment.

Chromium

Mean annual chromium concentrations showed to a large extent the same regional pattern as for zinc concentrations (Figure 23). River Alna had the highest annual mean concentration (1.2 µg/l), and also the largest variation between the sampling events. All the other rivers had annual mean concentrations below 0.3 µg/l, and all rivers except River Alna showed a tendency towards lower mean values in 2017 compared to the latest five-year mean.

Nickel

River Pasvikelva stands out with the clearly highest nickel concentrations, with an annual mean concentration of 6.9 µg/l (Figure 24). The nickel contamination in Pasvik is due to heavy influence from the Norilsk nickel plant, which is located a few kilometres away on the Russian side of the border. Among the other rivers, Rivers Alna and Orreelva had mean 2017 concentrations in the range 1-2 µg/l, four rivers were in the concentration range 0.5-1.0 µg/l, whereas the remaining 13 rivers had concentrations below 0.5 µg/l. There were relatively small deviations between the 2017 mean values for nickel compared to the latest five-year mean (2013-2017), with a possible exception for River Alna where the 2017 mean was almost 60% higher than the latest five-year mean. Continued monitoring will show if this part of a trend or the result of changed sampling frequency (quarterly in 2017 vs. monthly in 2013-2016).

Mercury

Out of 80 analysed samples in 2017 (4 from each river), 61 had Hg concentrations below LOQ (1 ng/l). Of the 19 samples that had Hg concentrations above LOQ, three samples had a Hg concentration of 3 ng/l, nine samples had 2 ng/l and seven samples had 1 ng/l. The samples with 3 ng/l came from Rivers Alna, Storelva and Nausta (Figure 25). Six rivers had no values above LOQ (Rivers Skienselva, Vosso, Driva, Orkla, Vefsna and Målselva).

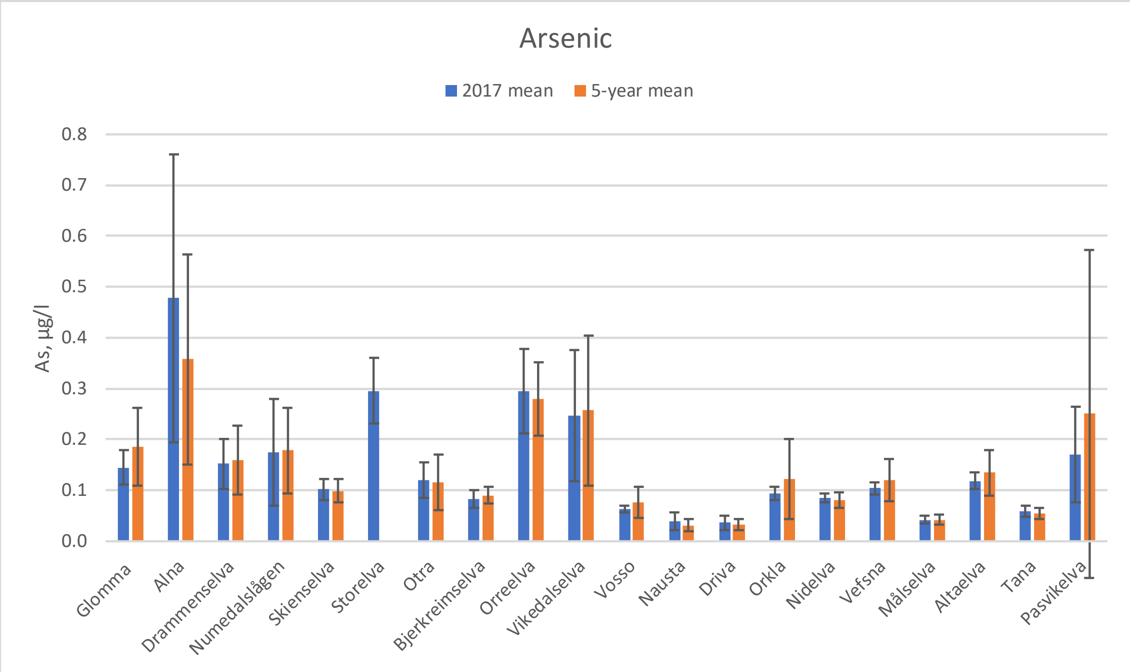


Figure 18. Arsenic. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

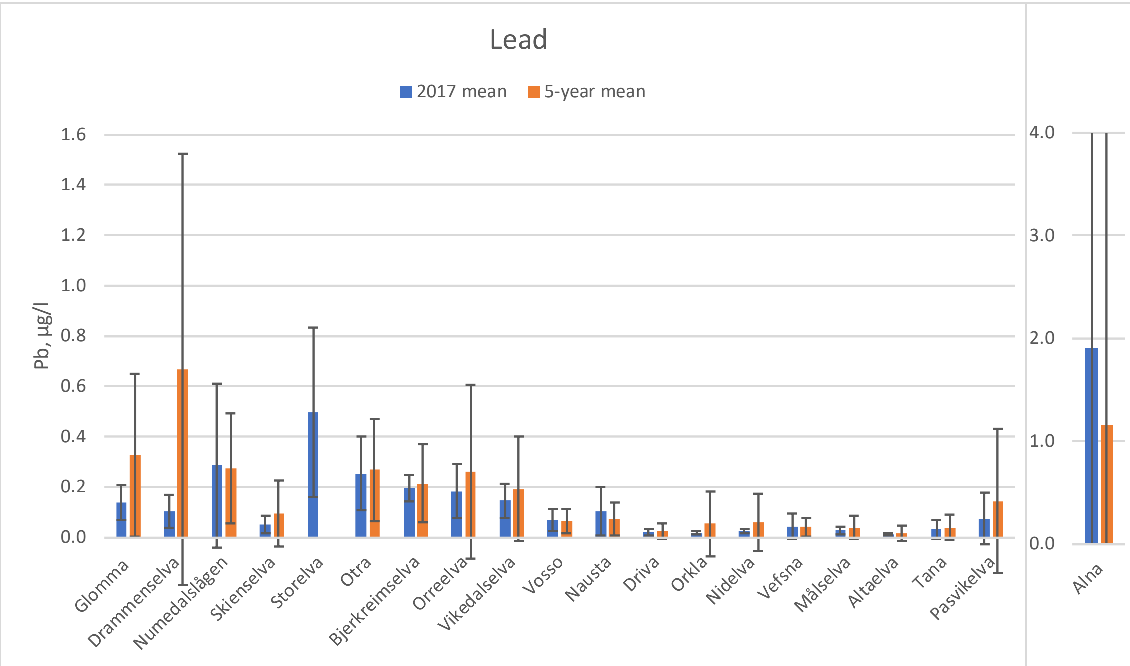


Figure 19. Lead. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean. Note different scales in left vs. right panel.

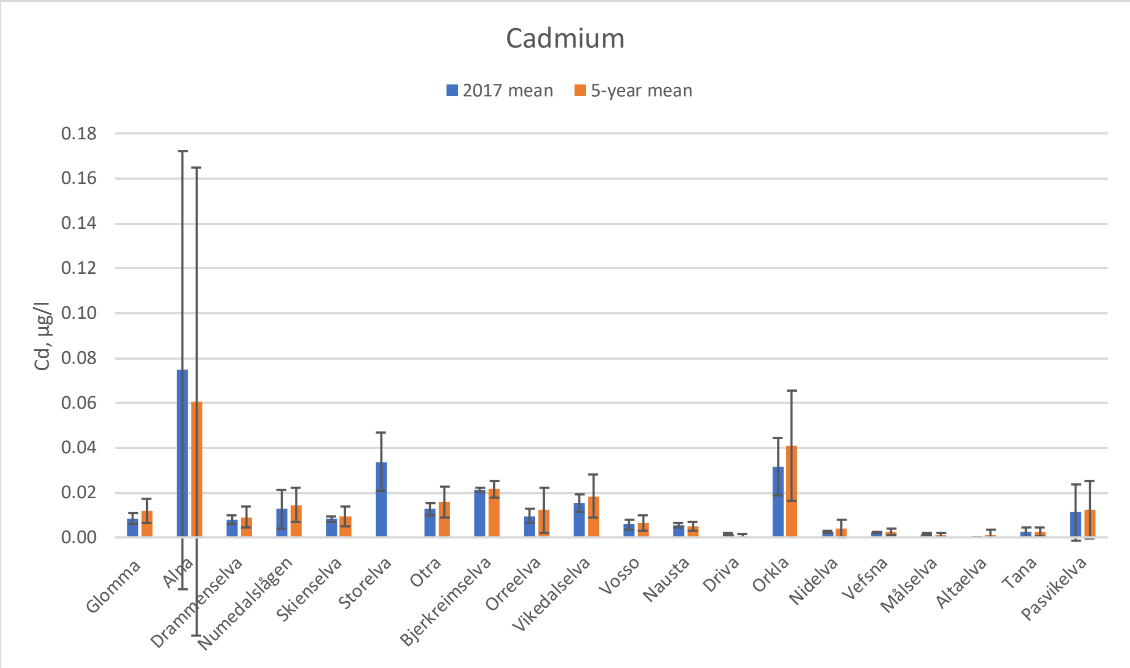


Figure 20. Cadmium. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

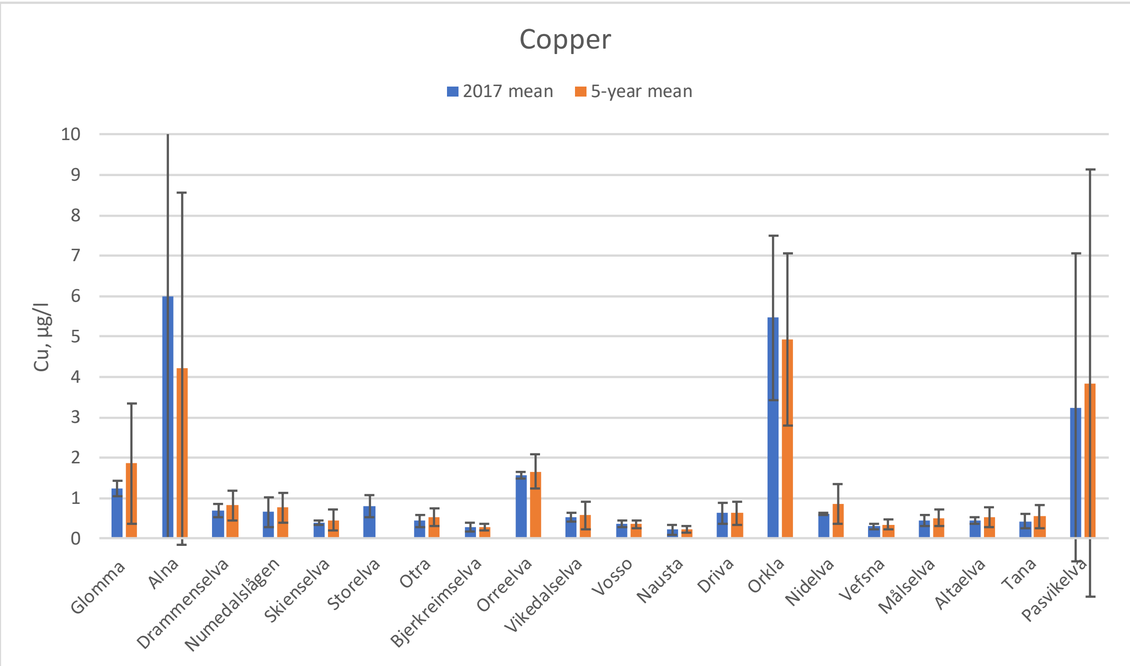


Figure 21. Copper. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

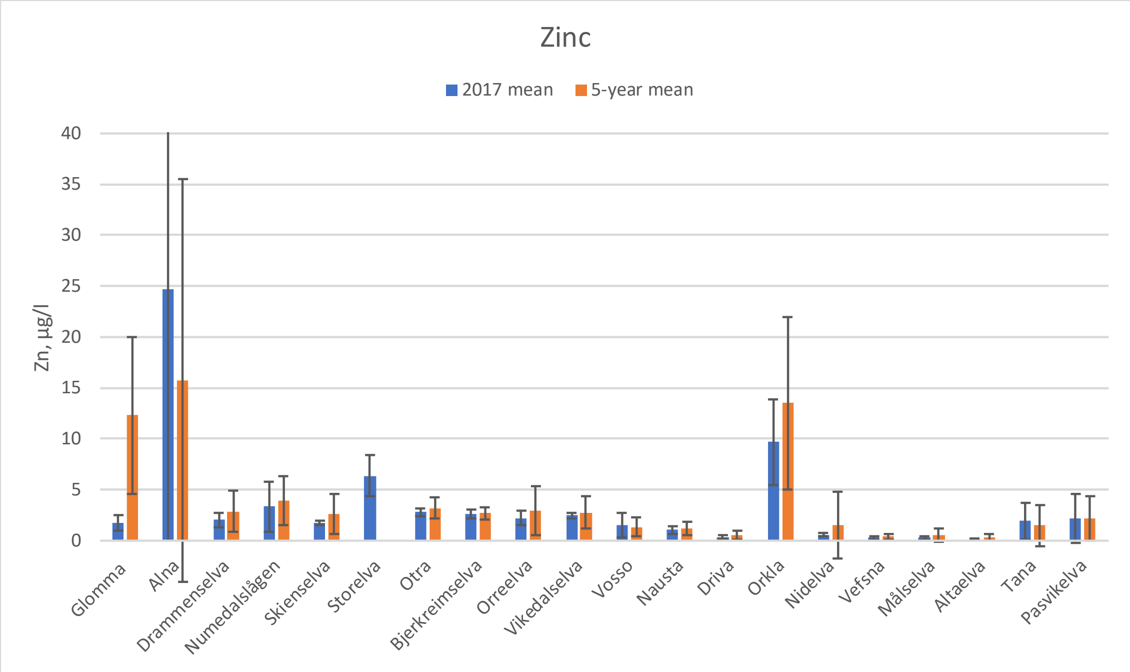


Figure 22. Zinc. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

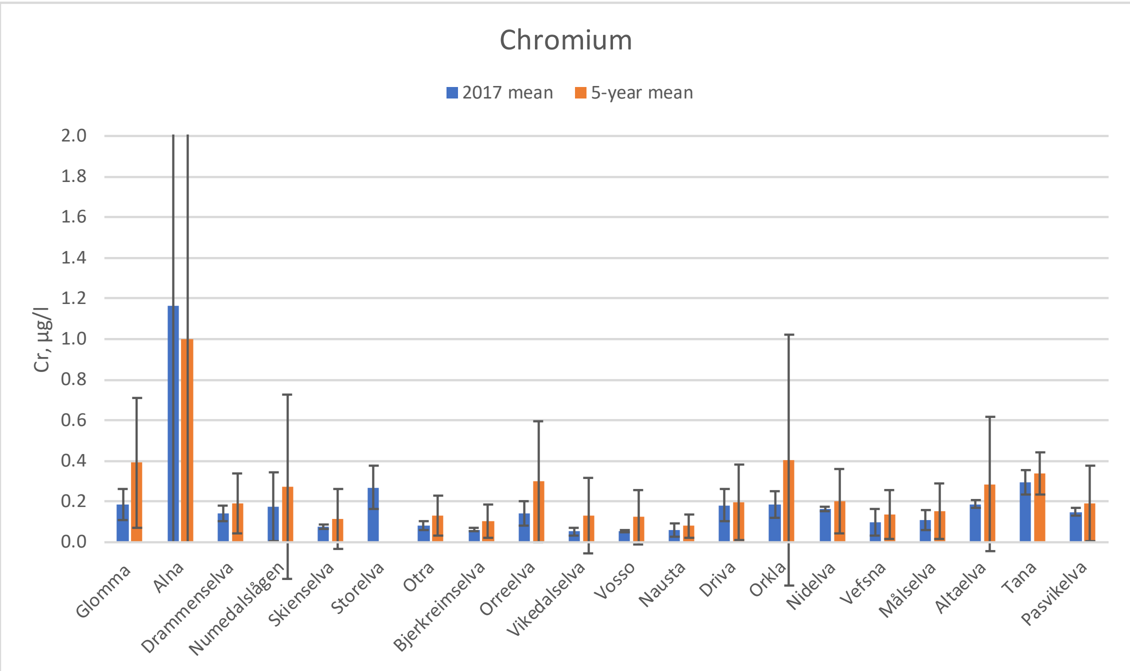


Figure 23. Chromium. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

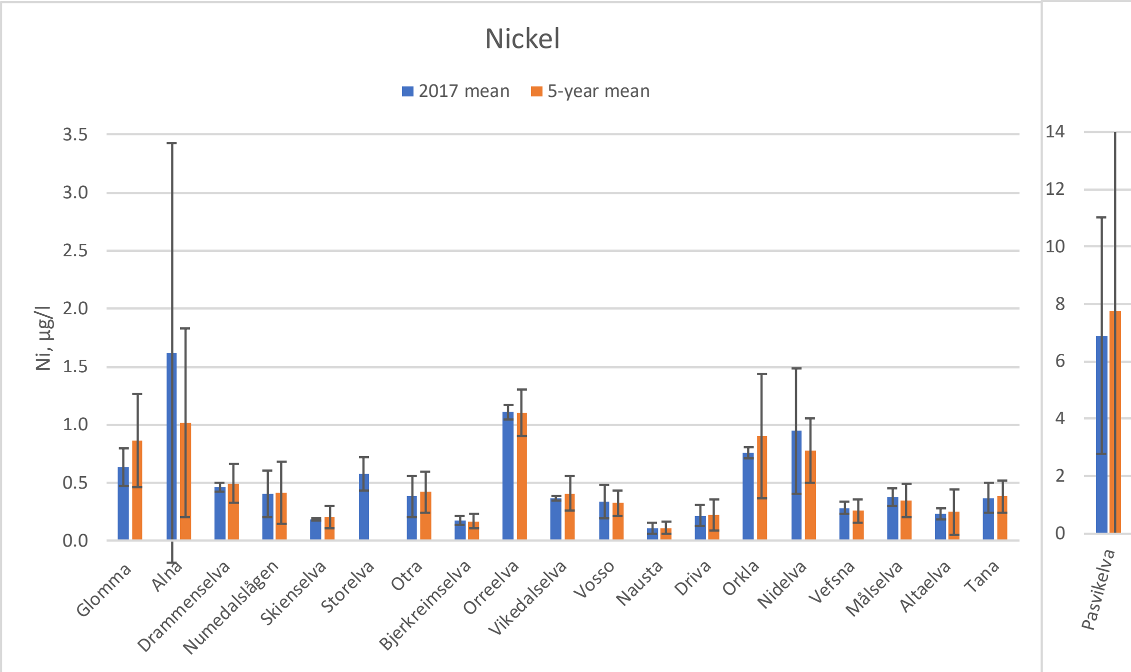


Figure 24. Nickel. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean. Note different scales in left vs. right panel.

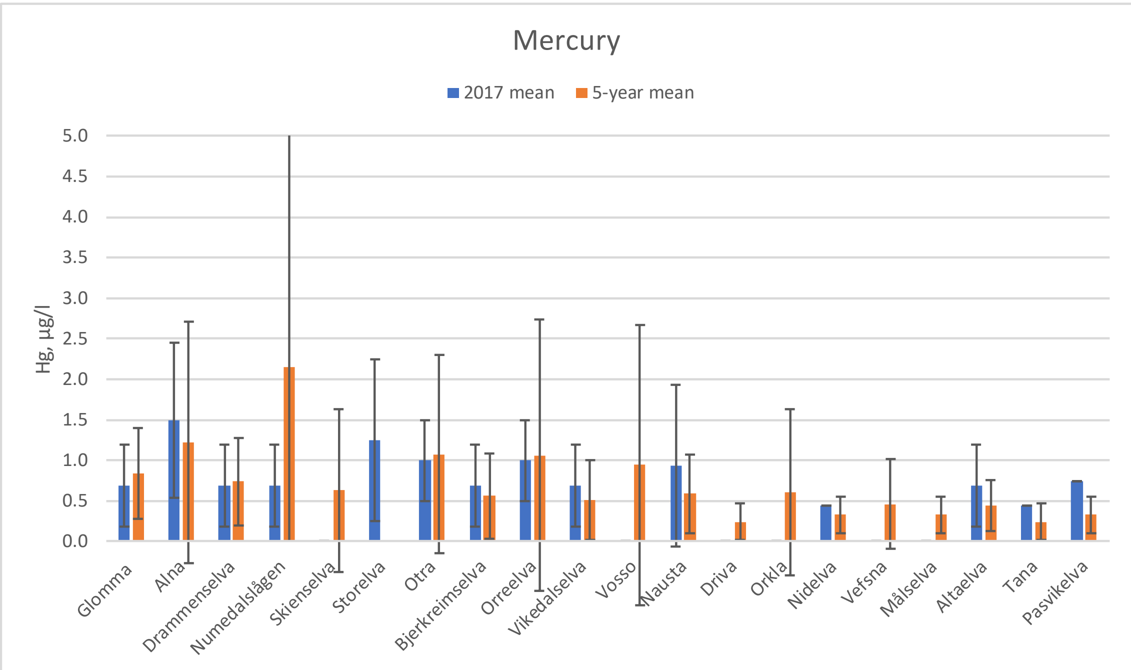


Figure 25. Mercury. Annual mean (2017) and five-year mean (2013-17) concentrations in the monitored rivers. Vertical bars show standard deviation of the mean.

3.3 Trends in concentrations and loads of nutrients, SPM, TOC and silicate

The trend analyses are conducted on both concentrations and loads (riverine transport of dissolved and particulate matter per unit of time). Element concentrations are the most important determinants of water quality in the rivers, whereas loads are more relevant when focusing on effects in coastal waters (e.g., nutrient export from land to sea).

Long-term trends (1990-2017) in loads and concentrations are shown in Table 11 and Table 12, whereas short-term trends (2004-2017) in concentrations are displayed in Table 13.

3.3.1 Trends in suspended particles, silicate and TOC

Long-term trends in rivers monitored monthly since 1990

The particle (SPM) load has increased significantly in Rivers Drammenselva and Numedalslågen (Table 11) and the analyses show that particle load is statistically correlated to water discharge in these rivers (in other words; there is no significant trend in SPM concentration in Numedalslågen, see Table 12). In contrast, loads of particles, total organic carbon and silicate are significantly reduced in River Vefsna, where there is no trend in water discharge.

Table 11. Long-term trends (1990-2017) in water discharge (Q) and loads (transport) of ammonium (NH_4), nitrate (NO_3), total nitrogen (Tot-N), phosphate (PO_4), total phosphorus (Tot-P), suspended particulate matter (SPM), total organic carbon (TOC) and silicate (SiO_2) in rivers monitored monthly since 1990. Table shows p-values.

River	Q	NH_4	NO_3	Tot-N	PO_4	Tot-P	SPM	TOC	SiO_2
Glomma	0.024	0.000	0.304	0.024	0.030	0.527	0.343	0.075	0.040
Drammenselva	0.007	0.007	0.089	0.013	0.001	0.001	0.003	0.001	0.000
Numedalslågen	0.058	0.123	0.385	0.006	0.011	0.014	0.048	0.003	0.001
Skienselva	0.033	0.022	0.000	0.477	0.304	0.089	0.752	0.000	0.002
Otra	0.286	0.053	0.000	0.874	0.304	0.693	0.385	0.502	0.221
Orreelva	0.036	0.429	0.477	0.527	0.105	0.069	0.144	0.040	0.030
Orkla	0.477	0.000	0.635	0.906	0.968	0.236	0.580	0.323	0.782
Vefsna	0.269	0.000	0.000	0.001	0.003	0.000	0.007	0.002	0.058
Altaelva	0.206	0.221	0.407	0.722	0.385	0.286	0.874	0.635	0.722

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

In all the rivers with increased water discharge there is also an increase in the load of total organic carbon and silicate. Silica is a major component of sand and clay and can therefore enter surface water through erosion. The increase in silica in several of the monitored rivers is therefore probably related to the increase in precipitation, water discharge and soil erosion. This can also explain the increase in TOC (Table 12, Figure 26). In addition, an increasing trend in TOC has been found in surface waters across large parts of the northern latitudes, and de Wit *et al.* (2007) and Haaland *et al.* (2010) found that this increase was closely related to the decline in sulphate and chloride concentrations in precipitation (acid rain). Rivers in the northern parts of Norway; Rivers Altaelva, Vefsna, and Orkla, do not have the same trend in TOC, and have also been less affected by acid rain[4].

Table 12. Long-term trends (1990-2017) in concentrations of ammonium (NH_4), nitrate (NO_3), total nitrogen (Tot-N), phosphate (PO_4), total phosphorus (Tot-P), suspended particulate matter (SPM), total organic carbon (TOC) and silicate (SiO_2) in rivers monitored monthly since 1990. Table shows p-values.

