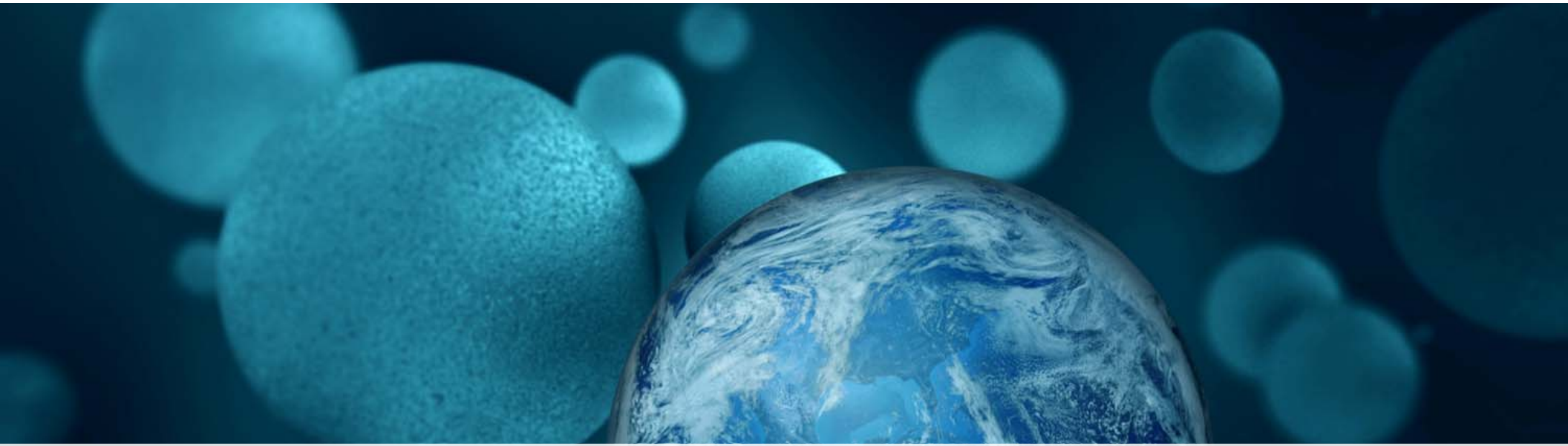

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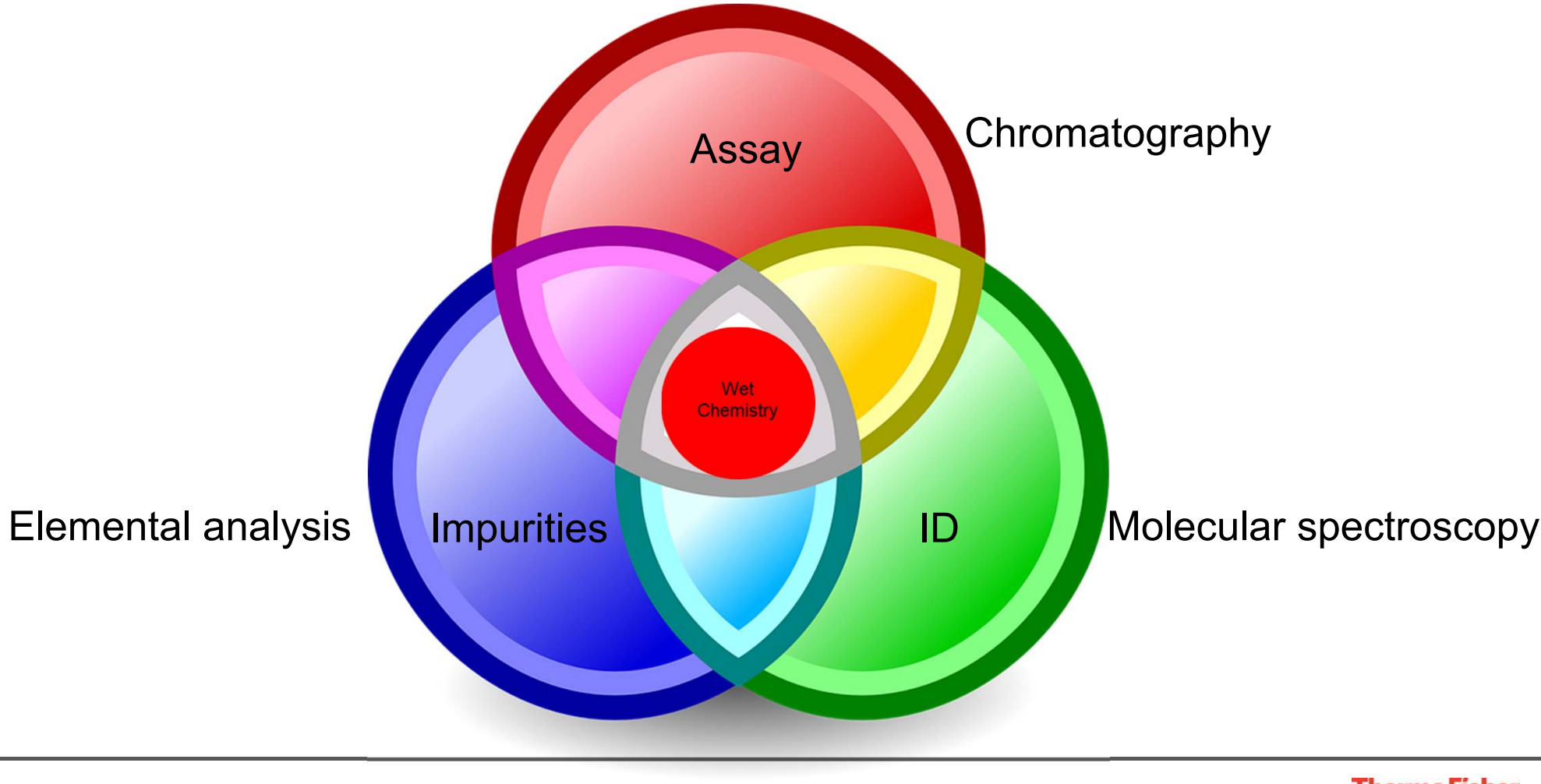
Automated Wet Chemistry Analysis – New Green Applications

