

*The Network Center for
The Acid Deposition Monitoring Network in East Asia*

**Report of the Inter-laboratory
Comparison Project 2000 on Inland Aquatic
Environment**

1st. Attempt

November 2001

Acid Deposition and Oxidant Research Center

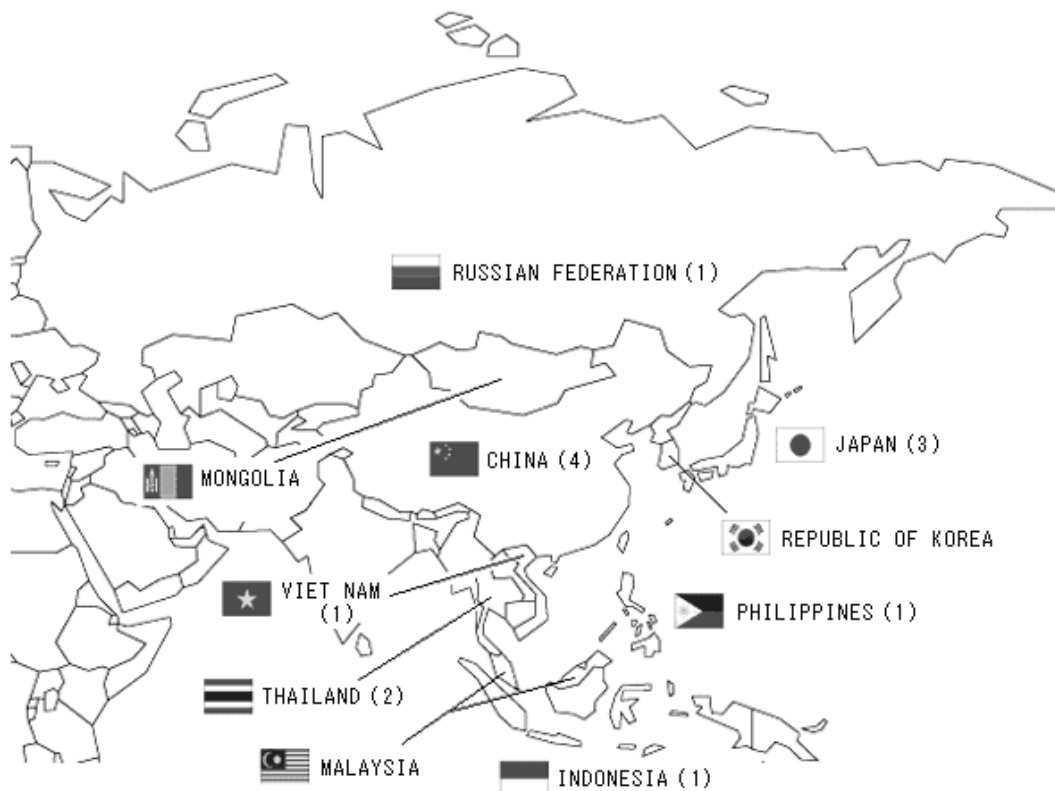
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1. INTRODUCTION

This inter-laboratory comparison project (round robin analysis survey of uniformly prepared artificial inland Aquatic Environment samples) was conducted among the analytical laboratories of the Acid Deposition Monitoring Network in East Asia (EANET), based on the Quality Assurance / Quality Control (QA/QC) Program of EANET. The purposes of this project are, through the evaluation of analytical results, analytical equipment and its operating condition and other practical problems, (i) to recognize the analytical precision and accuracy of the data in each participating laboratory, and give an opportunity to improve the quality of the analysis on Inland Aquatic Environment, and (ii) to improve reliability of analytical data through the assessment of suitable analytical methods and techniques.

Artificial Inland Aquatic Environment samples, which contain major ions, were prepared and distributed by the Network Center (NC). All of the participating laboratories submitted their analytical data to NC. Obtained data for pH, EC, and concentrations of SO_4^{2-} , NO_3^- , Cl^- , Na^+ , K^+ , Ca^{2+} , Mg^{2+} and NH_4^+ were compared with prepared values and statistically treated. List of the participating laboratories, individual analytical data with their Lab.IDs, and various statistical values are included in this report.



* figure in parenthesis shows the numbers of laboratories of each country (13 laboratories from 7 countries)

Fig.1 Laboratories participating in this Inter-comparison project of the EANET

2. PROCEDURE

2.1 Participating Laboratories

Laboratories in charge of chemical analysis of the participating countries of EANET are listed in APPENDIX 1. The Network Center (NC) shipped artificial inland aquatic environment samples to all of these 13 laboratories, and all laboratories of them submitted their analytical data to NC. The names and contact addresses of the participating laboratories are presented in APPENDIX 1.

2.2 Dispatched Artificial Inland Aquatic Environment Samples

Artificial inland aquatic environment samples are distributed to the laboratories. The information on the analytical precision and accuracy on individual parameters can be obtained.

Table 1 Outline of artificial inland aquatic environment sample

Name	Amount of the sample	Container	Number of samples	Note
Artificial inland aquatic environment sample	Approximately 1L	Poly-propylene bottle 1L	One bottle	To analyze directly

2.3 Analytical Parameters

All participating laboratories were expected to measure and submit the data with the units listed in Table 2 on ten parameters: pH, Electric Conductivity (EC), concentrations of sulfate, nitrate, chloride, sodium-ion, potassium-ion, calcium-ion, magnesium-ion, and ammonium-ion of the samples. It was informed to the participating laboratories that concentration of each parameter was within range described in Table 3.