River	NH_4	NO_3	Tot-N	PO_4	Tot-P	SPM	TOC	SiO_2
Glomma	0.000	0.298	0.247	0.003	0.488	0.135	0.324	0.006
Drammenselva	0.003	0.111	0.344	0.027	0.136	0.719	0.007	0.001
Numedalslågen	0.383	0.929	0.033	0.059	0.047	0.196	0.062	0.000
Skienselva	0.001	0.000	0.000	0.016	0.933	0.141	0.002	0.006
Otra	0.014	0.000	0.014	0.074	0.002	0.000	0.544	0.600
Orreelva	0.408	0.023	0.094	0.027	0.393	0.378	0.406	0.442
Orkla	0.000	0.862	0.022	0.165	0.129	0.012	0.082	0.053
Vefsna	0.000	0.000	0.002	0.037	0.006	0.001	0.388	0.706
Altaelva	0.007	0.498	0.069	0.116	0.801	0.006	0.309	0.934

Red - significantly upward $p<0.05$, orange - upward but not statistically significant $0.1>p>0.05$, green - significantly downward $p<0.05$, pale green - downward but not statistically significant $0.1>p>0.05$

Short-term (2004-2017) trends in 'new' rivers monitored monthly since 2017

Over the last 13 years, there has been a statistically significant upward trend in water discharge in River Tana, but no significant trends are detected for concentrations of nutrients, particles, silicate and TOC (Table 13). We also performed a trend analysis of water discharge only on the days of sampling. In this analysis there was no visible trend. This shows that even if there is an overall trend in water discharge, the grab samples may not reflect this, due to the low sampling frequency and variations in the water discharge on the days of sampling. Rivers Bjerkreimselva and Vosso had statistically significant upward trends (2004-2017) in TOC concentration, possibly because of decreasing acid deposition during the same period. Rivers Målselva and Pasvikelva had statistically significant increasing silicate concentrations during 2004-2017. In River Målselva, the increase was estimated to 1.1 % per year. Possible explanations for silicate variations are given above (based on Sen slope in the MK analysis).

[4] http://www.miljostatus.no/Tema/Luftforurensning/Sur-nedbor/

Table 13. Short-term (2004-17) trends in concentrations of ammonium (NH_4), nitrate (NO_3), total nitrogen (Tot-N), phosphate (PO_4), total phosphorus (Tot-P), suspended particulate matter (SPM), total organic carbon (TOC) and silicate (SiO_2) in 'new' rivers monitored monthly since 2017. Table shows p-values.

River	Q	NH_4-N	NO_3-N	Tot-N	PO_4-P	Tot-P	SPM	TOC	SiO_2
Bjerkreimselva	0.956	0.060	0.562	0.196	0.467	0.022	0.249	0.005	0.755
Vikedalselva	0.622	0.611	0.197	0.661	0.239	0.755	0.394	0.185	0.225
Vosso	0.412	0.015	0.319	0.710	0.032	0.256	0.503	0.050	0.371
Nausta	0.956	0.026	0.847	0.533	0.753	0.387	0.931	0.158	0.879
Driva	0.208	0.006	0.656	0.617	0.970	0.870	0.144	0.108	0.843
Nidelva	0.412	0.630	0.470	0.317	0.270	0.086	0.072	0.546	0.066
Målselva	0.171	0.013	0.093	0.176	0.481	0.339	0.402	0.899	0.007
Tana	0.033	0.189	0.287	0.119	0.515	0.888	0.948	0.554	0.980
Pasvikelva	0.208	0.849	0.326	0.574	0.066	0.766	0.149	0.930	0.018

Red - significantly upward $p<0.05$, orange - upward but not statistically significant $0.1>p>0.05$, green - significantly downward $p<0.05$, pale green - downward but not statistically significant $0.1>p>0.05$

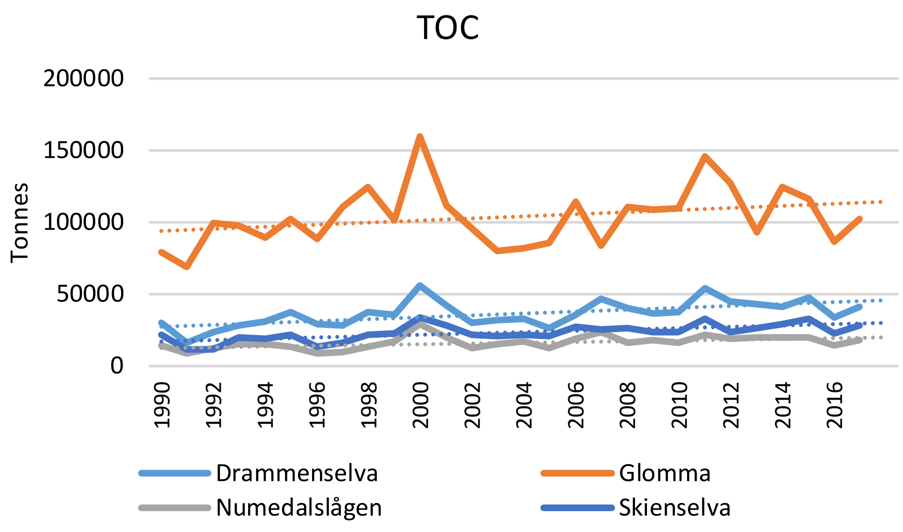


Figure 26. Annual riverine loads of total organic carbon (TOC) in Rivers Drammenselva, Glomma, Numedalslågen and Skienselva 1990-2017.

3.3.2 Nitrogen

Long-term trends in rivers monitored monthly since 1990

There was a significant upward trend in total nitrogen load over the period 1990-2017 for Rivers Glomma, Drammenselva and Numedalslågen (Table 11). The increase is estimated to 0.7, 1.1 and 1.6 % per year, respectively. River Numedalslågen has the highest estimated relative increase per year (Figure 27), and in this river, there has also been a significant increase in the total nitrogen concentration (Table 12). However, the loads of nitrate and ammonium have not increased significantly in the same rivers. Hence, it is likely that it is organic nitrogen that has increased, and this can be linked to the increase in total organic carbon, as organic matter contains nitrogen (Tipping 2002). The increase in TOC load is also of the same magnitude as the increase in total nitrogen, respectively 0.8, 1.9 and 1.7 % for these three rivers.

Nitrate loads and concentrations have decreased significantly in Rivers Skienselva (Figure 28), Otra and Vefsna. Ammonium loads have decreased significantly in all rivers except River Numedalslågen and River Orreelva. Ammonium is normally quickly assimilated by plants or converted into nitrate in river water (through nitrification processes) and therefore represents a less informative parameter for long-term trend assessments. The most significant sources of nitrate and ammonia include agriculture, wastewater, sewage systems from scattered dwellings and mineralisation. There has been a huge effort to implement measures aimed towards minimising nutrient losses from agriculture and sewage in the last decades. In addition, there has been reductions in atmospheric deposition of long-range transported nitrogen compounds since 1990 (Garmo and Skancke 2018).

Short-term (2004-2017) trends in 'new' rivers monitored monthly since 2017

For the 'new rivers' monitored monthly in 2017, there are statistically significant downward trends in the concentrations of ammonium in Rivers Bjerkreimselva, Vosso, Nausta, Driva and Målselva (Table 13). Figure 29 shows graphs for Driva, Målselva, Nausta and Vosso. These downward trends in ammonium were noted also in several of the rivers monitored monthly since 1990, and this decline therefore seems to be a general trend in large parts of Norway.

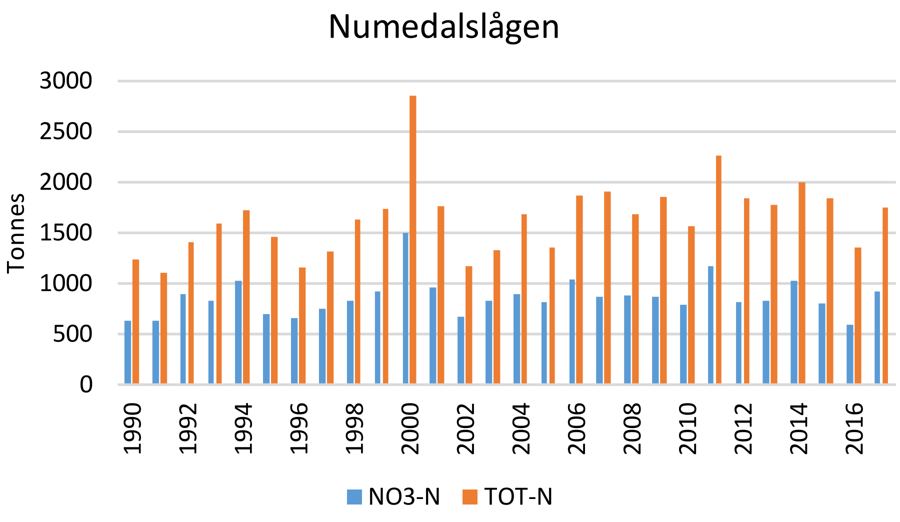


Figure 27. Annual riverine loads of total nitrogen (tot-N) and nitrate (NO_3-N) in River Numedalslågen 1990-2017.

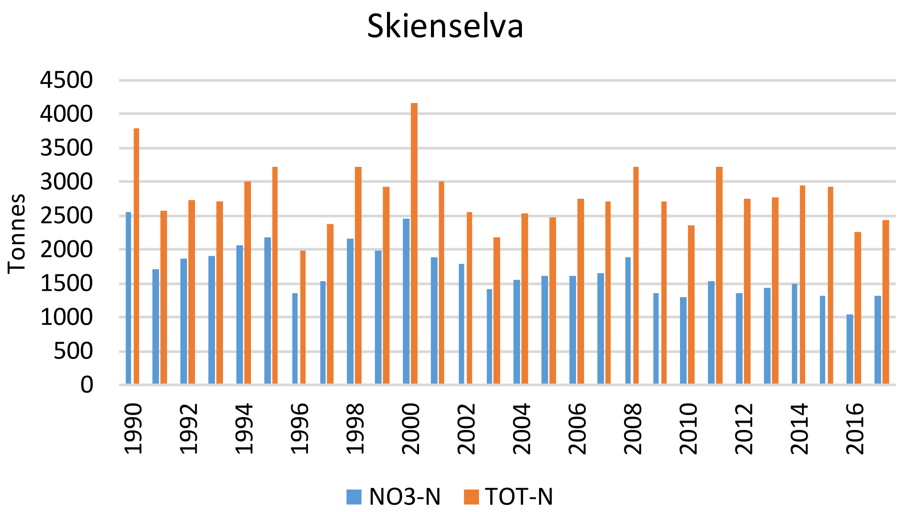


Figure 28. Annual riverine loads of total nitrogen (tot-N), nitrate (NO_3-N) and water discharge in River Skienselva 1990-2017.

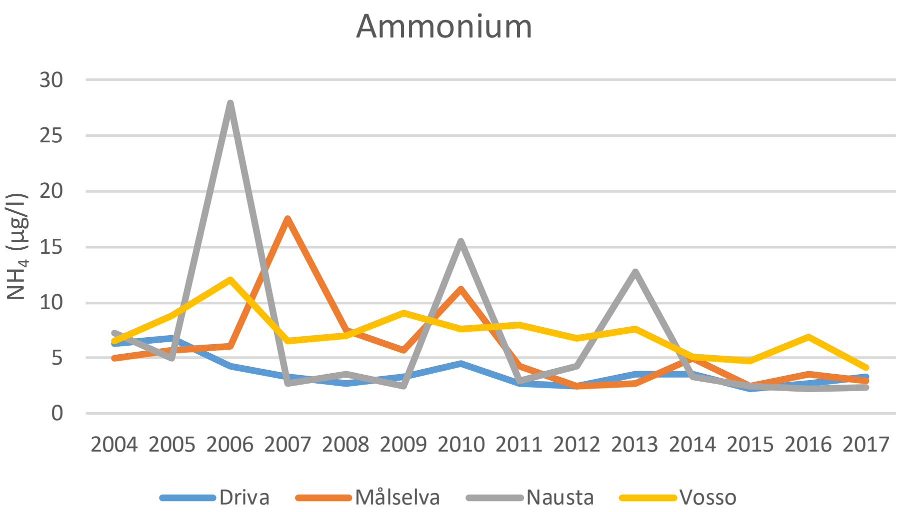


Figure 29. Annual mean ammonium concentrations in Rivers Driva, Målselva, Nausta and Vosso 2004-2017.

3.3.3 Phosphorus

Long-term trends in rivers monitored monthly since 1990

Total phosphorus loads have increased significantly in Rivers Drammenselva and Numedalslågen since 1990 (Table 11). This increase can partly be explained by an increase in water discharge and suspended particles in the same period. Previous analyses show that both water discharge and particles have high covariance with phosphorus in these rivers (Skarbøvik *et al*. 2017). In River Glomma there has been an increase in both load and concentration of phosphate, but not in total phosphorus (Table 12, Figure 30). In this river, the water discharge has increased, whereas the particle load has not. Phosphate has a high covariance with water discharge in this river, while total phosphorus has a high covariance with both particles and water discharge. In Rivers Skienselva and Orreelva there is a non-significant upward trend in total phosphorus load, which could be related to the significant increase in water discharge. In the same rivers, the concentration of phosphate has increased significantly, whereas no trends are detected for tot-P concentrations. In Rivers Vefsna and Otra there are significant downward trends in concentrations of total phosphorus, and in River Vefsna also the loads have decreased (Figure 31).

Short term (2004-2017) trends in 'new' rivers monitored monthly since 2017

In the period 2004-2017 the trend analyses show a statistically significant downward trend in total phosphorus in River Bjerkreimselva and a statistically significant upward trend in phosphate in River Vosso (Table 13). However, both these rivers have several samples below LOQ for phosphate; in River Vosso about 73 out of 148 samples are below LOQ while in River Bjerkreimselva about 19 out of 64 are below LOQ. These trends should therefore be regarded with caution.

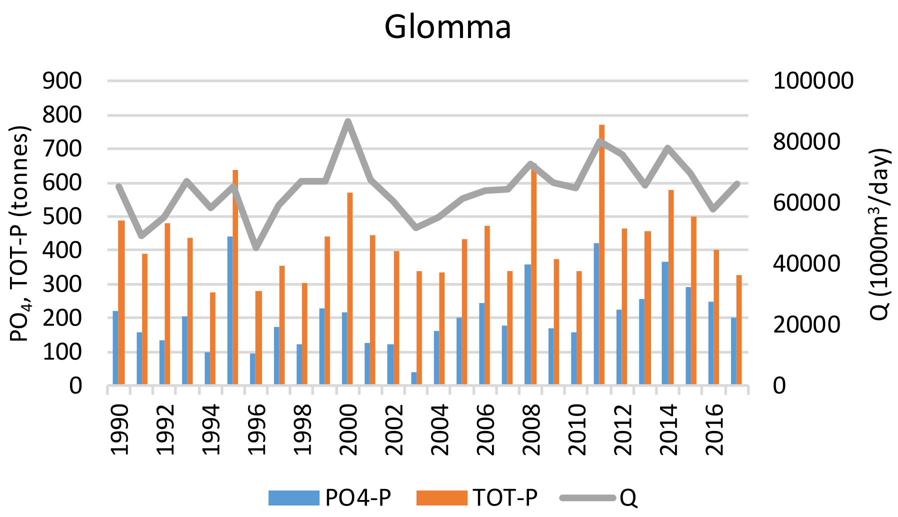


Figure 30. Annual riverine loads of total phosphorus (tot-P), phosphate (PO_4-P), and water discharge (Q) in River Glomma 1990-2017.

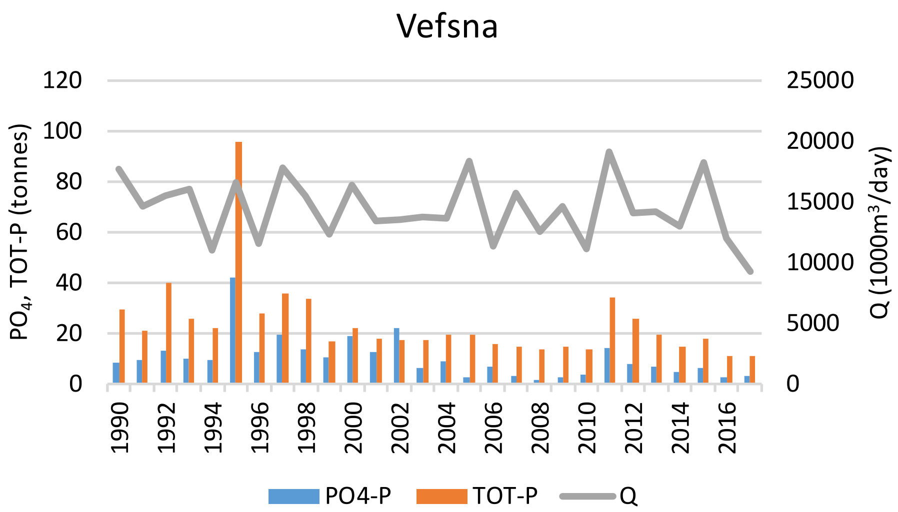


Figure 31. Annual riverine loads of total phosphorus (tot-P), phosphate (PO_4-P) and water discharge (Q) in River Vefsna 1990-2017.

3.4 Trends in metal concentrations and loads

Statistical trend tests were performed for concentrations and loads of copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), and nickel (Ni). In general, there is a significant downward trend in riverine metal concentrations for most of the metals. The loads of different metals have decreased in several of the rivers, and no rivers have significantly increasing metal loads.

The results are described in detail below, but in short, the analyses indicate:

- Of the 45 long-term trend tests carried out in the rivers monitored monthly since 1990 (5 metals and 9 rivers), 25 showed statistically significant downward trends in long-term **loads.** None of the rivers showed increasing trends in loads. 39 tests showed statistically significant downward trends in **concentrations**.

- For the shorter time period of 13 years (2004-2017), significant downward trends in **loads** were detected in 6 out of 45 tests (rivers monitored monthly since 1990). Statistically significant short-term upward trends in **concentrations** were detected for nickel in River Altaelva and River Driva, and for zinc in River Glomma. Nevertheless, across the rivers monitored monthly since 1990 and the 'new' rivers, statistically significant short-term downward trends in **concentrations** were detected in 24 out of 90 trend tests, which signifies that the downward trends in metals since 1990 seems to be continuing also after 2004.

Although this can be seen as a success of various efforts to reduce emissions of heavy metals, it should be emphasised that changed LOQs over time lead to uncertainties in the trend analyses for cadmium, nickel, and (to some extent) lead (see Skarbøvik *et al.*, 2007 and Stålnacke *et al.*, 2009, for details). Table 14 and Table 15 show the long-term trend analyses (1990-2017), whereas Table 16,Table 17, and Table 18 show the short-term trend analyses (2004-2017).

Table 14. Long-term trends (1990-2017) in metal loads in rivers monitored monthly since 1990. Table shows p-values

River	Q	Cd	Cu	Ni	Pb	Zn
Glomma	0.024	0.010	0.323	0.269	0.016	0.813
Drammenselva	0.007	0.003	0.144	0.343	0.167	0.407
Numedalslågen	0.058	0.018	0.013	0.527	0.114	0.048
Skienselva	0.033	0.000	0.005	0.003	0.693	0.286
Otra	0.286	0.016	0.407	0.001	0.407	0.016
Orreelva	0.036	0.607	0.221	0.155	0.236	0.553
Orkla	0.477	0.001	0.002	0.044	0.007	0.000
Vefsna	0.269	0.000	0.000	0.000	0.000	0.000
Altaelva	0.206	0.001	0.001	0.033	0.244	0.040

Red – significantly upward $p<0.05$, orange – upward but not statistically significant $0.1>p>0.05$, green – significantly downward $p<0.05$, pale green – downward but not statistically significant $0.1>p>0.05$

Table 15. Long-term trends (1990-2017) in metal concentrations in rivers monitored monthly since 1990. Table shows p-values

River	Cd	Cu	Ni	Pb	Zn
Glomma	0.000	0.001	0.001	0.000	0.297
Drammenselva	0.000	0.004	0.004	0.249	0.002
Numedalslågen	0.000	0.000	0.001	0.005	0.000
Skienselva	0.000	0.000	0.000	0.007	0.000
Otra	0.000	0.770	0.000	0.003	0.000
Orreelva	0.000	0.055	0.001	0.019	0.231
Orkla	0.001	0.000	0.003	0.000	0.000
Vefsna	0.000	0.000	0.002	0.000	0.000
Altaelva	0.000	0.000	0.074	0.000	0.000

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

Table 16. Short-term trends (2004-2017) in metal loads in rivers monitored monthly since 1990. Table shows p-values

River	Cd	Cu	Ni	Pb	Zn
Glomma	0.250	0.090	0.702	0.702	0.090
Drammenselva	0.870	0.412	0.412	0.171	0.622
Numedalslågen	0.702	0.298	0.477	0.622	0.477
Skienselva	0.870	0.298	0.090	0.547	0.352
Otra	0.250	0.043	0.112	0.784	0.071
Orreelva	0.352	0.622	0.622	0.784	0.870
Orkla	0.019	0.007	0.412	0.025	0.010
Vefsna	0.324	0.139	0.784	0.090	0.004
Altaelva	0.782	0.477	0.208	0.956	0.622

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

Table 17. Short-term trends (2004-2017) in metal concentrations in rivers monitored monthly since 1990. Table shows p-values

River	Cd	Cu	Ni	Pb	Zn
Glomma	0.485	0.008	0.544	0.973	0.014
Drammenselva	0.392	0.010	0.427	0.635	0.010
Numedalslågen	0.052	0.096	0.671	0.538	0.008
Skienselva	0.006	0.011	0.002	0.494	0.009
Otra	0.155	0.020	0.016	0.889	0.023
Orreelva	0.094	0.058	0.072	0.482	0.304
Orkla	0.158	0.004	0.626	0.031	0.046
Vefsna	0.101	0.071	0.051	0.225	0.006
Altaelva	0.056	0.010	0.041	0.690	0.243

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

Table 18. Short-term trends (2004-2017) in metal concentrations for 'new' rivers monitored monthly since 2017. Table shows p-values

River	Q	Cd	Cu	Ni	Pb	Zn
Bjerkreimselva	0.956	0.652	0.327	0.129	0.010	0.644
Vikedalselva	0.622	0.175	0.862	0.625	0.276	0.934
Vosso	0.412	0.040	0.055	0.360	0.322	0.090
Nausta	0.956	0.371	0.122	0.029	0.493	0.159
Driva	0.208	0.006	0.304	0.011	0.706	0.076
Nidelva	0.412	0.105	0.047	0.313	0.036	0.070
Målselva	0.171	0.005	0.718	0.068	0.171	0.267
Tana	0.033	0.021	0.264	0.263	0.455	0.777
Pasvikelva	0.208	0.138	1.000	0.742	0.382	0.826

Red - significantly upward p<0.05, orange - upward but not statistically significant 0.1>p>0.05, green - significantly downward p<0.05, pale green - downward but not statistically significant 0.1>p>0.05

3.4.1 Copper (Cu)

The LOQ for copper has not changed significantly over the monitoring period (since 1990), so the trend analyses for copper are regarded as less uncertain than for many other metals.

In the period 1990-2017 the concentrations of copper have decreased significantly in all rivers except Rivers Otra and Orreelva. The loads have decreased significantly in five rivers (Rivers Numedalslågen, Skienselva, Orkla, Vefsna and Altaelva).

In the more recent period 2004-2017, the concentrations of copper decreased significantly in seven rivers. Over the same time period, the loads of copper decreased significantly in two rivers (Rivers Otra and Orkla). In River Otra there was an upward trend in copper loads in the period 1996 - 2008, but after 2008 the loads decreased (Figure 32) and in 2017 the loads were back to the same level as before the increase started. The reason for the increase is uncertain, the water discharge has not increased in the same period and neither has the particle load.

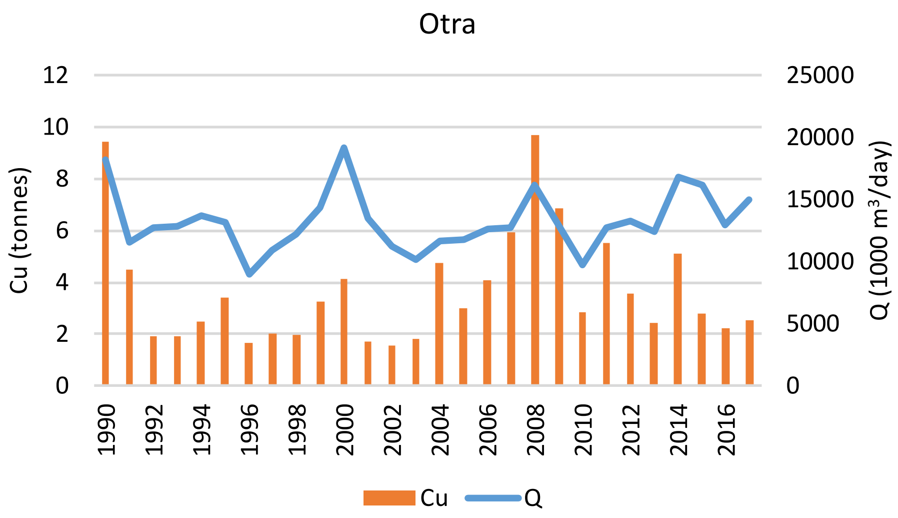


Figure 32. Annual riverine loads of copper (Cu) and water discharge (Q) in River Otra 1990-2017.

