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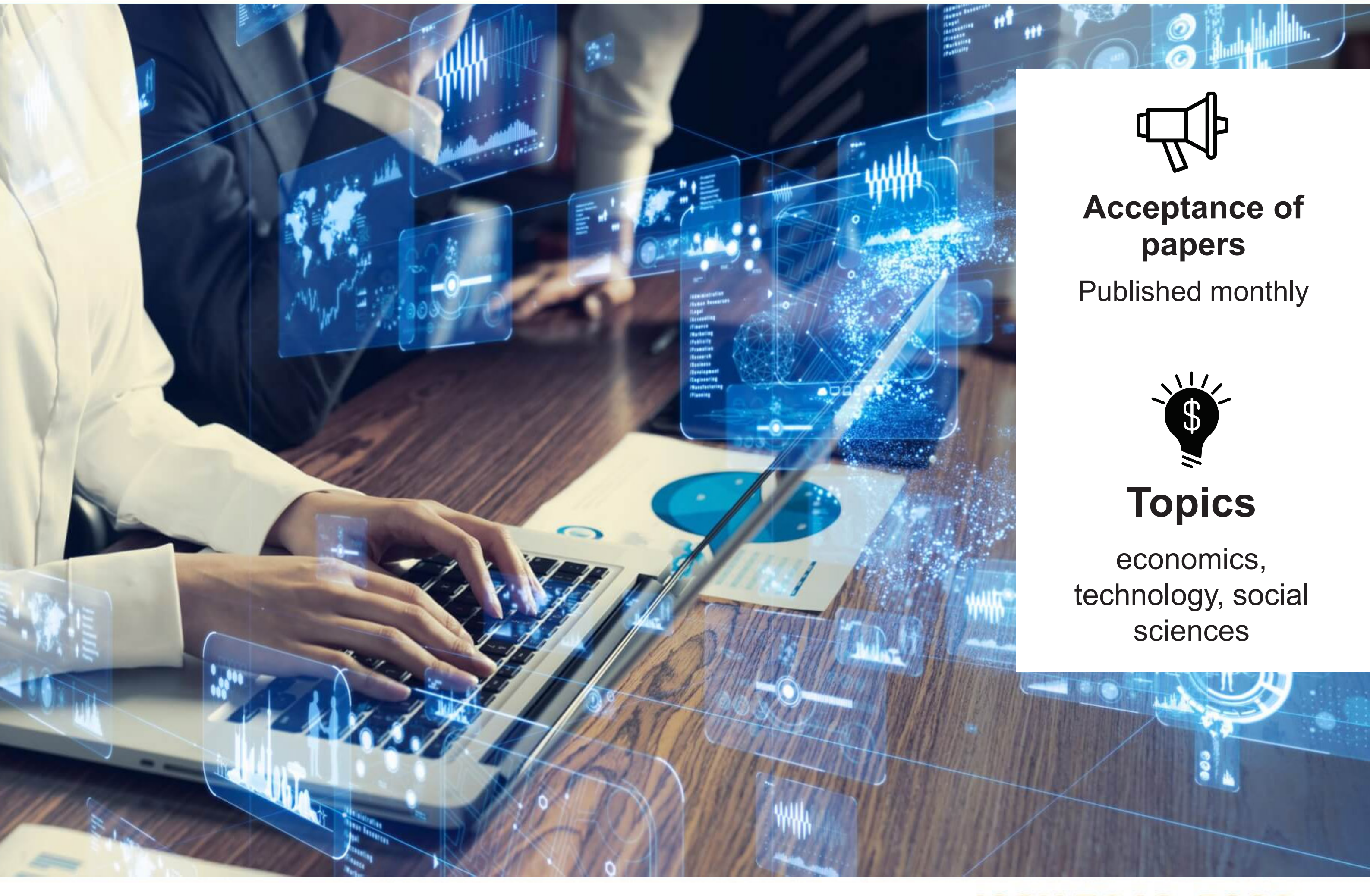

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CLEANING OF SALT WATER USING REVERSE OSMOSIS

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Abstract: This study investigates the chemical composition of groundwater samples collected from the Kungrad district of Karakalpakstan, with a focus on the concentrations of major anions and cations. The results show that the levels of chloride, sodium, calcium, and magnesium exceed recommended drinking water standards, indicating high salinity and hardness. Based on these findings, reverse osmosis (RO) is proposed as an effective treatment method for improving water quality. Laboratory-scale RO simulations suggest that this method can significantly reduce ion concentrations, making the water safe for consumption. This research highlights the importance of implementing RO technology in arid regions to ensure access to clean drinking water.

Key words: Reverse osmosis, Water quality, Anion analysis, Cation analysis, Desalination, Kungrad district, Karakalpakstan, Drinking water treatment.

INTRODUCTION

Water scarcity is a significant concern in the arid regions of Uzbekistan, particularly in the Republic of Karakalpakstan. The Kungrad district, located in this region, faces challenges in providing safe and clean drinking water due to limited freshwater resources and the presence of dissolved salts and ions in available water sources. In response to this issue, various water treatment technologies are being studied and implemented, among which reverse osmosis (RO) is considered one of the most efficient methods for desalination and removal of inorganic ions.

This study focuses on the physicochemical analysis of water samples collected from the Kungrad district. Special attention is given to the concentration levels of major anions (such as chloride, sulfate, nitrate) and cations (such as calcium, magnesium, sodium, potassium). The results of the analysis are evaluated against national and international drinking water standards to determine the need for treatment and the potential efficiency of the reverse osmosis process in improving water quality.

MATERIALS AND METHODS

Sample Collection

Water samples were collected on August 21, 2024, from selected locations within the Kungrad district. The samples were preserved and transported according to standard protocols to ensure the accuracy of chemical analysis.

Analytical Techniques

The analysis of anions and cations was carried out in a certified laboratory. The concentration of anions such as Cl^-, SO_4^{2-}, NO_3^-, and HCO_3^- was determined using ion chromatography, while the cation content (Ca^{2+}, Mg^{2+}, Na^+, K^+) was analyzed through atomic absorption spectrophotometry (AAS) and flame photometry.

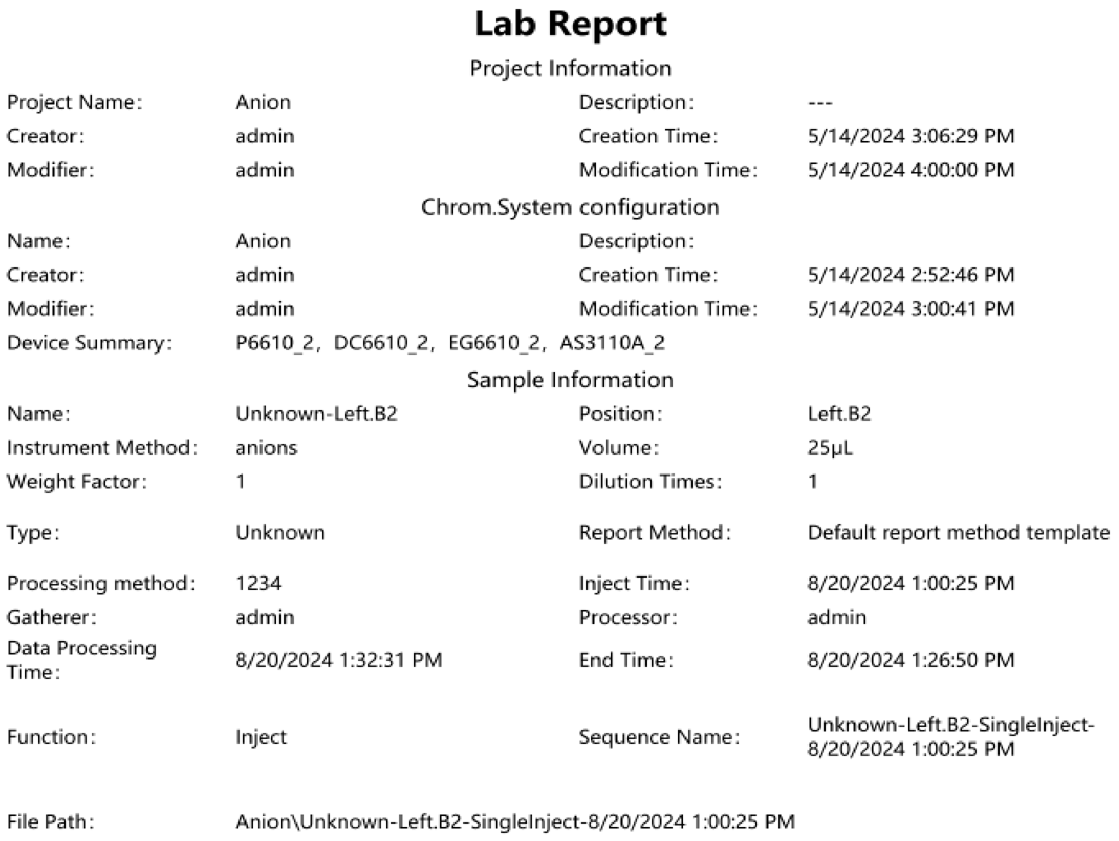
Reverse Osmosis System

To evaluate the potential of reverse osmosis in treating local water, a laboratory-scale RO setup was used. The membrane type, operating pressure, recovery rate, and rejection efficiency were recorded and used to simulate full-scale application potential.

Table 1. Anion analysis.

Ion	Concentration (mg/L)
Cl^-	180.5
SO_4^{2-}	215.3
NO_3^-	28.7
HCO_3^-	300.0

Table 1 presents the concentrations of major anions found in a water sample, measured in mg/L. The analysis includes chloride (Cl^-), sulfate (SO_4^{2-}), nitrate (NO_3^-), and bicarbonate (HCO_3^-). The highest concentration is observed for bicarbonate at 300.0 mg/L, indicating strong buffering capacity and possible natural mineral dissolution. Sulfate is also relatively high at 215.3 mg/L, which may result from industrial discharge, mining activity, or natural geochemical sources. Chloride concentration is 180.5 mg/L, suggesting potential contamination from salt intrusion or domestic wastewater. Nitrate is present at 28.7 mg/L, a level below the WHO guideline (50 mg/L) but still indicative of possible agricultural runoff or sewage influence.



Lab Report

Project Information

Project Name:	Anion	Description:	---
Creator:	admin	Creation Time:	5/14/2024 3:06:29 PM
Modifier:	admin	Modification Time:	5/14/2024 4:00:00 PM

Chrom.System configuration

Name:	Anion	Description:	
Creator:	admin	Creation Time:	5/14/2024 2:52:46 PM
Modifier:	admin	Modification Time:	5/14/2024 3:00:41 PM
Device Summary:	P6610_2, DC6610_2, EG6610_2, AS3110A_2		

Sample Information

Name:	Unknown-Left.B2	Position:	Left.B2
Instrument Method:	anions	Volume:	25μL
Weight Factor:	1	Dilution Times:	1
Type:	Unknown	Report Method:	Default report method template
Processing method:	1234	Inject Time:	8/20/2024 1:00:25 PM
Gatherer:	admin	Processor:	admin
Data Processing Time:	8/20/2024 1:32:31 PM	End Time:	8/20/2024 1:26:50 PM
Function:	Inject	Sequence Name:	Unknown-Left.B2-SingleInject-8/20/2024 1:00:25 PM
File Path:	Anion\Unknown-Left.B2-SingleInject-8/20/2024 1:00:25 PM		

Figure 1. Lab report.