Table 2 Reporting units of analyze

Analyze	Reporting Units	
PH	pH Unites	-
EC	milli siemens/meter	mS/m
SO ₄ ²⁻	milligram/liter	mg/L
NO ₃ ⁻	milligram/liter	mg/L
Cl ⁻	milligram/liter	mg/L
Na ⁺	milligram/liter	mg/L
K ⁺	milligram/liter	mg/L
Ca ²⁺	milligram/liter	mg/L
Mg ²⁺	milligram/liter	mg/L
NH ₄ ⁺	milligram/liter	mg/L

Table 3 Concentration range of artificial inland aquatic environment sample

Parameter	Range	Parameter	Range
pH	5.5– 8.5	Na ⁺	0.5 – 5.0 mg/L
EC	1.5 – 15 mS/m	K ⁺	0.05 – 0.5 mg/L
SO ₄ ²⁻	2 – 20 mg/L	Ca ²⁺	0.3 – 3 mg/L
NO ₃ ⁻	1 – 10 mg/L	Mg ²⁺	0.05 – 0.5 mg/L
Cl ⁻	1 – 10 mg/L	NH ₄ ⁺	0.3 – 3 mg/L

2.4 Analytical Method

Participating laboratories were expected to use analytical methods and data checking procedures that are specified in the “Technical Manual for Monitoring on Inland Aquatic Environment in East Asia (2000)” and “the QA/QC Program for Monitoring on Inland Aquatic Environment in East Asia (2000)”. Analytical methods specified in the manual are described in Table 4.

Table 4 Analytical methods specified in the manual

Parameter	Analytical method
pH	Glass electrode
EC	Conductivity cell
SO ₄ ²⁻ NO ₃ ⁻	Ion Chromatography or Spectrophotometry
Cl ⁻	Ion Chromatography or Titration
Na ⁺ K ⁺ Ca ²⁺ Mg ²⁺	Ion Chromatography or Atomic Absorption / Flame (emission) photometry
NH ₄ ⁺	Ion Chromatography or Spectrophotometry (Indophenol blue)

2.5 Data Checking Procedures

a) Calculation of ion balance (R_1)

(1) Total anion (A) equivalent concentration ($\mu\text{eq L}^{-1}$) is calculated by summing the concentrations of all anions (C: $\mu\text{mol L}^{-1}$).

$$A (\mu\text{eq L}^{-1}) = \sum n C_{Ai} (\mu\text{mol L}^{-1}) = 2C (\text{SO}_4^{2-}) + C (\text{NO}_3^-) + C (\text{Cl}^-)$$

n, C_{Ai} : electric charge of ion and concentration ($\mu\text{mol L}^{-1}$) of anion "i".

(2) Total cation (C) equivalent concentration ($\mu\text{eq L}^{-1}$) is calculated by summing the concentrations of all cations (C: $\mu\text{mol L}^{-1}$).

$$C (\mu\text{eq L}^{-1}) = \sum n C_{Ci} (\mu\text{mol L}^{-1}) = 10^{(6-\text{pH})} + C (\text{NH}_4^+) + C (\text{Na}^+) + C (\text{K}^+) \\ + 2C (\text{Ca}^{2+}) + 2C (\text{Mg}^{2+})$$

n, C_{Ci} : electric charge of ion and concentration ($\mu\text{mol L}^{-1}$) of cation "i".

(3) Calculation of ion balance (R_1)

$$R_1 = 100 \times (C-A) / (C+A)$$

(4) R_1 , which is calculated using the above equation, should be compared with standard values in Table 5. Re-measurement, check with standard solutions, and/or inspection of calibration curves should be undertaken, when R_1 is not within the range.

Table 5 Allowable ranges for R_1 in different concentration ranges

(C+A) [$\mu\text{eq / L}$]	R_1
< 50	+ 30 ~ - 30
50 ~ 100	+ 15 ~ - 15
> 100	+ 8 ~ - 8

(Reference) "Technical Manual for Monitoring on Inland Aquatic Environment in East Asia (2000)"

b) Comparison between calculated and measured electrical conductivity (R₂)

(1) Total electric conductivity (Λ_{calc}) should be calculated as follows;

$$\begin{aligned}\Lambda_{\text{calc}} (\mu\text{S cm}^{-1}) = & 349.7 \times 10^{(3-\text{pH})} + \{80.0 \times 2C (\text{SO}_4^{2-}) + 71.5 C (\text{NO}_3^-) \\ & + 76.3 C (\text{Cl}^-) + 73.5 C (\text{NH}_4^+) + 50.1 C (\text{Na}^+) + 73.5 \times C (\text{K}^+) \\ & + 59.8 \times 2C (\text{Ca}^{2+}) + 53.3 \times 2C (\text{Mg}^{2+})\} / 1000\end{aligned}$$

C: Molar concentrations ($\mu\text{mol L}^{-1}$) of ions in the parenthesis; each constant value is ionic equivalent conductance at 25°C.

(2) Ratio (R₂) of calculations (Λ_{calc}) to measurements (Λ_{meas}) in electric conductivity should be calculated as follows;

$$R_2 = 100 \times (\Lambda_{\text{calc}} - \Lambda_{\text{meas}}) / (\Lambda_{\text{calc}} + \Lambda_{\text{meas}})$$

(3) R₂, which is calculated using the above equation, should be compared with standard values in Table 6. Re-measurement, check with standard solutions, and/or inspection of calibration curves are necessary, when R₂ is not within the range.

Table 6 Allowable ranges for R₂ in different concentration ranges

$\Lambda_{\text{meas}} [\text{mS m}^{-1}]$	R ₂
< 0.5	+ 20 ~ - 20
0.5 ~ 3	+ 13 ~ - 13
> 3	+ 9 ~ - 9

(Reference) "Technical Manual for Monitoring on Inland Aquatic Environment in East Asia (2000)"

3. RESULTS

3.1 Outline of Results

The Network Center shipped artificial inland aquatic environment samples to 13 laboratories in the participating countries of EANET, and received the data on analytical results from all laboratories. Obtained data are summarized in Table 7. Statistics that were calculated for each constituent of the artificial Inland Aquatic Environment samples were: Average, Standard deviation (S.D.), Number of data (N), Minimum (Min.), and Maximum (Max.). For the calculation, outlying data that apart from the average greater than a factor of 3 of S.D. were not included. As shown in Table.7, average of submitted data were fairly well agreed with the prepared value/concentration within a range of $\pm 10\%$.