3.4.2 Lead (Pb)

As noted in previous reports (e.g. Skarbøvik *et al*. 2017), the LOQ for lead has changed with a factor of 100 over the monitoring period. However, trends after 2004 are not affected by these changes.

In the period 1990-2017 the concentrations of lead decreased significantly in all rivers, except in River Drammenselva. Riverine loads of lead have decreased significantly in Rivers Glomma, Orkla and Vefsna. However, the changes in LOQ imply that the interpretation of downward trends in lead loads should be made with caution. In River Drammenselva the riverine loads of lead have been highly variable, with an apparent increase in the latter years. However, in 2017 the loads decreased again (Figure 33). It cannot yet be concluded if this decrease is due to an actual decrease or if this is a result of moving from 12 to 4 water samples analysed for metals per year.

Considering only the 13-year period since 2004, there is a significant decrease in lead loads in River Orkla (Figure 34), and a tendency of decrease in River Vefsna. Lead concentrations show significant downward trends in Rivers Orkla, Nidelva and Bjerkreimselva.

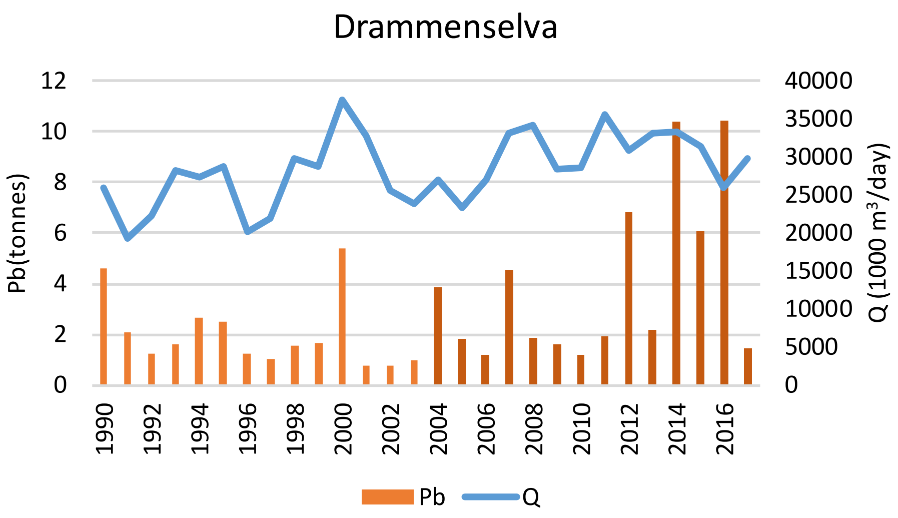


Figure 33. Annual riverine loads of lead (Pb) and water discharge in River Drammenselva 1990-2017. The period 2004-2017 is coloured a deeper shade.

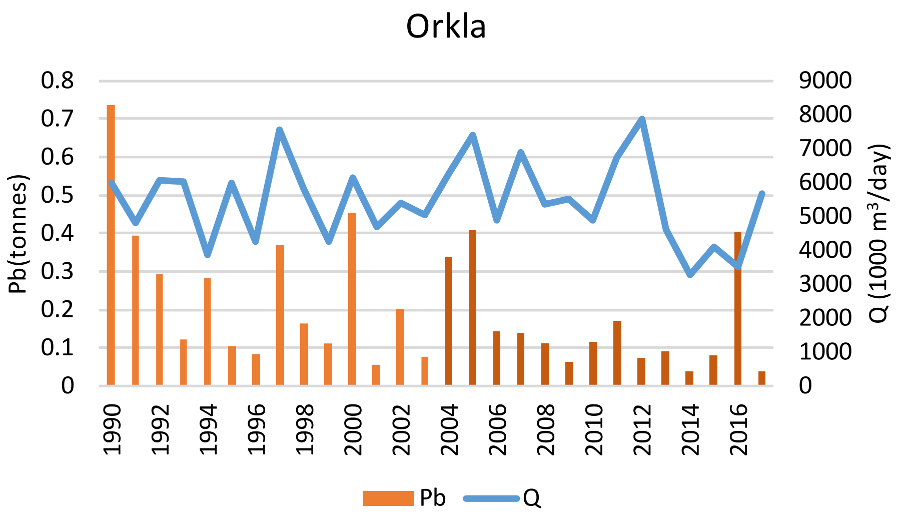


Figure 34. Annual riverine loads of lead (Pb) and water discharge in River Orkla 1990-2017. The period 2004-2017 is coloured a deeper shade.

3.4.3 Zinc (Zn)

The LOQ for zinc has not changed much during the two monitoring periods (1990-2017 and 2004-2017).

In the period 1990-2017 the concentrations of zinc decreased significantly in all rivers except River Glomma and River Orreelva. Riverine loads of zinc have decreased significantly in five rivers (Rivers Numedalslågen, Otra, Orkla, Altaelva and Vefsna). Considering the period after 2004 the concentration of zinc decreased significantly in six rivers while there was a significant increase in concentration in one river (River Glomma). None of the ‘new monthly rivers’ have any significant trends in zinc concentration. Rivers Orkla and Vefsna have significant downward short-term trends in riverine loads of zinc.

In the period 2011 to 2017 the loads of zinc were considerable higher in River Glomma (Figure 35) than in previous years. There was also a significant increase in concentrations of zinc in the period from 2004 to 2017. However, the load and concentration of zinc in 2017 is comparable to the period before the increase started. The reason for the increase in zinc is not known, sources of zinc can include galvanized surfaces and vehicle tyres. As reported in an earlier report (Skarbøvik *et al*. 2016), for many of the examined rivers the zinc loads show relatively low inter-annual variability as compared with many of the other metals. High loads in single years were almost solely explained by high single concentration values (e.g. 1993 in River Numedalslågen, 1990 in River Skienselva, 2005 in River Orreelva, and 2008 in River Altaelva). However, in River Glomma, the increased loads in 2011-2016 are not due to single samples with high concentrations. This suggests that the river for some years was affected by a point source, which now is significantly reduced or removed.

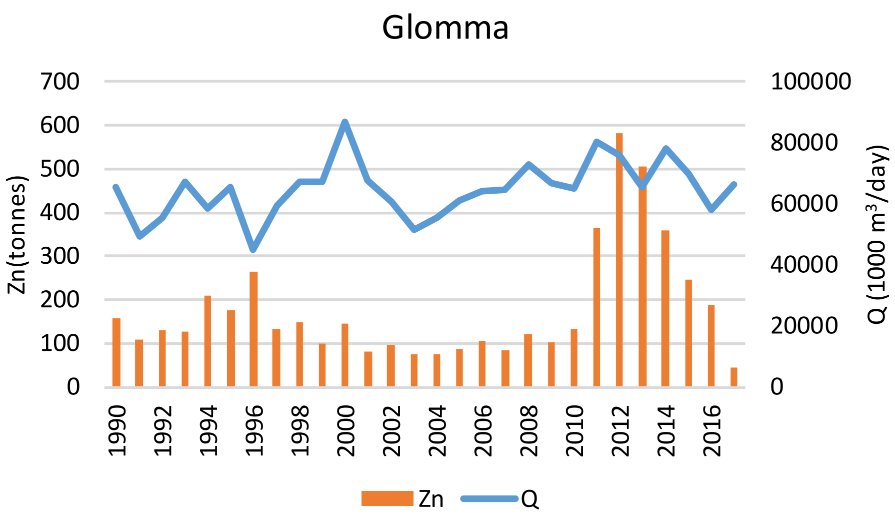


Figure 35. Annual riverine loads of zinc (Zn) and water discharge in River Glomma 1990-2017.

3.4.4 Cadmium (Cd)

The LOQ for cadmium has changed markedly over the monitoring period, from 100 ng/l in 1990 to 10 ng/l in 1991-2004, 5 ng/l in 2005-2014 and 3 ng/l since 2015. This means that the interpretation of downward trends in cadmium loads should be made with caution.

Over the period 1990-2017 the concentrations and loads of cadmium have decreased significantly in all rivers except loads in River Orreelva. About 25% of the cadmium observations in the nine rivers monitored monthly since 1990 were below LOQ, weakening the statistical power.

After 2004 there is a significant decreasing trend in cadmium concentration in River Skienselva and a significant decreasing cadmium load in River Orkla (Figure 36 and Figure 37). In these rivers there are no concentrations below LOQ after 2014. There are also statistically significant downward trends in cadmium concentrations in Rivers Vosso, Driva, Målselva and Tana. However, these rivers have a high percentage of samples below LOQ and trends are therefore difficult to evaluate.

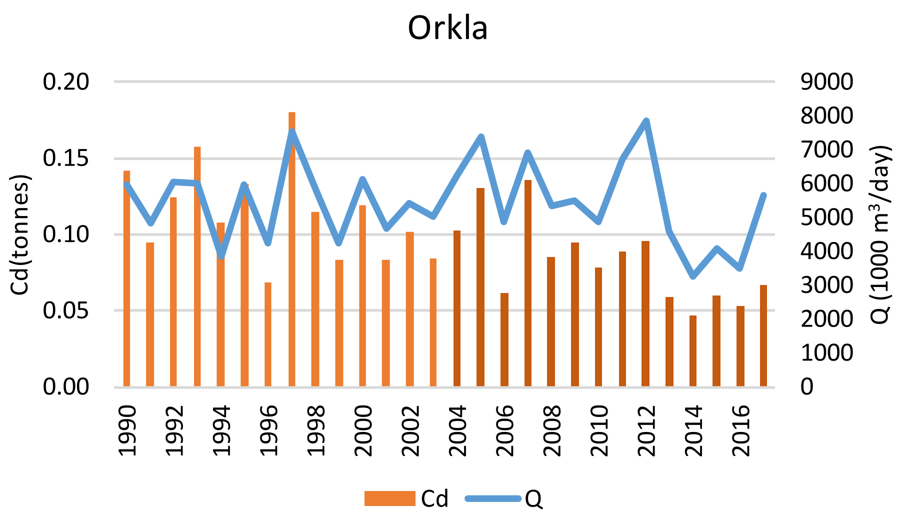


Figure 36. Annual riverine loads of cadmium (Cd) and water discharge in River Orkla 1990-2017. The period 2004-2017 is coloured a deeper shade.

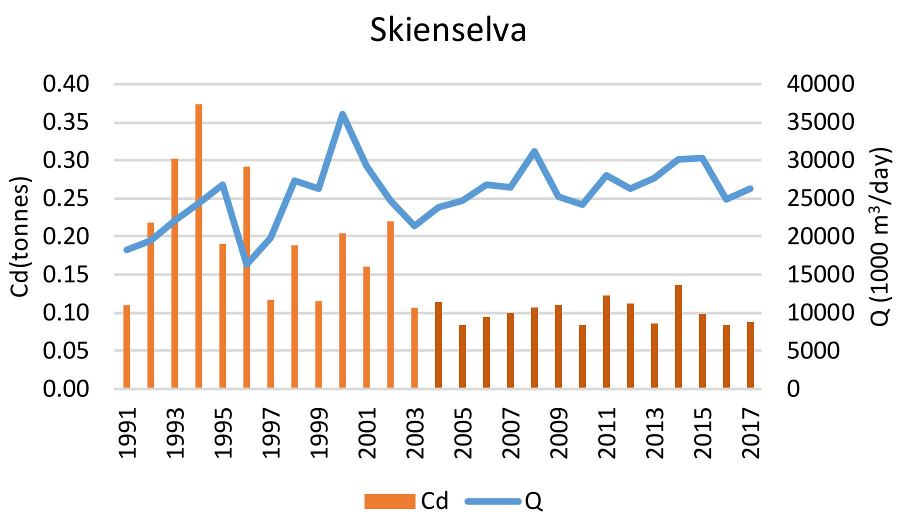


Figure 37. Annual riverine loads of cadmium (Cd) and water discharge in River Skienselva 1991-2017. The year 1990 is omitted due to many samples (8 out of 10) below the detection limit. The period 2004-2017 is coloured a deeper shade.

3.4.5 Nickel (Ni)

Like the case of lead and cadmium, the LOQ of nickel has changed over time, and the results of the trend analyses should therefore be treated with care.

In the period 1990-2017 the concentrations of nickel have decreased significantly in all rivers except River Altaelva (Figure 38). Loads of nickel have decreased in Rivers Skienselva, Otra, Vefsna and Altaelva. The concerns related to LOQ do not affect the short-term trends, since the LOQ has not changed since 2004. From 2004-2017 there was a significant decrease in nickel concentrations in Rivers Skienselva, Otra and Nausta. In Rivers Altaelva and Driva there are significant upward trends in nickel concentrations (River Driva shown in Figure 39), but an inspection of the whole data series back to 1990 indicates that these increases are not 'alarming' in any way; higher concentrations have been found earlier in River Altaelva (data before 2004 are scarce in Driva). There were no significant short-term trends in nickel loads from River Altaelva.

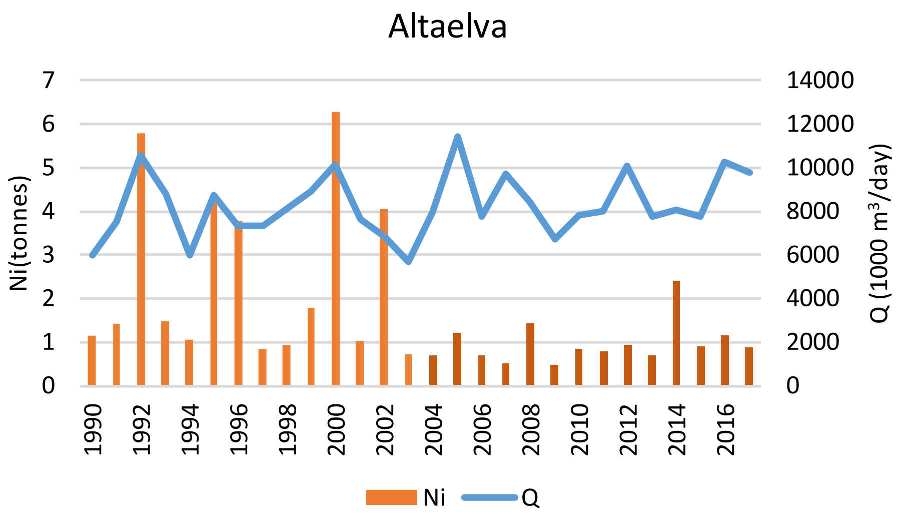


Figure 38. Annual riverine loads of nickel (Ni) and water discharge in River Altaelva 1991-2017. The period 2004-2017 is coloured a deeper shade.

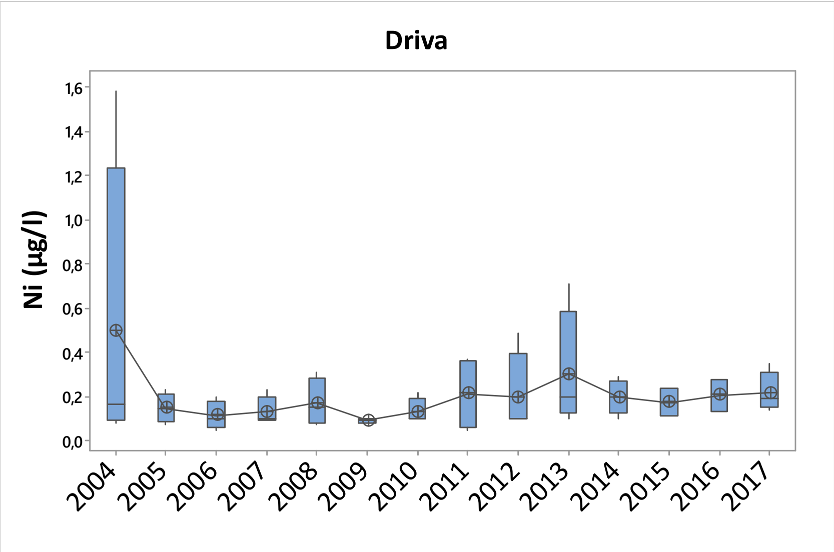


Figure 39. Concentration of nickel (Ni) in River Driva 2004-2017. The circle and line represent the mean, while the boxes represent the interquartile range.

3.5 Quality of dissolved organic matter

Dissolved organic matter (DOM) is a complex and dynamic material that affects numerous biogeochemical processes in the catchment. Spectroscopic techniques such as absorbance within the UV and visible light spectrum are commonly used to characterize the DOM. Light absorption at a certain wavelength is attributed to specific molecular segments or functional groups, and hence several spectral indices have been defined to describe characteristics such as the degree of aromaticity (sUVa) and molecular size (E2/E3) (Peuravuori & Pihlaja, 1997; Weishaar *et al.*, 2003). See Table 19 for details. The quality of DOM is governed by its source material, hydrological and climatic conditions, in addition to various local transformation processes. Generally, older and more degraded DOM has higher aromaticity and larger molecular size compared to fresh DOM (Kalbitz *et al.*, 2003; Marschner & Kalbitz, 2003).

Table 19. Overview of the absorbance indices used to describe DOM quality

	Name	Definition	Characteristic
sUVa	Specific UV absorbance	(Abs 254nm / DOC[5])*100	Aromaticity (positive relationship)
E2/E3		250 nm /365nm	Aromaticity (negative relationship) Molecular size (negative relationship)

For this analysis, regional and seasonal patterns in DOM quantity and quality have been investigated. This has been done by geographically grouping the rivers (Table 1) according to the four major drainage basins of Norway (rivers draining to the Barents Sea, the Norwegian Sea, the North Sea, and Skagerrak). In addition, data from the parallel monitoring of a different set of river sites (Kile *et al*. 2018) have been included to provide insight into possible changes in DOM quantity and quality along the river continuum. These monitoring sites are partly sites upstream of sites used for the current report, and partly different rivers with several sampling points.

Regional variation

In Figure 40 annual average levels of DOM quality expressed as a) sUVa and b) E2/E3 are presented in relation to DOM quantity (expressed as TOC concentration), and c) the TOC concentration is presented in relation to discharge, for each river. The largest geographical variation appears between rivers in the Skagerrak region (south-east) and the North Sea region (west). Rivers in the Skagerrak region displayed the highest TOC concentrations while the rivers in the North Sea region had the lowest concentrations. This can be explained by the higher primary productivity in the south-east providing ample supply of organic matter, while in the west intensive precipitation leads to dilution of the DOM present at an already lower yield. The two northern regions, North Sea and Barents Sea, are more similar in TOC concentration and lie in-between the two other regions. Interestingly, rivers in the North Sea region with the lowest TOC concentration is associated with DOM of more aromatic and larger size material. The reason for this is not known, but it could be related to differences in hydrological conditions and/or source of DOM. In the literature, DOM of relatively higher aromaticity and larger size range is associated with more humified and degraded material,

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

see e.g. Marschner and Kalbitz (2003). Rivers Orreelva and Alna, found in the lower and higher right corners of Figure 40a and b, respectively, have similar characteristics, but deviate from the other rivers in their regions. These rivers are likely to have DOM of a different character, given the highly deviating land use (River Orreelva is dominated by agriculture, and River Alna by agricultural land).

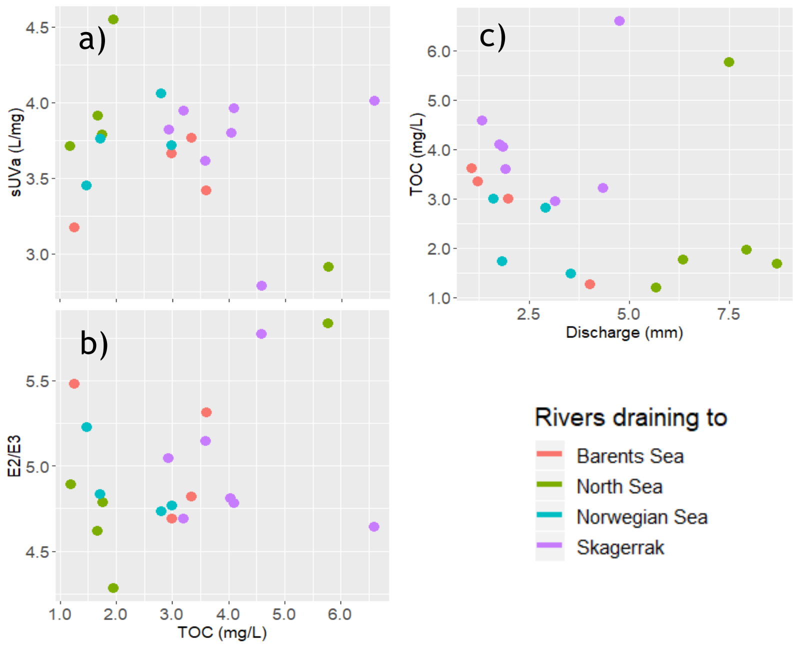


Figure 40. Relation between the a) sUVa, b) E2/E3 and TOC concentration, and between TOC concentration and discharge for rivers draining to the Barents Sea (n = 4), the North Sea (n = 5), the Norwegian Sea (n = 4), and Skagerrak (n = 7) (annual averages).

Seasonal variation

Seasonal trends in DOM quantity and quality are presented in Figure 41a-c by regional and total monthly averages. Total average TOC concentrations were found to peak during spring and autumn, with the highest levels measured during the latter season (Figure 41a). This can be attributed to the seasonal events of snow melt during spring and more frequent intensive rain during autumn, resulting in flushing of the forest floor. Regional averages display relatively large inter-seasonal variations, likely influenced by local discharge events.

Looking at the quality parameters, all regions display increasing aromaticity and decreasing molecular size throughout the year. This is hypothesized to result from seasonal variation in the dominating source of DOM; in early spring the major source of riverine DOM is less decomposed material with a broad continuum in size and aromaticity, while during summer the organic matter is subject to more extensive decomposition, leaving only the more aromatic and larger size DOM available for transport to the rivers. Similar trends have been described elsewhere, in particular for northern riverine systems (see e.g. Liu *et al.* (2014) and Spencer *et al.* (2008)).

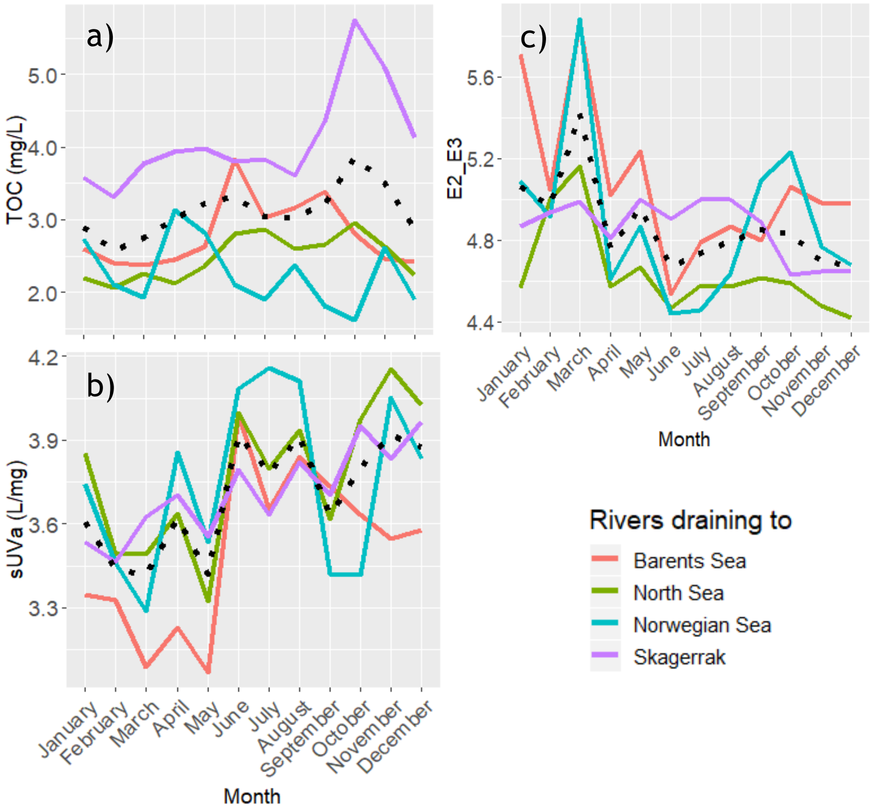


Figure 41. Monthly average values of a) TOC concentration, b) sUVa, and E2/E3 for rivers in the four regions of Barents Sea (n = 4), North Sea (n = 5), Norwegian Sea (n = 4), and Skagerrak (n = 7). Total monthly averages are illustrated by dashed line of black colour (n = 20).

Variability along the rivers

For some rivers, sampling has been conducted at three different sites along the river, all located in the lower part of the river. This provides an opportunity for studying changes in the quantity and quality of DOM due to differences in catchment characteristics, as well as processes within the river. In Figure 42, annual average values of a) TOC concentration, b) sUVa, and c) E2/E3 are presented for each of the three sampling sites (upstream, middle, downstream) for each river. In general, few of the rivers display marked differences in the DOM quantity and quality between the three sites. One exception is River Glomma/Vorma for which the upstream site was distinguished from the two lower lying sites both with regards to DOM quantity and quality. The upstream site is in River Vorma, representing a substantial side catchment, with potentially quite different characteristics than the larger River Glomma catchment, represented by the two sites downstream. In this case the aromaticity of the DOM increased downstream. This is in general the expected effect resulting from the DOM degradation happening in the river, but in this case differences in catchment characteristics may be just as important.