Hari Narayanan Ph.D.
Product Marketing Manager
Discrete Industrial Analyzer

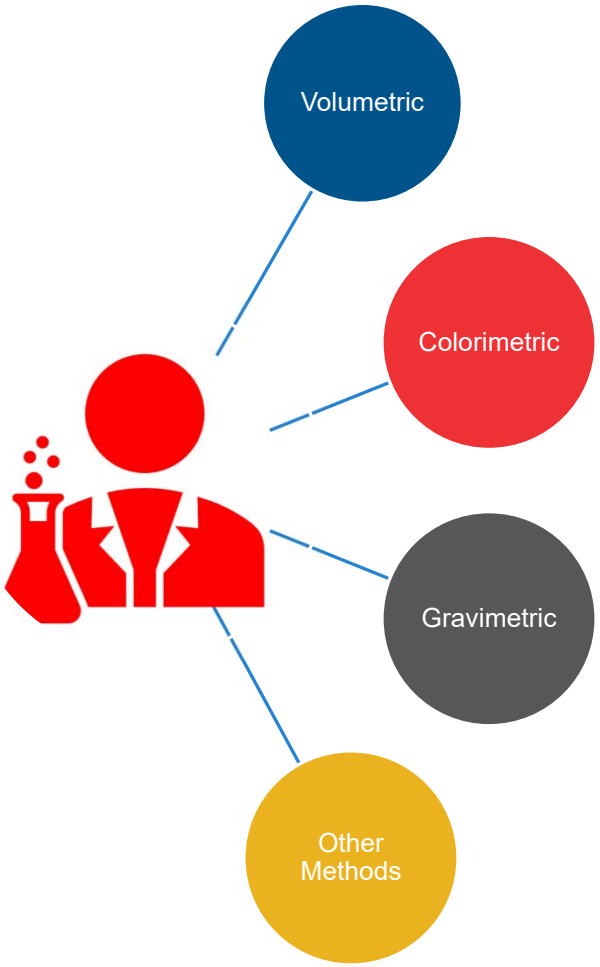
Agenda

1. Introduction to automated wet chemical analysis
2. Traditional workflow and limitations
3. Green workflow and advantages
4. Environmental applications
5. Summary

Sample Analysis



Wet Chemistry Analysis

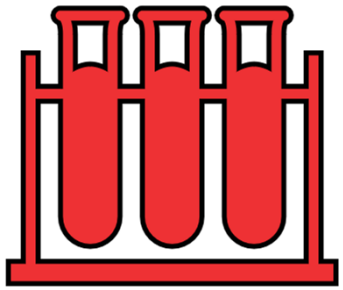


- Classical
- Liquids samples
- Manual methods
- Visual detection
- Labor intensive
- Time consuming