Table 7 Summary of analytical results of the artificial inland aquatic environment sample

Constituents	Prepared	Average	S.D.	N	Min.	Max.
pH	5.52	5.52	0.26	13	5.30	6.31
EC(mS/m)	3.64	3.49	0.18	13	2.96	3.72
SO ₄ ²⁻ (mg/L)	6.37	6.40	0.76	13	5.49	8.40
NO ₃ ⁻ (mg/L)	1.64	1.56	0.37	13	0.43	1.84
Cl ⁻ (mg/L)	3.71	3.52	0.43	13	2.31	4.13
Na ⁺ (mg/L)	2.36	2.23	0.13	13	1.99	2.43
K ⁺ (mg/L)	0.39	0.38	0.05	13	0.28	0.50
Ca ²⁺ (mg/L)	2.36	2.27	0.23	13	1.72	2.60
Mg ²⁺ (mg/L)	0.19	0.21	0.09	13	0.13	0.50
NH ₄ ⁺ (mg/L)	0.27	0.26	0.04	12	0.14	0.30

(note) Prepared : Value or concentration, which was calculated from the amount of chemicals, used for the preparation of samples.

The Data Quality Objectives (DQOs) of data obtained by the preparatory-phase activities of EANET was specified for every constituent as $\pm 15\%$ by the QA/QC program of the EANET. In this report, analytical data on artificial inland aquatic environmental samples were compared with the prepared value/concentration and evaluated by the DQO value: the flag "E" was put to the data that exceed by a factor of 2 of the DQO ($\pm 15\% \sim \pm 30\%$), and the flag "X" was put to the data that exceed more than a factor of 2 of the DQO ($< -30\%$ or $> 30\%$). A set of data for each sample were evaluated by the data checking procedures described in chapter 2.5 of this report. The flag "I" was put to poor ion balance data sets, and the flag "C" was put to poor conductivity agreement data sets.

The results were evaluated from the two aspects: i) comparison of individual parameters, and ii) comparison of circumstance of analysis in each participating laboratory. Evaluation of data for each constituent is shown in "3.2 Analytical Parameter", and evaluation of data by circumstance of analysis such as analytical method used, experience of personnel, and other analytical condition is described in "3.3 Circumstance of Sample Analysis".

Nine analytical data out of 129 exceeded the DQOs by a factor of 2 and flagged by "E". Seven analytical data out of 129 exceeded the DQOs more than a factor of 2 and flagged by "X". Flagged by "E" and "X" data were 16 out of 129, it shares about 12.4 percents of all reported data of samples.

Table 8 Number of flagged data

Flag*	pH	EC	SO42-	NO3-	Cl-	Na+	K+	Ca2+	Mg2+	NH4+	Total
E	0	1	0	1	1	1	3	1	0	1	9
X	0	0	1	1	1	0	0	0	3	1	7
Data within DQOs	13	12	12	11	11	12	10	12	10	10	113
Flagged(%)	0.0	7.7	7.7	15.4	15.4	7.7	23.1	7.7	23.1	16.7	12.4

*E : Value Exceeded the DQO by a factor of 2 of the DQO ($\pm 15\% \sim \pm 30\%$)

*X : Value Exceeded the DQO more than a factor of 2 of the DQO ($< -30\%$ or $> 30\%$)

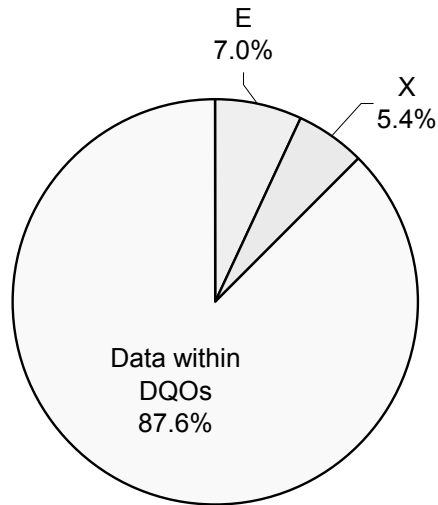


Fig.2 Percentage of flagged data

Table 9 Analytical Results

Lab.ID	pH	EC	SO42-	NO3-	Cl-	Na+	K+	Ca2+	Mg2+	NH4+	R1	R2
	-	(mS/m)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	-	-
1F29	5.42	3.54	5.96	1.57	3.62	2.33	0.41	2.51	X 0.28	0.30	5.4	1.7
1878	5.47	3.72	6.32	X 0.43	3.52	2.38	0.39	2.22	0.18	E 0.21	3.3	-4.5
1D43	5.73	3.43	5.93	1.76	3.63	2.06	E 0.31	2.07	0.18	0.26	-4.6	-1.2
1525	5.42	3.57	7.20	1.75	3.78	2.19	E 0.28	2.57	X 0.13	X 0.14	-5.8	2.6
1434	6.31	E 2.96	6.26	1.83	3.36	2.24	0.37	2.16	0.18	-		
1EC8	5.45	3.59	6.14	1.60	3.70	2.38	0.37	2.29	0.18	0.26	0.5	-0.1
1FA9	5.31	3.53	6.91	1.84	4.13	E 1.99	0.37	2.23	0.19	0.26	I -9.0	3.4
1BC8	5.53	3.46	6.54	1.65	3.71	2.26	0.38	2.24	0.19	0.26	-2.9	2.0
1648	5.43	3.39	6.12	1.63	3.72	2.25	0.37	2.38	0.19	0.26	0.2	2.9
1444	5.49	3.54	6.26	1.62	3.66	2.43	0.39	2.36	0.19	0.27	1.5	1.3
1788	5.48	3.52	X 8.40	E 1.30	X 2.31	2.15	E 0.50	E 1.72	X 0.50	0.30	-1.5	0.8
18D8	5.38	3.60	5.70	1.55	E 3.11	2.18	0.40	2.16	0.20	0.30	3.9	-3.6
1748	5.30	3.50	5.49	1.69	3.55	2.10	0.37	2.60	0.18	0.27	4.8	0.6
Expected value	5.52	3.64	6.37	1.64	3.71	2.36	0.39	2.36	0.19	0.27		
Number of data	13	13	13	13	13	13	13	13	13	12		
Average	5.52	3.49	6.40	1.56	3.52	2.23	0.38	2.27	0.21	0.26		
Minimum	5.30	2.96	5.49	0.43	2.31	1.99	0.28	1.72	0.13	0.14		
Maximum	6.31	3.72	8.40	1.84	4.13	2.43	0.50	2.60	0.50	0.30		
Standard deviation	0.26	0.18	0.76	0.37	0.43	0.13	0.05	0.23	0.09	0.04		