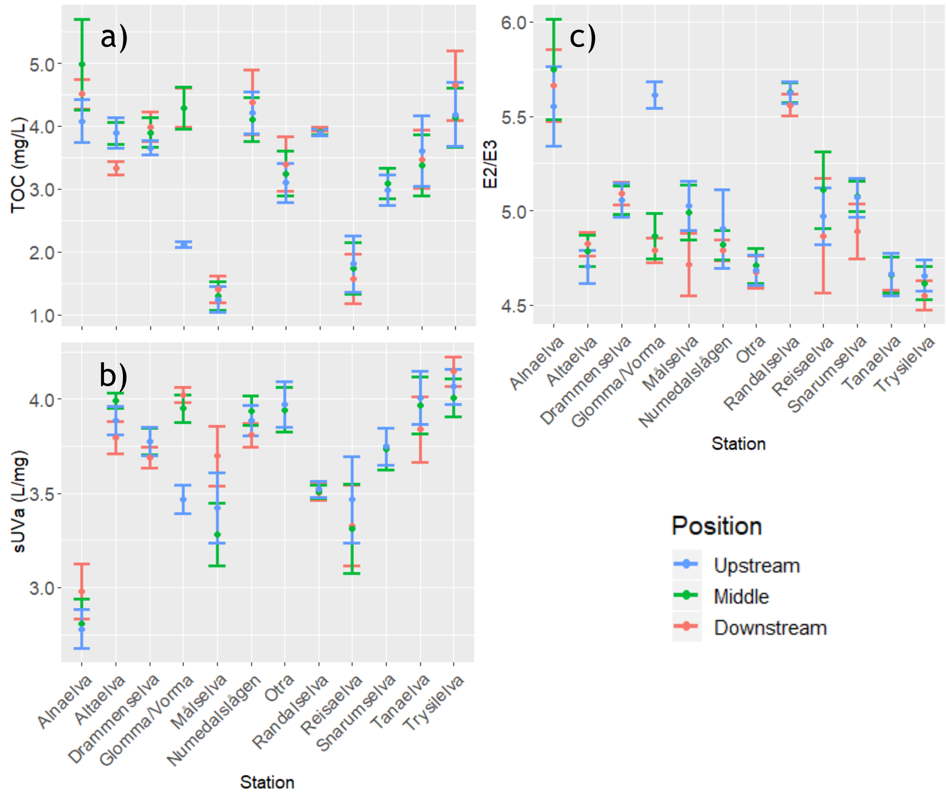


Figure 42. Annual (~ May-Dec) average levels of a) TOC concentration, b) sUVa, and c) E2/E3 for the rivers sampled at three different sites along the river (Upstream, Middle, and Downstream). Error bars illustrate one standard deviation of the mean.

3.6 Stable N- and O-isotopes in nitrate

Different sources of nitrate (NO_3) often have distinct nitrogen (N) and oxygen (O) isotopic compositions (Figure 43). Hence, identification of stable nitrogen and oxygen isotope ratios ($d^{15}N$ and $d^{18}O$) in NO_3 can be a suitable tool for tracing sources of NO_3 in surface water (Kendall, 1998). Biological cycling of NO_3 often changes isotopic ratios in a predictable manner owing to isotope fractionation, i.e. discrimination between light and heavy isotopes during the transformation process. Hence, the origin and history of exported NO_3 in many instances might be reconstructed from the isotopic compositions of N and O.

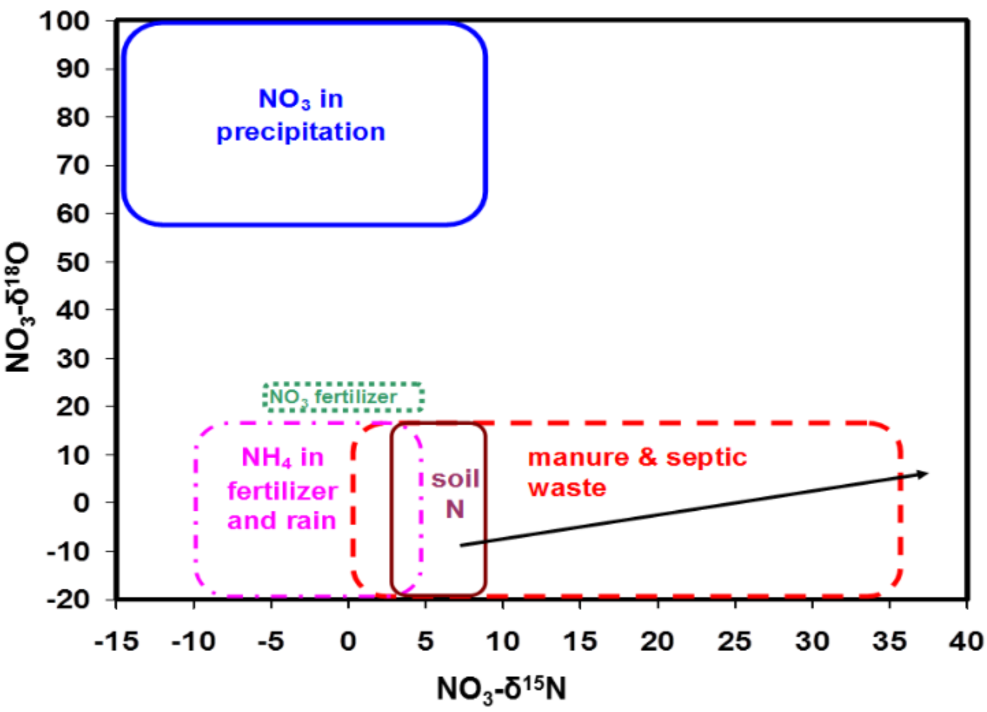


Figure 43. Typical ranges of $d^{15}N$ and $d^{18}O$ values of nitrate from various sources (from Kendall 1995).

N isotope ratios have been applied in many studies to discriminate between point sources (manure, sewage) and non-point sources (atmospheric deposition, synthetic fertiliser, soil organic matter) in river basins (Mayer *et al.*, 2002). However, N isotopes alone cannot differentiate between the various sources, especially the non-point sources (atmospheric deposition, synthetic fertiliser, soil nitrogen), because they usually have overlapping $d^{15}N$ values (Figure 43). Therefore, the method of measuring both N and O isotope ratios of NO_3 (the dual-isotope technique) can be quite useful (Amberger and Schmidt 1987; Revesz *et al.* 1997, Silva *et al.* 2000). The combined analysis of both $d^{15}N$ and $d^{18}O$ of NO_3 in many cases provides a valuable tool for differentiating between diffuse NO_3 sources in lowland rivers (fertiliser vs. manure; natural soil N vs. fertilizer and/or manure) and in upland catchments enriched with atmospheric N (natural soil N vs. atmospheric deposition).

To test the method in a Norwegian river, a one-day sampling campaign was carried out in River Alna, which runs through the city of Oslo. Three stations were sampled; 1. River Alna at

Kværnerbyen (two parallel samples), 2. River Alna at Bryn (two parallel samples), and 3. River Alna at Alfaset (four parallel samples). All stations are located within the Oslo urban area, with station 1 closest to the outlet (Figure 2). Results from the isotope analysis are shown in Figure 44. The stations were clearly separated in the diagram, and the parallel samples show only small deviations (i.e. high analytic precision). There were however relatively small differences in the isotopic signatures between the stations, and if the results were projected into the example diagram in Figure 43 they would place themselves in an area characterized by soil N and septic waste. This sounds reasonable when knowing that River Alna has its source areas in the south-eastern part of the Oslo forest and is heavily affected by urban runoff, as it discharges through part of the outer suburbs (Groruddalen) and Oslo city centre. Slightly higher $d^{15}N$ values at station 1 and 2 suggest and increasing influence of urban wastewater downstream the river. However, when bearing in mind the small number of sample plots and the small differences in the isotopic signatures, results should be interpreted with caution.

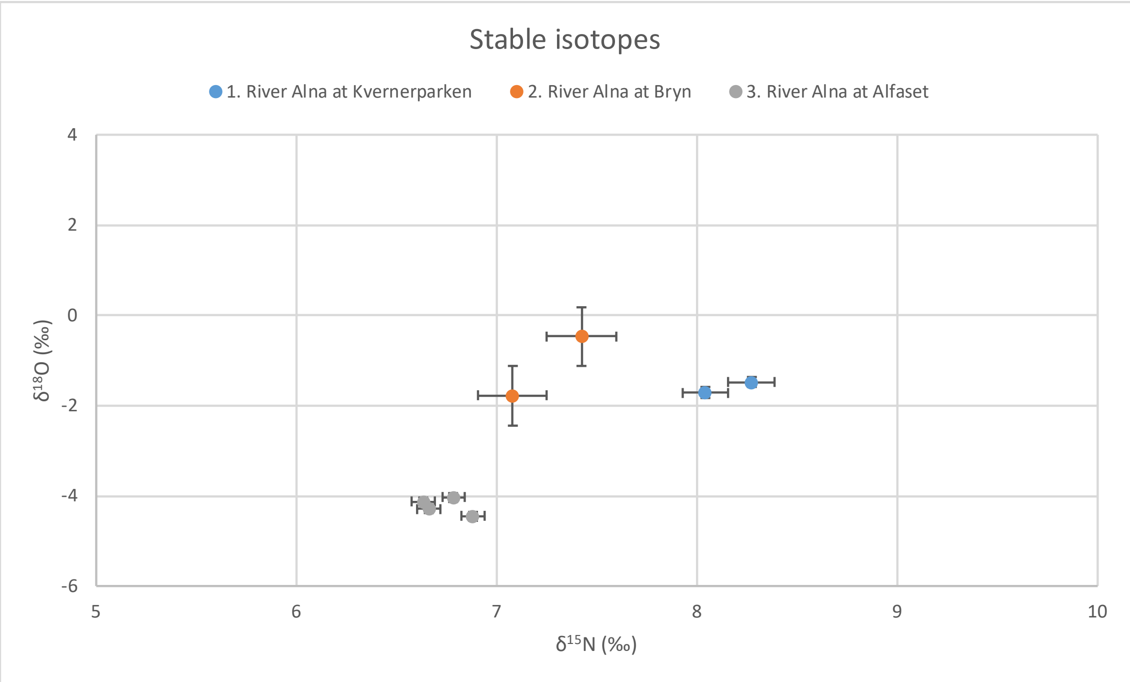


Figure 44. $d^{15}N$ and $d^{18}O$ values in samples from River Alna collected on 28 September 2017. Standard error bars are indicated.

In river catchments, multiple NO_3 sources, a mosaic of land-use types and complex hydrology can easily result in overlapping isotopic signals. Natural abundance isotope studies may therefore be more suitable as a complementary method than a stand-alone method under such conditions. However, it may still add value to more traditional chemical assays and source apportionment methods.

3.7 Modelling hydrology at Rivers Alna and Storelva

This chapter describes the setup of the conceptual rainfall-runoff model HBV (Lindström *et al*. 1997) and calibration on daily time-steps for Rivers Alna and Storelva (Figure 45). Setting up a hydrological model for these two rivers is the first step in a three-year effort to model contaminant dynamics in River Alna (with the INCA-tox model) and effects of climate change on River Storelva (with the INCA-N model).

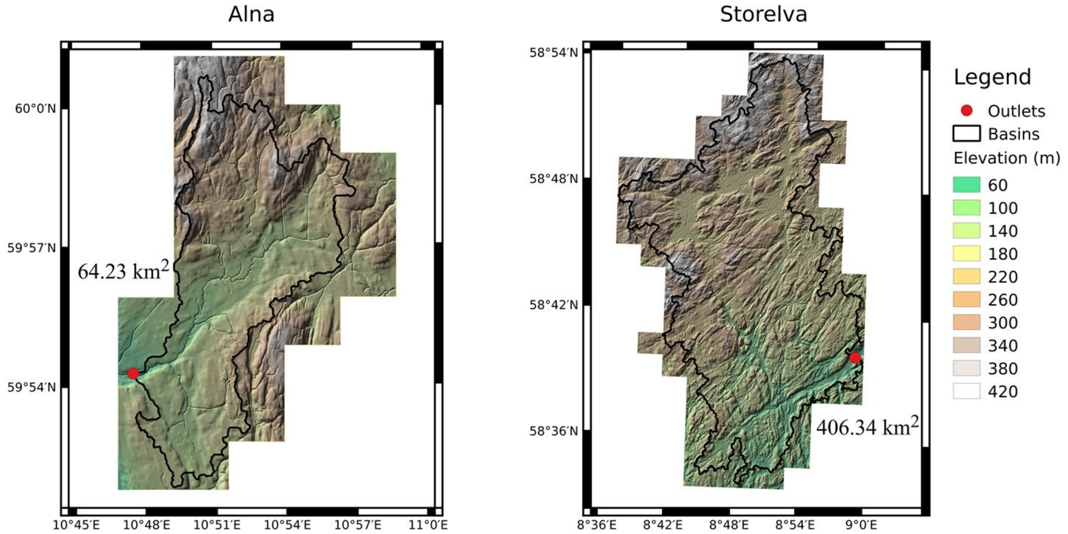


Figure 45. Rivers Alna and Storelva basins delineated from a 10 x 10 m elevation model (https://nedlasting.geonorge.no/) resampled to 25 x 25m. The red dots represent the basin outlets.

Data collection

The HBV models has seen extended and successful use in Scandinavia and one of the reasons explaining its popularity is the parsimony of its data requirements: at its most basic, only daily precipitation, mean daily air temperature, and discharge are required to run and evaluate the model.

Precipitation and temperature where downloaded from the frost.met.no portal where historic station data are stored. Temperature and precipitation data from all available stations within the catchments were downloaded and spatially averaged over the basins using Thiessen polygons (Goovaerts 2000).

Discharge at the basin outlets shown in Figure 45 was obtained from NVE.

Alna

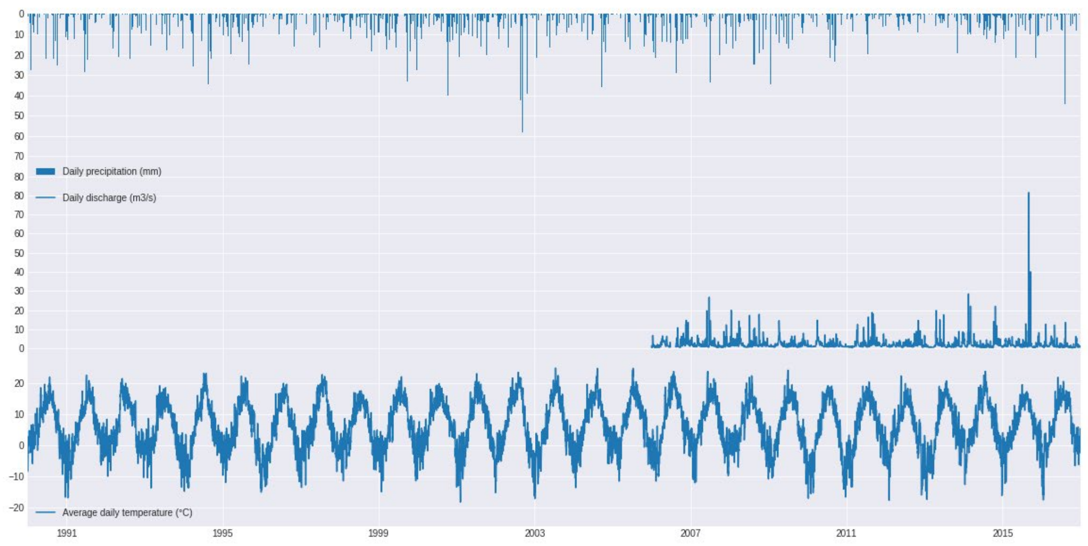


Figure 46. Precipitation (top), discharge (middle) and temperature (bottom) for the Alna river basin. Only a subset of the available data is shown to highlight high-frequency variations.

Storelva

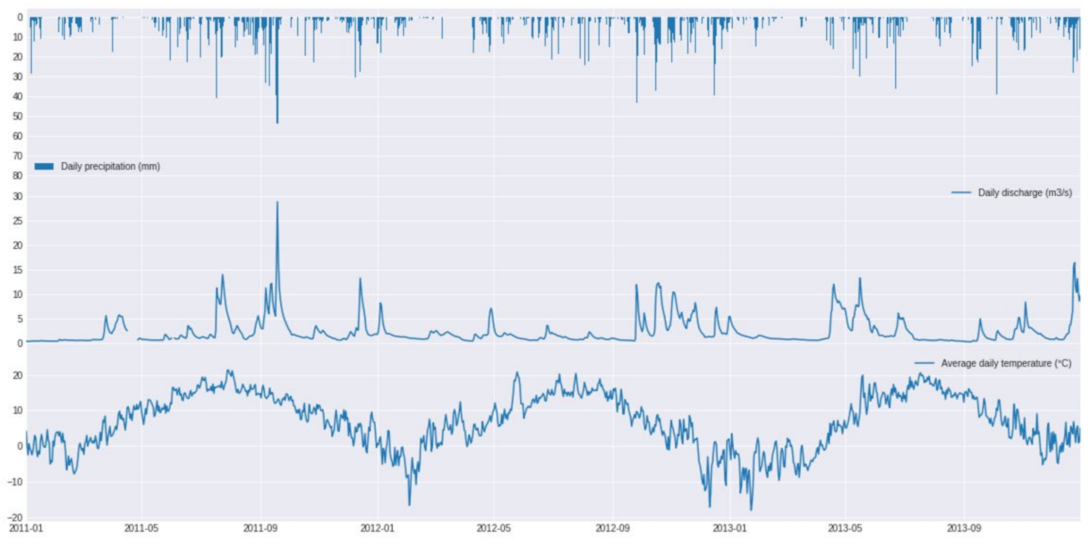


Figure 47. Precipitation (top), discharge (middle) and temperature (bottom) for the Storelva river basin. Only a subset of the available data is shown to highlight high-frequency variations.

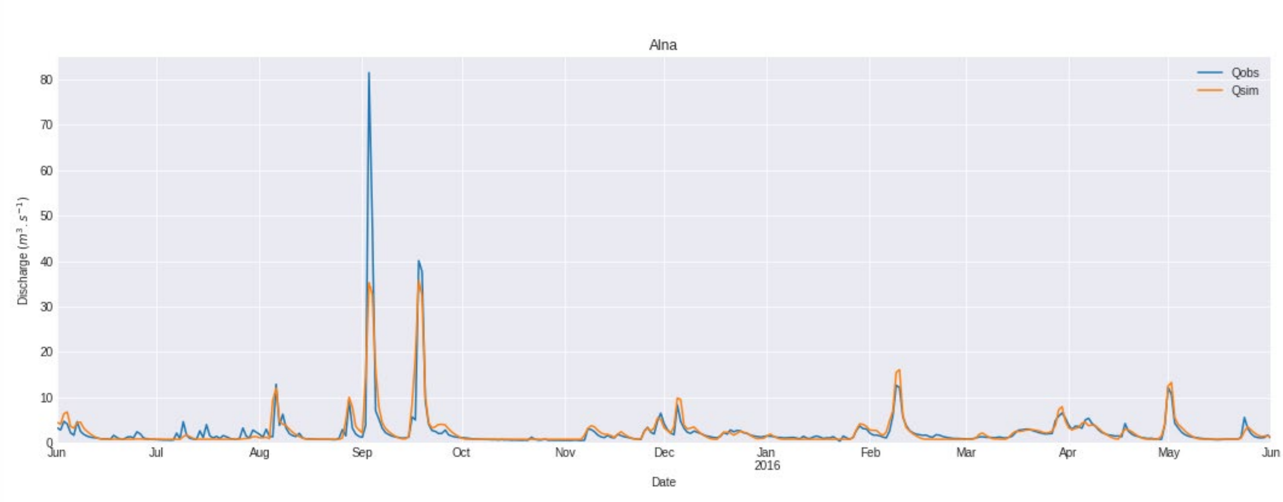
While precipitation and temperature were available for longer time periods, discharge data were only available for shorter periods and were the limiting factor in the calibration process (Figure 46 and Figure 47).

Modelling

The freely available HBV-light version was used to model discharge at the Rivers Alna and Storelva sampling sites. An automatic calibration procedure using a genetic algorithm (Seibert 2000) was used to automatically calibrate all model parameters simultaneously. For River

Storelva, a period of 18 months was used for warmup and the model was calibrated for the period 01-06-2009/31-12-2016. A Nash-Sutcliffe efficiency (NSE) of 0.81 was obtained this way, which indicates a quite successful calibration (Figure 48).

For River Alna the same approach was tried at first, but with a poor fit (NSE~= 0.5). A better result was obtained when calibration was done for shorter periods, e.g. an NSE of 0.74 for a calibration on the 01-06-2015/01-06/2016 period (Figure 48).



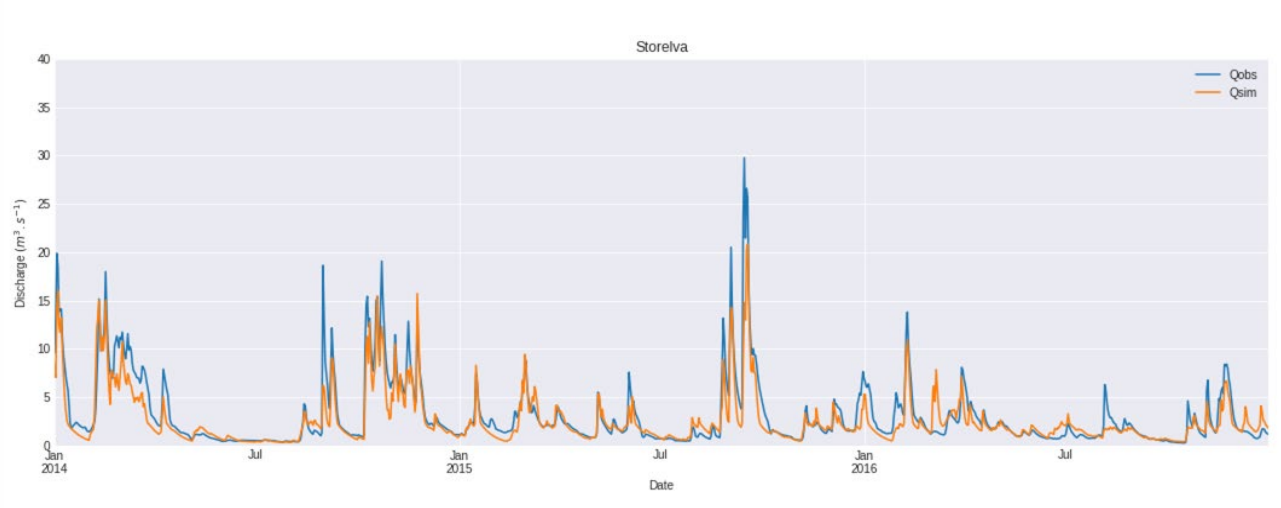


Figure 48. Observed (blue) and simulated (orange) discharge at Rivers Alna (top, NSE=0.74) and Storelva (bottom, NSE=0.81). Results for 2016 are shown for River Alna.

Discussion

While the automated calibration provides reasonably adequate results, several factors counteract a better fit. The Nash-Sutcliffe performance is biased towards a good fit of large flows, generally resulting in a poorer fit for baseflow simulations. The objective function should therefore be chosen according to the flow range of interest.

It is our belief that discharge station data should provide better information content than reanalysis or gridded datasets. However, this requires consistent station data and the number of stations used for the spatial interpolation varied over time, potentially introducing bias. This was of particular concern for River Alna, where a large number of stations were only intermittently available.

Another shortcoming was that the Thiessen-polygons methods does not account for elevation and temperature gradients in the basin. A further complicating issue at River Alna is the fact that this is an urban catchment with complex subsurface drainage systems that makes deriving representative catchment boundaries very difficult. Abstractions and/or inputs (as a result of e.g. pipes or microtopography) might not be well captured using digital elevation models only. Still it was possible to obtain decent fits by calibrating for shorter time periods. This suggests that results could be improved by using a better interpolation method for the spatial averaging, especially of precipitation, which is more spatially variable than temperature.

Another potential way of improvement would be the application of a semi-distributed model to allow for inhomogeneities in the basin - or use a more complex model that is specially designed for urban catchments and better accounts for belowground abstractions and inflows.

3.8 Sensor data from River Storelva

River Storelva is selected for more detailed studies on the effects of climate variability and climate change on rivers (see also previous chapter on modelling). To study short-term effects of climate variability on water chemistry, high-frequency data are collected at the Storelva sensor station, which is located at the same site as the manual sampling site.

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 2017, there was no clear snowmelt flood, except a minor flood in late April. Altogether, there were six flood events where the flow exceeded 40 m^3/s. The two floods that occurred in October were quite large, with water flows exceeding 100 and 130 m^3/s, respectively. The latter flow peak corresponded to a “10-year flood event”.