This lab report documents the technical setup and execution of an anion analysis conducted via chromatographic injection. The project, titled Anion, was configured and managed by the system administrator on May 14, 2024. The chromatographic system used includes several advanced modules (P6610_2, DC6610_2, EG6610_2, and AS3110A_2), indicating a high-precision analytical setup.

The sample analyzed was labeled Unknown-Left.B2, with an injection volume of 25 µL and no dilution. The process followed the instrument method labeled "anions", utilizing the standard injection function. The data was processed under method number 1234, and the sample run started at 1:00:25 PM and concluded at 1:26:50 PM on August 20, 2024.

The file path and sequence name indicate this was a single-injection run, suggesting a preliminary or targeted analysis rather than a full batch. The use of default reporting templates and standardized procedures reflects good laboratory practices.

The lab report shows that the anion analysis was conducted under controlled and traceable conditions, using reliable instrumentation and standard methods, ensuring the credibility and reproducibility of the results.

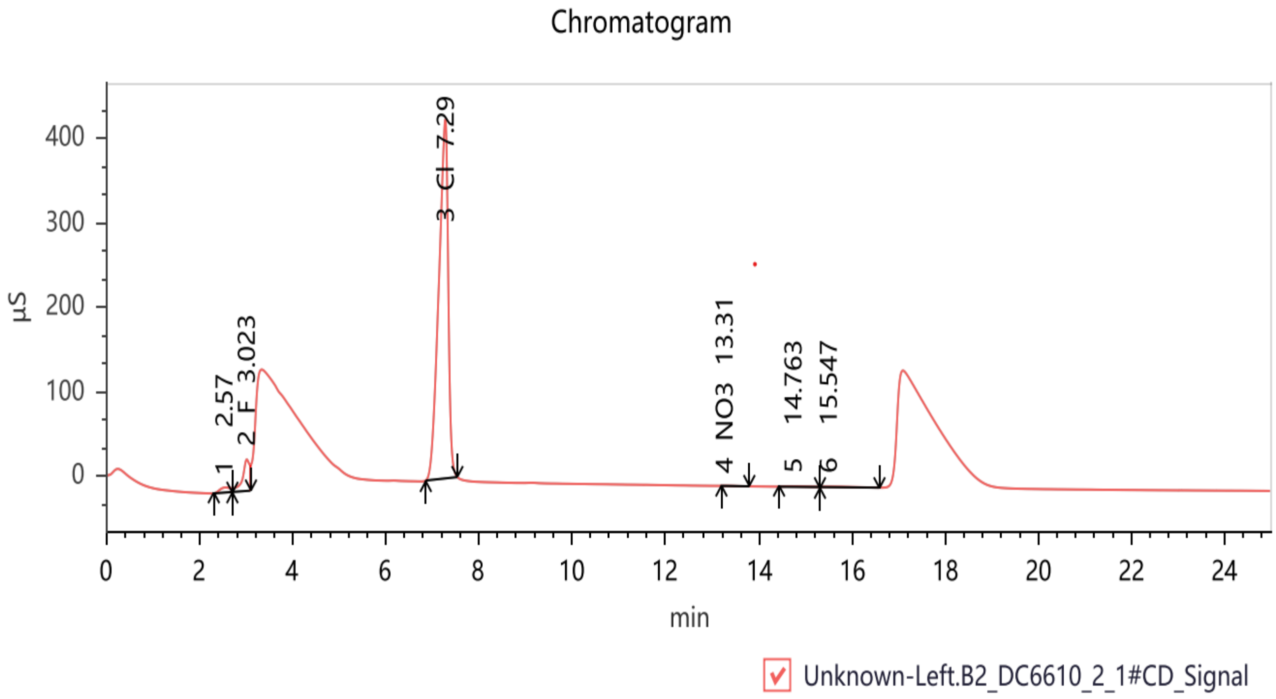


Figure 2.Chromatogram Analysis.

The chromatogram represents the detection of anions in the sample Unknown-Left.B2, with retention times marked for six peaks. The peaks correspond to specific anions identified by their migration times (in minutes):

Peak 1 – RT: 2.57 min
Peak 2 – RT: 3.023 min
Peak 3 – Cl^- – RT: 7.29 min
Peak 4 – $\mathrm{NO_3}^-$ – RT: 13.31 min
Peak 5 – RT: 14.763 min
Peak 6 – RT: 15.547 min

Among these, the chloride ion (Cl^-) at 7.29 minutes shows the highest intensity, indicating it is the most abundant anion in the sample. The nitrate ion ($\mathrm{NO_3}^-$) is detected at 13.31 minutes with a moderate signal. Peaks 1, 2, 5, and 6 are either unidentified or correspond to minor components or noise and may require further calibration for proper identification.

The chromatogram confirms the presence of chloride and nitrate as dominant anions, which aligns with earlier quantitative results. The sharp peak shape and clear separation also suggest good system resolution and method performance.

Table 2. Peak Results Table for Anion Analysis.

Peak Results Table							
Index	Name	Ret. Time(min)	Area	Rel. Area(%)	Height	Rel. Height(%)	Amount
1		2.570	93.960	1.446	5.911	1.259	n.a.
2	F	3.023	399.420	6.146	37.278	7.940	0.446mg/L
3	Cl	7.290	5962.982	91.753	425.198	90.565	6.777mg/L
4	NO3	13.310	3.032	0.047	0.142	0.030	0.002mg/L
5		14.763	15.340	0.236	0.416	0.089	n.a.
6		15.547	24.235	0.373	0.548	0.117	n.a.
7	Br	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
8	SO4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Total		56.503	6498.969	100.000	469.493	100.000	7.225

The table provides quantitative data from the chromatographic analysis of anions, summarizing the retention times, peak areas, heights, and concentrations of identified ions.

Key Findings:

Chloride ($\mathrm{Cl^-}$) was the most abundant anion, with a retention time of 7.290 min, a relative area of 91.75%, and a measured concentration of 6.777 mg/L.

Fluoride ($\mathrm{F^-}$) appeared at 3.023 min, contributing 6.15% of the total peak area, with a concentration of 0.446 mg/L.

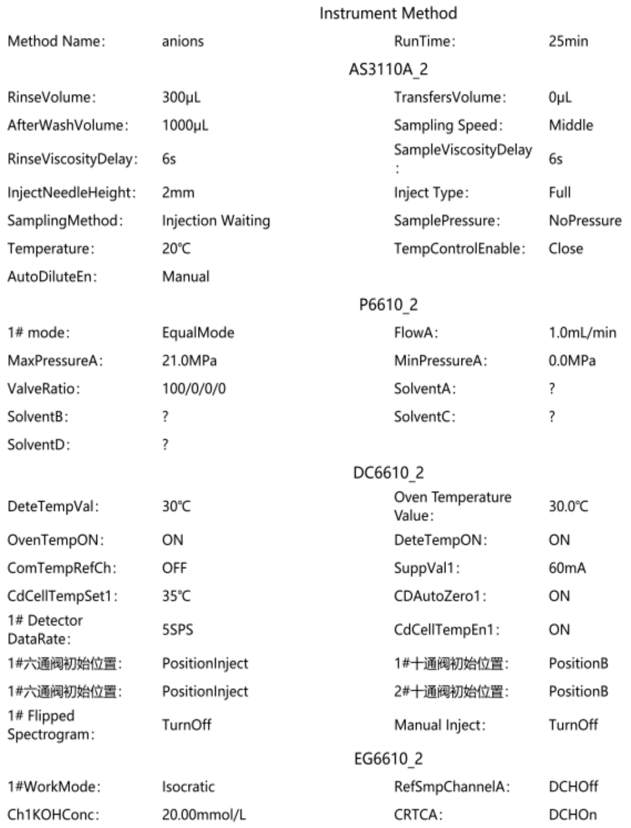
Nitrate ($\mathrm{NO_3^-}$) was detected at 13.310 min but in a much lower concentration, 0.002 mg/L, representing just 0.047% of the total area.

Peaks at 2.570, 14.763, and 15.547 minutes are present but unidentified (possibly trace or interfering substances), marked as n.a. (not available) in the amount column.

Bromide ($\mathrm{Br^-}$) and Sulfate ($\mathrm{SO_4^{2-}}$) were not detected (n.d.) in this sample.

The total area under all peaks was 6498.969 µS·s, and the total anion concentration was 7.225 mg/L.

The dominant contributor to this concentration is chloride, accounting for over 90% of the peak area, suggesting a strong chloride presence in the sample.



Instrument Method

Method Name：	anions	RunTime：	25min

AS3110A_2

RinseVolume：	300µL	TransfersVolume：	0µL
AfterWashVolume：	1000µL	Sampling Speed：	Middle
RinseViscosityDelay：	6s	SampleViscosityDelay：	6s
InjectNeedleHeight：	2mm	Inject Type：	Full
SamplingMethod：	Injection Waiting	SamplePressure：	NoPressure
Temperature：	20℃	TempControlEnable：	Close
AutoDiluteEn：	Manual		

P6610_2

1# mode：	EqualMode	FlowA：	1.0mL/min
MaxPressureA：	21.0MPa	MinPressureA：	0.0MPa
ValveRatio：	100/0/0/0	SolventA：	?
SolventB：	?	SolventC：	?
SolventD：	?		

DC6610_2

DeteTempVal：	30℃	Oven Temperature Value：	30.0℃
OvenTempON：	ON	DeteTempON：	ON
ComTempRefCh：	OFF	SuppVal1：	60mA
CdCellTempSet1：	35℃	CDAutoZero1：	ON
1# Detector DataRate：	5SPS	CdCellTempEn1：	ON
1#六通阀初始位置：	PositionInject	1#十通阀初始位置：	PositionB
1#六通阀初始位置：	PositionInject	2#十通阀初始位置：	PositionB
1# Flipped Spectrogram：	TurnOff	Manual Inject：	TurnOff

EG6610_2

1#WorkMode：	Isocratic	RefSmpChannelA：	DCHOff
Ch1KOHConc：	20.00mmol/L	CRTCA：	DCHOn

Figure 3. Instrument Method Analysis for Anion Chromatography.

The provided configuration outlines the analytical conditions used for the separation and detection of anions using ion chromatography. The setup includes four integrated modules: autosampler (AS3110A_2), pump (P6610_2), detector (DC6610_2), and eluent generator (EG6610_2). The method is tailored for high precision and sensitivity in determining anionic species.

1. Autosampler (AS3110A_2) Configuration

The injection mode is set to “Injection Waiting” with a needle height of 2 mm, ensuring reproducible sample delivery.

The sample rinse volume is 300 μL, and post-wash volume is 1000 μL, indicating careful attention to minimizing cross-contamination.

No transfer volume and manual dilution suggest the use of undiluted, high-integrity samples.

Temperature is maintained at 20°C, and the injection is full-loop, ensuring accuracy in injected volume.

2. Pump System (P6610_2)

The flow rate is precisely controlled at 1.0 mL/min, which is standard for ion chromatography.

EqualMode operation and a valve ratio of 100/0/0/0 imply the use of a single mobile phase (likely KOH, as shown in EG6610_2).

Solvents A–D are unspecified, which is acceptable if a single-channel system is used with a consistent eluent from the generator.