Automated Wet Chemical Analysis – Standalone Instruments

Analytical labs

Few samples per day



Few parameters per sample

- Automated wet chemical analyzers

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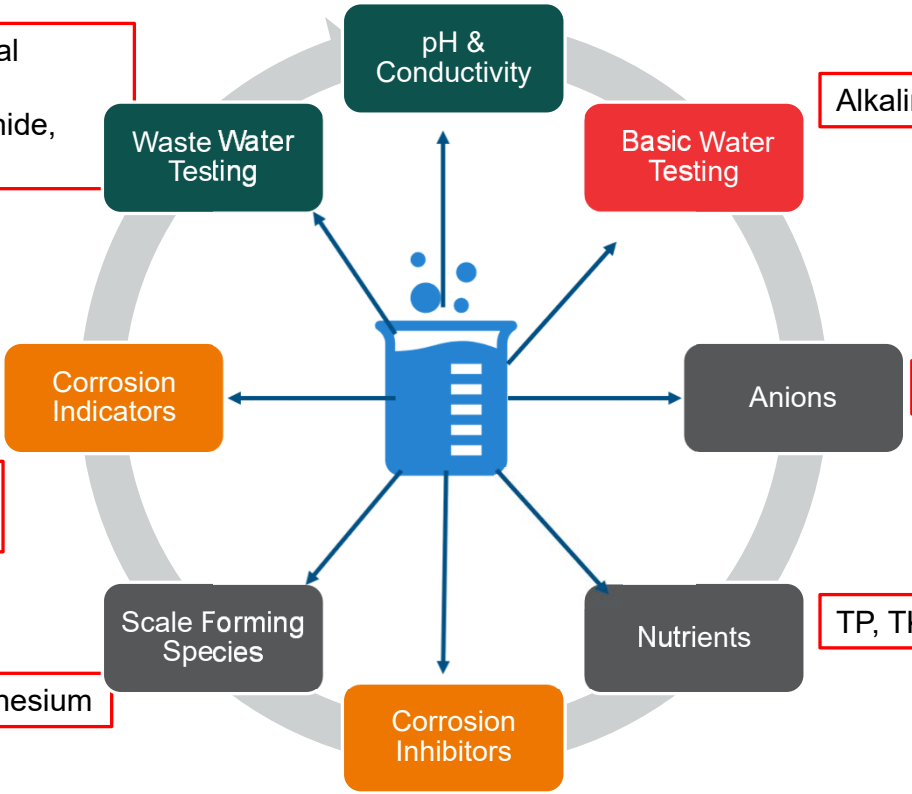
Industrial Water, Dinking Water and Waste Water – Multiparameter Analysis



Total Kjeldal Nitrogen (TKN), Total Phosphate, Total Phenol, Total Oxidizable Nitrogen (TON), Cyanide, Total Cyanide, Boron, Aluminium

Alkalinity, Total hardness

F,Cl,NO_2,NO_3,SO_4,PO_4, Thiocyanate, Sulfide

Hexavalent Chromium, Zinc, Manganese, Iron,

TP, TKN, TN, Nitrate, Ammonia, K,

Silica, Calcium, Magnesium

Ammonia, Zinc, Nitrite, Molybdenum

Single Sample – Many Parameters

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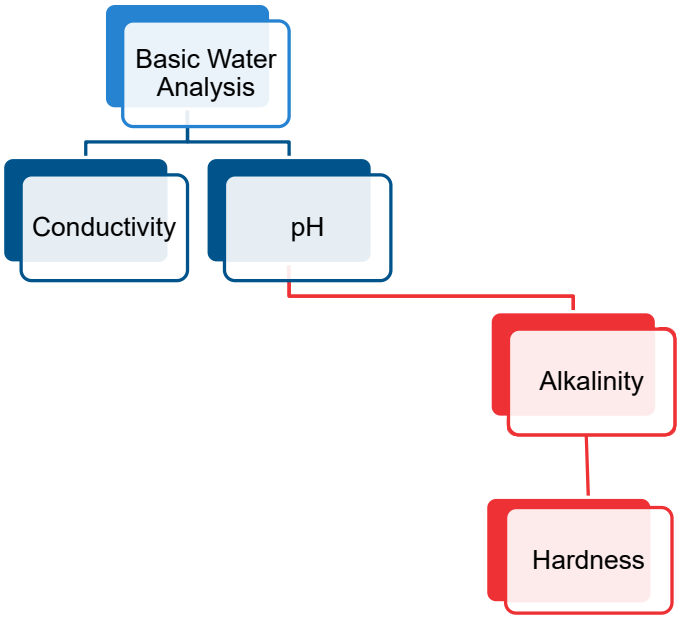
Traditional Wet Chemistry Workflow –Water Analysis