Water temperature

The water temperature exceeded 10ºC in late April, after which it dropped again during a minor snowmelt flood right after (Figure 49). During May the temperature increased rapidly and exceeded 20ºC by the end of the month. A sudden temperature decrease (to below 15ºC) occurred during a relatively big summer flood in early June. The temperature maximum (25ºC) was reached on July 15th. Thereafter the temperature fluctuated between 18 and 20ºC until late August and fell below 15ºC on September 10th.

pH

River Storelva has been heavily affected by acidification due to long-range transported air pollution and since the 1990’s the river has been limed to protect the salmon and sea trout populations from toxic waters (Miljødirektoratet 2017). 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 1th to June 15th). In other parts of the year the pH should be kept above 6.0.

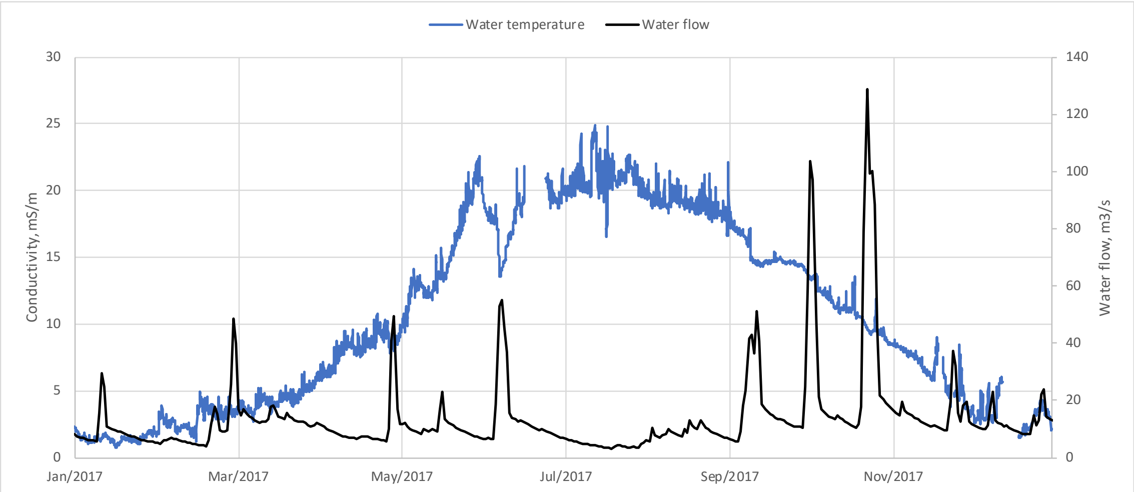


Figure 49. Water temperature and water flow at the outlet of River Storelva in 2017. The water flow data are from NVE’s station 18.4.0. Lundevann.

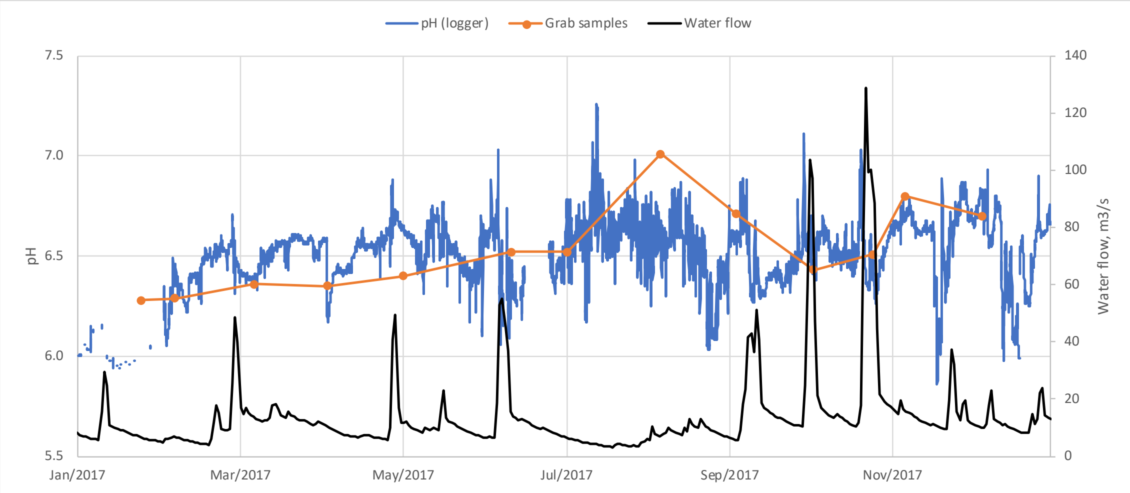


Figure 50. pH and water flow at the outlet of River Storelva in 2017. The water flow data are from NVE.

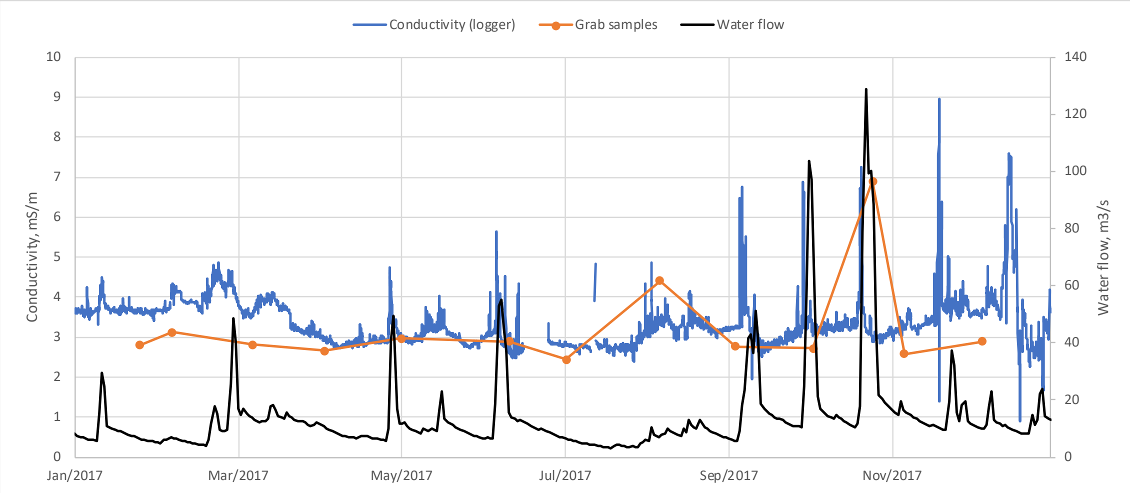


Figure 51. Conductivity and water flow at the outlet of River Storelva in 2017. The water flow data are from NVE.

The continuous pH monitoring shows that the pH was kept above 6.0 most of the time, except for a very short period in November when pH dropped to 5.8 (Figure 50). 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. There was quite good accordance between the sensor pH-data and pH values measured in grab samples (Figure 50).

Conductivity

The conductivity, which is a measure of the ionic concentration in water, was relatively stable throughout the year with values around 3-4 mS/m (Figure 51). Exceptions were during flood events, where the conductivity showed immediate responses and could double or triple within a few hours. This reflects massive wash-out of from the soils and a following increase in element concentrations in the early phase of the flood events. As illustrated in Figure 50 there was good accordance between the sensor data and conductivity measured in grab samples.

Turbidity

Turbidity is related to suspended particulate matter that affect the clarity of water. In River Storelva, with the lower parts of the catchment consisting of clay soils, the turbidity increases quickly during flood episodes (Figure 52). The turbidity values were especially high during the massive floods that occurred in October. At that time values also exceeded the turbidimeter's maximum measuring range of 50 NTU. There was relatively good correlation between the sensor data and turbidity measured in grab samples, but the data also demonstrate that grab samples tend to miss most turbidity peaks and thereby significantly underestimate the total particle load throughout the year. Given that many nutrients and contaminant species have high affinity to particles, grab samples will also underestimate the annual loads of these substances.

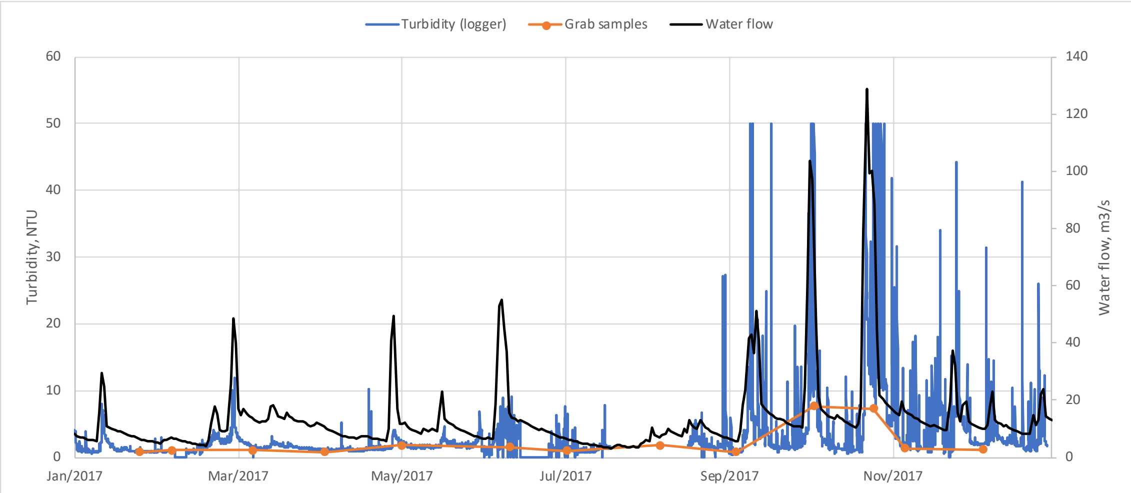


Figure 52. Turbidity and water flow at the outlet of Storelva in 2017. The water flow data are from NVE.

3.9 Samples from the 2017 autumn flood

In October 2017, the south-eastern part of the country was hit by two large flood events. During the last flood, a sampling campaign was carried out in selected rivers along the coast from Skien in east to Åna Sira in the west. Samples were collected from the following rivers: Skienselva, Tokkeelva, Storelva, Nidelva (Arendal), Tovdalselva, Otra, Mandalselva, Lyngdalselva, Kvina, and Sira. Here, results from three of the rivers belonging to the current river monitoring programme are briefly discussed.

The samples from Rivers Skienselva, Storelva and Otra were all collected close to or slightly after the flow peak (Figure 53).

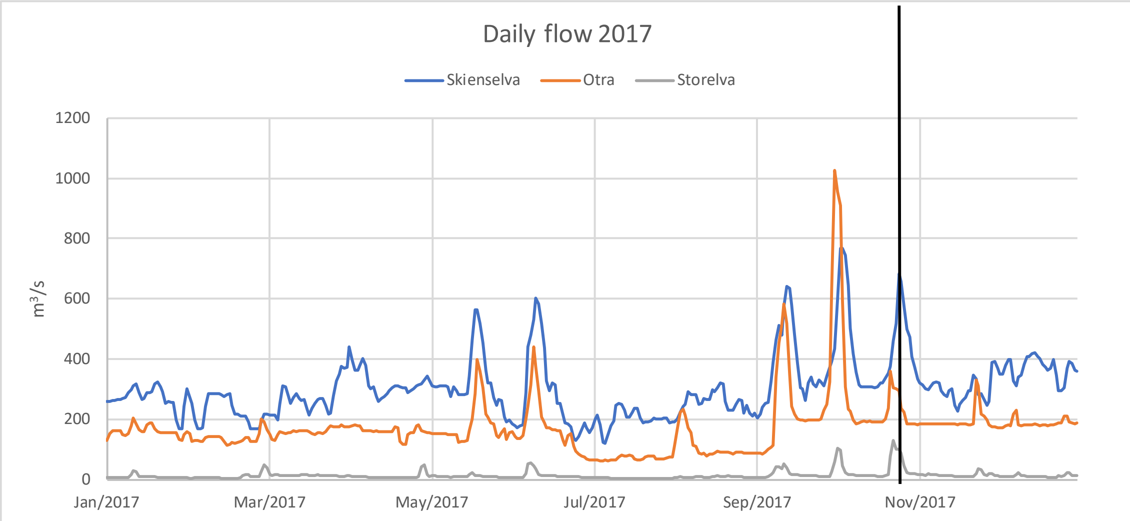


Figure 53. Daily water flow in Rivers Skienselva, Storelva and Otra. The vertical bar indicates the time of sampling.

Table 20. Water chemistry in Rivers Skienselva, Storelva and Otra during the flood event on 25-26 October 2007

		pH	KOND	SPM	TOC	PO_4-P	TOTP	NO_3-N	NH_4-N	TOTN	SiO_2	Ca	DOC	POC	Part. N	TDP	TDN
			mS/m	mg/l	mg C/l	µg/l P	µg/l P	µg/l N	µg/l N	µg/l N	mg SiO_2/l	mg/l	mg/L C	µg/l C	µg/l N	µg P/l	µg N/l
Skienselva	25/10/2017	6.80	2.31	7.53	4.00	6	11	160	2	330	2.79	2.55	4.10	438	27	6	
Skienselva	Avg 2017	6.78	1.98	1.30	2.94	2	6	138	11	262	2.23	2.03	2.96	164	18	3	220
Storelva	25/10/2017	6.51	69.40	8.40	8.60	7	17	91	9	415	3.36	5.55	8.20	487	44	4	
Storelva	Avg 2017	6.53	8.03	2.94	6.59	3	9	152	17	402	2.93	2.06	6.45	459	40	3	408
Otra	26/10/2017	5.76	1.66	1.98	6.00	2	7	73	20	270	2.03	0.82	5.80	332	23	2	
Otra	Avg 2017	6.10	1.57	1.43	3.21	1	4	74	9	206	1.56	0.79	3.22	301	25	2	185

When comparing the chemical conditions during the flood events with the mean 2017 water chemistry, the general picture is that the water chemistry in the three rivers was clearly, but not dramatically, affected by the floods (Table 20). However, when counting in the large water volumes, the element exports from river to fjords will be substantial during such flood events. In the cases of Rivers Skienselva and Otra, large upstream lakes and reservoirs might have dampened the instant effects on the water chemistry downstream. In addition, the late

October floods in Skienselva and Otra were smaller than the floods that occurred in mid-September and early October.

The most pronounced effects were observed for conductivity, suspended particulate matter, total organic carbon, phosphate and total phosphorus. The high conductivity measured in River Storelva (69.4 mS/m) indicates that the monitoring station was affected by seawater, possibly caused by a storm surge following the low-pressure front. The high calcium concentration in the sample also points at possible seawater intrusion.

Suspended particulate matter concentrations were 6 and 3 times higher than the annual average in Rivers Skienselva and Storelva, respectively. In River Otra, only a small increase in SPM was seen. The TOC concentrations increased at all three stations, especially in Rivers Skienselva and Otra where the concentrations were twice the annual average. Also, the phosphate and total P concentrations showed a doubling compared to the 2017 average. Regarding nitrogen, there were no clear effects on neither nitrate, ammonium or total N. Metals were not analysed in the flood samples.

4. Conclusions

Nearly all meteorological stations located in the near vicinity of the river monitoring stations show significant increase in air temperature over the period 1980-2017. The two meteorological stations, Blindern and Alta lufthavn, showed significant upward trends in precipitation during the same period. The Rivers Altaelva and Pasvikelva and River Bjerkreimselva have had a significant increase in water temperature over the last 20-25 years. Rivers Glomma, Drammenselva, Skienselva and Orreelva show significant upward trends in water flow since 1990.

Rivers Alna and Orreelva had much higher total phosphorus concentrations than the other rivers, with annual mean concentrations far higher than the WFD good/moderate boundary for their water types. All the other rivers had annual mean tot-P concentrations below the WFD good/moderate boundary. Rivers Alna and Orreelva had the highest annual mean total nitrogen concentrations, much higher than the WFD good/moderate boundary for their respective water types. Rivers in south-west Norway that receives the highest amount of atmospheric N deposition in Norway also had relatively high tot-N values. In River Bjerkreim, the annual mean value was slightly above the WFD good/moderate boundary.

Samples analysed for metals in the main programme are unfiltered, which means it is possible to state if annual mean concentrations are below – but not over - the threshold concentrations set by WFD environmental quality standards for priority substances and river basin-specific pollutants in freshwater. Based on mean concentrations in the individual rivers in 2017, there was no exceedances of threshold concentrations for arsenic, cadmium, copper, chromium and mercury. Alna had the highest annual concentrations of arsenic (0.48 µg/l), lead (1.9 µg/l), cadmium (0.07 µg/l), copper (6.0 µg/l), zinc (24.7 µg/l), chromium (1.2 µg/l) and mercury (1.75 ng/l). Pasvikelva had clearly the highest nickel concentrations, with an annual mean of 6.9 µg/l. Orkla also has elevated concentrations of e.g. copper (5.5 µg/l), zinc and cadmium. Storelva had surprisingly high values for e.g. arsenic, lead and cadmium, despite its sparsely populated and forest-dominated catchment. The annual mean zinc concentration in Glomma in 2017 was reduced to a more “normal” level (1.7 µg/l) compared to the last preceding years.

Long-term trends show that water discharge has increased significantly in Rivers Glomma, Drammenselva, Skienselva and Orreelva. Most of these rivers also had increases in the loads of total organic carbon, total nitrogen and silicate. Phosphorus loads have increased significantly in Rivers Drammenselva and Numedalslågen. In River Vefsna the loads of nitrogen and phosphorus have decreased significantly. Opposite trends for loads of inorganic nitrogen and total nitrogen in many of the Skagerrak rivers, illustrate that the fraction of organic nitrogen in river runoff is increasing. Metal loads and concentrations show mainly downward trends in all Norwegian rivers (1990-2017), but analyses of the short-term period (2004-2017) reveal statistically significant upward trends in zinc concentrations in River Glomma and nickel concentrations in River Altaelva.

Regional differences in DOM was found to be largest between rivers in the Skagerrak region and the North Sea region which is likely driven by differences in primary production and in precipitation patterns. DOM levels were found to peak with the onset of hydrological events of spring snow melt and autumn intensive precipitation, both leading to flushing of the forest floor. Seasonal variation is a result of changes in the dominating source of DOM; in spring, fresh organic matter becomes available for transport to the river (less aromatic and smaller size), while during summer and early autumn the organic matter is subject to more extensive humification (more aromatic and larger size) before reaching the river.

Analysis of stable nitrogen and oxygen isotope ratios ($d^{15}N$ and $d^{18}O$) in nitrate (NO_3) can be a suitable tool for tracing sources for nitrate in surface water. A one-day sampling campaign was carried out at three stations in River Alna. There were relatively small differences in the isotopic signatures between the stations, but the signals indicate that nitrate in the river might originate from soil N and septic waste. Slightly higher $d^{15}N$ values at the stations closest to the outlet suggests an increasing influence of urban wastewater downstream the river. However, with the small number of samples and the small differences in the isotopic signatures, results should be interpreted with caution.

To study short-term effects of climate variability on water chemistry, high-frequency data are collected at the Storelva sensor station, which is equipped with sensors that measure water temperature, pH, conductivity and turbidity on an hourly basis. The year 2017 was characterized by several floods and the sensor data nicely demonstrate the effects of flood events on water chemistry parameters, where especially conductivity and turbidity are highly responsive to increases in water flow.

In October 2017, the south-eastern part of the country was hit by two large flood events. During the last flood, a sampling campaign was carried out in Rivers Skienselva, Storelva and Otra. The most pronounced effects were on conductivity, suspended particulate matter, total organic carbon, phosphate and total phosphorus. Compared with the mean water chemistry in 2017, there were no dramatic changes in element concentrations, but when counting in the large water volumes, the element exports from river to fjords will be substantial during such flood events.

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6. Appendix

6.1 Riverine concentrations in 2017

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]
22.01.2017	521.68	7.22	5.28	9.80	7.18	3.40	3.40		8.00	13.00	4.00	410.00	29.00	580.00		4.44									
14.02.2017	443.11	7.51	4.93	1.50	1.44	3.00			2.00	5.00		350.00	28.00	520.00		3.51	<0.002	0.11	0.06	0.01	0.95	1.40	0.51	0.12	<1.0
06.03.2017	416.86	7.29	5.55	9.90	9.05	3.70			7.00	16.00		520.00	6.00	715.00		4.31									
05.04.2017	468.99	7.29	6.00	14.00	12.00	3.90	3.70	464.00	12.00	20.00	6.00	510.00	13.00	750.00	46.10	4.39									
04.05.2017	467.10	7.54	9.88	2.40	4.09	4.70	4.80	262.00	5.00	11.00	3.00	450.00	13.00	590.00	26.10	3.90	<0.002	0.14	0.16	0.01	1.33	2.00	0.67	0.22	<1.0
10.05.2017	608.72	7.15	5.07	6.20	9.20	4.40	4.30	342.00	9.00	16.00	4.00	360.00	10.00	575.00	25.10	3.75									
21.05.2017	1412.47	7.19	4.61	6.20	5.74	5.30	4.60	374.00	9.00	14.00	5.00	350.00	<2.0	610.00	23.10	3.79									
06.06.2017	1356.67	7.17	3.86	2.60	5.02	3.30	3.40		2.00	12.00	3.00	220.00	7.00	400.00		3.04									
12.06.2017	1559.70	7.42	5.68	2.90	4.61	3.70	3.50	277.00	13.00	10.00	2.00	300.00	3.00	490.00	24.60	3.04									
21.06.2017	1484.97	7.36	4.28	3.00	5.99	3.50	3.40	311.00	8.00	6.00	3.00	270.00	16.00	480.00	31.10	3.21									
03.07.2017	731.70	7.34	4.43	2.00	3.54	2.80	2.70	276.00	4.00	7.00	3.00	220.00	3.00	390.00	17.10	2.83									
07.08.2017	947.01	7.29	4.37	2.20	3.17	2.60	2.50	234.00	7.00	14.00	3.00	240.00	16.00	455.00	30.70	2.68	<0.002	0.14	0.10	0.01	1.33	0.96	0.51	0.13	<1.0
03.09.2017	730.58	7.24	3.85	1.80	2.67	5.20	5.10	266.00	2.00	9.00	3.00	200.00	11.00	400.00	31.00	3.13									
02.10.2017	949.83	7.27	5.28	6.00	8.66	4.90	4.70	350.00	7.00	14.00	4.00	460.00	<2.0	590.00	35.00	3.56	<0.002	0.19	0.22	0.01	1.34	2.60	0.85	0.28	2.00
06.11.2017	883.30	7.36	4.84	11.00	9.79	5.10	5.00	360.00	10.00	18.00	5.00	340.00	<2.0	550.00		4.05									
04.12.2017	677.42	7.27	5.04	14.00	21.70	6.00	5.90	429.00	20.00	20.00	6.00	370.00	<2.0	680.00	43.10	4.67									
Lower avg.	853.76	7.31	5.18	5.97	7.12	4.09	4.07	328.75	7.81	12.81	3.86	348.12	9.69	548.44	30.27	3.64	0.00	0.15	0.14	0.01	1.24	1.74	0.64	0.19	0.50
Upper avg..	853.76	7.31	5.18	5.97	7.12	4.09	4.07	328.75	7.81	12.81	3.86	348.12	10.19	548.44	30.27	3.64	0.00	0.15	0.14	0.01	1.24	1.74	0.64	0.19	1.25
Minimum	416.86	7.15	3.85	1.50	1.44	2.60	2.50	234.00	2.00	5.00	2.00	200.00	2.00	390.00	17.10	2.68	0.00	0.11	0.06	0.01	0.95	0.96	0.51	0.12	1.00
Maximum	1559.70	7.54	9.88	14.00	21.70	6.00	5.90	464.00	20.00	20.00	6.00	520.00	29.00	750.00	46.10	4.67	0.00	0.19	0.22	0.01	1.34	2.60	0.85	0.28	2.00
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	14.00	12.00	16.00	16.00	14.00	16.00	16.00	16.00	11.00	16.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	397.43	0.11	1.40	4.43	4.88	1.01	0.99	70.80	4.67	4.64	1.23	102.65	8.77	109.98	8.60	0.62	0.00	0.03	0.07	0.00	0.19	0.71	0.16	0.08	0.50