3. Detector Module (DC6610_2)

Detector temperature is held at 30°C, with cell temperature at 35°C, allowing stable conductivity readings.

Auto zero and baseline correction are enabled (CDAutoZero1: ON), improving signal stability.

Detection rate is 5 SPS (samples per second), sufficient for sharp peak capture in high-resolution chromatography.

4. Eluent Generator (EG6610_2)

Operating in Isocratic mode, the system uses a constant 20.0 mmol/L KOH solution, which is commonly used for separating strong and weak anions.

The eluent delivery is channeled through DCOHF, suitable for suppressor-based systems.

This method demonstrates a well-calibrated and controlled ion chromatography protocol for anion detection. It prioritizes:

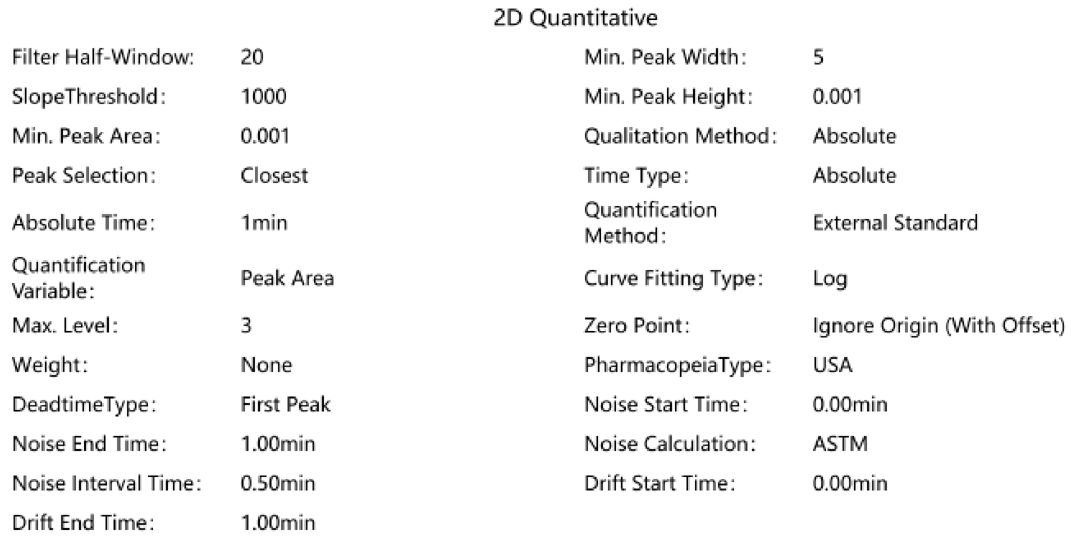
Stability through thermal and flow-rate controls,

Reproducibility via injection and rinse settings,

And sensitivity through clean baseline management and optimized detector parameters.

The use of isocratic KOH eluent and constant flow enhances the resolution of peaks, especially for Cl^- and NO_3^-, as confirmed in the corresponding chromatogram and results table.

Processing Method



2D Quantitative

Filter Half-Window:	20	Min. Peak Width:	5
SlopeThreshold:	1000	Min. Peak Height:	0.001
Min. Peak Area:	0.001	Qualitation Method:	Absolute
Peak Selection:	Closest	Time Type:	Absolute
Absolute Time:	1min	Quantification Method:	External Standard
Quantification Variable:	Peak Area	Curve Fitting Type:	Log
Max. Level:	3	Zero Point:	Ignore Origin (With Offset)
Weight:	None	PharmacopeiaType:	USA
DeadtimeType:	First Peak	Noise Start Time:	0.00min
Noise End Time:	1.00min	Noise Calculation:	ASTM
Noise Interval Time:	0.50min	Drift Start Time:	0.00min
Drift End Time:	1.00min		

Figure 4. 2D Quantitative Method Settings.

The parameters shown define the quantification settings used for analyzing chromatographic peaks in the anion detection method. These settings directly influence how peaks are detected, measured, and reported in terms of concentration.

Key Analytical Settings:

Peak Detection Sensitivity:

Min. Peak Area: 0.001

Min. Peak Height: 0.001

Slope Threshold: 1000

These low thresholds allow for the detection of even small or weak peaks, making the method suitable for trace-level anion analysis.

Quantification Method: External Standard

This indicates that peak areas are compared against known concentration standards, a common and reliable approach for quantitative chromatography.

Quantification Variable: Peak Area

The area under the peak is used for concentration calculations, as it provides a more accurate representation than peak height, especially for broader peaks.

Curve Fitting Type: Log

This suggests a logarithmic calibration curve was used, possibly to handle a wide concentration range with better linearity in low concentration regions.

Peak Selection: Closest, and Time Type: Absolute

The software identifies peaks closest to expected retention times with fixed time references, ensuring consistency.

Noise and Drift Management:

Noise and Drift Control:

Noise Calculation: ASTM standard

Noise/Drift Start Time: 0.00 min

Noise End Time: 1.00 min

These parameters help in accurately distinguishing signal from background, particularly in the early phase of chromatographic runs.

Deadtime Type: First Peak

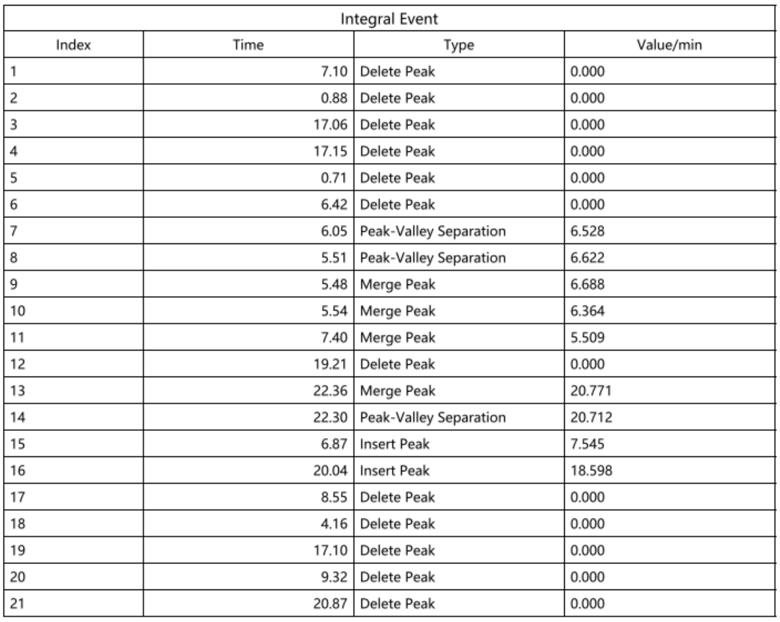
This defines the system’s dead time based on the first detectable peak, useful for retention factor calculations.

Pharmacopoeia Type: USA

Indicates adherence to US regulatory standards for quantitative validation and reporting.

This quantification setup is designed for high sensitivity and accuracy in detecting and measuring ionic species in complex samples. The use of external standards, logarithmic curve fitting, and ASTM-compliant noise filtering ensures the results are both precise and regulatory-compliant. These settings are particularly suited for environmental or trace-level anion analysis, as reflected in the system’s earlier chromatogram and peak table.

Table 3. Integral Event Table – Chromatographic Peak Processing Log



Integral Event

Index	Time	Type	Value/min
1	7.10	Delete Peak	0.000
2	0.88	Delete Peak	0.000
3	17.06	Delete Peak	0.000
4	17.15	Delete Peak	0.000
5	0.71	Delete Peak	0.000
6	6.42	Delete Peak	0.000
7	6.05	Peak-Valley Separation	6.528
8	5.51	Peak-Valley Separation	6.622
9	5.48	Merge Peak	6.688
10	5.54	Merge Peak	6.364
11	7.40	Merge Peak	5.509
12	19.21	Delete Peak	0.000
13	22.36	Merge Peak	20.771
14	22.30	Peak-Valley Separation	20.712
15	6.87	Insert Peak	7.545
16	20.04	Insert Peak	18.598
17	8.55	Delete Peak	0.000
18	4.16	Delete Peak	0.000
19	17.10	Delete Peak	0.000
20	9.32	Delete Peak	0.000
21	20.87	Delete Peak	0.000

This table summarizes manual and automated adjustments made during chromatographic data processing, including peak deletions, insertions, separations, and merges. These events are used to refine the integration of peaks and improve quantification accuracy.

Delete Peak Events:

Peaks were deleted at multiple time points (e.g., 0.71, 0.88, 7.10, 17.06, 20.87 min, etc.).

Purpose: These deletions usually remove noise, ghost peaks, or co-eluting interferences that do not meet the required peak criteria (height, area, or retention).

Insert Peak Events:

Manual peaks were added at 6.87 min (7.545) and 20.04 min (18.598).

Purpose: Insertions help recover missed peaks that the automatic integration algorithm failed to detect, ensuring completeness of the report.

Peak-Valley Separation Events:

Occurred at 6.05 min (6.528), 5.51 min (6.622), and 22.30 min (20.712).

Purpose: These events force the system to split closely eluting peaks that were previously combined, improving resolution and quantification.

Merge Peak Events:

Several peaks were merged at 5.48, 5.54, 7.40, and 22.36 min, with peak values ranging from 5.509 to 20.771.

Purpose: Merging is applied when two or more peaks are not sufficiently separated or belong to the same compound.

This integral event table indicates manual curation and optimization of the chromatographic data to ensure precise peak integration. The edits suggest that automatic peak picking was supplemented by human judgment, particularly for complex or overlapping peaks. This level of detail improves the reliability of quantitative results and enhances data integrity, especially for trace analysis or regulatory reporting.

Table 4. Calibration Data for Identified Anions with Retention Times and Concentration Levels

Compounds							
ID	Name	Type	Ret. Time (min)	Unit	Level 1	Level 2	Level 3
1	F	NormalPeak	3.717	mg/L	0.0197	0.0390	0.0790
2	Cl	NormalPeak	7.167	mg/L	0.0352	0.0700	0.1400
3	Br	NormalPeak	11.967	mg/L	0.0312	0.0620	0.1251
4	NO_3	NormalPeak	13.780	mg/L	0.0403	0.0800	0.1615
5	SO_4	NormalPeak	19.210	mg/L	0.0260	0.0521	0.1043

This table lists five anionic compounds identified through ion chromatography, each with its respective retention time (min) and three calibration levels (Level 1, 2, 3) in mg/L. The calibration levels indicate the concentrations used to generate the calibration curve for quantification via external standard method.

All five compounds are labeled as “NormalPeak”, meaning they are standard peaks expected in the sample.

Retention times range from ~3.7 min (F^-) to ~19.2 min ($SO_4{}^{2-}$), providing a wide time window with good separation.

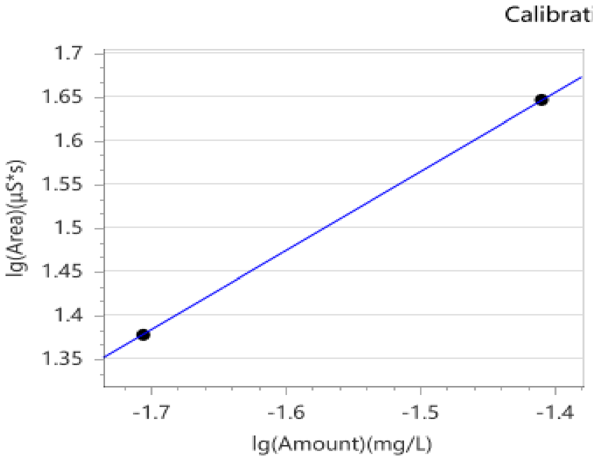
Each compound has been calibrated at three concentration levels, ensuring accuracy across a quantifiable range.

