

Direct determination of niobium at the low nanogram level in mineral waters and freshwaters

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Supporting information

Three tables

Nine pages

Table S1 Published niobium concentrations in seawater

System	Dissolved Nb concentration ^a	Original units	Dissolved Nb / ng L ⁻¹	Filtration	Experimental technique ^b	Type of study ^c	Reference
English Channel: 40 km SW Plymouth (surface) Plymouth Sound	0.01 - 0.02 BDL 0.05 - 0.1 0.005	$\mu\text{g L}^{-1}$	10 - 20 50 - 100 5	Unfiltered Filtered Unfiltered Filtered	Preconcentration: ferric oxide precipitation Paper chromatography with colorimetric detection DL: not given CRM: not mentioned	ENV	Carlisle and Hummerstone, 1965
Northeastern Pacific (45° 00' N, 164° 55': Surface Bottom Profile 0-5000 m; two stations	2.7 ^d 3.8 ^d	pmol kg^{-1}	≈ 0.25 ≈ 0.35	0.2 μm Nucleopore filter	Acidification HCl + HF Preconcentration: MAF-8HQ resin ICP-MS DL: not given CRM: not mentioned	ENV	Sohrin et al., 1998
Coastal seawater: Suruga Bay Deep Seawater Aquaculture Research Center, Shizuoka prefecture, Japan Depth: 687 m; 10 km from coast	3.7 \pm 0.3 (n = 4)	pmol kg^{-1}	≈ 0.34	0.2 μm Nucleopore filter	Acidification HCl + HF Preconcentration: TSK-8HQ resin ICP-MS PDL: 0.15 pmol kg^{-1} CRM: NASS-5	ANAL	Firdaus et al., 2007
Western North Pacific Ocean: ^e K1 (51°N, 165°E) K2 (47°N, 160°E)	D ^f : 5.55 AD ^f : 6.1 D ^f : 5.45 AD ^f : 6.25	pmol kg^{-1}		0.2 μm Nucleopore filter	Acidification pH 2.2, HCl + HF Preconcentration: TSK-8HQ resin ICP-MS	ENV	Firdaus et al., 2008

KNOT (44°N, 155°E)	D ^f : 6.05	PB: 0.005 pml kg ⁻¹
35N (35°N, 160°E)	D ^f : 5.25	CRM: SLRS-3, CASS-3
March 2005	AD ^f : 5.75	
	D ^f range: 4.0 - 7.2	
	AD ^f range: 4.7 - 8.4	
	LP ^f enriched both in surface and bottom	

^aValues in original units.

^bAbbreviations: DL: detection limit; CRM: certificate reference material; MAF-8HQ: 8-quinolinol immobilized fluoride containing metal alkoxide glass; ICP-MS: inductively coupled plasma mass spectrometry; TSK-8HQ: 8-hydroxyquinoline bonded covalently to a vinyl polymer resin; PDL: procedural detection limit; PB: procedural blank.

^cENV: environmental oriented study; ANAL: analytical method development study.

^dNumerical values for one profile in a table. A second profile is also plotted in a figure.

^eNumerical concentration values for all profiles. Values in italics: median values for the profile, calculated here.

^fD: filtered; AD: acidified no filtration; LP: labile particulate (= AD – D).