Alna

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]
20.01.2017	0.49	7.73	60.90	3.90	4.16	4.40	4.40		47.00	71.00	33.00	850.00	220.00	1800.00		6.75									
07.02.2017	0.43	7.90	76.20	4.00	5.19	4.30	4.00		50.00	76.00	39.00	770.00	270.00	1700.00		6.47	0.01	0.27	0.14	0.03	2.17	10.10	0.63	0.16	3.00
03.03.2017	1.87	7.83	63.80	10.00	11.30	5.70	5.60	1190.00	46.00	64.00	16.00	920.00	53.00	1600.00	144.00	7.33									
05.04.2017	1.66	7.87	40.60	9.50	10.90	4.70	4.40	1450.00	43.00	58.00	22.00	760.00	100.00	1320.00	141.00	6.75									
03.05.2017	0.64	8.06	44.80	4.60	4.14	4.40	4.20	1050.00	44.00	60.00	28.00	1130.00	<2.0	1380.00	113.00	4.65	<0.002	0.29	0.21	0.02	2.30	6.00	0.62	0.20	<1.0
08.06.2017	1.69	7.92	38.80	8.50	10.00	4.00	3.50	993.00	26.00	34.00	32.00	1050.00	28.00	1500.00	98.20	6.45									
05.07.2017	0.32	7.96	48.60	6.00	9.65	5.30	5.00	1230.00	110.00	150.00	58.00	1160.00	280.00	2000.00	95.80	7.48									
03.08.2017	0.58	7.99	38.10	5.20		4.30	4.20	631.00	79.00	94.00	61.00	1300.00	28.00	1900.00	54.80	6.81	0.00	0.47	0.49	0.03	3.12	9.00	0.90	0.35	<1.0
04.09.2017	0.48	8.03	41.60	3.60	2.83	3.80	3.70	653.00	120.00	100.00	70.00	1400.00	180.00	2100.00	87.20	7.65									
04.10.2017	1.41	8.07	32.50	20.00	21.25	5.00	5.00	1060.00	59.00	78.00	36.00	390.00	<2.0	1300.00	129.00	6.96	0.04	0.88	6.76	0.22	16.40	73.70	4.32	3.94	2.00
07.11.2017	2.55	8.04	26.60	6.60	11.06	5.60	5.50	580.00	39.00	49.00	30.00	750.00	37.00	1100.00		7.59									
05.12.2017	0.68	8.05	39.70	3.90	4.58	3.50	3.50	384.00	49.00	59.00	38.00	960.00	250.00	1600.00	50.30	7.33									
Lower avg.	1.07	7.95	46.02	7.15	8.64	4.58	4.42	922.10	59.33	74.42	38.58	953.33	120.50	1608.33	101.48	6.85	0.01	0.48	1.90	0.07	6.00	24.70	1.62	1.16	1.25
Upper avg..	1.07	7.95	46.02	7.15	8.64	4.58	4.42	922.10	59.33	74.42	38.58	953.33	120.83	1608.33	101.48	6.85	0.01	0.48	1.90	0.07	6.00	24.70	1.62	1.16	1.75
Minimum	0.32	7.73	26.60	3.60	2.83	3.50	3.50	384.00	26.00	34.00	16.00	390.00	2.00	1100.00	50.30	4.65	0.00	0.27	0.14	0.02	2.17	6.00	0.62	0.16	1.00
Maximum	2.55	8.07	76.20	20.00	21.25	5.70	5.60	1450.00	120.00	150.00	70.00	1400.00	280.00	2100.00	144.00	7.65	0.04	0.88	6.76	0.22	16.40	73.70	4.32	3.94	3.00
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	11.00	12.00	12.00	10.00	12.00	12.00	12.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	0.73	0.11	14.21	4.63	5.31	0.70	0.72	341.47	28.90	29.97	16.29	277.07	110.84	305.40	34.10	0.81	0.02	0.28	3.24	0.10	6.95	32.71	1.81	1.85	0.96

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]
23.01.2017	334.10	7.00	3.50	0.68	0.83	2.90	2.70		<1.0	4.00	2.00	220.00	8.00	340.00		2.76									
07.02.2017	327.92	7.06	3.36	0.97	1.11	2.80			2.00	4.00		210.00	15.00	345.00		2.68	<0.002	0.10	0.04	0.01	0.49	1.30	0.45	0.17	<1.0
07.03.2017	311.44	7.10	3.43	1.40	1.10	2.40			<1.0	4.00		220.00	2.00	350.00		2.66									
04.04.2017	324.27	7.15	4.17	1.70	2.02	3.50	3.50	223.00	3.00	7.00	3.00	300.00	6.00	480.00	26.20	3.28									
02.05.2017	224.80	7.24	4.38	1.40	1.68	3.60	3.50	208.00	1.00	5.00	2.00	390.00	9.00	510.00	20.10	3.00	<0.002	0.13	0.12	0.01	0.74	2.60	0.44	0.11	<1.0
16.05.2017	207.34	7.10	3.44	0.95	1.19	3.10	2.80	203.00	1.00	4.00	2.00	190.00	5.00	350.00	12.70	2.66									
23.05.2017	702.34	7.07	3.52	1.80	2.84	3.30	3.00	306.00	3.00	6.00	2.00	220.00	12.00	385.00	19.90	2.79									
06.06.2017	415.79	7.11	3.48	0.89	1.54	3.70	3.40	293.00	2.00	2.00	2.00	190.00	20.00	365.00	25.80	2.79									
19.06.2017	534.85	7.03	3.43	1.50	3.33	4.20	4.00	299.00	4.00	7.00	2.00	230.00	<2.0	415.00	28.90	2.96									
26.06.2017	367.72	7.12	3.44	1.10	1.78	3.70	3.70	225.00	1.00	8.00	3.00	190.00	14.00	375.00	15.10	2.81									
04.07.2017	176.59	6.99	3.62	0.76	1.05	3.70	3.50	201.00	2.00	6.00	3.00	170.00	20.00	360.00	16.10	2.57									
07.08.2017	356.99	7.09	2.95	1.00	1.25	3.50	3.40	209.00	2.00	2.00	2.00	130.00	20.00	310.00	9.80	2.31	<0.002	0.17	0.06	0.01	0.63	1.50	0.44	0.11	<1.0
04.09.2017	286.45	7.20	3.32	0.52	0.79	3.70	3.70	212.00	<1.0	5.00	2.00	170.00	18.00	340.00	21.00	2.57									
03.10.2017	667.64	7.27	3.86	2.60	4.09	5.40	5.30	382.00	4.00	11.00	4.00	310.00	<2.0	400.00	34.60	3.04	<0.002	0.21	0.19	0.01	0.89	2.70	0.52	0.18	2.00
06.11.2017	426.73	7.24	4.10	3.80	1.42	4.80	4.60	256.00	4.00	8.00	3.00	310.00	10.00	500.00	21.30	3.41									
05.12.2017	339.43	7.21	3.63	0.33	1.40	3.20	3.20	108.00	2.00	7.00	2.00	220.00	7.00	370.00	9.40	2.94									
Lower avg.	375.28	7.12	3.60	1.34	1.71	3.59	3.59	240.38	1.94	5.62	2.43	229.38	10.38	387.19	20.07	2.83	0.00	0.15	0.10	0.01	0.69	2.03	0.46	0.14	0.50
Upper avg..	375.28	7.12	3.60	1.34	1.71	3.59	3.59	240.38	2.12	5.62	2.43	229.38	10.62	387.19	20.07	2.83	0.00	0.15	0.10	0.01	0.69	2.03	0.46	0.14	1.25
Minimum	176.59	6.99	2.95	0.33	0.79	2.40	2.70	108.00	1.00	2.00	2.00	130.00	2.00	310.00	9.40	2.31	0.00	0.10	0.04	0.01	0.49	1.30	0.44	0.11	1.00
Maximum	702.34	7.27	4.38	3.80	4.09	5.40	5.30	382.00	4.00	11.00	4.00	390.00	20.00	510.00	34.60	3.41	0.00	0.21	0.19	0.01	0.89	2.70	0.52	0.18	2.00
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	14.00	13.00	16.00	16.00	14.00	16.00	16.00	16.00	13.00	16.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	148.93	0.09	0.36	0.86	0.94	0.74	0.69	67.49	1.15	2.36	0.65	66.38	6.58	60.00	7.51	0.27	0.00	0.05	0.07	0.00	0.17	0.73	0.04	0.04	0.50

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]
23.01.2017	83.98	6.91	3.23	1.10	1.72	2.80	2.80		2.00	6.00	2.00	200.00	39.00	350.00		3.34									
06.02.2017	87.53	6.96	3.30	1.30	3.09	2.40			4.00	7.00		140.00	33.00	280.00		2.74	0.00	0.08	0.09	0.01	0.33	2.00	0.29	0.07	<1.0
06.03.2017	64.32	6.94	4.48	4.30	5.51	3.20			7.00	34.00		340.00	39.00	570.00		4.11									
03.04.2017	191.58	6.90	3.33	3.90	6.89	5.10	5.10	548.00	8.00	15.00	3.00	220.00	23.00	450.00	45.00	4.18									
02.05.2017	84.82	7.05	4.71	6.40	7.21	4.60	4.40	334.00	7.00	14.00	5.00	670.00	59.00	785.00	33.80	3.92	0.00	0.18	0.20	0.01	0.75	3.50	0.40	0.16	<1.0
06.06.2017	104.53	6.92	2.54	1.20	2.23	3.80	3.40	251.00	1.00	6.00	3.00	120.00	30.00	290.00	19.70	2.91									
03.07.2017	86.99	7.07	2.60	1.50	1.45	3.50	3.20	172.00	2.00	6.00	5.00	89.00	12.00	255.00	19.50	2.70									
07.08.2017	101.37	6.92	2.48	2.10	3.55	3.20	3.10	210.00	4.00	7.00	<1.0	87.00	27.00	350.00	16.00	2.16	0.00	0.12	0.08	0.01	0.41	1.10	0.25	0.05	<1.0
05.09.2017	73.44	7.00	2.53	0.74	1.22	3.20	3.20	136.00	1.00	5.00	3.00	92.00	37.00	255.00	13.60	2.51									
02.10.2017	276.45	6.81	3.62	28.00	26.06	7.20	7.00	2200.00	56.00	76.00	11.00	320.00	<2.0	580.00	181.00	4.54	0.01	0.32	0.77	0.03	1.15	6.70	0.69	0.42	2.00
06.11.2017	159.28	6.98	3.08	5.20	2.01	5.90	5.90	412.00	6.00	12.00	3.00	240.00	41.00	490.00	29.40	4.31									
04.12.2017	120.95	7.04	3.28	2.40	10.30	3.60	3.60	215.00	8.00	10.00	2.00	210.00	42.00	425.00	21.70	3.77									
Lower avg.	119.60	6.96	3.27	4.84	5.94	4.04	4.17	497.56	8.83	16.50	3.70	227.33	31.83	423.33	42.19	3.43	0.00	0.18	0.28	0.01	0.66	3.33	0.41	0.18	0.50
Upper avg..	119.60	6.96	3.27	4.84	5.94	4.04	4.17	497.56	8.83	16.50	3.80	227.33	32.00	423.33	42.19	3.43	0.00	0.18	0.28	0.01	0.66	3.33	0.41	0.18	1.25
Minimum	64.32	6.81	2.48	0.74	1.22	2.40	2.80	136.00	1.00	5.00	1.00	87.00	2.00	255.00	13.60	2.16	0.00	0.08	0.08	0.01	0.33	1.10	0.25	0.05	1.00
Maximum	276.45	7.07	4.71	28.00	26.06	7.20	7.00	2200.00	56.00	76.00	11.00	670.00	59.00	785.00	181.00	4.54	0.01	0.32	0.77	0.03	1.15	6.70	0.69	0.42	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	61.55	0.07	0.73	7.52	6.94	1.41	1.40	651.44	15.09	20.36	2.82	163.70	14.91	161.74	52.98	0.80	0.00	0.10	0.33	0.01	0.37	2.46	0.20	0.17	0.50

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]
25.01.2017	255.56	6.74	1.86	<0.3	0.50	2.50	2.50		<1.0	3.00	1.00	130.00	5.00	215.00		2.19									
22.02.2017	211.91	6.69	1.92	0.36	0.45	2.50			<1.0	3.00		130.00	8.00	250.00		2.19	<0.002	0.09	0.04	0.01	0.36	1.80	0.17	0.09	<1.0
14.03.2017	270.48	6.74	1.92	0.69	0.54	2.40			5.00	4.00		140.00	<2.0	230.00		2.27									
06.04.2017	377.73	6.83	2.15	0.48	0.46	2.30	2.20	84.50	<1.0	3.00	2.00	130.00	3.00	235.00		2.14									
03.05.2017	312.61	6.85	1.96	0.45	0.40	2.50	2.40	115.00	<1.0	2.00	<1.0	180.00	4.00	250.00	14.30	2.19	<0.002	0.08	0.03	0.01	0.34	1.60	0.18	0.07	<1.0
14.06.2017	438.33	6.75	1.94	1.20	1.36	2.60	2.80	158.00	1.00	5.00	2.00	160.00	<2.0	320.00	12.40	2.27									
06.07.2017	123.43	6.74	1.98	1.20	0.89	3.50	3.40	158.00	1.00	5.00	2.00	130.00	23.00	305.00	14.40	2.12									
09.08.2017	280.48	6.85	1.85	0.32	0.39	2.70	2.60	142.00	1.00	16.00	4.00	110.00	24.00	245.00	26.40	1.91	<0.002	0.12	0.04	0.01	0.41	1.60	0.19	0.07	<1.0
13.09.2017	642.85	6.81	2.04	1.00	0.62	3.30	3.00	140.00	2.00	7.00	4.00	130.00	6.00	285.00	16.20	2.21									
04.10.2017	767.33	6.89	1.90	0.91	1.36	3.20	3.10	168.00	3.00	5.00	1.00	140.00	12.00	210.00	24.70	2.13	<0.002	0.12	0.10	0.01	0.45	2.00	0.19	0.08	<1.0
01.11.2017	334.77	6.82	1.96	1.90	1.65	3.60	3.40	162.00	2.00	6.00	5.00	120.00	32.00	270.00		2.27									
06.12.2017	396.99	6.67	1.94	0.69	0.81	3.10	3.10	79.30	2.00	4.00	2.00	130.00	14.00	255.00	9.10	2.27									
Lower avg.	367.71	6.78	1.95	0.77	0.79	2.85	2.85	134.09	1.42	5.25	2.30	135.83	10.92	255.83	16.79	2.18	0.00	0.10	0.05	0.01	0.39	1.75	0.18	0.08	0.00
Upper avg..	367.71	6.78	1.95	0.79	0.79	2.85	2.85	134.09	1.75	5.25	2.40	135.83	11.25	255.83	16.79	2.18	0.00	0.10	0.05	0.01	0.39	1.75	0.18	0.08	1.00
Minimum	123.43	6.67	1.85	0.30	0.39	2.30	2.20	79.30	1.00	2.00	1.00	110.00	2.00	210.00	9.10	1.91	0.00	0.08	0.03	0.01	0.34	1.60	0.17	0.07	1.00
Maximum	767.33	6.89	2.15	1.90	1.65	3.60	3.40	168.00	5.00	16.00	5.00	180.00	32.00	320.00	26.40	2.27	0.00	0.12	0.10	0.01	0.45	2.00	0.19	0.09	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	7.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	180.67	0.07	0.08	0.48	0.44	0.46	0.42	33.53	1.22	3.67	1.43	18.32	10.04	33.90	6.40	0.10	0.00	0.02	0.03	0.00	0.05	0.19	0.01	0.01	0.00

Storelva

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]
25.01.2017	6.58	6.28	2.80	0.84	1.48	6.70	6.30		1.00	6.00	3.00	190.00	22.00	410.00		3.69									
06.02.2017	6.97	6.29	3.12	1.10	1.74	6.00	5.90		2.00	7.00	2.00	200.00	32.00	430.00		3.60	<0.002	0.25	0.35	0.04	0.59	7.00	0.55	0.23	<1.0
08.03.2017	13.72	6.36	2.81	1.10	1.40	5.80	5.80	518.00	<1.0	12.00	2.00	200.00	8.00	440.00	34.80	3.47									
04.04.2017	10.68	6.35	2.65	0.82	1.56	5.80	5.60	295.00	1.00	7.00	3.00	250.00	15.00	400.00	22.20	3.32									
02.05.2017	11.53	6.40	2.96	1.80	2.48	5.80	5.50	439.00	3.00	7.00	2.00	250.00	25.00	440.00	37.30	2.91	<0.002	0.24	0.31	0.03	0.62	5.50	0.45	0.22	1.00
12.06.2017	15.58	6.52	2.89	1.50	2.46	7.30	7.10	634.00	5.00	6.00	3.00	100.00	22.00	400.00	81.90	2.57									
03.07.2017	6.45	6.52	2.44	1.00	1.35	5.50	5.50	361.00	2.00	10.00	6.00	82.00	4.00	320.00	30.80	1.86									
07.08.2017	7.13	7.01	4.40	1.80	2.89	5.70	5.60	469.00	1.00	10.00	5.00	130.00	11.00	465.00	39.40	1.89	<0.002	0.31	0.33	0.02	0.85	4.20	0.52	0.20	<1.0
04.09.2017	5.87	6.71	2.77	0.77	1.53	6.20	6.40	461.00	2.00	7.00	4.00	85.00	6.00	345.00	38.80	1.94									
03.10.2017	97.06	6.43	2.72	7.70	9.50	9.10	8.80	791.00	8.00	16.00	4.00	110.00	<2.0	330.00	57.10	3.26	<0.002	0.38	1.00	0.05	1.19	8.80	0.78	0.43	3.00
06.11.2017	16.36	6.80	2.58	1.40	1.80	6.70	6.70	281.00	2.00	7.00	3.00	120.00	29.00	360.00	20.90	2.91									
05.12.2017	9.88	6.70	2.89	1.20	1.69	6.50	6.50	310.00	3.00	6.00	3.00	170.00	32.00	470.00	27.80	3.36									
Lower avg.	17.32	6.53	2.92	1.75	2.49	6.42	6.31	455.90	2.50	8.42	3.33	157.25	17.17	400.83	39.10	2.90	0.00	0.30	0.50	0.03	0.81	6.38	0.57	0.27	1.00
Upper avg..	17.32	6.53	2.92	1.75	2.49	6.43	6.31	455.90	2.58	8.42	3.33	157.25	17.33	400.83	39.10	2.90	0.00	0.30	0.50	0.03	0.81	6.38	0.57	0.27	1.50
Minimum	5.87	6.28	2.44	0.77	1.35	5.50	5.50	281.00	1.00	6.00	2.00	82.00	2.00	320.00	20.90	1.86	0.00	0.24	0.31	0.02	0.59	4.20	0.45	0.20	1.00
Maximum	97.06	7.01	4.40	7.70	9.50	9.10	8.80	791.00	8.00	16.00	6.00	250.00	32.00	470.00	81.90	3.69	0.00	0.38	1.00	0.05	1.19	8.80	0.78	0.43	3.00
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	12.00	12.00	12.00	12.00	12.00	12.00	12.00	10.00	12.00	12.00	12.00	12.00	12.00	12.00	10.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	25.38	0.23	0.50	1.91	2.26	0.99	0.94	161.63	2.07	3.06	1.23	60.77	11.05	51.56	18.23	0.68	0.00	0.06	0.34	0.01	0.28	1.98	0.14	0.11	1.00

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]
23.01.2017	155.36	6.11	1.52	<0.3	0.37	2.30	2.30		<1.0	3.00	<1.0	82.00	9.00	190.00		1.67									
06.02.2017	127.23	6.12	1.67	<0.3	0.50	2.20			<1.0	2.00		87.00	10.00	185.00		1.65	<0.002	0.10	0.15	0.01	0.30	2.50	0.27	0.06	1.00
06.03.2017	149.28	6.04	2.09	0.48	0.82	3.20			<1.0	3.00		120.00	<2.0	255.00		2.03									
03.04.2017	178.60	5.92	1.58	<0.3	0.65	2.20	2.10	184.00	<1.0	3.00	2.00	79.00	<2.0	175.00	11.80	1.58									
08.05.2017	153.10	6.32	1.44	0.34	0.86	2.00	2.20	218.00	<1.0	2.00	<1.0	93.00	3.00	148.00	17.50	1.26	0.01	0.09	0.13	0.01	0.36	2.60	0.30	0.07	<1.0
06.06.2017	147.44	6.48	1.42	0.50	0.93	2.00	1.80	245.00	<1.0	3.00	3.00	67.00	6.00	155.00		1.12									
03.07.2017	63.62	6.22	1.42	0.84	1.46	2.50	2.20	288.00	<1.0	4.00	4.00	47.00	<2.0	160.00	24.60	0.92									
07.08.2017	173.33	6.12	1.50	0.98	1.24	3.30	3.20	62.90	1.00	5.00	2.00	57.00	10.00	215.00		1.12	<0.002	0.12	0.28	0.02	0.46	2.80	0.32	0.09	<1.0
11.09.2017	513.74	6.02	1.67	3.20	6.65	5.00	4.90	837.00	4.00	14.00	4.00	58.00	15.00	280.00	61.70	1.89									
09.10.2017	184.71	5.93	1.49	0.85	1.37	4.10	4.10	340.00	1.00	3.00	2.00	60.00	12.00	210.00	27.40	1.60	<0.002	0.17	0.45	0.01	0.62	3.30	0.65	0.11	2.00
06.11.2017	184.96	6.03	1.36	0.56	1.06	3.90	3.90	306.00	1.00	4.00	2.00	64.00	16.00	230.00	19.50	1.67									
06.12.2017	178.04	6.21	1.54	0.52	0.72	3.00	2.90	193.00	2.00	3.00	1.00	73.00	15.00	205.00	15.90	1.71									
Lower avg.	184.12	6.13	1.56	0.69	1.39	2.98	2.96	297.10	0.75	4.08	2.00	73.92	8.00	200.67	25.49	1.52	0.00	0.12	0.25	0.01	0.43	2.80	0.39	0.08	0.75
Upper avg..	184.12	6.13	1.56	0.76	1.39	2.97	2.96	297.10	1.33	4.08	2.20	73.92	8.50	200.67	25.49	1.52	0.00	0.12	0.25	0.01	0.43	2.80	0.39	0.08	1.25
Minimum	63.62	5.92	1.36	0.30	0.37	2.00	1.80	62.90	1.00	2.00	1.00	47.00	2.00	148.00	11.80	0.92	0.00	0.09	0.13	0.01	0.30	2.50	0.27	0.06	1.00
Maximum	513.74	6.48	2.09	3.20	6.65	5.00	4.90	837.00	4.00	14.00	4.00	120.00	16.00	280.00	61.70	2.03	0.01	0.17	0.45	0.02	0.62	3.30	0.65	0.11	2.00
More than 70% >LOD	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	7.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	109.10	0.16	0.19	0.80	1.69	0.96	1.04	218.22	0.89	3.23	1.14	19.90	5.40	40.39	16.81	0.34	0.00	0.04	0.15	0.00	0.14	0.36	0.18	0.02	0.50

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]
23.01.2017	42.86	6.34	3.77	<0.3	<0.2		1.40		<1.0	3.00	1.00	370.00	<2.0	440.00		1.59									
06.02.2017	31.29	6.20	3.91	0.40	0.55	1.40			1.00	3.00		420.00	<2.0	500.00		1.71	0.00	0.09	0.21	0.02	0.40	3.20	0.20	0.07	<1.0
06.03.2017	51.22	6.48	4.33	0.31	0.43	1.60			<1.0	3.00		460.00	<2.0	560.00		1.84									
04.04.2017	43.61	6.29	3.31	<0.3	0.30	1.30	1.30	98.10	<1.0	3.00	2.00	300.00	<2.0	395.00	12.10	1.37									
02.05.2017	32.87	6.52	3.73	<0.3	0.18	1.40	1.30	139.00	<1.0	2.00	<1.0	490.00	6.00	495.00	14.20	1.55	<0.002	0.06	0.12	0.02	0.19	2.40	0.14	0.05	<1.0
13.06.2017	37.18	6.57	3.83	0.54	0.59	1.50	1.50	185.00	<1.0	4.00	2.00	300.00	<2.0	430.00	15.10	1.38									
03.07.2017	27.82	6.69	3.38	0.34	0.33	1.50	1.40	147.00	<1.0	7.00	7.00	260.00	<2.0	385.00	16.10	1.22									
07.08.2017	74.06	6.47	3.51	0.59	0.73	2.00	2.30	251.00	3.00	6.00	1.00	300.00	<2.0	440.00	22.90	1.49	<0.002	0.08	0.22	0.02	0.34	2.80	0.21	0.07	<1.0
06.09.2017	44.40	6.62	3.86	1.60	2.39	3.30	2.90	706.00	4.00	18.00	6.00	390.00	<2.0	640.00	77.10	1.86									
10.10.2017	64.88	6.48	3.40	0.47	0.65	1.90	2.10	305.00	2.00	5.00	2.00	390.00	4.00	520.00	13.80	1.46	<0.002	0.10	0.23	0.02	0.18	2.20	0.15	0.07	2.00
01.11.2017	54.25	6.42	3.16	<0.3	0.50	1.80	1.90	160.00	2.00	4.00	2.00	320.00	6.00	470.00	11.30	1.52									
11.12.2017	107.94	6.29	3.58	<0.3	0.43	1.70	1.70	132.00	1.00	13.00	6.00	310.00	5.00	445.00	14.50	1.67									
Lower avg.	51.03	6.45	3.65	0.35	0.59	1.76	1.78	235.90	1.08	5.92	2.90	359.17	1.75	476.67	21.90	1.56	0.00	0.08	0.19	0.02	0.28	2.65	0.18	0.06	0.50
Upper avg..	51.03	6.45	3.65	0.48	0.61	1.76	1.78	235.90	1.58	5.92	3.00	359.17	3.08	476.67	21.90	1.56	0.00	0.08	0.19	0.02	0.28	2.65	0.18	0.06	1.25
Minimum	27.82	6.20	3.16	0.30	0.18	1.30	1.30	98.10	1.00	2.00	1.00	260.00	2.00	385.00	11.30	1.22	0.00	0.06	0.12	0.02	0.18	2.20	0.14	0.05	1.00
Maximum	107.94	6.69	4.33	1.60	2.39	3.30	2.90	706.00	4.00	18.00	7.00	490.00	6.00	640.00	77.10	1.86	0.00	0.10	0.23	0.02	0.40	3.20	0.21	0.07	2.00
More than 70% >LOD	yes	yes	yes	no	yes	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	11.00	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	22.54	0.15	0.32	0.37	0.59	0.56	0.52	187.56	1.00	4.81	2.36	72.17	1.68	72.22	20.96	0.19	0.00	0.02	0.05	0.00	0.11	0.44	0.04	0.01	0.50