Samples for Multiple Analytes + Multiple Reagents & Standards Preparation + Multiple Instruments Calibration, Maintenance, Consumables + Multiple Users + Training + Long Turnaround time = Time & Money + Profit



Traditional Wet chemistry: Titration+ISE, Flow Analyzers

- 50-100 mL Samples per test
- mL Reagents
- Liters of Waste Generation
- Multiple Instruments
- Sequential
- Typically Single or max 4 Parameters per sample
- High cost per analysis

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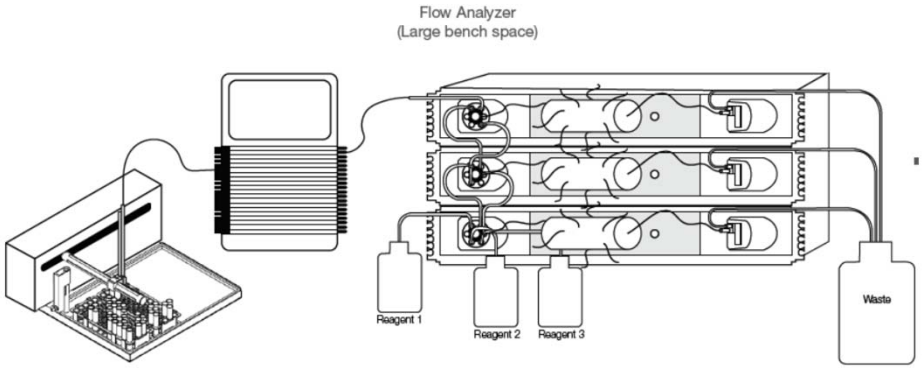
Traditional Wet Chemistry Workflow – Water Analysis

Limitations of Multi Parameter setup with ISE, pH and Conductivity

- Sequential measurements
- Multiple burettes and Sensors
- ISE – Shelf life, matrix effect and sensitivity
- Carry over -time consuming – Rinsing and cleaning after each tests
- Large bench space
- Limited number of parameters
- Low throughput
- Periodic calibration and sensor maintenance
- Large sample volume
- Large reagent consumption and waste generation
- Complex systems to work and maintain
- Needs skilled operators

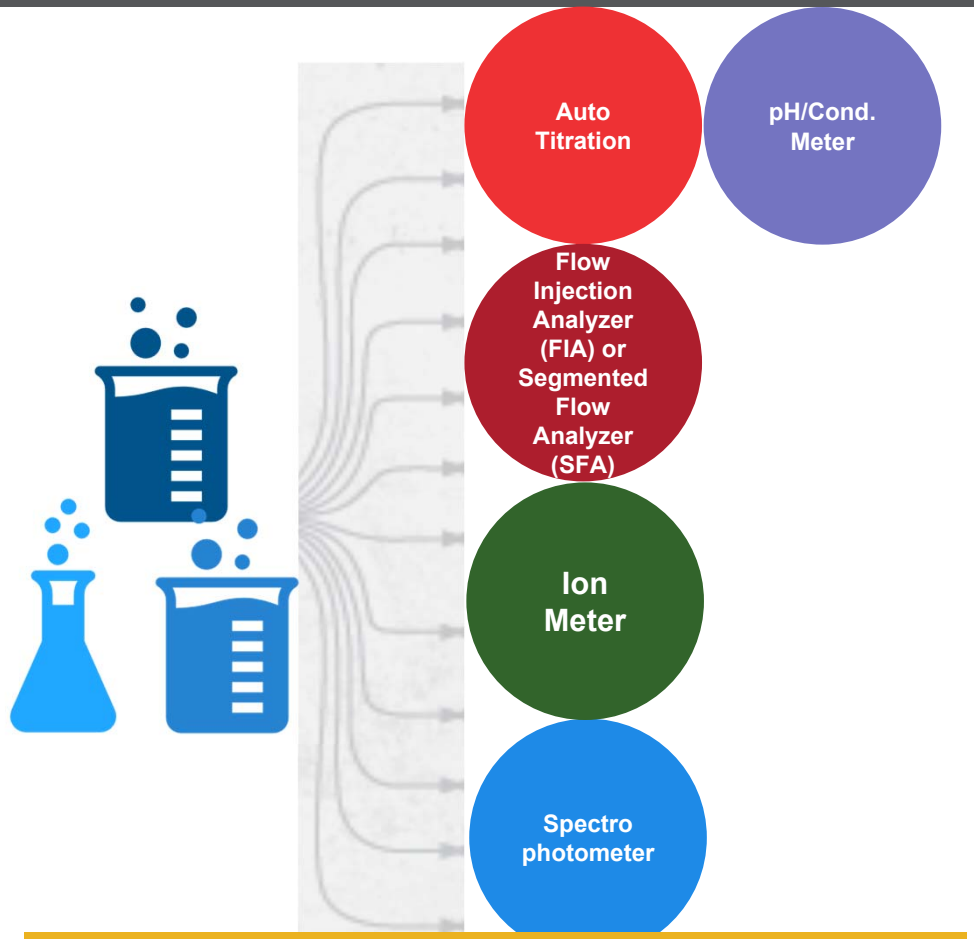
Traditional Wet Chemistry Workflow –Water Analysis

