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Purpose-made capillary electrophoresis instruments coupled with contactless conductivity detection as a simple and inexpensive solution for water analysis: a case study in Vietnam

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Supplementary figures

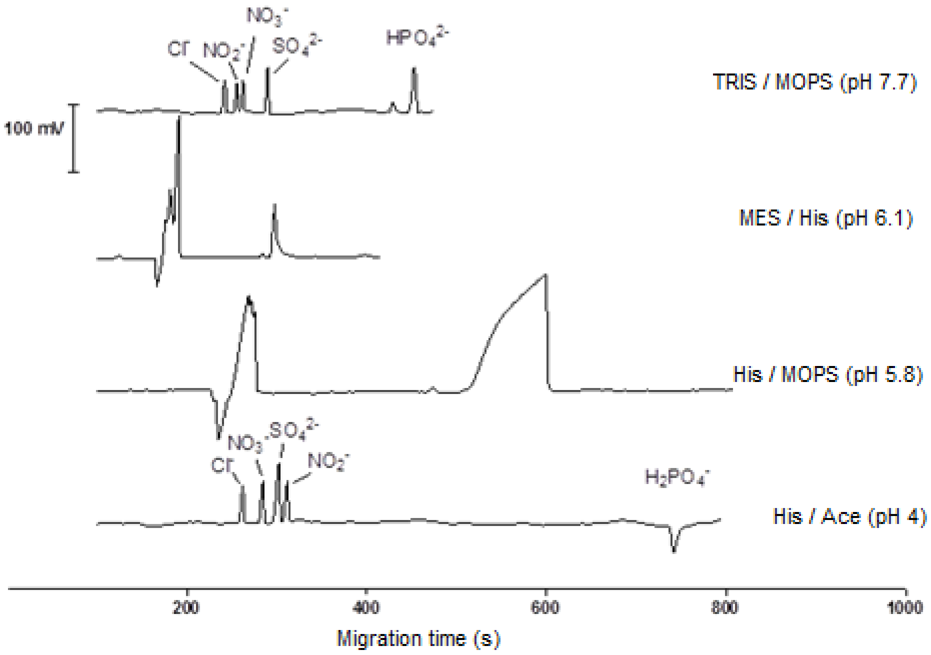

Fig. S1 Electropherograms for the separations of inorganic anions with CE-C^{4}D using different background electrolyte (BGE) solutions.

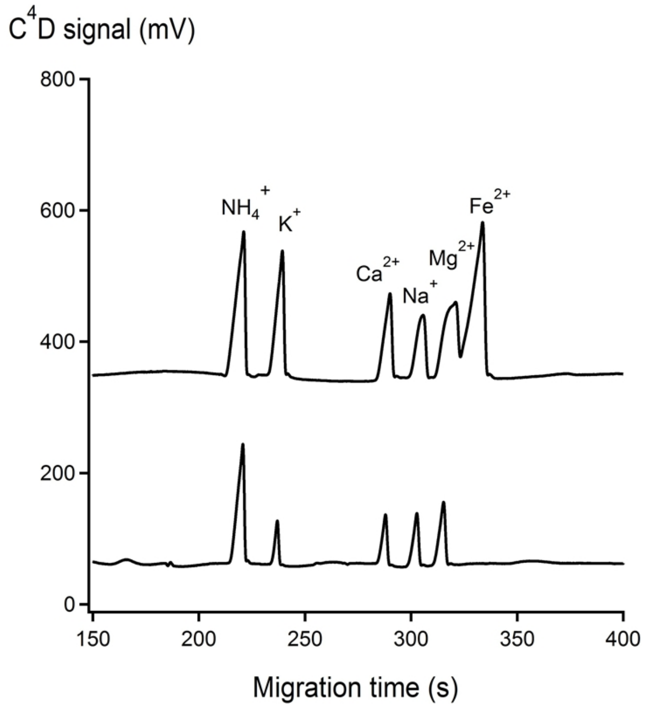

Fig. S2 Electropherograms for the CE-C^{4}D separation of inorganic cations with the absence and presence of ferrous cation at a high concentration (2 mg/L). CE conditions: Electrolyte solution: 12 mM histidine and 2 mM 18-crown-6 adjusted to pH 3.7 with CH_3COOH. Voltage: +15 kV. Capillary: fused-silica, 25 µm id, $L_t = 65$ cm ($L_{eff} = 49$ cm).