E:Value exceeded the DQO(±15) by a factor of 2 I:Poor ion balance (R1)

X:Value exceeded the DQO(±15) more than a factor of 2 C:Poor conductivity agreement (R2)

3.2 Analytical Parameter



Fig.3 Distribution of pH data normalized by prepared value

Table 10 Analytical method and flagged data of pH

Analytical Method

pH meter and electrode	13/13
Other method	0/13

Flagged data

	E	X	Flagged (%)
Sample	0	0	0.0

All participating laboratories used pH meter with glass electrode for measurement of pH. Most of obtained data were fairly agreed with prepared value.

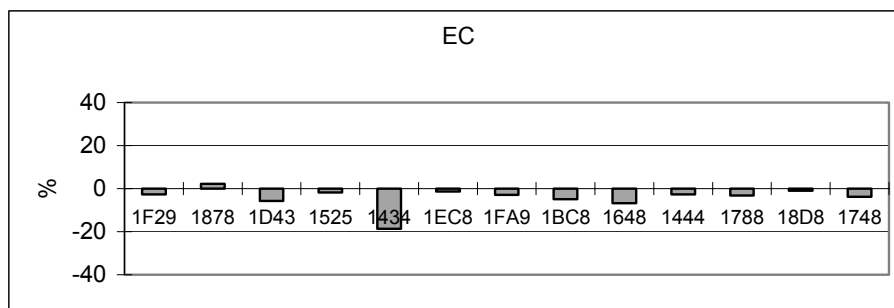


Fig.4 Distribution of EC data normalized by prepared value

Table 11 Analytical method and flagged data of EC

Analytical Method

Conductivity meter and cell	13/13
Other method	0/13

Flagged data

	E	X	Flagged (%)
Sample	1	0	7.7

All participating laboratories used conductivity cell for the measurement of EC. Obtained data were almost agreed with the prepared value. However, Lab.ID 1434 submitted flagged data by “E”. Most of the laboratories reported lower data than prepared value.

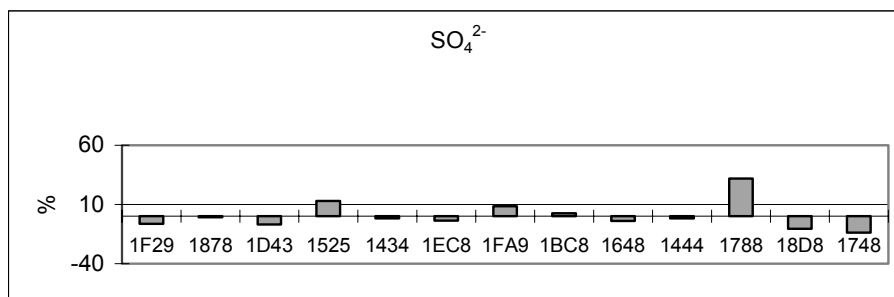


Fig.5 Distribution of SO₄²⁻ data normalized by prepared concentration

Table 12 Analytical method and flagged data of SO₄²⁻

Analytical Method

Ion chromatography	12/13
spectrophotometry	1/13

Flagged data

	E	X	Flagged (%)
Sample	0	1	7.7

All of the participating laboratories except one used ion chromatography for the determination of SO₄²⁻. Lab.ID 1788 used other method (spectrophotometry) without ion chromatography. Its data was flagged by "X".

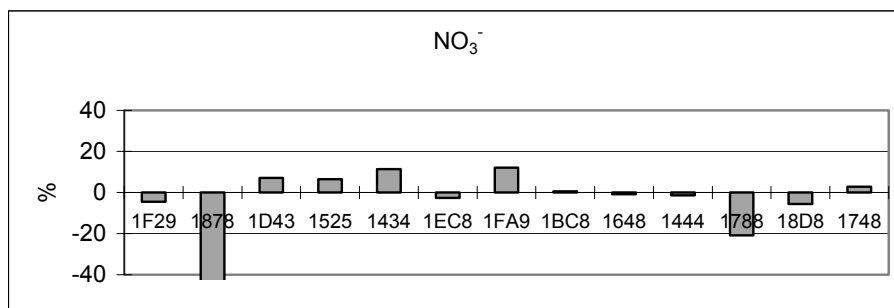


Fig.6 Distribution of NO₃⁻ data normalized by prepared concentration

Table 13 Analytical method and flagged data of NO₃⁻

Analytical Method

Ion chromatography	10/13
spectrophotometry	3/13

Flagged data

	E	X	Flagged (%)
Sample	1	1	15.4

Same as SO₄²⁻, most of participating laboratories used ion chromatography for the determination of NO₃⁻. Three laboratories used spectrophotometry. Lab.ID 1878 and 1788 obtained data were all flagged with spectrophotometry. Perhaps there is a problem of the method in this case.

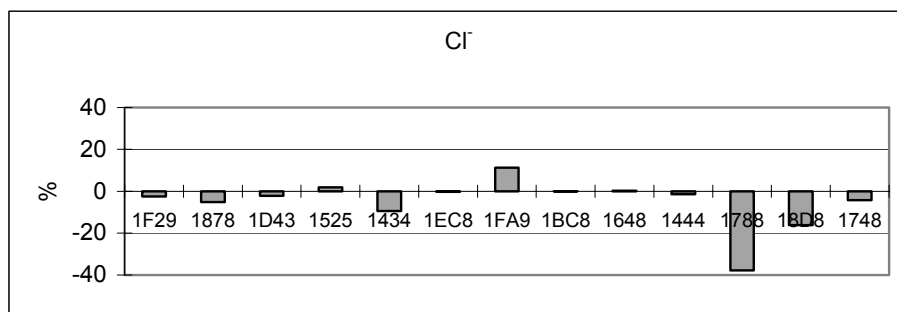


Fig.7 Distribution of Cl⁻ data normalized by prepared concentration

Table 14 Analytical method and flagged data of Cl⁻

Analytical Method

Ion chromatography	12/13
titration method	1/13

Flagged data

	E	X	Flagged (%)
Sample	1	1	15.4

Same as SO₄²⁻ and NO₃⁻, most laboratories used ion chromatography for the determination of Cl⁻. Lab.ID 1788 (titration method) and 18D8 (ion chromatography) submitted significantly different values from the prepared concentration.