Limitations of Flow Injection Analyzers (FIA) or Segmented Flow Analyzer (SFA)



- Batch Analyzers
- Limited number of parameters limited by number of channels
- Large sample, reagent consumption and waste generation
- Complex systems to work
- Periodical tube change and maintenance
- Needs expert users

Dinking Water, Industrial Process Water and Waste Water – Multiparameter Analysis



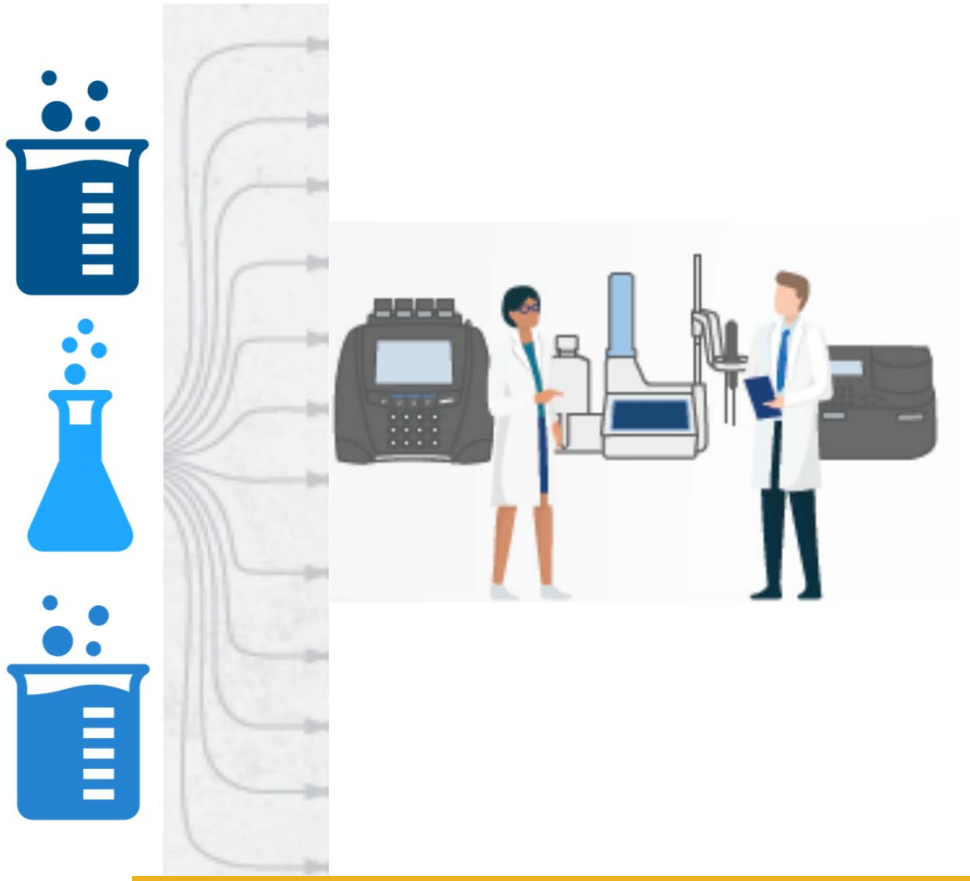
Multiple parameters – Multiple instruments