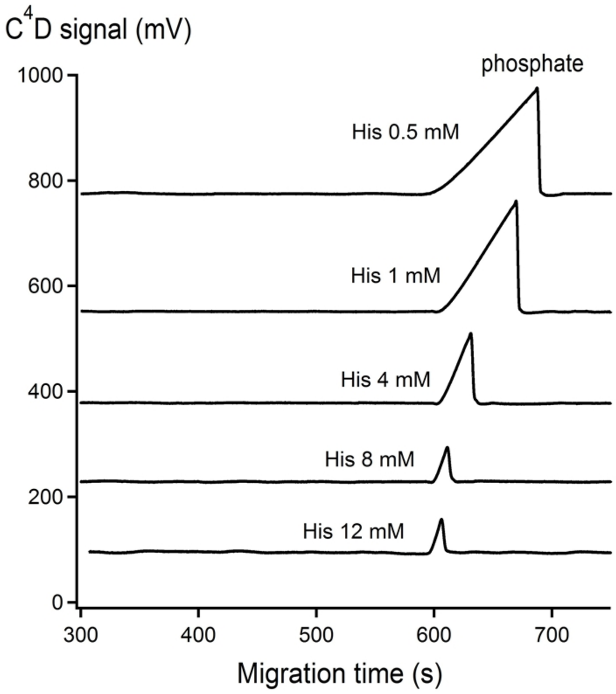

Fig. S3 Electropherograms for the CE-C^{4}D analysis of phosphate. CE conditions: Voltage: -15 kV. Capillary: fused-silica, 25 µm id, L_t = 52 cm (L_{eff} = 36 cm). BGE solutions: 0.5 - 12 mM histidine adjusted to pH 3.5 with CH_3COOH;

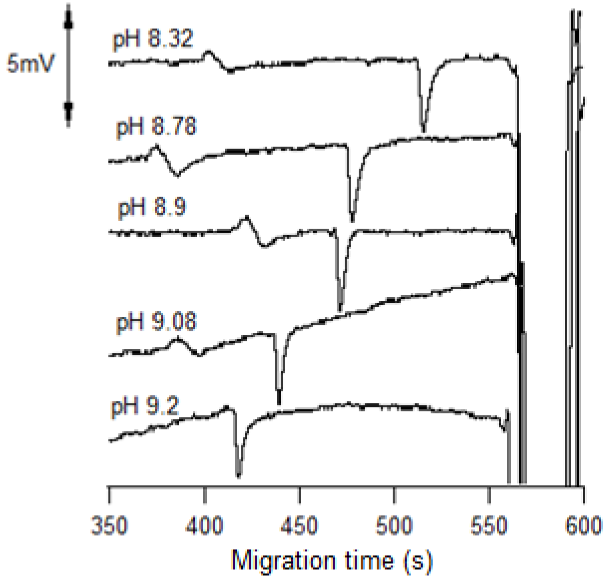

Fig. S4 Effect of the pH of the BGE on the shape / height of As(III) peak. Solutions containing As(III) (5 mg/L) were injected with the siphoning effect at a height of 20 cm for 45 seconds and separated at - 20 kV over a capillary of 60 cm total length. The C^4D detector was situated at the effective length of 52 cm.

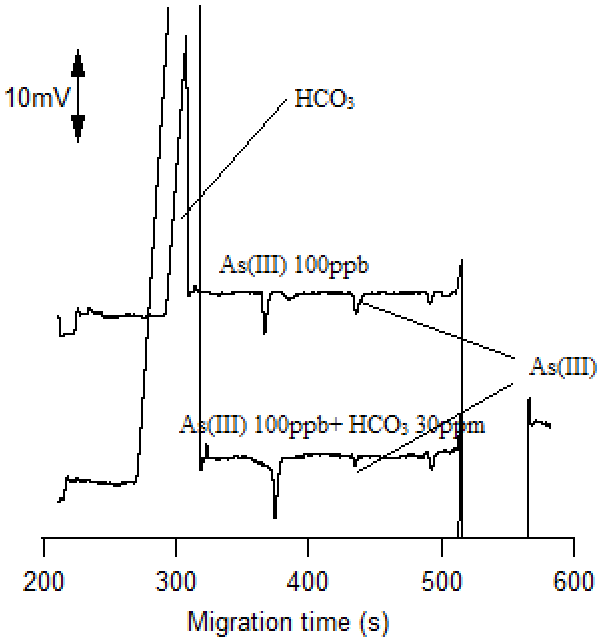

Fig. S5 Effect of the abundant presence of bicarbonate (at 30 mg/L) on the shape / height of As(III) peak. Solutions containing 100 µg/L As(III) were electrokinetically injected at - 6 kV for 60s and separated at - 20 kV over a capillary of 60 cm total length. The C^4D detector was situated at the effective length of 52 cm.