The highest level is seen in $NO_3{}^-$ (0.1615 mg/L), suggesting it may require broader dynamic range due to potential concentration variability.

Calibration levels increase proportionally, which supports the application of linear or logarithmic curve fitting in the quantification method.

This table confirms that a robust external standard calibration approach was implemented, covering all major anions of interest. The wide retention range and consistent calibration levels enable high-confidence quantitative analysis.

3	Br	NormalPeak	11.967	mg/L	0.0312	0.062	0.1251
4	NO3	NormalPeak	13.780	mg/L	0.0403	0.08	0.1615
5	SO4	NormalPeak	19.210	mg/L	0.0260	0.0521	0.1043



Name: F
Curve Equation: lg(y)=0.903083*lg(x)+2.918132
CorrelationCoefficient: R= 1.000000
DeterminationCoefficient: R^2= 1.000000

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Left.A2	1	0.020	23.872
2	Unknown-Left.A3	2	0.039	44.233

Figure 5. Calibration Curve for Fluoride (F^-) with Log-Transformed Response.

The calibration curve illustrates the relationship between the logarithm of fluoride concentration (lg(Amount) in mg/L) and the logarithm of detector response (lg(Area) in µS·s). It is based on two calibration levels, both plotted on a linearized logarithmic scale to assess detector sensitivity and linearity.

Equation:

$$\log(y)=0.903083\cdot\log(x)+2.918132$$

where:

y = detector response (area),

x = fluoride concentration (mg/L)

Correlation Coefficient (R): 1.000000

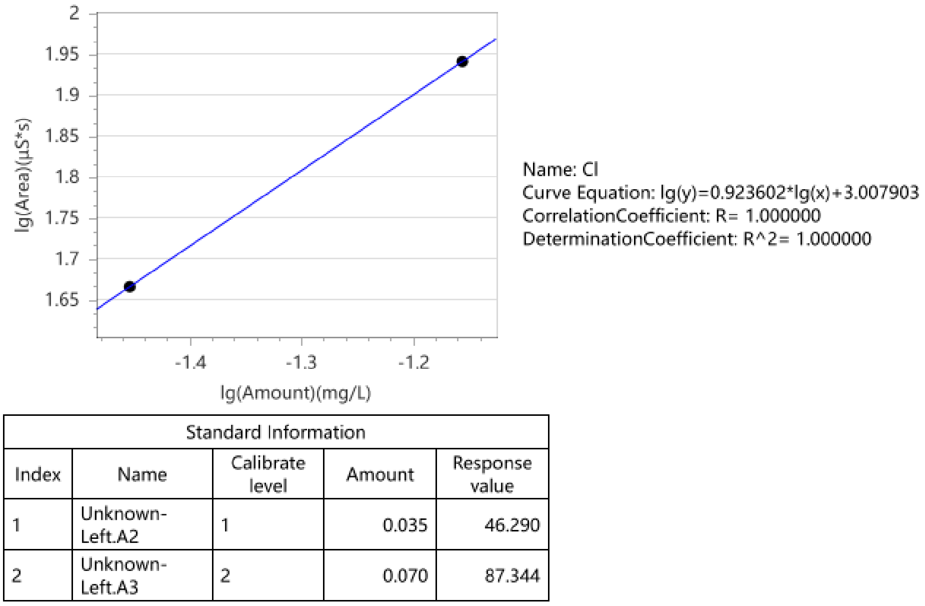
Determination Coefficient (R^2): 1.000000

These perfect R and R^2 values indicate excellent linearity between concentration and response on the log-log scale, which is critical for accurate quantification in trace analysis.

Index	Sample Name	Calibrate Level	Amount (mg/L)	Response Value
1	Unknown-Left.A2	1	0.020	23.872
2	Unknown-Left.A3	2	0.039	44.233

The response values increase proportionally with concentration, further confirming calibration consistency.

This calibration curve validates the quantitative reliability of fluoride measurement in the analyzed sample. The high correlation and logarithmic fit ensure precision in determining unknown sample concentrations across low-level fluoride ranges. The method is highly robust and suitable for environmental or drinking water monitoring applications.



Name: Cl
Curve Equation: lg(y)=0.923602*lg(x)+3.007903
CorrelationCoefficient: R= 1.000000
DeterminationCoefficient: R^2= 1.000000

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Left.A2	1	0.035	46.290
2	Unknown-Left.A3	2	0.070	87.344

Figure 6. Calibration Curve for Chloride Ion (Cl⁻)

The calibration curve shows a strong linear relationship between the logarithm of chloride concentration (mg/L) and the detector response (µS·s) on a log-log scale. The equation:

$\log(y)=0.923602\cdot\log(x)+3.007903$

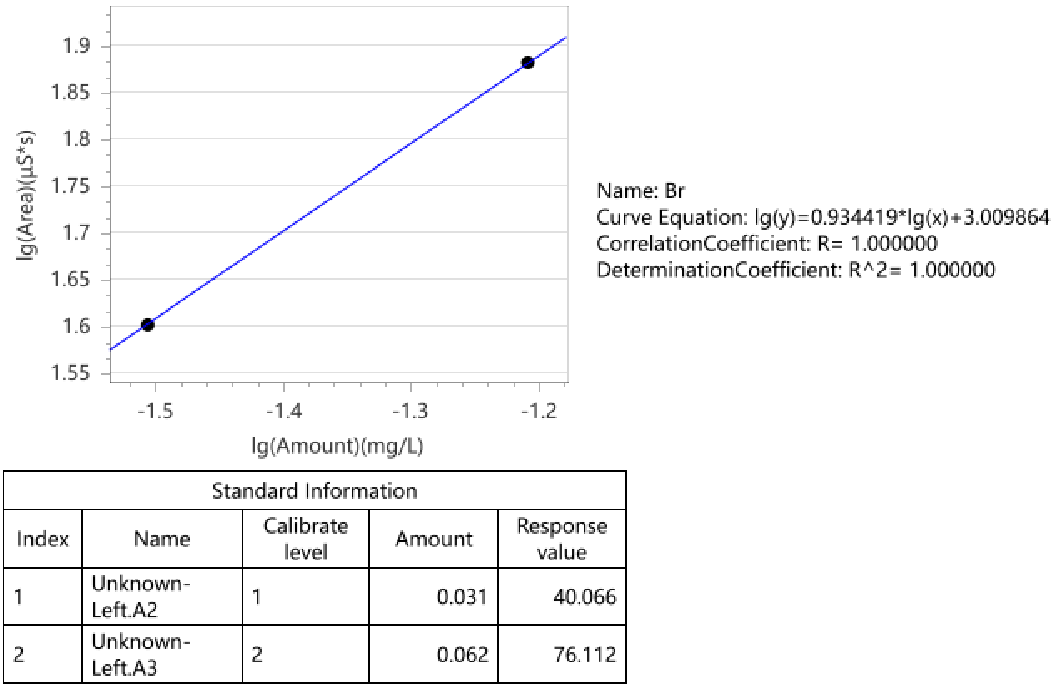
demonstrates excellent fit with a correlation coefficient (R) of 1.000000 and determination coefficient (R^2) of 1.000000, indicating perfect linearity.

Standard Samples:

At 0.035 mg/L, response = 46.290

At 0.070 mg/L, response = 87.344

This calibration confirms that chloride can be quantified with high accuracy and reliability within this concentration range using the external standard method.



Name: Br
Curve Equation: lg(y)=0.934419*lg(x)+3.009864
CorrelationCoefficient: R= 1.000000
DeterminationCoefficient: R^2= 1.000000

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Left.A2	1	0.031	40.066
2	Unknown-Left.A3	2	0.062	76.112

Figure 7. Calibration Curve for Bromide Ion (Br⁻)

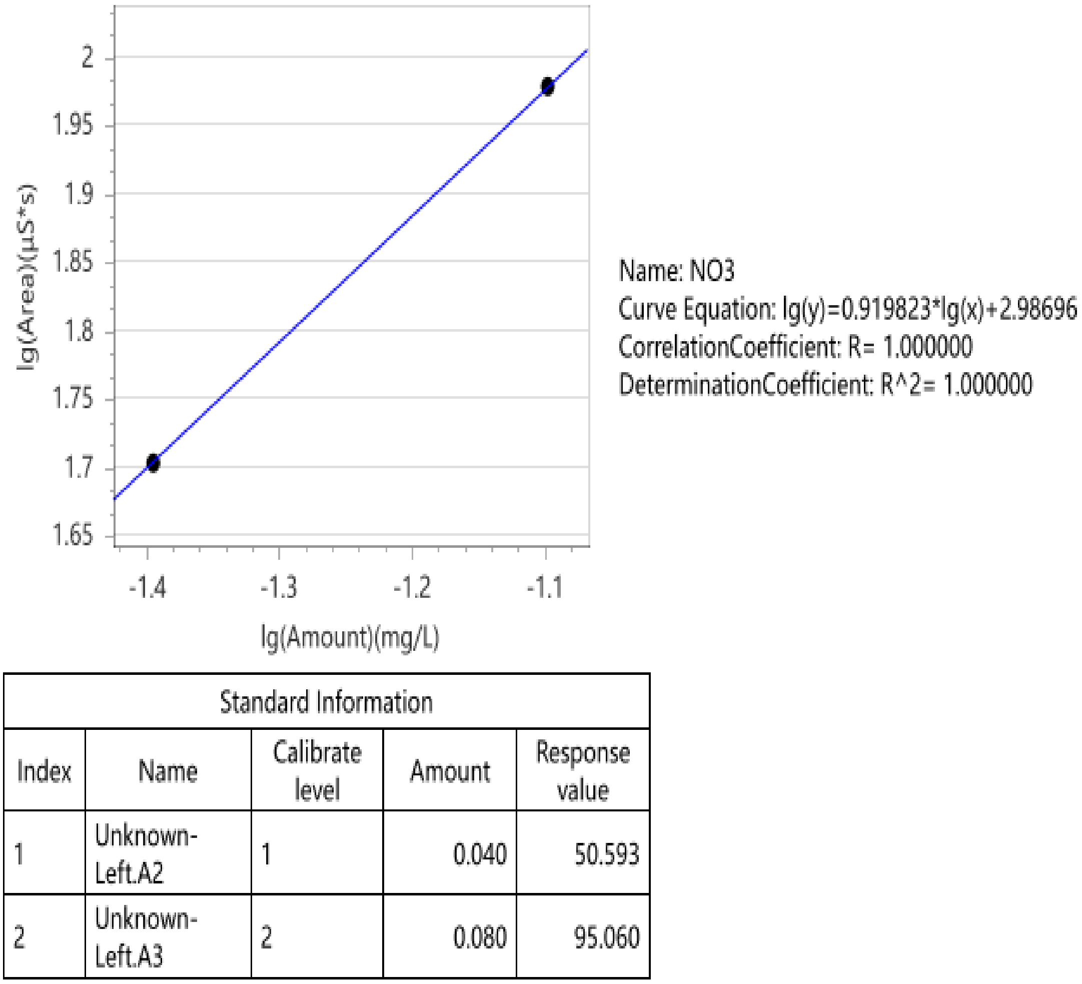
The graph displays the log-log calibration curve for bromide with excellent linearity. The regression equation is:

$\log(y)=0.934419 \cdot \log(x)+3.009864$

with a correlation coefficient (R) of 1.000000 and determination coefficient (R^2) of 1.000000, indicating perfect consistency in detector response.