- Problems

- Multiple testing methods for a sample
- Large sample volume, excessive reagent consumption and waste generation
- Multiple instruments
- Skilled users
- Labor intensive

- Impact
- Long Hands on Sample Time
- Throughput, Response time, Results accuracy
- Cost per Analysis
- Frequent maintenance
- Users Training

Dinking Water, Industrial Process Water and Waste Water – Multiparameter Analysis



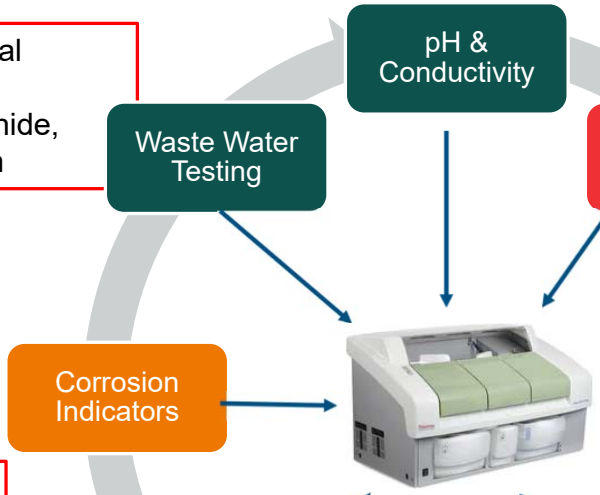
Multiple parameters –Multiple operators

- Problems

- Multiple testing methods for a sample
- Large sample volume, excessive reagent consumption and waste generation
- Multiple instruments
- Skilled users
- Labor intensive

- Impact
- Long Hands on Sample Time
- Throughput, Response time, Results accuracy
- Cost per Analysis
- Frequent maintenance
- Users Training

Dinking Water, Industrial Process Water and Waste Water – Multiparameter Analysis



pH & Conductivity

Waste Water Testing

Basic Water Testing

Corrosion Indicators

Anions

Scale Forming Species

Nutrients

Corrosion Inhibitors

Total Kjeldal Nitrogen (TKN), Total Phosphate, Total Phenol, Total Oxidizable Nitrogen (TON), Cyanide, Total Cyanide, Boron, Aluminium

Alkalinity, Total hardness

Hexavalent Chromium, Zinc, Manganese, Iron,

$F, Cl, NO_2, NO_3, SO_4, PO_4$, Thiocyanate, Sulfide

Silica, Calcium, Magnesium

TP, TKN, TN, Nitrate, Ammonia, K,

Ammonia, Zinc, Nitrite, Molybdenum

Single Instrument – Single Operator – Many Parameters

Consolidate Your Water Analysis

- pH
- Conductivity
- Alkalinity
- Total Hardness
- Silica
- Chloride, Sulfate, Fluoride, Phosphate, Nitrite, Nitrate
- Ammonia, Calcium, Magnesium
- Total Iron
- Hexavalent Chromium
- Zinc, Molybdenum
- Total Phosphate
- Cyanide, Total Cyanide
- Total Phenol
- Total Kjeldal Nitrogen
- Total Oxidizable Nitrogen
- Boron

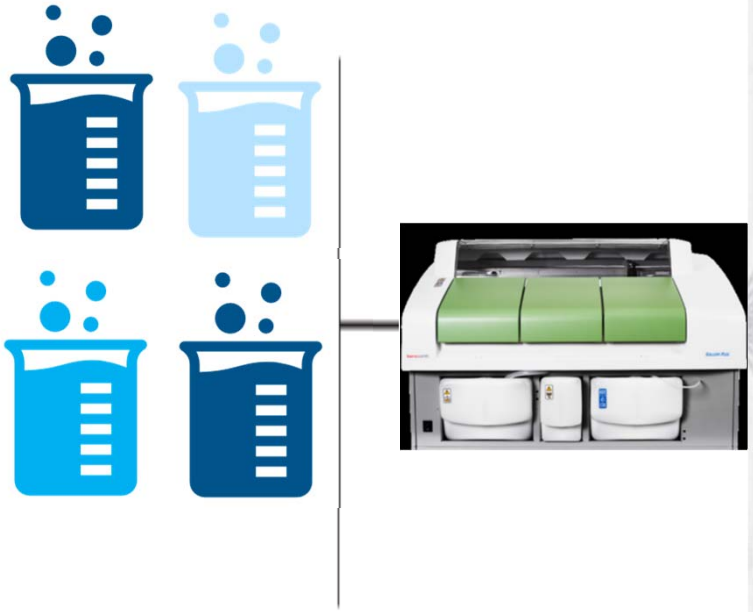
Auto Titration

Flow Injection Analyzer (FIA) or Segmented Flow Analyzer (SFA)