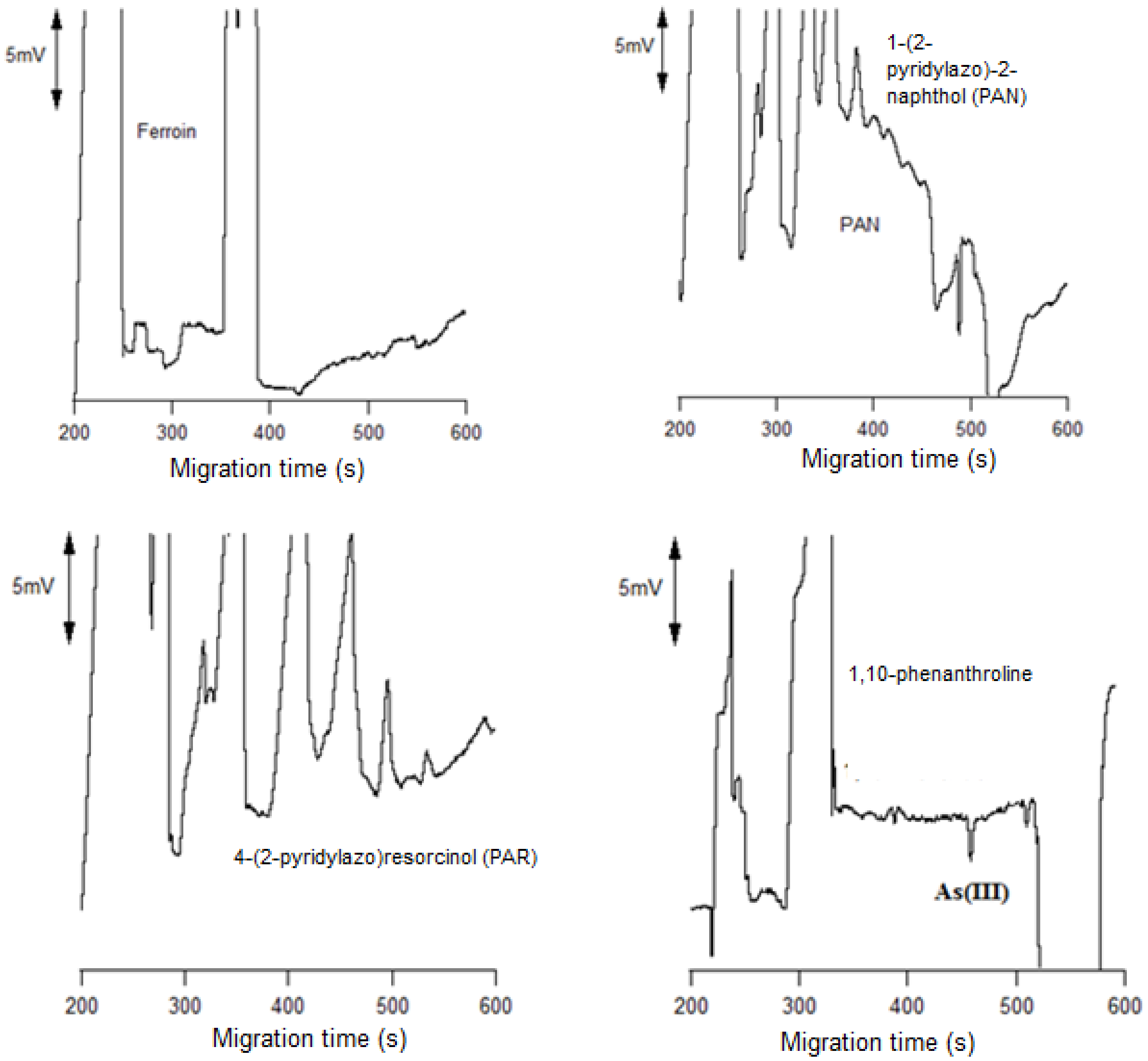

Fig. S6 Effect of the complexing reagent on the shape / height of As(III) peak. Solutions containing As(III) (100 µg/L) and spiked with ferrous cation (20 mg/L) were electrokinetically injected at - 6 kV for 60s and separated at - 20 kV over a capillary of 60 cm total length. The C^4D detector was situated at the effective length of 52 cm.