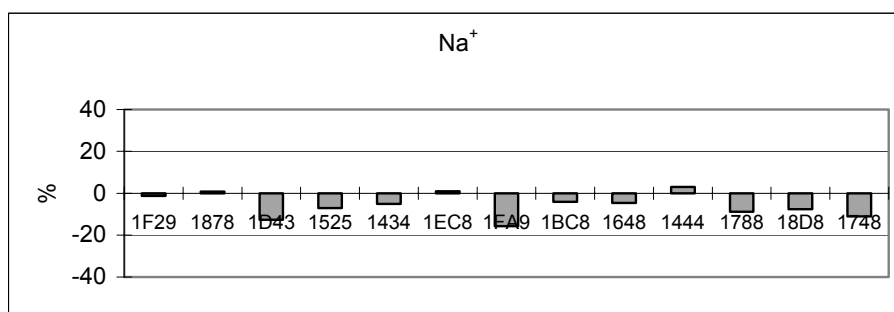


Fig.8 Distribution of Na⁺ data normalized by prepared concentration

Table 15 Analytical method and flagged data of Na⁺

Analytical Method

Ion chromatography	8/13
Atomic absorption / Flame (emission) photometry	5/13

Flagged data

	E	X	Flagged (%)
Sample	1	0	7.7

Among 13 participating laboratories, 8 laboratories used ion chromatography, 5 laboratories used atomic absorption/flame (emission) photometry. Most of the laboratories reported lower data than prepared concentration.

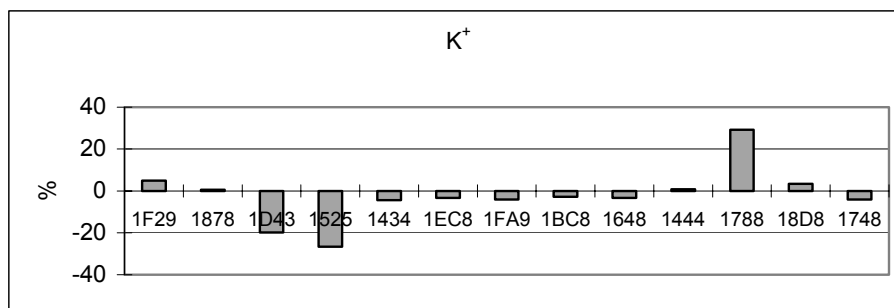


Fig.9 Distribution of K⁺ data normalized by prepared concentration

Table 16 Analytical method and flagged data of K⁺

Analytical Method

Ion chromatography	8/13
Atomic absorption / Flame (emission) photometry	5/13

Flagged data

	E	X	Flagged (%)
Sample	3	0	23.1

Same as Na⁺, 8 laboratories used ion chromatography, 5 laboratories used atomic absorption/flame (emission) photometry for the determination of K⁺. There was no clear difference among the data obtained by these two analytical methods. Lab.ID 1D43 & 1525 (ion chromatography) and 1788 (Flame (emission) photometry) submitted significantly different values from the prepared concentration.

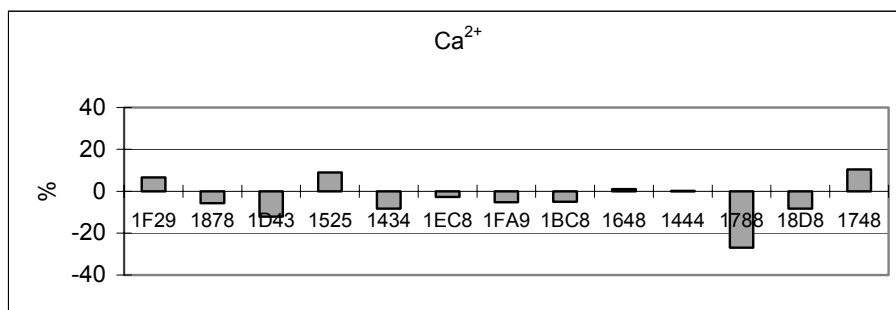


Fig.10 Distribution of Ca²⁺ data normalized by prepared concentration

Table 17 Analytical method and flagged data of Ca²⁺

Analytical Method

Ion chromatography	8/13
Atomic absorption / Flame (emission) photometry	4/13
Titration	1/13

Flagged data

	E	X	Flagged (%)
Sample	1	0	7.7

Lab.ID 1788 (titration) submitted significantly different data from the prepared concentration.

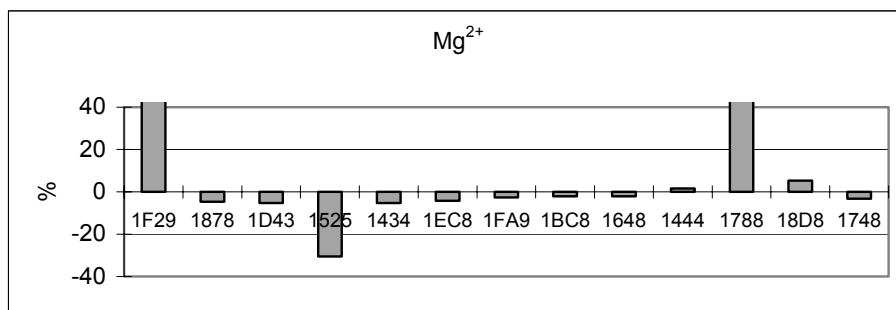


Fig.11 Distribution of Mg²⁺ data normalized by prepared concentration

Table 18 Analytical method and flagged data of Mg²⁺

Analytical Method

Ion chromatography	8/13
Atomic absorption / Flame (emission) photometry	4/13
Titration (Calculation)	1/13

Flagged data

	E	X	Flagged (%)
Sample	0	3	23.1

Among 13 participating laboratories, 8 laboratories used ion chromatography, 4 laboratories used atomic absorption/flame (emission) photometry. The one laboratory (Lab.ID 1788) determined the concentration of Mg²⁺ by calculation. Lab.ID 1F29 & 1525 and 1788 submitted significantly different values from the prepared concentration.