pH/Cond/ Ion Meter

Spectro photometer

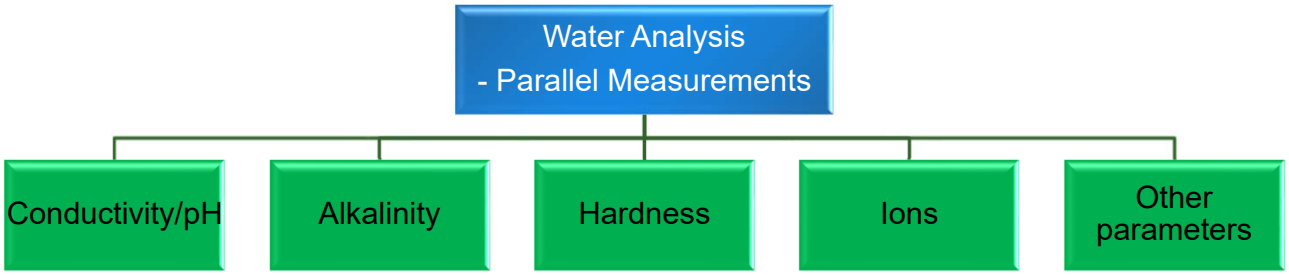
Multiple Parameters – Multiple Instruments



- pH
- Conductivity
- Alkalinity
- Total Hardness
- Silica
- Chloride, Sulfate, Fluoride, Phosphate, Nitrite, Nitrate
- Ammonia, Calcium, Magnesium
- Total Iron
- Hexavalent Chromium
- Zinc, Molybdenum
- Total Phosphate
- Cyanide, Total Cyanide
- Total Phenol
- Total Kjeldal Nitrogen
- Total Oxidizable Nitrogen
- Boron

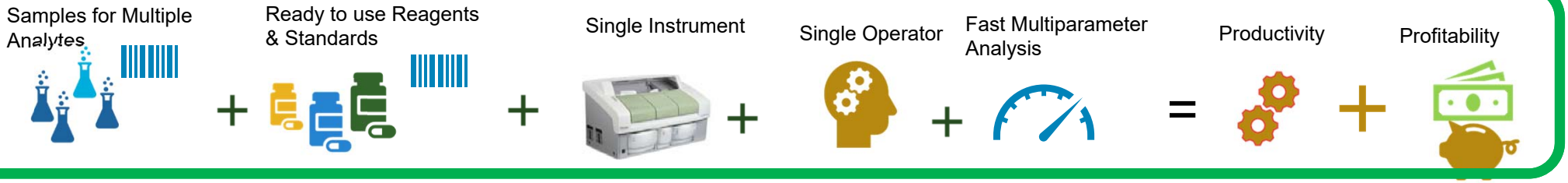
Single Instrument – Many Parameters

Green Workflow – Consolidated Water Analysis



Gallery Platform

- 2µL to 120 µL Reagents
- Max 200µL per test
- Few mL of Waste
- Single Platform
- Fully Automated
- Parallel & Simultaneous analysis
- Multiple parameters per sample
- Reduced cost per analysis



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Thermo Scientific™ Gallery™ Discrete Analyzer Platform