Supplementary tables:

Table S1. LODs for different inorganic cations and anions obtained with a portable manual CE-C^{4}D system, a portable automated CE-C^{4}D instrument and an automated dual - channel CE-C^{4}D instrument. Electrolyte solution for cations analysis: 12 mM histidine and 2 mM 18-crown-6 adjusted to pH 3.7 with CH_3COOH. Electrolyte solution for anions analysis: 12 mM histidine adjusted to pH 4 with CH_3COOH.

Ion	**LOD (mg/L) obtained with different in-house-made CE-C^{4}D systems**		
	Manual portable CE-C^{4}D	**Automated portable CE-C^{4}D**	**Automated dual-channel CE-C^{4}D**
NH_4^+		0.08	0.03
K^+		0.2	0.1
Ca^{2+}		0.1	0.1
Na^+		0.2	0.1
Mg^{2+}		0.1	0.1
Cl^-	0.04	0.06	0.08
SO_4^{2-}	0.04	0.10	0.08
NO_2^- - N	0.01	0.02	0.02
NO_3^- - N	0.03	0.03	0.06

Table S2. Concentrations of major inorganic cations in groundwater determined with CE-C^{4}D and with standard reference methods (AAS, AES and UV spectrometry)

S	**NH_4^+ (µM)**			**K^+ (µM)**			**Ca^{2+} (µM)**			**Na^+ (µM)**			**Mg^{2+} (µM)**		
	CE	**UV**	**D %**	**CE**	**AES**	**D %**	**CE**	**AAS**	**D %**	**CE**	**AES**	**D %**	**CE**	**AAS**	**D %**
1	172	186	-7.5	125	138	-8.9	2329	2373	-1.8	565	648	-12.7	2004	2067	-3.0
02	615	624	-1.4	105	99	6.0	3033	2914	4.1	574	611	-6.1	1404	1437	-2.3
03	304	289	5.2	86	85	1.0	3612	3294	9.7	653	635	2.8	1146	1136	0.8
04	1783	1658	7.6	134	121	11	2636	2528	4.3	690	668	3.3	1358	1299	4.5
05	273	278	-1.8	75	75	0	3670	3413	7.5	666	678	-1.8	1342	1368	-1.9
06	211	203	4.2	113	107	5.8	4467	4211	6.1	580	634	-8.5	1508	1463	3.1
07	400	413	-3.1	157	136	14.9	2396	2384	0.5	704	771	-8.6	1958	1959	0
08	152	169	-10.1	90	92	-1.7	3477	3527	-1.4	604	630	-4.1	1358	1451	-6.4
09	224	225	-0.3	113	105	7.1	3657	3281	11.5	641	632	1.4	1508	1474	2.4
10	160	181	-11.7	69	77	-10.2	3300	3389	-2.6	614	636	-3.5	1100	1255	-12.4
11	252	259	-2.7	89	85	5.2	4887	4610	6.0	511	556	-8.2	1571	1564	0.4
12	186	198	-6.5	78	72	8.4	4192	3839	9.2	830	813	2.2	1529	1489	2.7
13	281	302	-7.1	73	78	-5.5	3708	3481	6,5	656	721	-9	1429	1431	-0.1
14	242	246	-1.7	75	73	2.0	3522	3608	-2.4	655	631	3.7	1025	1129	-9.2
15	1615	1775	-9.0	139	140	-1.1	2638	2756	-4.3	545	590	-7.8	1304	1341	-2.8
r^2	**0.98889**			**0.91389**			**0.95548**			**0.87672**			**0.95031**		

D % is the deviation of the result obtained with CE-C^{4}D from that with the standard reference method; $D\ \% = \{(R_{CE\text{-}C4D} - R_{reference}) / R_{reference}\} \times 100\ \%$

r^2: correlation coefficient between the results obtained with CE-C^{4}D and those with the standard reference method (AAS, AES or UV)