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]
24.01.2017	4.13	7.57	19.60	3.50	6.98	5.50	5.10		19.00	49.00	10.00	1700.00	26.00	2100.00		2.89									
06.02.2017	1.99	7.71	19.70	5.70	8.32	5.40			26.00	56.00		1600.00	21.00	2100.00		2.04	<0.002	0.25	0.26	0.01	1.58	2.90	1.11	0.22	1.00
06.03.2017	6.02	7.63	19.10	6.60	12.40	5.40			31.00	70.00		1600.00	<2.0	2400.00		2.02									
03.04.2017	2.11	7.63	20.60	2.50	4.11	5.40	5.10	1460.00	7.00	40.00	7.00	1080.00	91.00	1700.00	223.00	0.09									
02.05.2017	1.84	7.64	20.50	4.80	5.58	6.10	5.60	1760.00	9.00	45.00	8.00	730.00	150.00	1450.00	244.00	0.06	<0.002	0.21	0.09	0.01	1.45	1.60	1.11	0.10	<1.0
06.06.2017	3.56	7.59	19.80	3.60	3.50	6.40	5.30	1010.00	9.00	38.00	7.00	470.00	60.00	1130.00	161.00	0.67									
04.07.2017	3.46	7.99	21.40	3.70	4.00	6.30	6.00	1430.00	10.00	46.00	7.00	6.00	4.00	615.00	198.00	1.25									
01.08.2017	7.33	7.77	19.80	2.70	4.84	5.50	5.00	1320.00	15.00	52.00	10.00	<2.0	9.00	625.00	221.00	3.32	0.00	0.32	0.09	0.01	1.66	1.60	1.03	0.10	<1.0
04.09.2017	3.94	7.67	19.20	3.30	9.47	5.10	4.90	2770.00	10.00	45.00	8.00	54.00	20.00	650.00	439.00	4.31									
02.10.2017	61.16	7.71	18.70	6.10	10.39	6.20	5.80	2900.00	48.00	91.00	19.00	230.00	6.00	820.00	387.00	4.20	<0.002	0.40	0.28	0.01	1.58	2.80	1.19	0.15	2.00
06.11.2017	8.24	7.73	17.40	7.40	13.07	6.10	6.00	1450.00	33.00	67.00	25.00	940.00	25.00	1500.00	179.00	4.76									
04.12.2017	5.68	7.77	18.00	14.00	18.80	5.80	5.50	3260.00	59.00	88.00	28.00	1100.00	<2.0	1800.00	376.00	3.71									
Lower avg.	9.12	7.70	19.48	5.32	8.46	5.77	5.43	1928.89	23.00	57.25	12.90	792.50	34.33	1407.50	269.78	2.44	0.00	0.30	0.18	0.01	1.57	2.22	1.11	0.14	0.75
Upper avg..	9.12	7.70	19.48	5.33	8.46	5.77	5.43	1928.89	23.00	57.25	12.90	792.67	34.67	1407.50	269.78	2.44	0.00	0.30	0.18	0.01	1.57	2.22	1.11	0.14	1.25
Minimum	1.84	7.57	17.40	2.50	3.50	5.10	4.90	1010.00	7.00	38.00	7.00	2.00	2.00	615.00	161.00	0.06	0.00	0.21	0.09	0.01	1.45	1.60	1.03	0.10	1.00
Maximum	61.16	7.99	21.40	14.00	18.80	6.40	6.00	3260.00	59.00	91.00	28.00	1700.00	150.00	2400.00	439.00	4.76	0.00	0.40	0.28	0.01	1.66	2.90	1.19	0.22	2.00
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	12.00	12.00	12.00	12.00	12.00	12.00	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	16.52	0.11	1.11	3.16	4.63	0.44	0.41	818.85	16.95	17.92	8.03	642.43	44.97	634.64	102.54	1.67	0.00	0.08	0.11	0.00	0.09	0.72	0.07	0.06	0.50

Vikedalselva

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]
23.01.2017	12.13	6.29	2.99	<0.3	0.37	1.00	1.00		<1.0	3.00	1.00	200.00	3.00	250.00		0.93									
06.02.2017	7.47	6.61	3.26	0.31	0.36	1.10			<1.0	3.00		240.00	5.00	320.00		1.13	<0.002	0.18	0.10	0.02	0.45	2.70	0.38	0.03	<1.0
06.03.2017	8.93	7.01	3.75	0.39	0.70	1.10			1.00	3.00		380.00	<2.0	460.00		1.26									
03.04.2017	14.75	6.60	2.86	0.32	0.63	1.20	1.20	161.00	<1.0	3.00	2.00	170.00	<2.0	250.00		0.86									
02.05.2017	7.74	6.91	3.62	0.31	0.42	1.40	1.20	137.00	<1.0	2.00	<1.0	290.00	13.00	355.00	14.30	1.01	<0.002	0.44	0.10	0.02	0.65	2.70	0.38	0.04	<1.0
06.06.2017	14.31	6.66	2.69	1.10	0.82	3.50	3.10	465.00	5.00	11.00	3.00	260.00	4.00	460.00	23.70	0.80									
17.07.2017	9.59	6.36	2.37	1.40	2.19	3.10	2.80	432.00	10.00	18.00	7.00	180.00	11.00	415.00	53.80	0.62									
07.08.2017	23.99	6.41	1.89	0.73	1.05	1.80	1.70	271.00	2.00	4.00	1.00	160.00	4.00	270.00		0.67	<0.002	0.17	0.24	0.01	0.62	2.40	0.37	0.07	<1.0
04.09.2017	6.13	6.79	2.52	0.38	0.71	1.70	1.60	316.00	1.00	4.00	1.00	230.00	3.00	325.00	28.50	0.89									
09.10.2017	11.59	6.62	2.22	<0.3	0.83	1.50	1.70	162.00	2.00	3.00	1.00	180.00	2.00	280.00	17.20	0.88	<0.002	0.20	0.15	0.01	0.43	2.10	0.34	0.06	2.00
06.11.2017	13.91	6.57	2.03	<0.3	0.87	1.60	1.60	202.00	1.00	3.00	1.00	150.00	5.00	250.00	15.30	0.89									
04.12.2017	11.08	6.66	3.03	<0.3	0.87	1.10	1.10	162.00	3.00	5.00	2.00	230.00	11.00	340.00	12.10	1.15									
Lower avg.	11.80	6.62	2.77	0.41	0.82	1.68	1.70	256.44	2.08	5.17	1.90	222.50	5.08	331.25	23.56	0.92	0.00	0.25	0.15	0.02	0.54	2.48	0.37	0.05	0.50
Upper avg..	11.80	6.62	2.77	0.51	0.82	1.68	1.70	256.44	2.42	5.17	2.00	222.50	5.42	331.25	23.56	0.92	0.00	0.25	0.15	0.02	0.54	2.48	0.37	0.05	1.25
Minimum	6.13	6.29	1.89	0.30	0.36	1.00	1.00	137.00	1.00	2.00	1.00	150.00	2.00	250.00	12.10	0.62	0.00	0.17	0.10	0.01	0.43	2.10	0.34	0.03	1.00
Maximum	23.99	7.01	3.75	1.40	2.19	3.50	3.10	465.00	10.00	18.00	7.00	380.00	13.00	460.00	53.80	1.26	0.00	0.44	0.24	0.02	0.65	2.70	0.38	0.07	2.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	no	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	7.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	4.76	0.21	0.60	0.37	0.48	0.81	0.71	123.62	2.68	4.67	1.89	65.52	3.94	78.14	14.52	0.19	0.00	0.13	0.07	0.00	0.11	0.29	0.02	0.02	0.50

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]
23.01.2017	96.91	6.36	2.42	0.39	0.45	1.10	1.10		1.00	3.00	2.00	160.00	2.00	215.00		1.13									
06.02.2017	20.91	6.38	2.31	0.42	0.49	1.10			<1.0	2.00		160.00	<2.0	220.00		1.15	<0.002	0.07	0.13	0.01	0.49	3.30	0.53	0.06	<1.0
06.03.2017	15.46	6.50	2.17	0.64	1.17	1.00			1.00	4.00		160.00	<2.0	220.00		1.08									
03.04.2017	154.24	6.59	2.64	0.54	0.43	1.10	1.10	185.00	<1.0	4.00	2.00	180.00	<2.0	250.00	8.30	1.19									
02.05.2017	27.21	6.68	2.89	0.46	<0.1	1.40	1.30	130.00	<1.0	3.00	1.00	260.00	8.00	310.00	12.40	1.34	<0.002	0.06	0.04	0.01	0.33	1.40	0.38	0.05	<1.0
06.06.2017	268.06	6.32	1.41	0.34	0.54	1.20	1.00	124.00	<1.0	<1.0	<1.0	78.00	6.00	130.00	9.40	0.93									
03.07.2017	127.98	6.47	1.12	0.57	0.50	1.00	0.95	123.00	<1.0	2.00	5.00	40.00	<2.0	110.00	8.20	0.70									
07.08.2017	132.33	6.47	1.02	0.36	0.46	1.10	1.00	138.00	<1.0	2.00	1.00	30.00	4.00	93.00	11.70	0.67	<0.002	0.05	0.05	0.00	0.32	0.71	0.22	0.05	<1.0
04.09.2017	34.06	6.65	1.17	1.10	3.01	1.20	1.10	424.00	3.00	8.00	1.00	45.00	2.00	165.00	41.30	0.86									
02.10.2017	177.08	6.71	1.28	<0.3	0.63	1.20	1.20	163.00	2.00	4.00	2.00	60.00	9.00	72.00	9.50	0.84	<0.002	0.07	0.04	0.00	0.31	0.70	0.23	0.05	<1.0
06.11.2017	70.76	6.67	1.49	0.50	0.61	1.60	1.60	122.00	3.00	5.00	2.00	120.00	8.00	250.00		1.18									
04.12.2017	29.74	6.63	1.80	<0.3	0.93	1.30	1.40	118.00	2.00	4.00	2.00	140.00	3.00	230.00	11.50	1.20									
Lower avg.	96.23	6.54	1.81	0.44	0.77	1.19	1.18	169.67	1.00	3.42	1.80	119.42	3.50	188.75	14.04	1.02	0.00	0.06	0.07	0.01	0.36	1.53	0.34	0.05	0.00
Upper avg..	96.23	6.54	1.81	0.49	0.78	1.19	1.18	169.67	1.50	3.50	1.90	119.42	4.17	188.75	14.04	1.02	0.00	0.06	0.07	0.01	0.36	1.53	0.34	0.05	1.00
Minimum	15.46	6.32	1.02	0.30	0.10	1.00	0.95	118.00	1.00	1.00	1.00	30.00	2.00	72.00	8.20	0.67	0.00	0.05	0.04	0.00	0.31	0.70	0.22	0.05	1.00
Maximum	268.06	6.71	2.89	1.10	3.01	1.60	1.60	424.00	3.00	8.00	5.00	260.00	9.00	310.00	41.30	1.34	0.00	0.07	0.13	0.01	0.49	3.30	0.53	0.06	1.00
More than 70% >LOD	yes	yes	yes	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	8.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	78.41	0.14	0.65	0.22	0.75	0.17	0.20	97.95	0.80	1.83	1.20	69.99	2.79	73.59	11.13	0.22	0.00	0.01	0.04	0.00	0.09	1.23	0.15	0.01	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]
31.01.2017	25.33	5.95	1.98	<0.3	0.22	1.20	1.30		1.00	3.00	3.00	91.00	<2.0	146.00		1.21									
06.02.2017	20.84	6.06	1.95	<0.3	0.42	1.30			1.00	3.00		76.00	<2.0	129.00		1.26	<0.002	0.03	0.04	0.01	0.14	1.10	0.09	0.03	<1.0
13.03.2017	14.68	6.36	2.26	0.80	0.99	2.20			5.00	9.00		210.00	4.00	325.00		1.82									
04.04.2017	29.02	5.63	2.01	<0.3	0.46	1.60	1.60	148.00	<1.0	3.00	4.00	46.00	<2.0	112.00	9.40	0.95									
09.05.2017	23.94	6.27	1.69	<0.3	0.59	1.50	1.50	153.00	1.00	3.00	<1.0	25.00	4.00	85.00	13.00	0.89	<0.002	0.03	0.05	0.01	0.13	0.85	0.07	0.03	<1.0
13.06.2017	23.66	6.21	1.14	0.58	0.98	1.40	1.40	129.00	2.00	4.00	1.00	29.00	<2.0	95.00	12.50	0.69									
03.07.2017	24.05	6.24	1.04	0.47	0.67	2.40	2.40	186.00	<1.0	5.00	6.00	18.00	<2.0	116.00	16.60										
15.08.2017	22.48	6.33	1.12	<0.3	0.85	2.60	2.60	187.00	2.00	5.00	3.00	61.00	<2.0	160.00	15.70	0.77	<0.002	0.03	0.07	0.00	0.23	0.72	0.10	0.07	<1.0
19.09.2017	12.11	6.23	1.56	<0.3	0.35	2.00	2.00	143.00	2.00	5.00	3.00	150.00	<2.0	260.00	32.80	0.76									
04.10.2017	29.34	6.18	1.51	1.20	3.75	4.00	4.00	626.00	11.00	9.00	8.00	<2.0	<2.0	160.00	68.90	1.05	<0.002	0.07	0.24	0.01	0.39	1.60	0.18	0.10	3.00
06.11.2017	43.58	6.28	1.23	<0.3	0.51	2.00	2.00	156.00	2.00	4.00	2.00	85.00	<2.0	180.00		1.14									
12.12.2017	32.12	6.10	1.90	<0.3	0.23	1.30	1.30	85.70	2.00	4.00	5.00	87.00	<2.0	170.00	6.60	1.25									
Lower avg.	25.10	6.15	1.62	0.25	0.83	1.96	2.01	201.52	2.42	4.75	3.50	73.17	0.67	161.50	21.94	1.07	0.00	0.04	0.10	0.01	0.22	1.07	0.11	0.06	0.75
Upper avg..	25.10	6.15	1.62	0.45	0.83	1.96	2.01	201.52	2.58	4.75	3.60	73.33	2.33	161.50	21.94	1.07	0.00	0.04	0.10	0.01	0.22	1.07	0.11	0.06	1.50
Minimum	12.11	5.63	1.04	0.30	0.22	1.20	1.30	85.70	1.00	3.00	1.00	2.00	2.00	85.00	6.60	0.69	0.00	0.03	0.04	0.00	0.13	0.72	0.07	0.03	1.00
Maximum	43.58	6.36	2.26	1.20	3.75	4.00	4.00	626.00	11.00	9.00	8.00	210.00	4.00	325.00	68.90	1.82	0.00	0.07	0.24	0.01	0.39	1.60	0.18	0.10	3.00
More than 70% >LOD	yes	yes	yes	no	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	8.00	11.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	8.15	0.20	0.41	0.28	0.95	0.79	0.83	162.03	2.87	2.14	2.22	59.20	0.78	69.38	20.54	0.32	0.00	0.02	0.10	0.00	0.12	0.39	0.05	0.03	1.00

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]
23.01.2017	177.04	7.08	4.30	0.38	0.41	2.30	2.40		1.00	4.00	1.00	290.00	<2.0	380.00		3.69									
06.02.2017	75.07	7.11	3.74	0.34	0.32	1.30			<1.0	2.00		190.00	<2.0	265.00		2.94	<0.002	0.05	0.01	<0.003	0.54	0.17	0.18	0.13	<1.0
06.03.2017	45.58	7.20	4.26	<0.3	0.39	1.20			<1.0	1.00		240.00	<2.0	315.00		3.36									
10.04.2017	82.63	7.20	5.12	0.56	2.33	3.20	3.40	206.00	3.00	7.00	4.00	310.00	<2.0	470.00	20.40	3.71									
08.05.2017	83.63			0.64	3.34	2.90	2.90	443.00	3.00	7.00	2.00	240.00	3.00	335.00		3.30	<0.002	0.05	0.04	0.00	1.02	0.55	0.35	0.29	<1.0
12.06.2017	255.70	6.97	1.63	1.90	7.05	1.00	1.00	192.00	7.00	6.00	1.00	28.00	<2.0	92.00	15.00	1.93									
03.07.2017	181.14	7.09	1.82	0.73	3.40	1.20	1.00	122.00	1.00		9.00	27.00	<2.0	82.00	10.20	2.00									
08.08.2017	102.14	7.14	2.29	0.80	1.08	1.00	0.96	130.00	1.00	4.00	1.00	34.00	<2.0	91.00	9.00	2.31	<0.002	0.03	0.02	<0.003	0.54	0.35	0.20	0.20	<1.0
11.09.2017	40.33	7.13	3.44	<0.3	0.45	0.94	0.88	72.60	<1.0	3.00	3.00	68.00	<2.0	133.00	8.60	2.59									
02.10.2017	35.22	7.32	3.64	<0.3	0.63	0.89	0.87	126.00	3.00	2.00	<1.0	95.00	<2.0	140.00	9.10	2.61	<0.002	<0.025	0.01	<0.003	0.42	0.25	0.14	0.11	<1.0
21.11.2017	52.14	7.14	3.44	<0.3	0.36	0.82	0.94	73.10	1.00	<1.0	<1.0	160.00	6.00	250.00	5.10	3.00									
11.12.2017	70.38	7.25	5.56	<0.3	0.87	0.98	1.00	128.00	2.00	3.00	4.00	400.00	12.00	525.00	12.20	4.65									
Lower avg.	100.08	7.15	3.57	0.45	1.72	1.48	1.53	165.86	1.83	3.55	2.50	173.50	1.75	256.50	11.20	3.01	0.00	0.03	0.02	0.00	0.63	0.33	0.22	0.18	0.00
Upper avg..	100.08	7.15	3.57	0.57	1.72	1.48	1.53	165.86	2.08	3.64	2.70	173.50	3.25	256.50	11.20	3.01	0.00	0.04	0.02	0.00	0.63	0.33	0.22	0.18	1.00
Minimum	35.22	6.97	1.63	0.30	0.32	0.82	0.87	72.60	1.00	1.00	1.00	27.00	2.00	82.00	5.10	1.93	0.00	0.03	0.01	0.00	0.42	0.17	0.14	0.11	1.00
Maximum	255.70	7.32	5.56	1.90	7.05	3.20	3.40	443.00	7.00	7.00	9.00	400.00	12.00	525.00	20.40	4.65	0.00	0.05	0.04	0.00	1.02	0.55	0.35	0.29	1.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	no
n	12.00	11.00	11.00	12.00	12.00	12.00	10.00	9.00	12.00	11.00	10.00	12.00	12.00	12.00	8.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	68.65	0.09	1.26	0.46	2.03	0.83	0.97	113.27	1.78	2.20	2.54	125.11	2.99	152.66	4.69	0.79	0.00	0.01	0.01	0.00	0.27	0.16	0.09	0.08	0.00

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]
25.01.2017	49.17	7.36	7.00	0.48	1.08	3.70	3.60		<1.0	3.00	3.00	310.00	3.00	425.00		3.41									
06.02.2017	46.49	7.50	6.81	0.36	0.50	2.60			<1.0	3.00		220.00	3.00	335.00		3.39	<0.002	0.08	0.01	0.03	4.02	9.30	0.70	0.18	<1.0
08.03.2017	43.25	7.66	6.99	<0.3	0.21	2.40			<1.0	2.00		150.00	<2.0	275.00		3.28									
05.04.2017	70.08	7.37	9.69	1.20	2.92	4.60	4.60	346.00	2.00	8.00	3.00	200.00	<2.0	370.00	30.90	3.34									
03.05.2017	38.97	7.40	6.69	0.94	1.39	3.80	3.80	217.00	<1.0	4.00	1.00	310.00	3.00	390.00		3.36	<0.002	0.10	0.03	0.05	8.26	15.70	0.79	0.25	<1.0
06.06.2017	88.96	7.38	4.26	0.48	1.61	3.10	2.70	169.00	<1.0	1.00	1.00	110.00	2.00	220.00	13.60	2.42									
03.07.2017	136.77	7.36	4.68	0.76	2.08	2.50	2.40	230.00	1.00	6.00	5.00	90.00	<2.0	220.00	15.50	2.44									
07.08.2017	49.16	7.52	6.65	0.64	0.93	2.70	3.00	171.00	2.00	2.00	2.00	220.00	<2.0	260.00	13.40	2.76	<0.002	0.11	0.02	0.02	5.70	6.20	0.81	0.21	<1.0
04.09.2017	44.33	7.61	6.96	<0.3	0.46	2.10	2.20	131.00	2.00	3.00	2.00	160.00	<2.0	275.00	9.10	2.81									
02.10.2017	17.14	7.74	8.21	<0.3	0.34	1.90	1.80	145.00	2.00	4.00	2.00	270.00	<2.0	350.00	11.80	2.94	<0.002	0.09	0.01	0.03	3.87	7.50	0.75	0.10	<1.0
06.11.2017	42.18	7.58	6.83	0.45	0.82	4.50	4.40	153.00	<1.0	3.00	1.00	210.00	4.00	400.00	9.30	3.58									
04.12.2017	51.34	7.60	6.56	<0.3	0.86	2.00	2.00	145.00	2.00	3.00	2.00	200.00	8.00	330.00	10.30	3.15									
Lower avg.	56.49	7.51	6.78	0.44	1.10	2.99	3.05	189.67	0.92	3.50	2.20	204.17	1.92	320.83	14.24	3.07	0.00	0.09	0.02	0.03	5.46	9.68	0.76	0.18	0.00
Upper avg..	56.49	7.51	6.78	0.54	1.10	2.99	3.05	189.67	1.42	3.50	2.20	204.17	2.92	320.83	14.24	3.07	0.00	0.09	0.02	0.03	5.46	9.68	0.76	0.18	1.00
Minimum	17.14	7.36	4.26	0.30	0.21	1.90	1.80	131.00	1.00	1.00	1.00	90.00	2.00	220.00	9.10	2.42	0.00	0.08	0.01	0.02	3.87	6.20	0.70	0.10	1.00
Maximum	136.77	7.74	9.69	1.20	2.92	4.60	4.60	346.00	2.00	8.00	5.00	310.00	8.00	425.00	30.90	3.58	0.00	0.11	0.03	0.05	8.26	15.70	0.81	0.25	1.00
More than 70% >LOD	yes	yes	yes	no	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	8.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	30.60	0.13	1.40	0.29	0.79	0.95	1.00	67.42	0.51	1.88	1.23	70.12	1.73	69.86	7.10	0.39	0.00	0.01	0.01	0.01	2.04	4.21	0.05	0.06	0.00

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]
24.01.2017	109.48	7.20	3.96	1.70	2.46	3.10	3.10		2.00	4.00	3.00	130.00	2.00	230.00		2.14									
07.02.2017	59.05	7.13	3.30	0.63	1.60	2.70			2.00	4.00		95.00	<2.0	200.00		1.97	<0.002	0.09	0.03	0.00	0.64	0.45	0.68	0.17	<1.0
06.03.2017	46.72	7.16	3.44	1.30	1.78	2.70			<1.0	4.00		98.00	<2.0	210.00		2.05									
03.04.2017	84.54	7.09	3.76	2.40	3.55	2.90	2.80	177.00	3.00	6.00	2.00	120.00	<2.0	220.00		2.31									
02.05.2017	65.75	7.15	3.33	0.54	0.73	2.90	2.80	85.40	<1.0	2.00	1.00	130.00	4.00	195.00	8.80	1.94	<0.002	0.08	0.02	<0.003	0.65	0.81	1.76	0.16	<1.0
06.06.2017	362.45	7.04	3.24	0.37	0.69	2.70	2.60	104.00	<1.0	<1.0	<1.0	89.00	<2.0	180.00	10.50	1.98									
03.07.2017	168.17	7.20	3.33	0.59	1.40	2.60	2.50	130.00	1.00	4.00	5.00	60.00	<2.0	170.00	12.00	1.82									
07.08.2017	78.99	7.17	3.05	0.56	0.55	2.80	2.70	146.00	2.00	3.00	2.00	57.00	8.00	175.00	13.40	1.68	<0.002	0.08	0.02	0.00	0.61	0.53	0.67	0.15	<1.0
04.09.2017	56.76	7.25	2.96	0.32	1.01	2.90	2.80	156.00	2.00	3.00	2.00	54.00	4.00	165.00	13.90	1.76									
11.10.2017	50.84	7.25	3.19	0.31	0.32	2.70	2.80	170.00	1.00	3.00	<1.0	65.00	5.00	160.00	14.30	1.79	<0.002	0.10	0.03	<0.003	0.57	0.54	0.68	0.17	1.00
06.11.2017	99.14	7.33	3.54	5.70	5.97	2.90	2.80	248.00	4.00	7.00	2.00	94.00	5.00	220.00	17.00	2.46									
04.12.2017	71.35	7.41	5.33	8.00	8.19	2.80	2.70	243.00	8.00	14.00	3.00	140.00	<2.0	320.00	25.10	2.57									
Lower avg.	104.44	7.20	3.54	1.87	2.35	2.81	2.76	162.16	2.08	4.50	2.00	94.33	2.33	203.75	14.38	2.04	0.00	0.08	0.02	0.00	0.62	0.58	0.95	0.16	0.25
Upper avg..	104.44	7.20	3.54	1.87	2.35	2.81	2.76	162.16	2.33	4.58	2.20	94.33	3.33	203.75	14.38	2.04	0.00	0.08	0.02	0.00	0.62	0.58	0.95	0.16	1.00
Minimum	46.72	7.04	2.96	0.31	0.32	2.60	2.50	85.40	1.00	1.00	1.00	54.00	2.00	160.00	8.80	1.68	0.00	0.08	0.02	0.00	0.57	0.45	0.67	0.15	1.00
Maximum	362.45	7.41	5.33	8.00	8.19	3.10	3.10	248.00	8.00	14.00	5.00	140.00	8.00	320.00	25.10	2.57	0.00	0.10	0.03	0.00	0.65	0.81	1.76	0.17	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	no	yes	yes	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	8.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	87.83	0.10	0.63	2.46	2.43	0.14	0.16	55.67	2.02	3.37	1.23	30.73	1.92	43.49	5.00	0.28	0.00	0.01	0.01	0.00	0.04	0.16	0.54	0.01	0.00