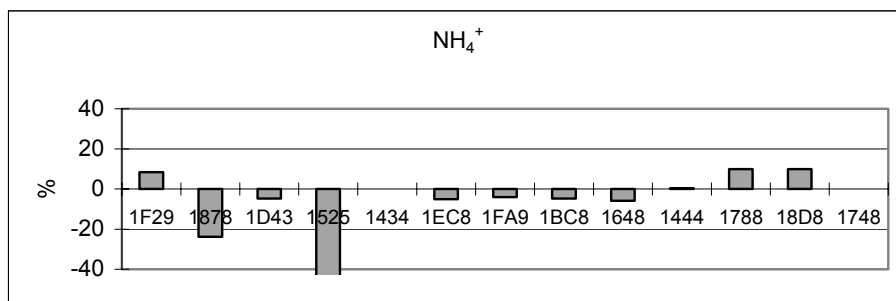


Fig.12 Distribution of NH₄⁺ data normalized by prepared concentration

Table 19 Analytical method and flagged data of NH₄⁺

Analytical Method

Ion chromatography	7/12
Spectrophotometry (Indophenol)	3/12
Spectrophotometry (Other method)	2/12

Flagged data

	E	X	Flagged (%)
Sample	1	1	16.7

Most participating laboratories used recommended analytical method of EANET for the determination of NH₄⁺: 7 laboratories used ion chromatography and 3 laboratories used Spectrophotometry (Indophenol). The data of two laboratories (Lab.ID 1878 and 1525) were flagged.

Overall Evaluation

Data on pH and EC were less varied compared with other ionic constituents. Measured data on pH & EC were slightly lower than the prepared value. Cause of this discrepancy is not clear by the results of this round robin project. Analytical data of ionic constituents were varied particularly for ions (NO_3^- , Mg^{2+} and NH_4^+) as described in Fig.13. The cause of large deviation of analytical data for some ions (NO_3^- , Mg^{2+} and NH_4^+) was supposed to be the difficulty of analysis on lower concentration constituents. Possible causes of these deviations were not clear by limited information obtained by this project. Quality of data is expected to be improved in the future by accumulation of experience on round robin analysis survey and QA/QC activities in each laboratories.

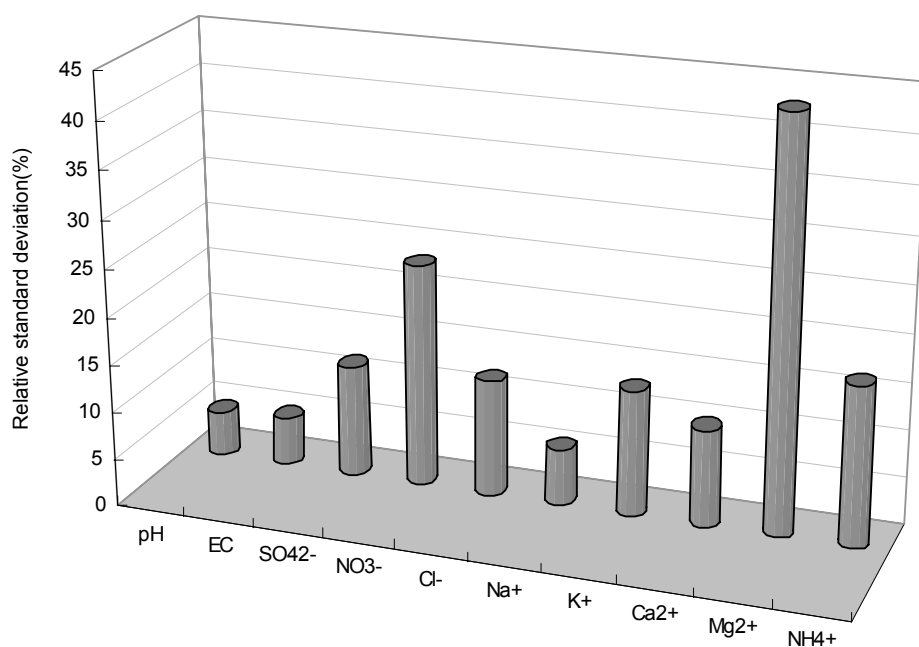


Fig.13 Relative standard deviation of each constituents

(Relative standard deviation (%) = Standard deviation / Average * 100, Reported data after outliers were removed)

3.3 Circumstance of Sample Analysis

Methods Used

As shown in Fig.14, most of participating laboratories used recommended methods of EANET, particularly for pH and EC, Cl^- , SO_4^{2-} , NO_3^- , Na^+ , K^+ measurements. The codes for the various analytical methods used in this project are shown in Table 20. In general, much difference of data was not found among different analytical methods. In future projects, the questionnaire should be improved to obtain more correct and detailed information such as history of the equipment and frequency of usage and so on.