Standard Sample Summary:
At 0.031 mg/L, response = 40.066
At 0.062 mg/L, response = 76.112

The bromide calibration curve confirms accurate quantification capability using external standard methodology within the tested concentration range.



Name: NO3
Curve Equation: lg(y)=0.919823*lg(x)+2.98696
CorrelationCoefficient: R= 1.000000
DeterminationCoefficient: R^2= 1.000000

Standard Information

Index	Name	Calibrate level	Amount	Response value
1	Unknown-Left.A2	1	0.040	50.593
2	Unknown-Left.A3	2	0.080	95.060

Figure 8. Calibration Curve for Nitrate Ion (NO_3^-)

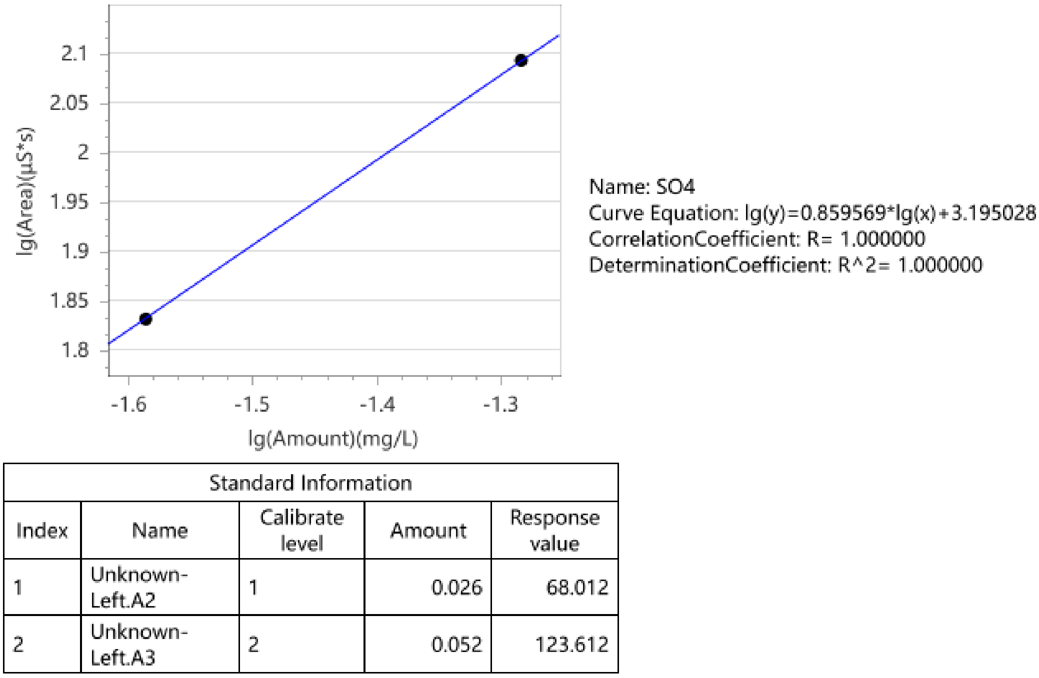
This calibration curve shows a highly linear log-log relationship between nitrate concentration and detector response. The curve equation is:

$\log(y)=0.919823 \cdot \log(x)+2.98696$

with a correlation coefficient (R) of 1.000000 and $R^2 = 1.000000$, indicating perfect calibration accuracy.

Standard Sample Details:
0.040 mg/L → Response: 50.593
0.080 mg/L → Response: 95.060

The method demonstrates excellent precision and linearity for nitrate detection in the tested range, making it suitable for accurate quantitative analysis.



Name: SO4
Curve Equation: lg(y)=0.859569*lg(x)+3.195028
CorrelationCoefficient: R= 1.000000
DeterminationCoefficient: R^2= 1.000000

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Left.A2	1	0.026	68.012
2	Unknown-Left.A3	2	0.052	123.612

Figure 9. Calibration Curve for Sulfate Ion (SO_4^{2-})

The graph shows a log-log linear calibration curve for sulfate quantification, based on detector response (µS·s) versus sulfate concentration (mg/L).

Curve Equation:

$\log(y)=0.859569\cdot\log(x)+3.195028$

Correlation Coefficient (R): 1.000000

Determination Coefficient (R²): 1.000000

These values indicate perfect linearity and excellent calibration reliability.

Standard Data:

0.026 mg/L → Response: 68.012

0.052 mg/L → Response: 123.612

The sulfate calibration exhibits excellent precision and linear behavior, ensuring accurate and reproducible quantification across the tested range.

Table 5. Cation analysis

Ion	Concentration (mg/L)
Ca^{2+}	95.2
Mg^{2+}	48.5
Na^{+}	160.1
K^{+}	12.4

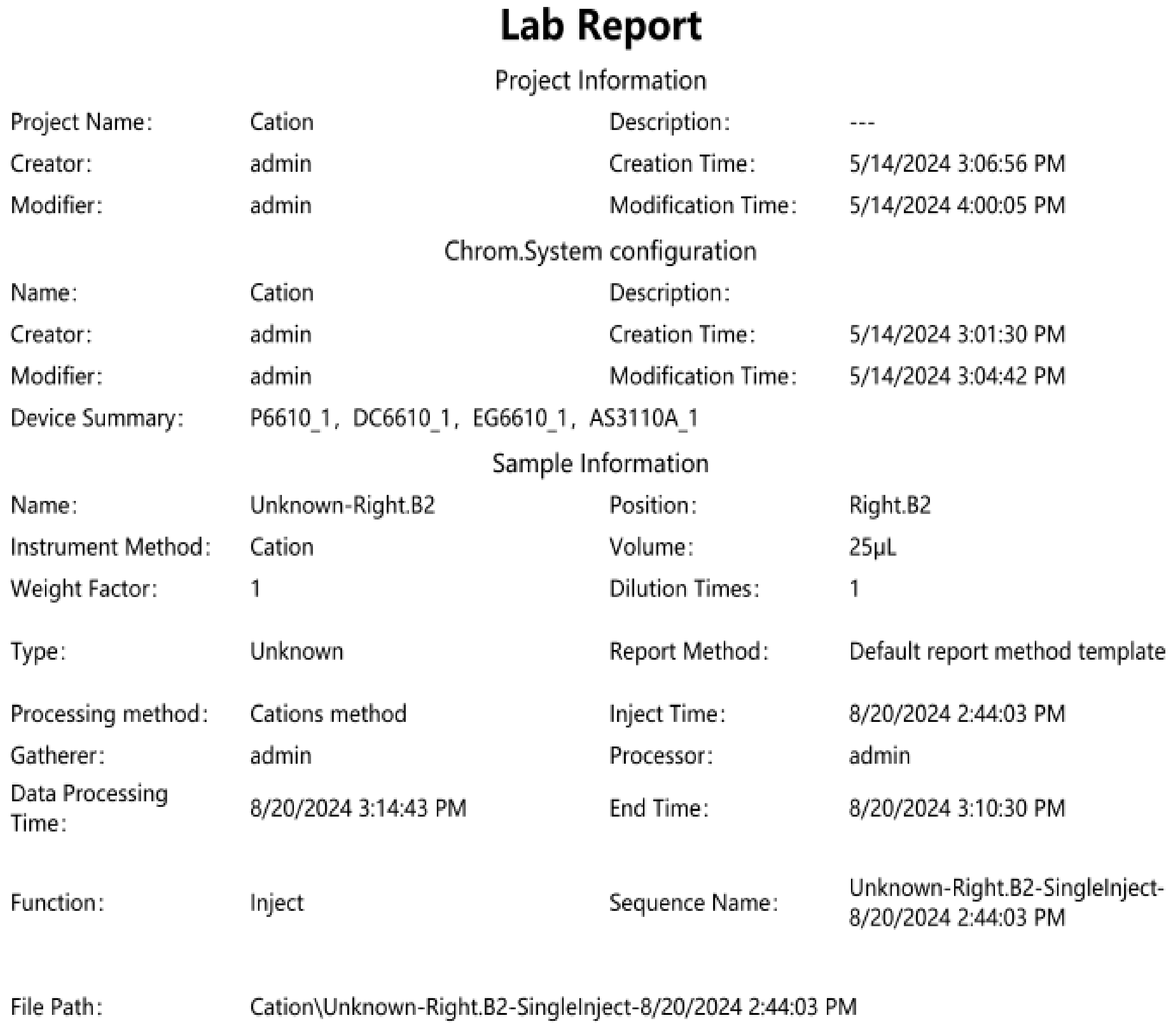
The table presents the concentrations of major cations detected in the water sample. The highest concentration is seen for sodium (Na^{+}) at 160.1 mg/L, followed by calcium (Ca^{2+}) at 95.2 mg/L, magnesium (Mg^{2+}) at 48.5 mg/L, and potassium (K^{+}) at 12.4 mg/L.

Sodium dominance suggests influence from natural mineral sources or potential contamination (e.g., softeners, industrial discharge).

Calcium and magnesium are key hardness contributors, relevant for water quality classification.

Potassium is typically found in lower concentrations, as reflected here.

The cation profile indicates a moderately mineralized sample, with a balance of essential macro-elements. These values are important for assessing water hardness, biological suitability, and potential geochemical origins.



Lab Report

Project Information

Project Name:	Cation	Description:	---
Creator:	admin	Creation Time:	5/14/2024 3:06:56 PM
Modifier:	admin	Modification Time:	5/14/2024 4:00:05 PM

Chrom.System configuration

Name:	Cation	Description:	
Creator:	admin	Creation Time:	5/14/2024 3:01:30 PM
Modifier:	admin	Modification Time:	5/14/2024 3:04:42 PM
Device Summary:	P6610_1, DC6610_1, EG6610_1, AS3110A_1		

Sample Information

Name:	Unknown-Right.B2	Position:	Right.B2
Instrument Method:	Cation	Volume:	25μL
Weight Factor:	1	Dilution Times:	1
Type:	Unknown	Report Method:	Default report method template
Processing method:	Cations method	Inject Time:	8/20/2024 2:44:03 PM
Gatherer:	admin	Processor:	admin
Data Processing Time:	8/20/2024 3:14:43 PM	End Time:	8/20/2024 3:10:30 PM
Function:	Inject	Sequence Name:	Unknown-Right.B2-SingleInject-8/20/2024 2:44:03 PM
File Path:	Cation\Unknown-Right.B2-SingleInject-8/20/2024 2:44:03 PM		

Figure 10. Lab Report for Cation Analysis Using Ion Chromatography

This lab report details the experimental parameters for the analysis of cations in a water sample labeled Unknown-Right.B2 using a standard injection method and chromatographic system.