Table S2 Published niobium concentrations in freshwater systems

System	Dissolved Nb ^a	Original units	Dissolved Nb / ng L ⁻¹	Filtration	Experimental technique ^b	Type of study ^c	Reference
Median Finnish surface water	<1	µg L ⁻¹	<1000		No information		Koljonen et al., 1992
145 Norwegian hard rock groundwater samples (n = 145)	median: 0.008	µg L ⁻¹	8	No filtration	Acidification: in the lab HNO ₃ No preconcentration	ENV	Reimann et al., 1996
Oslo subset (n = 89)	median: 0.006		6		ICP-MS		
Bergen subset (n = 56)	median: 0.01 20% BDL		10		DL: 0.002 µg L ⁻¹ CRM: not mentioned		
Median Norwegian surface waters (n = 473)	< 0.04	µg L ⁻¹	< 40	No filtration	No information	ENV	Skjelkvale et al., 1996
Taiwan lakes, ponds and reservoirs (n = 50)	< 1	ppb	< 1000	0.45 µm Nalgene filter	ICP-MS CRM: not mentioned DL: not given, probably 1 ppb	ENV	Chen et al., 2004
Streams in the Barents region (n = 847)	median: 0.015 <0.01 - 0.27	µg L ⁻¹	15	0.45 µm	ICP-MS DL: 0.01 µg L ⁻¹	ENV	Salminen et al., 2004
Cuyuni basin (southern Venezuela (15 rivers)	0.05, 0.02, 0.01, 0.01, 0.00, 0.01, 0.01, 0.02, 0.02, 0.00, 0.01, 0.00, 0.01, 0.01, 0.01	ppb	0 - 50	0.22 µm nitrate cellulose Sartorius filter	Acidification pH 1 HNO ₃ ICP-MS DL: not given CRM: SLRS-3	ENV	Tobiani et al., 2004
St Lawrence	22.5	pmol kg ⁻¹	2.09				Gaillardet et al., 2005

World average	18.2		1.69				
Streams in Europe (n = 807)	<0.002 - 0.096 median: 0.004 25% BDL	$\mu\text{g L}^{-1}$	4	0.45 μm	ICP-MS DL: 0.002 $\mu\text{g L}^{-1}$ CRM: not mentioned	ENV	Salminen, 2007
Munsala stream, Finland (n = 36)	0.02 - 0.17 median: 0.08		80	Unfiltered	Acidification pH < 2 ICP-MS (no details given)	ENV	Åström et al., 2008
Simpevarp and Forsmark surface and groundwaters, Finland:				0.45 μm			
Petalax streams (n = 5)	0.03 - 0.08 median: 0.05		50				
S-F lakes (n = 7)	0.004 - 0.038 median: 0.011		11				
S-F streams (n = 9)	0.005 - 0.085 median: 0.044		44				
S-F groundwaters (n = 24)	0.032 - 2.25 median: 0.138		138				
Coal-mine discharges, 140 abandoned mines, Pennsylvania, US	percentile 75: 0.010 percentile 100: 0.030 71% BDL	$\mu\text{g L}^{-1}$	10 30	0.45 μm nitrocellulose capsule filter	Acidification pH < 2 (HNO_3) ICP-MS DL: 0.01 ppb	ENV	Cravotta, 2008
Uji River, Japan	75	pmol kg^{-1}	7.0	0.2 μm Nuclepore filter	Acidification pH 2.2 ($\text{HCl} + \text{HF}$) Preconcentration: TSK-8HQ resin ICP-MS PB: 0.005 pmol kg^{-1} CRM: SLRS-3, CASS-3	ENV	Firdaus et al., 2008

European bottled waters (n = 884)	<0.01 – 537 median: <0.01 88.7% BDL	$\mu\text{g L}^{-1}$	< 10	unfiltered	ICP-MS DL: 0.01 $\mu\text{g L}^{-1}$	ENV	Reimann and Birke, 2010
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^aValues in original units; BDL: below detection limit.

^bAbbreviations: ICP-MS: inductively coupled plasma mass spectrometry, CRM: certificate reference material, DL: detection limit, TSK-8HQ: 8-hydroxyquinoline bonded covalently to a vinyl polymer resin, PB: procedural blank.

^c ENV: environmental oriented study; ANAL: analytical method development study.

Table S3 Published niobium concentration values in certificate reference materials (CRM)

CRM	Water type	Measured value	Reference
SLRS-3 ^a	River water reference material for trace metals	31 pmol kg ⁻¹ (2.9 ng L ⁻¹)	Firdaus et al., 2008
SLRS-5 ^b	River water reference material for trace metals	2.8 ng L ⁻¹	This work
CASS-3 ^a	Near-shore seawater reference material for trace metals	6.7 pmol kg ⁻¹ (0.62 ng L ⁻¹)	Firdaus et al., 2008
NASS-5 ^b	Seawater certified reference material for trace metals.	7.8 pmol kg ⁻¹ (0.72 ng L ⁻¹)	Firdaus et al., 2007

^aSupplier: National Research Council Canada, discontinued.

^bSupplier: National Research Council Canada, available.

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