Table S3. Concentrations of major inorganic anions in groundwater determined with CE-C^{4}D and with standard reference IC method

S	**Cl^- (μM)**			**SO_4^{2-} (μM)**		
	CE	**IC**	**D %**	**CE**	**IC**	**D %**
01	279	268	4.3	48	46	4.1
02	159	153	3.9	< 10	9	-
03	447	409	9.2	< 10	9	-
04	734	768	-4.4	< 10	9	-
05	700	742	-5.6	< 10	10	-
06	745	794	-6.2	392	409	-4.3
07	226	240	-5.8	< 10	9	-
08	407	402	1.3	57	58	-2.1
09	325	357	-8.9	30	30	-1.8
10	475	482	-1.6	41	41	0.3
11	847	906	-6.5	263	287	-8.2
12	1226	1291	-5.1	157	145	8.0
13	818	904	-9.5	< 10	10	-
14	438	482	-9.2	< 10	9	-
15	818	903	-9.4	<8	9	
r^2	**0.99413**			**0.99761**		

D % is the deviation of the result obtained with CE-C^{4}D from that with the standard reference method; D % = $\{(R_{CE\text{-}C4D} - R_{reference}) / R_{reference}\} \times 100$ %

r^2: correlation coefficient between the results obtained with CE-C^{4}D and those with IC

Table S4. Concentrations of major inorganic ions in water samples collected from 5 lakes in Hanoi and determined with CE-C^4D

Data with 'µM' unit:

Lake name	**Sample No.**	**Cl^- (µM)**	**NO_3^- (µM)**	**SO_4^{2-} (µM)**	**NO_2^- (µM)**	**NH_4^+ (µM)**	**K^+ (µM)**	**Ca^{2+} (µM)**	**Na^+ (µM)**	**Mg^{2+} (µM)**
Ho Tay	T1	936.17	< 1.43	188.44	< 1.43	11.1	248.7	475	1665.2	337.5
	T2	1031.51	< 1.43	195.1	15.71	16.7	241	477.5	2434.8	350
	T3	1027.84	57.12	195.63	< 1.43	16.7	253.8	522.5	2600	358.3
Giang Vo	GV1	697.83	< 1.43	158.96	< 1.43	400	282.1	1192.5	2365.2	450
	GV2	718.42	< 1.43	167.81	< 1.43	366.7	269.2	1117.5	2273.9	425
Thanh Nhan	TN1	597.69	27.84	151.15	27.14	38.9	271.8	1020	2260.9	433.3
	TN2	600.51	30.7	150.94	24.29	38.9	269.2	967.5	2152.2	408.3
Dong Da	DD1	611.23	23.56	151.46	33.57	422.2	228.2	662.5	1373.9	258.3
	DD2	603.9	29.27	147.08	36.43	122.2	205.1	605	1265.2	233.3
Hoan Kiem	HK1	223.11	29.27	105.52	< 1.43	5.6	84.6	540	500	70.8
	HK2	231.29	14.99	107.92	< 1.43	5.6	79.5	507.5	487	70.8

Lake name	**Sample No.**	**Cl^- (µmol/L)**			**NO_3^- (µmol/L)**			**SO_4^{2-} (µmol/L)**			**NO_2^- (µmol/L)**		
		IC	**CE**	**D %**	**IC**	**CE**	**D %**	**IC**	**CE**	**D %**	**IC**	**CE**	**D %**
Ho Tay	T1	958.17	936.17	-2.29	5	< 1.43	-	218.23	188.44	-13.65	< 4.29	< 1.43	-
	T2	1052.38	1031.51	-1.98	10.71	< 1.43	-	216.56	195.1	-9.93	17.14	15.71	-8.53
	T3	968.04	1027.84	6.17	52.12	57.12	10.77	211.56	195.63	-7.56	4.29	< 1.43	-
Giang Vo	GV1	726.31	697.83	-3.94	< 3.57	< 1.43	-	154.69	158.96	2.76	8.57	< 1.43	-1.34
	GV2	723.21	718.42	-0.65	< 3.57	< 1.43	-	154.27	167.81	8.81	< 4.29	< 1.43	-
Thanh Nhan	TN1	633.8	597.69	-5.7	28.56	27.84	-2.59	156.88	151.15	-3.67	24.29	27.14	11.72
	TN2	597.69	600.51	0.47	32.13	30.7	-2.37	140.21	150.94	7.63	21.43	24.29	12.75
Dong Da	DD1	616.87	611.23	-0.95	23.56	23.56	-0.33	153.13	151.46	-1.09	32.14	33.57	4.74
	DD2	605.59	603.9	-0.3	32.84	29.27	-11.98	142.92	147.08	2.91	40.71	36.43	-9.5
Hoan Kiem	HK1	222.55	223.11	0.27	29.99	29.27	-2.45	98.75	105.52	6.85	7.14	< 1.43	-
	HK2	217.75	231.29	6.22	13.56	14.99	8.97	96.88	107.92	11.38	< 4.29	< 1.43	-