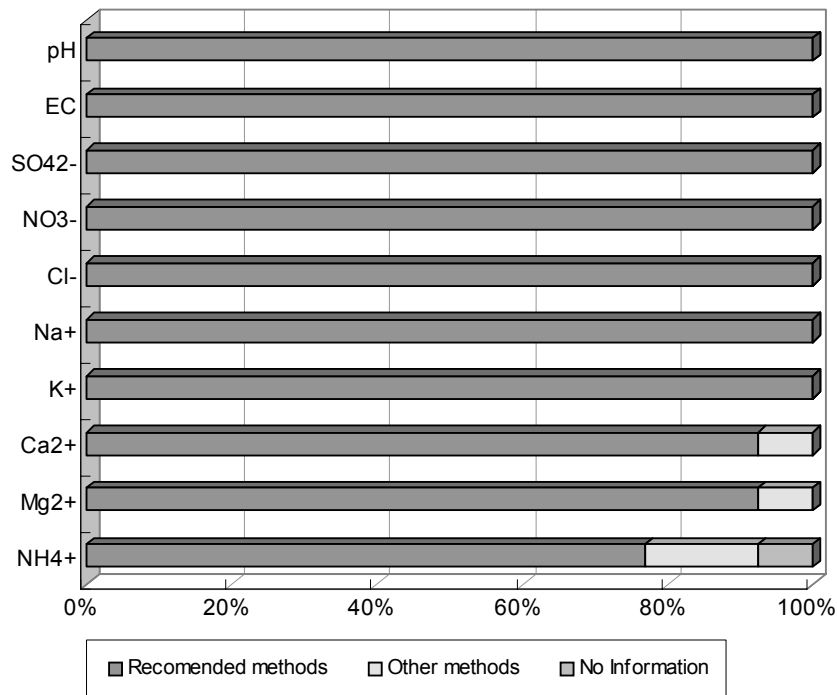


Fig.14 Ratio of recommended method used in the project

Table 20 List of methods

Code	Method
0	pH meter with electrode
1	Conductivity cell
2	Titration
3	Atomic absorption / Flame (emission) photometry
4	Ion chromatography
5	Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP - AES)
6	Calculation
7	Spectrophotometry
8	Inductively Coupled Plasma - Mass Spectrometry (ICP - MS)
9	Graphite Furnace Atomic Absorption spectrometry (GFAA)
X	Other method
?	No information

Table 21 Analytical Method

Method	pH	EC	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	NH ₄ ⁺
0	13									
1		13(1)								
2					1(1)			1(1)	1(1)	
3						5	5(1)	4	4	
4			12	10	12(1)	8(1)	8(2)	8	8(2)	7(1)
5										
6										
7			1(1)	3(2)						3(1)
8										
9										
X										2
?										
Flagged E	0	1	0	1	1	1	3	1	0	1
Flagged X	0	0	1	1	1	0	0	0	3	1

Reverse mesh is recommended method of EANET

():Number of data, which flagged by "E" or "X"

Number of Staff in Charge of Measurement

Number of staff in charge of measurement on Inland Aquatic Environment samples is described in Table 22. In 4 laboratories, only one person carried out measurement of sample. In other laboratories, 2 or 3 persons carried out measurement, and usually their responsibilities were separated by the methods used for analysis such as anions and cations or pH, EC and ionic items. In most cases that more than one person carried out the analysis of the round robin sample, anions and cations were separately analyzed by different persons.

Table 22 Staff in charge of measurement

Lab.ID	Total	pH	EC	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	NH ₄ ⁺
1F29	1	A	A	A	A	A	A	A	A	A	A
1878	2	A	A	A	B	A	A	A	A	A	B
1D43	2	A	A	A	A	A	A	A	B	B	A
1525	2	A	A	B	B	B	A	A	A	A	A
1434	3	A	A	B	C	B	B	B	B	B	-
1EC8	1	A	A	A	A	A	A	A	A	A	A
1FA9	3	A	A	B	B	B	C	C	C	C	C
1BC8	1	A	A	A	A	A	A	A	A	A	A
1648	3	A	A	B	B	B	C	C	C	C	A
1444	1	A	A	A	A	A	A	A	A	A	A
1788	2	A	A	B	B	B	A	A	B	B	B
18D8	3	A	A	B	B	B	C	C	C	C	A
1748	3	A	A	B	B	B	C	C	C	C	A

“-”: No information, “A”, “B”, “C”, and “D” represent individuals of staff in each laboratory who are in charge of measurement. Reverse mesh: “E” or “X” in sample flagged Data.

Years of experience

By information obtained through this project, clear evidence of data quality improvement was not found in terms of “years of experience of the staff”. 76% of the participating laboratories had one or no flag.

Table 23 Years of experience

Unit: year

Lab.ID	pH	EC	SO42-	NO3-	Cl-	Na+	K+	Ca2+	Mg2+	NH4+
1F29	2	2	2	2	2	2	2	2	2	2
1878	3	3	3	5	3	3	3	3	3	5
1D43	1	1	1	1	1	1	1	1	1	1
1525	0	0	0	0	0	0	0	0	0	0
1434	3	3	2	1	2	2	2	2	2	-
1EC8	8	8	8	8	8	8	8	8	8	8
1FA9	3	3	9	9	9	6	6	6	6	6
1BC8	3	3	3	5	3	3	3	3	3	6
1648	5	5	16	16	16	12	12	12	12	5
1444	0	0	0	0	0	0	0	0	0	0
1788	16	16	7	7	7	16	16	7	7	7
18D8	22	22	6	6	6	14	14	14	14	22
1748	5	5	5	1	1	2	2	2	2	5

“-”:No information

Reverse mesh:Data were Flagged by “E” or “X” in sample

1 year means experienced with one year or less.

Number of flagged data in laboratories

The attribution of flagged data in each laboratory is as shown in Table 24.

Table 24 Number of flagged data in each laboratory.

Number of flagged data	Number of laboratories	Share
0	5	38%
1	5	38%
2	1	8%
3	1	8%
6	1	8%

Number of excellent laboratories without flagged data was 5, which was equivalent to 1/3 of the whole participating laboratories. Moreover, laboratories that submitted two or less flagged data, which seemed to be managed comparatively well, were 11 (85% of whole).

On the other hand, one laboratory with six flagged data particularly needs improvement. This laboratory could use neither ion chromatography nor atomic absorption spectrometry, and used another analytical equipment.