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]
24.01.2017	35.70	7.52	8.11	0.46	1.85	1.80	1.80		1.00	3.00	2.00	30.00	<2.0	90.00		1.50									
06.02.2017	33.78	7.61	8.10	<0.3	<0.2	1.80			<1.0	2.00		54.00	<2.0	124.00		1.86	<0.002	0.10	0.01	<0.003	0.27	0.22	0.28	0.06	<1.0
07.03.2017	31.79	7.73	10.20	<0.3	<0.2	1.40			<1.0	1.00		82.00	<2.0	150.00		2.16									
04.04.2017	32.10	7.49	6.82	1.80	3.21	1.80	1.80	168.00	2.00	5.00	2.00	31.00	<2.0	115.00	14.00	1.65									
02.05.2017	57.31	7.67	8.99	1.10	2.05	1.70	1.70	227.00	1.00	2.00	<1.0	46.00	<2.0	97.00	25.20	1.38	<0.002	0.10	0.03	<0.003	0.31	0.27	0.28	0.09	<1.0
06.06.2017	127.30	7.09	4.70	0.34	1.07	1.60	1.70	127.00	<1.0	2.00	2.00	27.00	3.00	104.00	11.70	1.28									
04.07.2017	228.38	7.33	3.41	0.71	1.55	1.30	1.20	83.30	<1.0	3.00	<1.0	12.00	<2.0	65.00	8.00	1.03									
14.08.2017	163.67	7.21	2.71	1.10	3.38	3.00	3.10	249.00	2.00	8.00	2.00	4.00	<2.0	100.00	16.50	1.08	<0.002	0.12	0.12	0.00	0.40	0.52	0.35	0.19	<1.0
04.09.2017	148.34	7.43	5.04	<0.3	0.71	1.30	1.40	83.90	<1.0	2.00	<1.0	13.00	<2.0	70.00	8.90	1.14									
02.10.2017	96.71	7.75	6.42	<0.3	0.18	0.97	0.87	69.20	2.00	2.00	2.00	27.00	<2.0	72.00	5.80	1.21	<0.002	0.10	0.01	0.00	0.23	<0.15	0.23	0.05	<1.0
06.11.2017	50.50	7.61	5.84	<0.3	0.27	2.20	2.30	93.70	1.00	2.00	3.00	31.00	3.00	140.00	11.90	1.50									
04.12.2017	41.21	7.65	7.37	<0.3	0.37	1.80	1.80	50.20	<1.0	2.00	1.00	140.00	3.00	230.00	4.70	1.93									
Lower avg.	87.23	7.51	6.48	0.46	1.22	1.72	1.77	127.92	0.75	2.83	1.40	41.42	0.75	113.08	11.86	1.48	0.00	0.10	0.04	0.00	0.30	0.25	0.29	0.10	0.00
Upper avg..	87.23	7.51	6.48	0.61	1.25	1.72	1.77	127.92	1.25	2.83	1.70	41.42	2.25	113.08	11.86	1.48	0.00	0.10	0.04	0.00	0.30	0.29	0.29	0.10	1.00
Minimum	31.79	7.09	2.71	0.30	0.18	0.97	0.87	50.20	1.00	1.00	1.00	4.00	2.00	65.00	4.70	1.03	0.00	0.10	0.01	0.00	0.23	0.15	0.23	0.05	1.00
Maximum	228.38	7.75	10.20	1.80	3.38	3.00	3.10	249.00	2.00	8.00	3.00	140.00	3.00	230.00	25.20	2.16	0.00	0.12	0.12	0.00	0.40	0.52	0.35	0.19	1.00
More than 70% >LOD	yes	yes	yes	no	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	65.49	0.21	2.25	0.48	1.16	0.52	0.61	71.30	0.45	1.90	0.67	37.39	0.45	45.51	6.28	0.36	0.00	0.01	0.05	0.00	0.07	0.16	0.05	0.06	0.00

Målselva

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]
30.01.2017	170.08	7.56	9.42	0.35	0.49	1.70	1.90		<1.0	6.00	2.00	87.00	3.00	165.00		2.96									
13.02.2017	88.39	7.72	10.10	<0.3	0.39	1.20	1.10		<1.0	2.00	1.00	92.00	5.00	165.00		3.06	<0.002	0.04	0.01	<0.003	0.34	<0.15	0.33	0.06	<1.0
05.03.2017	42.74	7.70	10.20	<0.3	<0.2	1.10	1.10	39.00	<1.0	2.00	<1.0	95.00	<2.0	170.00	2.70	3.13									
04.04.2017	46.05	7.71	10.30	<0.3	0.24	1.10	1.10	33.40	<1.0	2.00	2.00	82.00	<2.0	150.00		3.09									
07.05.2017	51.60	7.68	9.18	1.00	2.39	2.80	2.80	139.00	3.00	5.00	1.00	120.00	<2.0	235.00	18.70	3.11	<0.002	0.05	0.04	0.00	0.66	0.49	0.49	0.17	<1.0
12.06.2017	622.37	7.41	5.48	6.70	21.60	1.60	2.00	365.00	22.00	27.00	2.00	30.00	<2.0	136.00	33.90	3.13									
03.07.2017	383.39	7.54	5.47	2.10	6.80	1.00	0.92	108.00	5.00	8.00	1.00	20.00	<2.0	75.00	6.50	2.12									
06.08.2017	206.20	7.64	6.42	0.76	4.17	0.93	0.88	59.20	1.00	1.00	2.00	19.00	<2.0	69.00	7.10	2.05	<0.002	0.04	0.03	<0.003	0.43	0.28	0.38	0.12	<1.0
11.09.2017	60.39	7.65	8.35	<0.3	0.40	0.93	1.20	72.50	2.00	4.00	4.00	21.00	<2.0	91.00	8.90	2.29									
02.10.2017	36.39	7.83	8.51	<0.3	1.04	0.83	0.81	94.30	2.00	2.00	2.00	35.00	<2.0	39.00	8.80	2.44	<0.002	0.04	0.03	<0.003	0.38	0.28	0.32	0.08	<1.0
05.11.2017	56.37	7.81	8.73	<0.3	0.81	1.20	1.20	116.00	2.00	3.00	4.00	56.00	4.00	140.00	9.40	2.83									
04.12.2017	27.49	7.80	9.48	<0.3	<0.2	0.79	0.82	20.80	1.00	2.00	2.00	75.00	8.00	134.00	1.90	2.98									
Lower avg.	149.29	7.67	8.47	0.91	3.19	1.26	1.32	104.72	3.17	5.33	1.92	61.00	1.67	130.75	10.88	2.77	0.00	0.04	0.03	0.00	0.45	0.26	0.38	0.11	0.00
Upper avg..	149.29	7.67	8.47	1.08	3.23	1.26	1.32	104.72	3.50	5.33	2.00	61.00	3.00	130.75	10.88	2.77	0.00	0.04	0.03	0.00	0.45	0.30	0.38	0.11	1.00
Minimum	27.49	7.41	5.47	0.30	0.20	0.79	0.81	20.80	1.00	1.00	1.00	19.00	2.00	39.00	1.90	2.05	0.00	0.04	0.01	0.00	0.34	0.15	0.32	0.06	1.00
Maximum	622.37	7.83	10.30	6.70	21.60	2.80	2.80	365.00	22.00	27.00	4.00	120.00	8.00	235.00	33.90	3.13	0.00	0.05	0.04	0.00	0.66	0.49	0.49	0.17	1.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	no	yes	yes	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	10.00	12.00	12.00	12.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	181.32	0.12	1.75	1.85	6.13	0.56	0.61	99.29	5.95	7.13	1.04	35.19	1.86	54.08	9.89	0.42	0.00	0.01	0.01	0.00	0.14	0.14	0.08	0.05	0.00

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]
23.01.2017	37.81	7.48	8.01	<0.3	<0.2	3.50	3.50		3.00	5.00	7.00	87.00	<2.0	205.00		6.00									
06.02.2017	35.67	7.64	8.50	0.46	<0.33	3.40			3.00	5.00		84.00	<2.0	195.00		6.39	<0.002	0.13	0.01	<0.003	0.39	<0.15	0.24	0.19	<1.0
06.03.2017	33.61	7.59	8.86	<0.3	<0.2	3.20			2.00	5.00		94.00	<2.0	215.00		6.62									
03.04.2017	33.51	7.63	8.49	<0.3	0.20	3.30	3.30	68.10	<1.0	4.00	3.00	53.00	<2.0	170.00	5.40	6.15									
07.05.2017	60.25	7.79	11.20	<0.3	0.66	2.90	2.80	157.00	1.00	5.00	2.00	110.00	23.00	265.00	17.90	6.43	<0.002	0.12	0.01	<0.003	0.39	<0.15	0.17	0.17	<1.0
06.06.2017	134.44	7.55	8.62	0.97	1.30	3.70	3.70	337.00	6.00	8.00	5.00	82.00	<2.0	235.00	40.40	5.59									
09.07.2017	347.11	7.41	7.06	0.84	4.54	3.20	3.00	163.00	5.00	8.00	4.00	47.00	<2.0	175.00	17.40	3.92									
14.08.2017	172.85	7.57	7.83	0.38	1.06	3.70	3.80	180.00	5.00	8.00	5.00	50.00	<2.0	200.00	18.60	3.81	<0.002	0.13	0.01	<0.003	0.58	0.23	0.28	0.21	<1.0
03.09.2017	164.42	7.59	8.12	<0.3	0.66	3.50	3.80	133.00	6.00	8.00	5.00	14.00	<2.0	190.00	16.50	4.24									
01.10.2017	102.53	7.64	6.62	<0.3	0.51	3.40	3.40	118.00	2.00	5.00	3.00	27.00	<2.0	170.00	13.20	3.84	<0.002	0.09	0.01	<0.003	0.44	0.15	0.24	0.18	2.00
30.10.2017	74.60	7.58	7.39	<0.3	0.32	3.30	3.30	182.00	3.00	10.00	8.00	53.00	30.00	230.00	18.10	4.41									
05.12.2017	43.46	7.49	7.82	<0.3	0.50	3.00	3.10	93.50	4.00	6.00	4.00	74.00	<2.0	190.00		5.06									
Lower avg.	103.36	7.58	8.21	0.22	0.81	3.34	3.37	159.07	3.33	6.42	4.60	64.58	4.42	203.33	18.44	5.21	0.00	0.12	0.01	0.00	0.45	0.10	0.23	0.19	0.50
Upper avg..	103.36	7.58	8.21	0.42	0.87	3.34	3.37	159.07	3.42	6.42	4.60	64.58	6.08	203.33	18.44	5.21	0.00	0.12	0.01	0.00	0.45	0.17	0.23	0.19	1.25
Minimum	33.51	7.41	6.62	0.30	0.20	2.90	2.80	68.10	1.00	4.00	2.00	14.00	2.00	170.00	5.40	3.81	0.00	0.09	0.01	0.00	0.39	0.15	0.17	0.17	1.00
Maximum	347.11	7.79	11.20	0.97	4.54	3.70	3.80	337.00	6.00	10.00	8.00	110.00	30.00	265.00	40.40	6.62	0.00	0.13	0.01	0.00	0.58	0.23	0.28	0.21	2.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	no	yes	no	yes	yes	no
n	12.00	12.00	12.00	12.00	12.00	12.00	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	8.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	92.36	0.10	1.15	0.23	1.21	0.25	0.34	77.12	1.78	1.88	1.84	28.54	9.65	28.79	9.89	1.11	0.00	0.02	0.00	0.00	0.09	0.04	0.05	0.02	0.50

Tana

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]
23.01.2017	53.15	7.32	6.79	<0.3	0.29	2.20	2.10		6.00	9.00	5.00	84.00	5.00	180.00		10.26									
05.02.2017	50.66	7.36	7.13	0.31	0.28	2.00			4.00	6.00		89.00	2.00	180.00		10.67	<0.002	0.07	0.01	<0.003	0.29	0.86	0.26	0.26	<1.0
05.03.2017	49.83	7.42	7.96	0.33	0.46	2.10			2.00	7.00		100.00	120.00	510.00		10.80									
03.04.2017	43.46	7.37	8.25	<0.3	0.34	1.80	1.80	130.00	11.00	16.00	13.00	<2.0	<2.0	305.00	15.50	10.89									
07.05.2017	56.35	7.40	7.36	0.47	0.75	1.90	2.00	211.00	<1.0	2.00	3.00	59.00	110.00	340.00	30.00	8.72	<0.002	0.06	0.09	0.01	0.60	4.60	0.33	0.24	<1.0
11.06.2017	2267.34	6.78	2.64	2.10	2.57	5.70	5.80	515.00	7.00	18.00	5.00	5.00	<2.0	225.00	41.80	4.80									
03.07.2017	782.29	6.98	3.17	0.49	1.52	3.10	2.90	170.00	3.00	8.00	4.00	<2.0	7.00	142.00	15.60	3.84									
07.08.2017	359.49	7.21	3.95	0.72	1.02	4.60	4.50	287.00	2.00	5.00	3.00	10.00	<2.0	165.00	21.60	5.40	<0.002	0.06	0.02	<0.003	0.56	1.20	0.56	0.38	<1.0
04.09.2017	317.49	7.14	4.06	0.75	1.69	4.50	4.40	367.00	2.00	9.00	6.00	<2.0	4.00	160.00	40.20	5.94									
08.10.2017	144.28	7.38	4.57	<0.3	0.55	3.00	2.70	135.00	2.00	6.00	2.00	14.00	<2.0	140.00	14.00	6.66	<0.002	0.04	0.01	<0.003	0.26	1.00	0.33	0.30	1.00
07.11.2017	120.80	7.40	5.65	<0.3	0.74	2.60	2.50	193.00	5.00	10.00	7.00	50.00	8.00	230.00	19.90	8.91									
04.12.2017	80.56	7.22	5.43	1.30	1.39	2.40	2.30	112.00	2.00	5.00	4.00	54.00	18.00	195.00	11.20	10.03									
Lower avg.	360.48	7.25	5.58	0.54	0.97	2.99	3.10	235.56	3.83	8.42	5.20	38.75	22.83	231.00	23.31	8.08	0.00	0.06	0.03	0.00	0.43	1.92	0.37	0.29	0.25
Upper avg..	360.48	7.25	5.58	0.64	0.97	2.99	3.10	235.56	3.92	8.42	5.20	39.25	23.50	231.00	23.31	8.08	0.00	0.06	0.03	0.00	0.43	1.92	0.37	0.29	1.00
Minimum	43.46	6.78	2.64	0.30	0.28	1.80	1.80	112.00	1.00	2.00	2.00	2.00	2.00	140.00	11.20	3.84	0.00	0.04	0.01	0.00	0.26	0.86	0.26	0.24	1.00
Maximum	2267.34	7.42	8.25	2.10	2.57	5.70	5.80	515.00	11.00	18.00	13.00	100.00	120.00	510.00	41.80	10.89	0.00	0.07	0.09	0.01	0.60	4.60	0.56	0.38	1.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	638.06	0.20	1.91	0.55	0.70	1.27	1.33	132.87	2.91	4.58	3.12	37.80	43.03	107.59	11.40	2.60	0.00	0.01	0.04	0.00	0.18	1.80	0.13	0.06	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]
24.01.2017	45.71	7.16	3.31	<0.3	<0.2	3.00	3.10		<1.0	3.00	1.00	47.00	4.00	150.00		5.42									
05.02.2017	44.39	7.07	3.28	<0.3	<0.2	3.00			<1.0	3.00		52.00	<2.0	160.00		5.70	<0.002	0.08	0.01	<0.003	0.42	0.84	0.84	0.12	<1.0
05.03.2017	44.76	7.07	3.93	<0.3	<0.2	3.10			<1.0	2.00		58.00	<2.0	180.00		5.70									
03.04.2017	44.24	7.18	4.21	<0.3	0.79	3.60	3.50	199.00	<1.0	4.00	2.00	75.00	30.00	275.00	24.90	6.39									
07.05.2017	97.55	7.08	3.35	1.00	1.79	2.90	3.00	518.00	2.00	6.00	2.00	71.00	49.00	280.00	74.10	5.16	<0.002	0.30	0.22	0.03	8.82	5.70	9.83	0.16	1.00
11.06.2017	1416.34	7.12	4.67	0.88	1.06	4.30	4.80	228.00	5.00	7.00	4.00	20.00	4.00	245.00	22.20	5.16									
03.07.2017	336.17	7.16	3.46	0.50	0.89	4.80	4.60	151.00	2.00	7.00	3.00	<2.0	10.00	165.00	15.10	3.17									
06.08.2017	204.94	7.26	3.47	0.66	0.43	3.40	3.40	341.00	32.00	39.00	33.00	<2.0	190.00	445.00	43.90	4.50	<0.002	0.17	0.04	0.01	2.46	1.20	9.18	0.16	<1.0
05.09.2017	223.78	7.20	3.53	0.57	1.11	4.60	4.50	230.00	3.00	6.00	4.00	4.00	3.00	146.00	21.40	5.64									
08.10.2017	113.94	7.17	3.58	<0.3	1.30	3.50	3.60	170.00	2.00	7.00	4.00	12.00	3.00	170.00	14.60	4.89	<0.002	0.13	0.02	0.01	1.28	0.97	7.71	0.15	1.00
06.11.2017	89.38	7.24	3.56	<0.3	0.66	3.60	3.50	228.00	2.00	7.00	2.00	28.00	59.00	295.00	21.60	5.96									
03.12.2017	70.76	7.11	3.30	<0.3	0.59	3.50	3.80	92.20	1.00	4.00	1.00	34.00	33.00	250.00	10.40	6.06									
Lower avg.	227.66	7.15	3.64	0.30	0.72	3.61	3.78	239.69	4.08	7.92	5.60	33.42	32.08	230.08	27.58	5.31	0.00	0.17	0.07	0.01	3.24	2.18	6.89	0.15	0.50
Upper avg..	227.66	7.15	3.64	0.48	0.77	3.61	3.78	239.69	4.42	7.92	5.60	33.75	32.42	230.08	27.58	5.31	0.00	0.17	0.07	0.01	3.24	2.18	6.89	0.15	1.00
Minimum	44.24	7.07	3.28	0.30	0.20	2.90	3.00	92.20	1.00	2.00	1.00	2.00	2.00	146.00	10.40	3.17	0.00	0.08	0.01	0.00	0.42	0.84	0.84	0.12	1.00
Maximum	1416.34	7.26	4.67	1.00	1.79	4.80	4.80	518.00	32.00	39.00	33.00	75.00	190.00	445.00	74.10	6.39	0.00	0.30	0.22	0.03	8.82	5.70	9.83	0.16	1.00
More than 70% >LOD	yes	yes	yes	no	yes	yes	yes	yes	no	yes	yes	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	10.00	9.00	12.00	12.00	10.00	12.00	12.00	12.00	9.00	12.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
St.dev	385.26	0.06	0.43	0.25	0.49	0.64	0.64	124.61	8.76	9.96	9.70	26.60	53.53	87.53	19.87	0.85	0.00	0.09	0.10	0.01	3.81	2.35	4.13	0.02	0.00

6.2 Riverine loads in 2017

River	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	66361.59	188018.53	102438.78	202.23	325.30	8238.49	213.78	13199.36	88033.23	0.00	3.81	3.82	0.23	31.01	45.73	16.49	5.01	24.25
Alna	114.32	433.37	200.18	2.04	2.60	36.34	3.23	60.73	290.34	0.00	0.03	0.16	0.01	0.43	1.85	0.11	0.10	0.07
Drammenselva	29870.72	20771.38	41294.36	26.22	67.88	2618.65	103.43	4256.08	31359.80	0.00	1.89	1.44	0.09	8.23	24.33	5.27	1.70	12.56
Numedalslågen	10670.06	34165.26	18136.10	58.34	91.66	925.45	109.34	1751.35	14343.85	0.02	0.94	1.97	0.07	3.46	18.99	2.09	1.12	5.02
Skienselva	26230.14	8159.18	27818.26	16.42	51.40	1310.18	102.30	2443.61	20926.66	0.00	1.05	0.69	0.09	3.98	17.74	1.78	0.72	0.00
Storelva	1195.99	2400.34	3326.06	2.19	5.05	60.27	5.06	162.64	1344.68	0.00	0.16	0.39	0.02	0.48	3.62	0.32	0.17	1.15
Otra	15013.28	12416.40	18506.81	8.66	31.74	389.93	55.14	1185.91	8767.34	0.01	0.70	1.55	0.07	2.55	15.78	2.33	0.48	6.19
Bjerkreimselva	4732.46	1050.63	3089.28	2.53	12.35	603.64	4.72	819.86	2724.14	0.00	0.15	0.36	0.04	0.45	4.41	0.30	0.11	1.62
Orreelva	698.61	2581.72	1529.75	9.74	19.67	123.30	3.62	277.74	926.21	0.00	0.10	0.07	0.00	0.40	0.69	0.30	0.04	0.47
Vikedalselva	1173.02	363.71	756.66	1.06	2.31	91.34	2.24	140.27	382.91	0.00	0.10	0.07	0.01	0.23	1.03	0.16	0.03	0.33
Vosso	8870.26	1942.29	3805.13	3.43	9.26	307.52	15.08	500.90	3063.19	0.00	0.21	0.16	0.01	1.04	2.83	0.82	0.16	0.00
Nausta	2327.01	666.59	1640.96	2.03	3.82	56.38	0.70	130.24	882.64	0.00	0.04	0.11	0.00	0.21	0.98	0.10	0.05	1.08
Driva	8526.63	8171.28	4747.43	8.08	14.20	471.76	5.17	722.08	8815.20	0.00	0.12	0.07	0.01	2.07	1.09	0.72	0.61	0.00
Orkla	5664.28	2813.33	6187.65	2.36	7.81	371.07	4.97	621.38	6099.19	0.00	0.19	0.04	0.07	11.65	20.41	1.58	0.40	0.00
Nidelva (Tr.heim)	9006.91	6989.41	9147.44	6.61	12.95	305.18	7.55	656.44	6682.57	0.00	0.27	0.08	0.01	2.03	1.94	3.15	0.53	1.45
Vefsna	9281.74	4889.76	5793.36	3.34	11.09	94.01	3.61	327.47	4305.80	0.00	0.36	0.19	0.01	1.06	1.05	0.98	0.38	0.00
Målselva	9376.60	31979.37	4586.72	30.42	41.29	144.95	4.56	411.56	9261.58	0.00	0.14	0.09	0.00	1.49	0.92	1.29	0.37	0.00
Altaelva	9802.33	6845.72	12029.95	15.47	26.17	194.93	12.02	704.78	16367.01	0.00	0.41	0.04	0.00	1.72	0.58	0.87	0.68	3.13
Tana	22379.09	15559.89	37357.09	40.51	104.63	88.83	50.52	1643.93	44068.97	0.00	0.45	0.19	0.01	3.67	11.75	3.62	2.72	3.95
Pasvikelva	16794.16	5889.35	25140.29	36.10	55.74	121.76	150.42	1471.33	30671.61	0.00	1.09	0.44	0.07	20.04	12.63	49.83	0.94	4.70

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The Norwegian Environment Agency is working for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are a government agency under the Ministry of Climate and Environment and have 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.

We implement and give advice on the development of climate and environmental policy. We are professionally independent. This means that we act independently in the individual cases that we decide and when we communicate knowledge and information or give advice.

Our principal functions include collating and communicating environmental information, exercising regulatory authority, supervising and guiding regional and local government level, giving professional and technical advice, and participating in international environmental activities.