D % is the deviation of the result obtained with CE-C^4D from that with the standard reference method; $D\ \% = \{(R_{CE\text{-}C4D} - R_{reference}) / R_{reference}\} \times 100\ \%$

Data with ‘mg/L’ unit:

Lake name	**Sample No.**	**Cl^- (mg/L)**	**NO_3^- (mg-N/L)**	**SO_4^{2-} (mg/L)**	**NO_2^- (mg-N/L)**	**NH_4^+ (mg/L)**	**K^+ (mg/L)**	**Ca^{2+} (mg/L)**	**Na^+ (mg/L)**	**Mg^{2+} (mg/L)**
Ho Tay	T1	33.2	< 0.02	18.1	< 0.02	0.2	9.7	19	38.3	8.1
	T2	36.6	< 0.02	18.7	0.2	0.3	9.4	19.1	56.0	8.4
	T3	36.4	0.8	18.8	< 0.02	0.3	9.9	20.9	59.8	8.6
Giang Vo	GV1	24.7	< 0.02	15.3	< 0.02	7.2	11.0	47.7	54.4	10.8
	GV2	25.5	< 0.02	16.1	< 0.02	6.6	10.5	44.7	52.3	10.2
Thanh Nhan	TN1	21.2	0.4	14.5	0.4	0.7	10.6	40.8	52.0	10.4
	TN2	21.3	0.4	14.5	0.3	0.7	10.5	38.7	49.5	9.8
Dong Da	DD1	21.7	0.3	14.5	0.5	7.6	8.9	26.5	31.6	6.2
	DD2	21.4	0.4	14.1	0.5	2.2	8.0	24.2	29.1	5.6
Hoan Kiem	HK1	7.9	0.4	10.1	< 0.02	0.1	3.3	21.6	11.5	1.7
	HK2	8.2	0.2	10.4	< 0.02	0.1	3.1	20.3	11.2	1.7

Table S5. Concentrations of arsenic in groundwater samples collected in Van Phuc (Hanoi) and determined with CE-C^{4}D and with the standard reference AAS –HVG method

No	**Sample name**	**As(III) concentration (µg/L)**		**As(III) concentration (µM)**		**D %**
		CE	**AAS-HVG**	**CE**	**AAS-HVG**	
1	VPNN 1	373 ± 17	367	5.0 ± 0.2	4.9	1,6
2	VPNN 2	394± 4	408	5.3 ± 0.1	5.4	3,5
3	VPNN 3	198±16	201	2.6 ± 0.2	2.7	1,5
4	VPNN 4	343± 11	356	4.6 ± 0.1	4.8	3,7
5	VPNN 5	ND	<5	ND	<0.1	-
6	VPNN 6	185 ±11	183	2.5 ± 0.1	2.4	1,1
7	VPNN 7	394± 5	404	5.3 ± 0.1	5.4	2,5
8	VPNN8	321± 5	323	4.3 ± 0.1	4.3	0,6
9	VPNN 9	ND	7.6	ND	0.1	-
10	VPNN 10	ND	<5	ND	<0.1	-
11	VPNN 11	ND	<5	ND	<0.1	-
12	VPNN 12	231± 2	222	3.1 ± 0.1	3	3,9
13	VPNN 13	324± 8	326	4.3 ± 0.1	4.4	0,6
14	VPNN 14	ND	<5	ND	<0.1	-
15	VPNN 15	57.4 ± 2	53.5	0.8	0.7	7,0

D % is the deviation of the result obtained with CE-C^{4}D from that with the standard reference method; D % = $\{(R_{CE\text{-}C4D} - R_{reference}) / R_{reference}\} \times 100$ %

ND: Not detected (<5 µg/L)