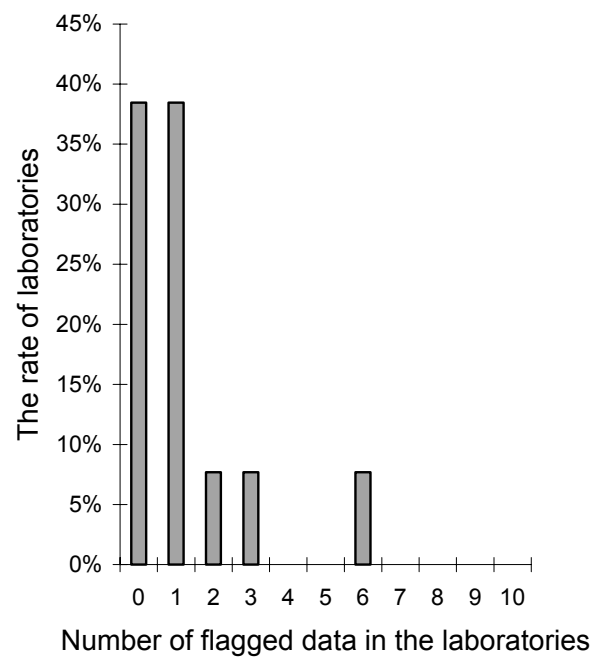


Fig.15 The distribution of laboratories with the number of flagged data

4. REFERENCES

- 1) Technical Manuals for Monitoring on Inland Aquatic Environment in East Asia: Adopted at The Second Interim Scientific Advisory Group Meeting of Acid Deposition Monitoring Network in East Asia, March 2000.
- 2) Quality Assurance / Quality Control (QA/QC) Program for Monitoring on Inland Aquatic Environment in East Asia: Adopted at The Second Interim Scientific Advisory Group Meeting of Acid Deposition Monitoring Network in East Asia, March 2000.

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APPENDIX 2 Original Data

Lab.ID	pH -	EC (mS/m)	SO ₄ ²⁻ (mg/L)	NO ₃ ⁻ (mg/L)	Cl ⁻ (mg/L)	Na ⁺ (mg/L)	K ⁺ (mg/L)	Ca ²⁺ (mg/L)	Mg ²⁺ (mg/L)	NH ₄ ⁺ (mg/L)
1F29	5.42	3.54	5.96	1.57	3.62	2.33	0.41	2.51	0.28	0.30
1878	5.47	3.72	6.32	0.43	3.52	2.38	0.39	2.22	0.18	0.21
1D43	5.73	3.43	5.93	1.76	3.63	2.06	0.31	2.07	0.18	0.26
1525	5.42	3.57	7.20	1.75	3.78	2.19	0.28	2.57	0.13	0.14
1434	6.31	2.96	6.26	1.83	3.36	2.24	0.37	2.16	0.18	-
1EC8	5.45	3.59	6.14	1.60	3.70	2.38	0.37	2.29	0.18	0.26
1FA9	5.31	3.53	6.91	1.84	4.13	1.99	0.37	2.23	0.19	0.26
1BC8	5.53	3.46	6.54	1.65	3.71	2.26	0.38	2.24	0.19	0.26
1648	5.43	3.39	6.12	1.63	3.72	2.25	0.37	2.38	0.19	0.26
1444	5.49	3.54	6.26	1.62	3.66	2.43	0.39	2.36	0.19	0.27
1788	5.48	3.52	8.40	1.30	2.31	2.15	0.50	1.72	0.50	0.30
18D8	5.38	3.60	5.70	1.55	3.11	2.18	0.40	2.16	0.20	0.30
1748	5.30	3.50	5.49	1.69	3.55	2.10	0.37	2.60	0.18	0.27
Expected value	5.52	3.64	6.37	1.64	3.71	2.36	0.39	2.36	0.19	0.27
Number of data	13	13	13	13	13	13	13	13	13	12
Average	5.52	3.49	6.40	1.56	3.52	2.23	0.38	2.27	0.21	0.26
Minimum	5.30	2.96	5.49	0.43	2.31	1.99	0.28	1.72	0.13	0.14
Maximum	6.31	3.72	8.40	1.84	4.13	2.43	0.50	2.60	0.50	0.30
Standard deviation	0.26	0.18	0.76	0.37	0.43	0.13	0.05	0.23	0.09	0.04

APPENDIX 3 Normalized by prepared value

Original data / Expected Value * 100 (%)

Lab. ID	pH (%)	EC (%)	SO ₄ ²⁻ (%)	NO ₃ ⁻ (%)	Cl ⁻ (%)	Na ⁺ (%)	K ⁺ (%)	Ca ²⁺ (%)	Mg ²⁺ (%)	NH ₄ ⁺ (%)
1F29	98.2	97.3	93.5	95.6	97.6	98.7	104.9	106.6	145.8	108.4
1878	99.1	102.3	99.2	26.2	94.8	100.8	100.5	94.3	95.3	76.2
1D43	103.8	94.3	93.1	107.1	97.8	87.3	80.1	87.9	94.7	95.2
1525	98.2	98.2	113.0	106.5	101.8	92.9	73.4	109.0	69.5	52.7
1434	114.3	81.4	98.2	111.4	90.5	94.9	95.6	91.7	94.7	-
1EC8	98.7	98.7	96.3	97.3	99.8	101.0	96.6	97.3	95.8	94.9
1FA9	96.2	97.0	108.4	112.1	111.3	84.3	95.9	94.7	97.4	96.0
1BC8	100.2	95.1	102.6	100.6	100.1	95.8	97.2	95.0	97.9	95.2
1648	98.4	93.2	96.0	99.2	100.2	95.3	96.6	101.1	97.9	94.1
1444	99.5	97.3	98.2	98.6	98.6	103.0	100.8	100.2	101.6	100.4
1788	99.3	96.8	131.8	79.1	62.2	91.1	129.2	73.0	263.2	109.9
18D8	97.5	99.0	89.5	94.4	83.8	92.4	103.4	91.7	105.3	109.9
1748	96.0	96.2	86.2	102.8	95.7	89.0	95.9	110.4	96.8	100.0
Minimum	96.0	81.4	86.2	26.2	62.2	84.3	73.4	73.0	69.5	52.7
Maximum	114.3	102.3	131.8	112.1	111.3	103.0	129.2	110.4	263.2	109.9
Average	99.9	95.9	100.5	94.7	94.9	94.4	97.7	96.4	112.0	94.4