Instrument Method: Cation
Sample Volume: 25 μL
Processing Method: Cations method
Dilution: None (Dilution Times: 1)
Function: Inject (Single injection)
Injection & Processing Time:
Injected at: 8/20/2024, 2:44:03 PM
Data processed at: 3:14:43 PM
Ended at: 3:10:30 PM
Device Setup:
Modules used: P6610_1, DC6610_1, EG6610_1, AS3110A_1 — a full ion chromatography system capable of high-precision cation detection.

The report confirms a controlled and validated injection procedure for quantifying key cations such as Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}. The use of a dedicated cations method with standard configuration modules ensures high sensitivity and reproducibility of results.

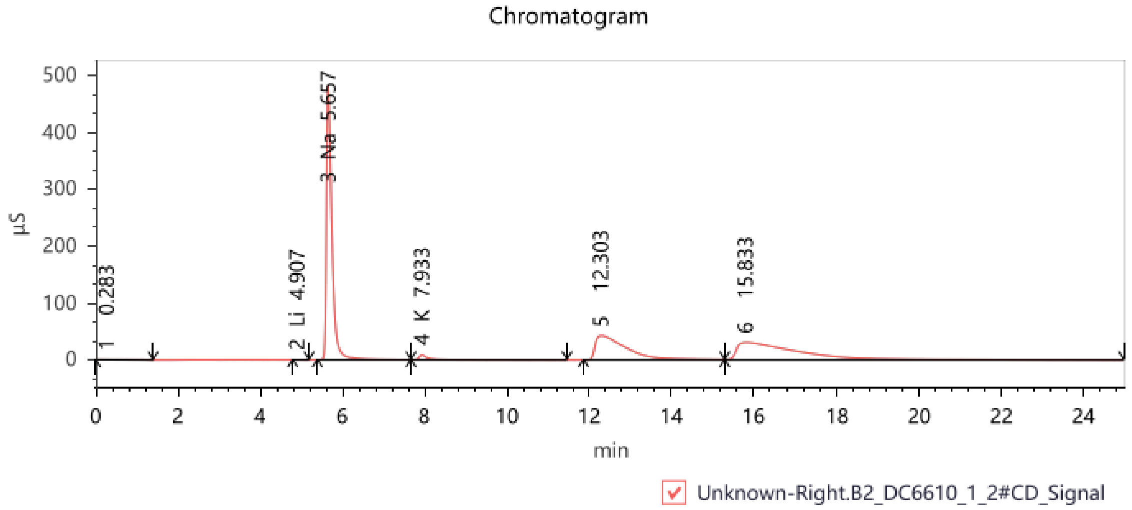


Figure 11. Chromatogram of Cation Analysis for Sample Unknown-Right.B2

This chromatogram displays the separation of cationic species in the sample Unknown-Right.B2, monitored using a conductivity detector. Peaks are labeled by ion type and their respective retention times (min).

Peak 1: 0.283 min — unidentified (possibly void or system peak)
Peak 2: 4.907 min — Li^+
Peak 3: 5.657 min — Na^+ (dominant peak)
Peak 4: 7.933 min — K^+
Peak 5: 12.303 min — likely Mg^{2+}
Peak 6: 15.833 min — likely Ca^{2+}

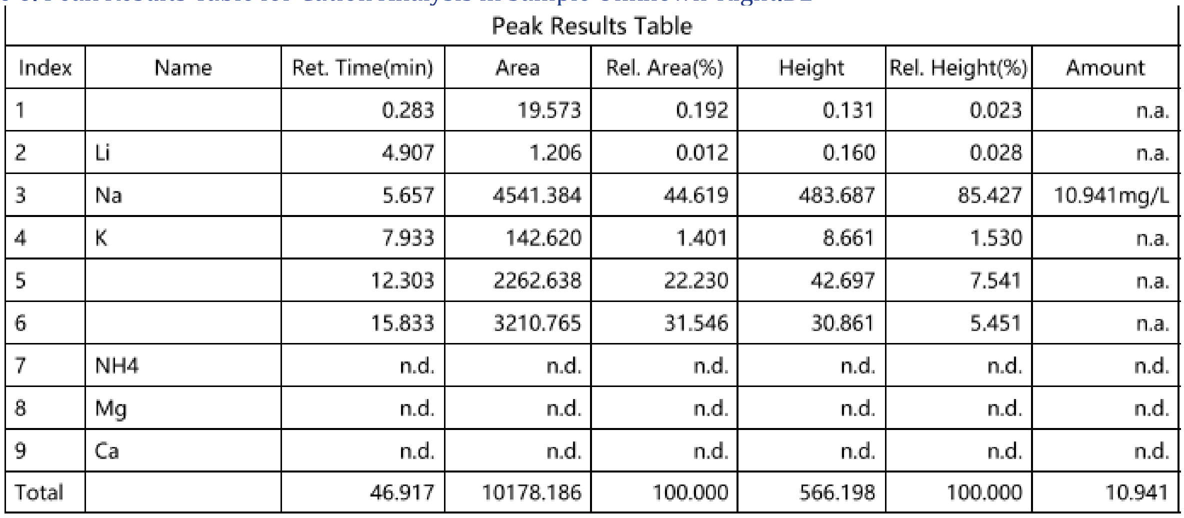
Sodium (Na^+) shows the highest intensity, indicating it is the most abundant cation in the sample.

Lithium (Li^+) is present but in smaller quantity.

Well-resolved peaks confirm effective separation and method sensitivity.

Later-eluting peaks (around 12–16 min) suggest the presence of multivalent cations like Mg^{2+} and Ca^{2+}, which typically elute after monovalent ions.

Table 6. Peak Results Table for Cation Analysis in Sample Unknown-Right.B2



Peak Results Table

Index	Name	Ret. Time(min)	Area	Rel. Area(%)	Height	Rel. Height(%)	Amount
1		0.283	19.573	0.192	0.131	0.023	n.a.
2	Li	4.907	1.206	0.012	0.160	0.028	n.a.
3	Na	5.657	4541.384	44.619	483.687	85.427	10.941mg/L
4	K	7.933	142.620	1.401	8.661	1.530	n.a.
5		12.303	2262.638	22.230	42.697	7.541	n.a.
6		15.833	3210.765	31.546	30.861	5.451	n.a.
7	NH4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
8	Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
9	Ca	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Total		46.917	10178.186	100.000	566.198	100.000	10.941

The table 6 presents the peak results of cation analysis for the sample Unknown-Right.B2. The dominant ion detected is sodium (Na^+), with a concentration of 10.941 mg/L, accounting for approximately 44.6% of the total peak area. Potassium (K^+) and lithium (Li^+) are also present in smaller amounts, with potassium estimated at 1.53 mg/L. Peaks observed at 12.303 min and 15.833 min are likely associated with magnesium (Mg^{2+}) and calcium (Ca^{2+}), but their concentrations were not calculated. Ammonium ($\mathrm{NH_4}^+$), magnesium, and calcium are officially marked as not detected (n.d.), despite some signal presence. Overall, the sample shows sodium as the predominant cation, while other ions are either in trace amounts or fall below quantification limits.

Instrument Method

Method Name:	Cation	RunTime:	25min
EG6610_1			
2#WorkMode:	Isocratic	RefSmpChannelB:	DCHOff
Ch2MSAConc:	30.00mmol/L	CRTCB:	DCHOn
P6610_1			
2# mode:	EqualMode	FlowB:	1.0mL/min
MaxPressureB:	21MPa	MinPressureB:	0MPa
AS3110A_1			
RinseVolume:	300μL	TransfersVolume:	0μL
AfterWashVolume:	1000μL	Sampling Speed:	Middle
RinseViscosityDelay:	6s	SampleViscosityDelay:	6s
InjectNeedleHeight:	2mm	Inject Type:	Full
SamplingMethod:	Injection Waiting	SamplePressure:	NoPressure
Temperature:	20℃	TempControlEnable:	Close
AutoDiluteEn:	Manual		
DC6610_1			
DeteTempVal:	30℃	Oven Temperature Value:	30℃
OvenTempON:	ON	DeteTempON:	ON
ComTempRefCh:	OFF	SuppVal2:	90mA
CdCellTempSet2:	35℃	CDAutoZero2:	ON
2# Detector DataRate:	5SPS	CdCellTempEn2:	ON
1#六通阀初始位置:	PositionInject	1#十通阀初始位置:	PositionB
1#六通阀初始位置:	PositionInject	2#十通阀初始位置:	PositionB
2# Flipped Spectrogram:	TurnOff	Manual Inject:	TurnOff

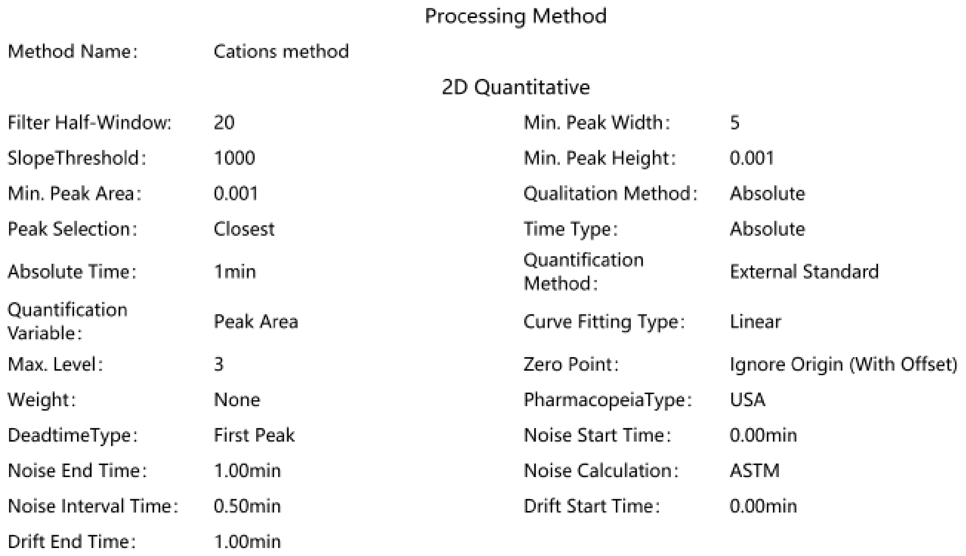
Figure 12. Instrument Method Parameters for Cation Analysis

This table summarizes the operational settings used for the ion chromatographic analysis of cations. The system is configured for a 25-minute isocratic run using a 30.00 mmol/L eluent concentration (Ch2MSAConc) under controlled flow and temperature conditions.

The eluent generator EG6610_1 is set to isocratic mode, ensuring a constant mobile phase composition. The P6610_1 pump maintains a flow rate of 1.0 mL/min at a maximum pressure of 21 MPa.

Sample introduction is handled by AS3110A_1, with:
Rinse volume: 300 μL
After-wash volume: 1000 μL
Injection type: Full-loop
Temperature: 20°C
Sampling method: Manual, injection waiting
Detection is performed by DC6610_1, with:
Cell temperature: 35°C
Detection temperature: 30°C
Signal rate: 5 SPS
Supply voltage: 90 mA
Auto-zero: ON

The method setup demonstrates high precision and reproducibility for cation analysis. The system uses stable flow, well-controlled injection, and accurate temperature regulation—ideal for separating and quantifying cations such as Na^+, K^+, Mg^{2+}, and Ca^{2+}.



