

Supplementary Information

Title: Organic nitrogen steadily increasing in Norwegian rivers draining to the Skagerrak coast

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Table with legend

Table S1. Background characteristics of the five Norwegian rivers included in the analysis (exact location of monitoring station, and catchment area).

River	UTM North (m)	UTM East (m)	Catchment area (km ²)
Drammenselva	6624446	556695	17034
Glomma	6573156	621600	41918
Numedalslågen	6551828	561347	5577
Otra	6450006	438495	3738
Skienselva	6562920	534741	10772

Table S2. Details of linear mixed effect model for parameter: dissolved inorganic nitrogen (load in $\text{mg m}^{-2} \text{yr}^{-1}$, DIN). Note log transformation to ensure normality of response variable. For abbreviations: CI = confidence intervals, p = p – value, Interc. = Intercept, Ndep = N deposition, Sdep = S deposition, Temp = Temperature, Precip = Precipitation, Dis = Discharge.

L.DIN			
<i>Predictors</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	43.79	26.38 – 61.20	<0.001
Ndep	0.00	0.00 – 0.00	0.001
Precip	-0.00	-0.00 – -0.00	0.045
Temp	-0.03	-0.04 – -0.03	<0.001
Dis	0.01	0.01 – 0.02	<0.001
Year	-0.02	-0.03 – -0.01	<0.001
Random Effects			
σ^2	0.05		
T00 Month	0.81		
T00 River	0.06		
N Month	12		
N River	5		
Observations	180		
Marginal R ²	0.921		

Table S3. Details of linear mixed effect model for parameter: total organic nitrogen (load in $\text{mg m}^{-2} \text{ yr}^{-1}$, TON). Note log transformation to ensure normality of response variable. For abbreviations: CI = confidence intervals, p = p – value, Interc. = Intercept, Ndep = N deposition, Sdep = S deposition, Temp = Temperature, Precip = Precipitation, Dis = Discharge.

		L.TON	
<i>Predictors</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	1.62	1.35 – 1.90	<0.001
Sdep	-0.00	-0.00 – -0.00	0.003
Temp	0.01	0.00 – 0.02	0.010
Dis	0.01	0.01 – 0.01	<0.001
Random Effects			
σ^2	0.06		
T00 Month	0.15		
T00 River	0.13		
N Month	12		
N River	5		
Observations	180		
Marginal R ²	0.744		

Table S4. Details of linear mixed effect model for parameter: dissolved inorganic nitrogen to total phosphorus (ratio in molar:molar, DIN:TP). Note square-root transformation to ensure normality of response variable. For abbreviations: CI = confidence intervals, p = p – value, Interc. = Intercept, Ndep = N deposition, Sdep = S deposition, Temp = Temperature, Precip = Precipitation, Dis = Discharge.

S.DIN.TP			
<i>Predictors</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	162.36	43.06 – 281.66	0.008
Ndep	0.02	0.01 – 0.02	<0.001
Precip	-0.01	-0.01 – -0.00	0.028
Temp	-0.12	-0.16 – -0.08	<0.001
Year	-0.08	-0.14 – -0.02	0.009
Random Effects			
σ^2	2.66		
T00 Month	2.71		
T00 River	0.63		
N Month	12		
N River	5		
Observations	180		
Marginal R ²	0.704		

Table S5. Details of linear mixed effect model for parameter: dissolved inorganic nitrogen to total organic nitrogen (ratio in molar:molar, DIN:TON). Discharge (Dis) was kept in the model as likelihood ratio (ML) test to compare alternative models (with/without Dis as fixed term) showed its importance for final model (Zuur et al. 2009). Note square-root transformation to ensure normality of response variable. For abbreviations: CI = confidence intervals, p = p – value, Interc. = Intercept, Ndep = N deposition, Sdep = S deposition, Temp = Temperature, Precip = Precipitation, Dis = Discharge.

S.DIN.TON			
<i>Predictors</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	60.83	42.43 – 79.22	<0.001
Sdep	-0.00	-0.00 – -0.00	<0.001
Precip	-0.00	-0.00 – -0.00	0.016
Temp	-0.02	-0.03 – -0.02	<0.001
Dis	0.00	-0.00 – 0.00	0.803
Year	-0.03	-0.04 – -0.02	<0.001

Random Effects

σ^2	0.03
T00 Month	0.00
T00 River	0.07
N Month	12
N River	5
Observations	180
Marginal R ²	0.630

Table S6. Details of linear mixed effect model for parameter: total organic carbon to total organic nitrogen (ratio in molar:molar, TOC:TON). Note square-root transformation to ensure normality of response variable. For abbreviations: CI = confidence intervals, p = p – value, Interc. = Intercept, Ndep = N deposition, Sdep = S deposition, Temp = Temperature, Precip = Precipitation, Dis = Discharge.

S.TOC.TON			
<i>Predictors</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	71.27	38.93 – 103.61	<0.001
Temp	-0.02	-0.03 – -0.01	<0.001
Dis	0.00	0.00 – 0.01	0.001
Year	-0.03	-0.05 – -0.02	<0.001
Random Effects			
σ^2	0.18		
T00 Month	0.08		
T00 River	0.05		
N Month	12		
N River	5		
Observations	180		
Marginal R ²	0.203		

Figures with legends

Figure S1. Time series of total organic carbon (TOC) related parameters. Here data was only included from 1999 – 2017 due to lack of monitoring prior to 1999. The figure was generated using the freely available software R (R CoreTeam 2020, Version 4.0.2, <https://www.R-project.org/>).