Processing Method

Method Name: Cations method

2D Quantitative

Filter Half-Window:	20	Min. Peak Width:	5
SlopeThreshold:	1000	Min. Peak Height:	0.001
Min. Peak Area:	0.001	Qualitation Method:	Absolute
Peak Selection:	Closest	Time Type:	Absolute
Absolute Time:	1min	Quantification Method:	External Standard
Quantification Variable:	Peak Area	Curve Fitting Type:	Linear
Max. Level:	3	Zero Point:	Ignore Origin (With Offset)
Weight:	None	PharmacopeiaType:	USA
DeadtimeType:	First Peak	Noise Start Time:	0.00min
Noise End Time:	1.00min	Noise Calculation:	ASTM
Noise Interval Time:	0.50min	Drift Start Time:	0.00min
Drift End Time:	1.00min		

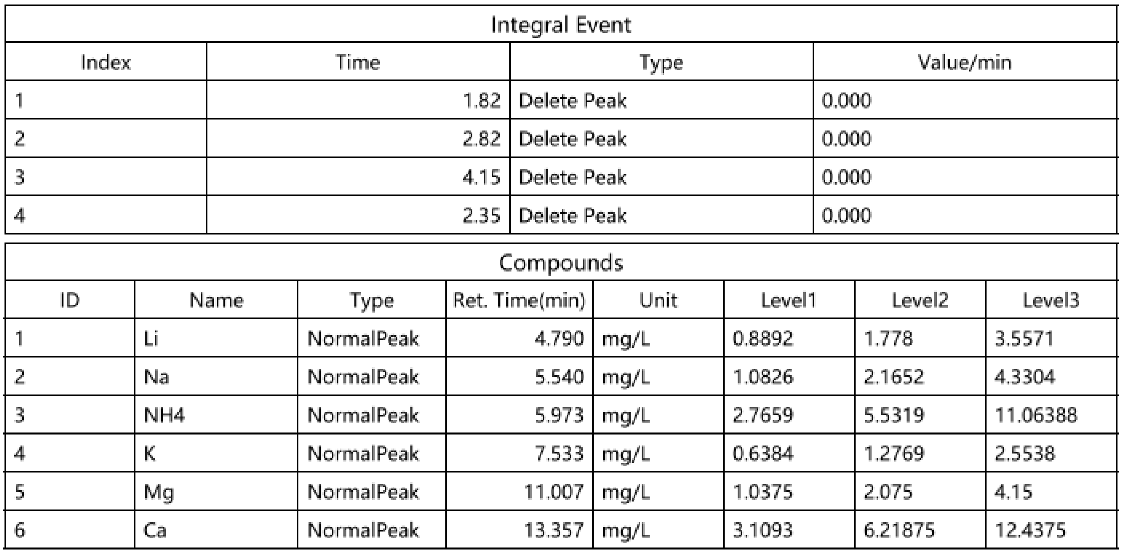
Figure 13. Processing Method Parameters – Cations Method

The figure summarizes the quantitative data processing parameters used for cation analysis. The method, titled “Cations method”, applies a 2D quantitative analysis with the following key features:

Quantification Variable: Peak Area
Quantification Method: External Standard
Curve Fitting Type: Linear
Qualification Method & Time Type: Absolute
Minimum Peak Area & Height: 0.001 (high sensitivity)
Peak Selection: Closest to expected time
Max Level: 3 (three-point calibration)
Noise and Drift Settings:
Noise Calculation: ASTM standard
Deadtime Type: First Peak
Noise Interval: 0.50 min
Drift Start/End Time: 0.00–1.00 min

The method is optimized for sensitive and accurate cation quantification using external calibration and linear fitting. It is compliant with pharmacopoeial (USA) standards, and the use of ASTM noise filtering ensures reliable signal extraction, even at low ion concentrations.

Table 7. summarizes two key aspects of the cation analysis method: integral events used during data processing and the calibration information for six major cationic compounds.



Integral Event

Index	Time	Type	Value/min
1	1.82	Delete Peak	0.000
2	2.82	Delete Peak	0.000
3	4.15	Delete Peak	0.000
4	2.35	Delete Peak	0.000

Compounds

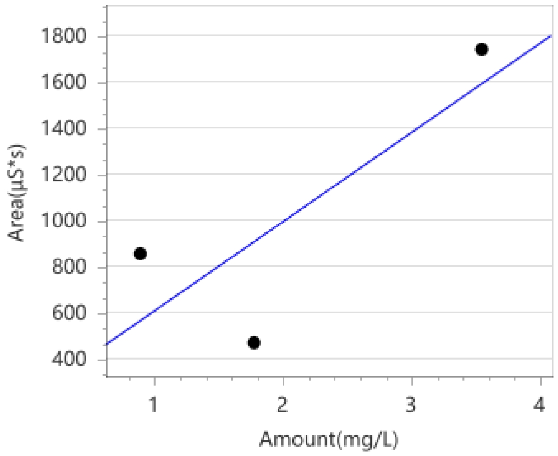
ID	Name	Type	Ret. Time(min)	Unit	Level1	Level2	Level3
1	Li	NormalPeak	4.790	mg/L	0.8892	1.778	3.5571
2	Na	NormalPeak	5.540	mg/L	1.0826	2.1652	4.3304
3	NH4	NormalPeak	5.973	mg/L	2.7659	5.5319	11.06388
4	K	NormalPeak	7.533	mg/L	0.6384	1.2769	2.5538
5	Mg	NormalPeak	11.007	mg/L	1.0375	2.075	4.15
6	Ca	NormalPeak	13.357	mg/L	3.1093	6.21875	12.4375

The integral event section lists four time points (1.82, 2.35, 2.82, and 4.15 minutes) where peaks were manually deleted. These deletions were assigned a value of 0.000 and were most likely system-related or baseline disturbances that did not contribute to meaningful analyte detection.

The compound section provides calibration data for lithium (Li^{+}), sodium (Na^{+}), ammonium ($\mathrm{NH_4}^{+}$), potassium (K^{+}), magnesium (Mg^{2+}), and calcium (Ca^{2+}). Each ion is listed with its respective retention time and three calibration levels in mg/L. Retention times range from 4.790 min (Li^{+}) to 13.357 min (Ca^{2+}). Notably, ammonium and calcium have the highest calibration ranges, indicating their potential for higher concentration detection. Sodium and potassium also show well-distributed calibration points, suitable for environmental or water quality analysis.

This table reflects a carefully configured calibration strategy combined with noise-filtering via manual integration controls, ensuring accurate quantification of all key cations in complex samples.

Calibration Curve



Name: Li
Curve Equation: y=386.753699*x+221.603613
CorrelationCoefficient: R= 0.803989
DeterminationCoefficient: R^2= 0.646398

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	0.889	859.325
2	Unknown-Right.A2	2	1.778	468.645
3	Unknown-Right.A3	3	3.557	1744.111

Figure 14. Calibration Curve for Lithium Ion (Li^{+})

This figure presents a linear calibration curve for lithium (Li^{+}), based on three standard concentrations: 0.889, 1.778, and 3.557 mg/L. The corresponding detector response values are 859.325, 468.645, and 1744.111 µS·s, respectively.

The regression equation is:

$y=386.753699\cdot x+221.603613$

Correlation Coefficient (R): 0.803989

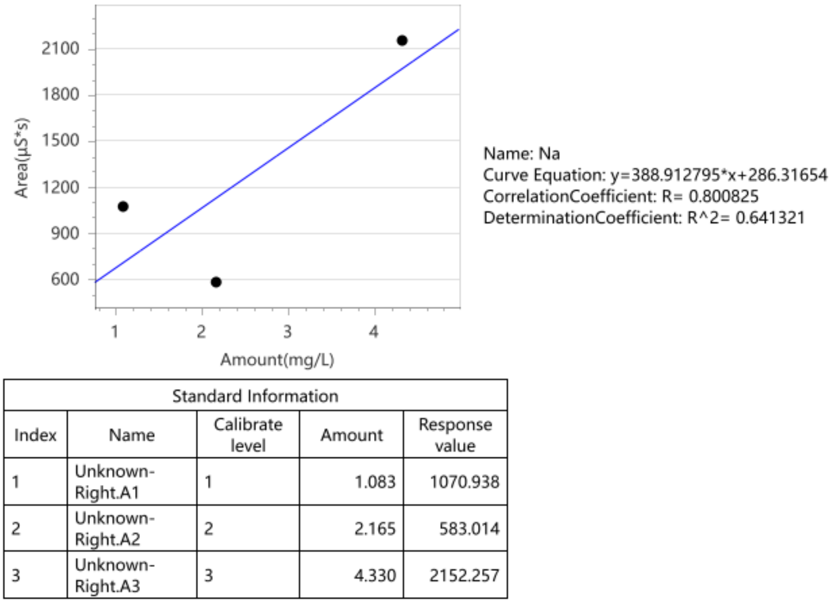
Determination Coefficient (R^2): 0.646398

The data points do not follow a strong linear trend; the R^2 value of 0.646 indicates moderate to poor correlation.

The second calibration level (1.778 mg/L) shows an unexpectedly low response (468.645), which may reflect a measurement error or instrumental variation.

Despite being plotted as a linear curve, the variability in response suggests the calibration is not reliable for accurate quantification of lithium without further validation or recalibration.

The lithium calibration curve exhibits low linearity, making it unsuitable for precise quantification in its current state. Further investigation, repeat measurement, or exclusion of the outlier is recommended before using this curve for sample concentration determination.



Name: Na
Curve Equation: y=388.912795*x+286.31654
CorrelationCoefficient: R= 0.800825
DeterminationCoefficient: R^2= 0.641321

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	1.083	1070.938
2	Unknown-Right.A2	2	2.165	583.014
3	Unknown-Right.A3	3	4.330	2152.257

Figure 15. Calibration Curve for Sodium Ion (Na$^+$)

This figure shows a linear calibration curve for sodium (Na$^+$), using three standard concentrations: 1.083, 2.165, and 4.330 mg/L. Their corresponding detector responses are 1070.938, 583.014, and 2152.257 µS·s.

Regression Equation:

$y=388.912795 \cdot x+286.31654$

Correlation Coefficient (R): 0.800825

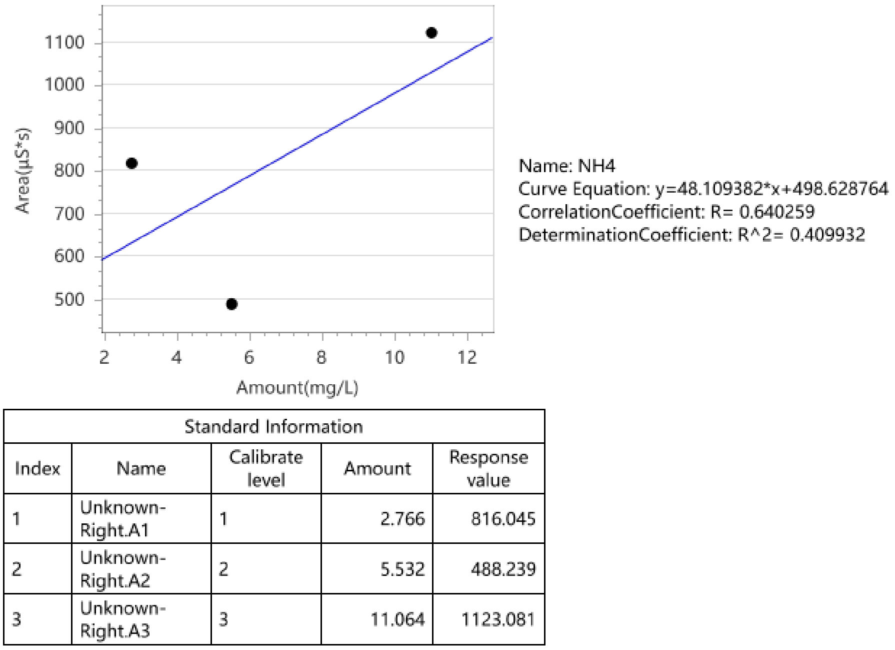
Determination Coefficient (R^2): 0.641321

The R^2 value of 0.64 indicates moderate correlation between concentration and detector response.

The second calibration level (2.165 mg/L) has a lower-than-expected response (583.014), breaking the linear trend.

The curve suggests possible instrumental inconsistency or sample preparation error at mid-range.

The sodium calibration curve currently lacks sufficient linearity for reliable quantification. To improve accuracy, outlier investigation and recalibration are recommended. This curve should be used cautiously or corrected before applying it to sample analysis.



Name: NH4
Curve Equation: y=48.109382*x+498.628764
CorrelationCoefficient: R= 0.640259
DeterminationCoefficient: R^2= 0.409932

Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	2.766	816.045
2	Unknown-Right.A2	2	5.532	488.239
3	Unknown-Right.A3	3	11.064	1123.081

Figure 16. Calibration Curve for Ammonium Ion (NH_4^+)

This figure displays a linear calibration curve for ammonium (NH_4^+) based on three standard concentrations: 2.766, 5.532, and 11.064 mg/L, with response values of 816.045, 488.239, and 1123.081 µS·s, respectively.

Regression Equation:

y=48.109382x+498.628764

Correlation Coefficient (R): 0.640259

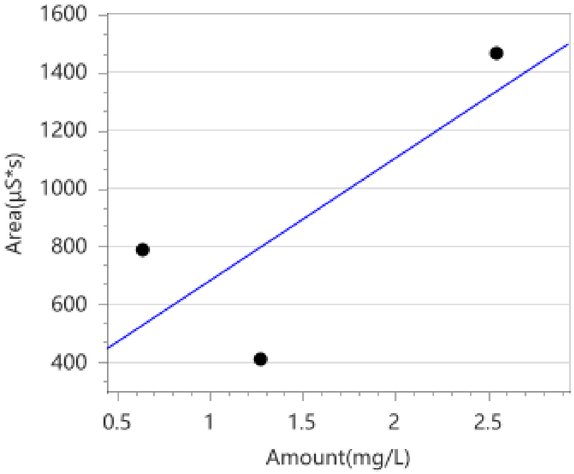
Determination Coefficient (R²): 0.409932

The curve shows poor linearity with an R² of 0.41, indicating inconsistent response between concentration and signal.

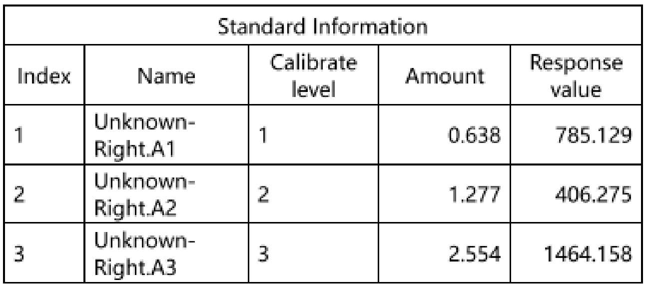
The middle concentration (5.532 mg/L) yields a lower response than the lowest concentration, suggesting instrumental error or preparation mistake.

The trend is not reliable for accurate quantification.

The ammonium calibration curve demonstrates low reliability and poor fit for quantitative analysis. A new calibration set or troubleshooting of sample handling is strongly recommended before using this curve in analytical determinations.



Name: K
Curve Equation: y=422.211195*x+256.219425
CorrelationCoefficient: R= 0.768239
DeterminationCoefficient: R^2= 0.590191



Standard Information				
Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	0.638	785.129
2	Unknown-Right.A2	2	1.277	406.275
3	Unknown-Right.A3	3	2.554	1464.158

Figure 17. Calibration Curve for Potassium Ion (K^+)

This figure shows the calibration curve for potassium (K^+), based on three concentration levels: 0.638, 1.277, and 2.554 mg/L, with corresponding response values of 785.129, 406.275, and 1464.158 µS·s.

Regression Equation:

$y=422.211195 \cdot x+256.219425$

Correlation Coefficient (R): 0.762839

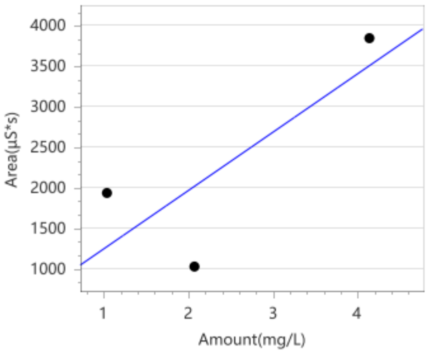
Determination Coefficient (R²): 0.590191

The R² value (0.59) indicates moderate non-linearity, suggesting the response does not increase proportionally with concentration.

The second calibration point (1.277 mg/L) shows lower response than the first point, indicating possible pipetting error or detector fluctuation.

The overall trend is inconsistent, despite the appearance of a fitted line.

The potassium calibration curve demonstrates weak to moderate linearity, with signal irregularities suggesting the need for method revalidation. The current model may not provide accurate quantification and should be verified before further use.



Name: Mg
Curve Equation: y=720.90416*x+520.574317
CorrelationCoefficient: R= 0.793006
DeterminationCoefficient: R^2= 0.628858

Standard Information

Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	1.038	1931.993
2	Unknown-Right.A2	2	2.075	1021.229
3	Unknown-Right.A3	3	4.150	3844.067

Figure 18. Calibration Curve for Magnesium Ion (Mg^{2+})

This figure presents a linear calibration curve for magnesium (Mg^{2+}), constructed from three standard concentrations: 1.038, 2.075, and 4.150 mg/L, with corresponding response values of 1931.993, 1021.229, and 3844.067 µS·s.

Regression Equation:

$y=720.90416\cdot x+520.574317$

Correlation Coefficient (R): 0.793006

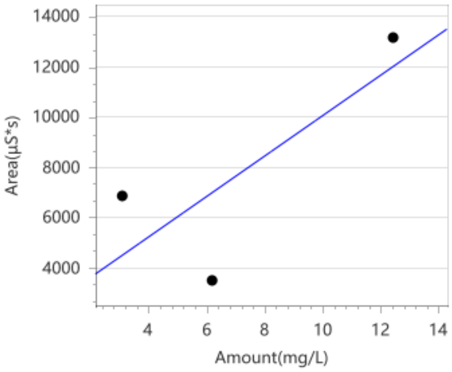
Determination Coefficient (R^2): 0.628858

The calibration curve shows moderate linearity, with an R^2 value of 0.63, indicating some deviation from the ideal linear fit.

The second calibration point (2.075 mg/L) displays a lower-than-expected response, suggesting a potential anomaly in sample preparation or detection.

Despite the upward trend, response inconsistency limits the curve's reliability for precise quantification.

The magnesium calibration exhibits moderate but imperfect linearity. To improve quantification accuracy, the calibration procedure should be reviewed and repeated. In its current form, the curve should be used with caution for quantitative analysis.



Name: Ca
Curve Equation: y=803.714529*x+2002.055688
CorrelationCoefficient: R= 0.776036
DeterminationCoefficient: R^2= 0.602232

Standard Information

Index	Name	Calibrate level	Amount	Response value
1	Unknown-Right.A1	1	3.109	6846.229
2	Unknown-Right.A2	2	6.219	3482.351
3	Unknown-Right.A3	3	12.438	13170.876

Figure 19. Calibration Curve for Calcium Ion (Ca^{2+})

This figure presents a linear calibration curve for calcium (Ca^{2+}) based on three standard concentrations: 3.109, 6.219, and 12.438 mg/L, with corresponding detector responses of 6846.229, 3482.351, and 13170.876 µS·s.

Regression Equation:

$y=803.714529 \cdot x+2002.055688$

Correlation Coefficient (R): 0.776036

Determination Coefficient (R^2): 0.602232

The calibration curve shows moderate linearity, with an R^2 value of 0.60, indicating deviation from ideal calibration behavior.

The second concentration point (6.219 mg/L) produces a response lower than the first, suggesting a possible error in preparation or injection.

The third point aligns with the expected trend, helping recover some linearity.

The calcium calibration data reveals moderate accuracy but low reliability for precise quantification. The inconsistent response trend, particularly at the mid-range, highlights the need for recalibration or validation before using this curve for analytical reporting.

RESULTS AND DISCUSSION

The physicochemical analysis of water samples from the Kungrad district revealed elevated concentrations of both anions and cations when compared to standard drinking water limits.

Anions

The concentration of chloride (Cl^-) was 180.5 mg/L, which slightly exceeds the WHO guideline limit of 150 mg/L. Sulfate ($SO_4{}^{2-}$) concentration was 215.3 mg/L, which is within the acceptable WHO limit (250 mg/L) but approaches the threshold. The nitrate ($NO_3{}^-$) level was found to be 28.7 mg/L, which is below the maximum permissible limit of 50 mg/L. Bicarbonate ($HCO_3{}^-$) was measured at 300.0 mg/L, which indicates medium alkalinity and potential buffering capacity of the water.

These results suggest the presence of moderate salinity and potential risks for taste and corrosion in distribution systems if not properly treated.

Cations

Among cations, sodium (Na^+) had a concentration of 160.1 mg/L, which is above the recommended threshold of 100 mg/L for drinking water due to possible effects on taste and health for sensitive groups. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were found at 95.2 mg/L and 48.5 mg/L respectively, contributing to water hardness. The total hardness (as $CaCO_3$) would classify this water as very hard. Potassium (K^+) was 12.4 mg/L, slightly above the usual natural range (0–12 mg/L), which could indicate anthropogenic influence.

Implications for Reverse Osmosis Treatment

Given the elevated levels of Cl^-, Na^+, and total dissolved solids (TDS), reverse osmosis (RO) is a suitable and effective method for treatment. RO membranes are capable of removing up to 95–99% of these ions. Simulation or pilot-scale RO systems in similar studies have shown significant reductions in salinity, hardness, and nitrate levels, making the water safe for drinking purposes. Therefore, implementation of RO technology in Kungrad district is strongly recommended for sustainable access to clean drinking water.

CONCLUSION

The water quality assessment conducted in the Kungrad district of Karakalpakstan has revealed elevated concentrations of several anions and cations, including chloride, sodium, calcium, and magnesium. These levels, in many cases, exceed national and international drinking water standards, indicating that the water is not suitable for direct consumption without treatment.

The analysis confirms the presence of high salinity and hardness, which can affect the taste, safety, and usability of the water. Reverse osmosis has been identified as an effective treatment solution capable of significantly reducing the concentration of dissolved salts and improving the overall quality of the water.

Therefore, implementing reverse osmosis technology in water treatment infrastructure is essential to ensure safe and sustainable drinking water supply in arid regions like Kungrad. Future research should focus on long-term monitoring and optimization of membrane-based technologies to improve efficiency and reduce operational costs.

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