Consolidated testing - Rapid Multiparameter Wet Chemical Analyzer

Single platform – Parallel analysis

1	Colorimetric/turbidimetric
2	Enzymatic
3	Electrochemical

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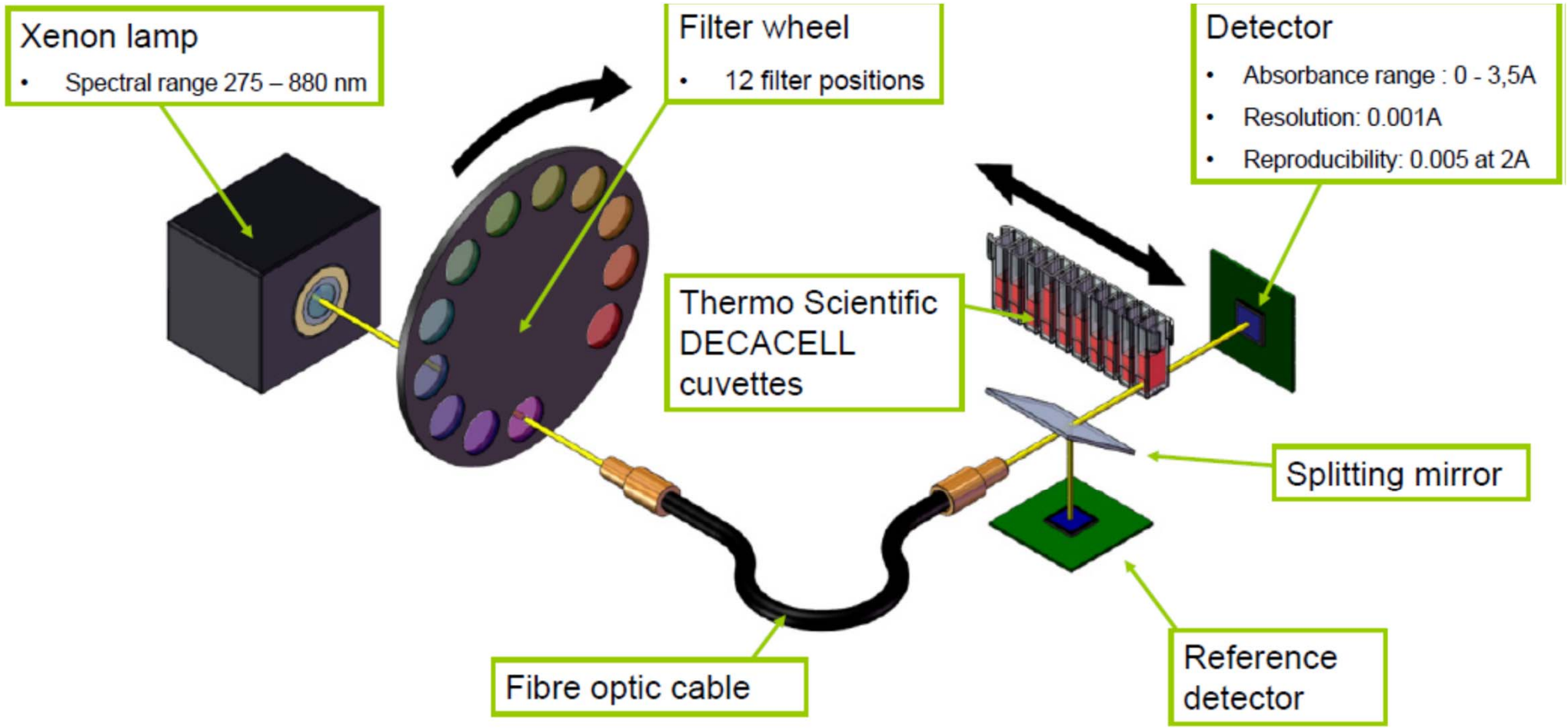
How Does a Discrete Analyzer Work? Method Test Flow



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How Does a Discrete Analyzer work? Method Test Flow

For a basic assay, in this case sulphate

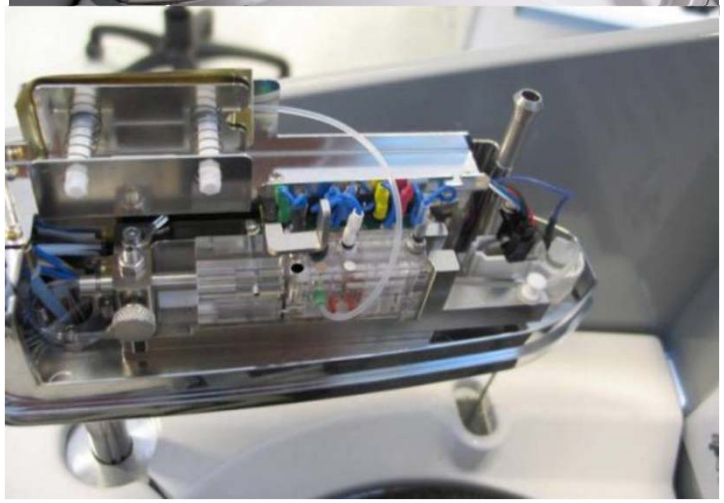
- Add an aliquot of sample
- Shine 420 nm light through the sample and measure the intensity in Absorbance units (AU)
- Add an aliquot of reagent (Barium chloride)
- Wait for and period of time for the reaction to occur (300 seconds)
- Shine 420 nm light through again and the difference in intensity is the absorbance ΔA for each sample

Gallery Discrete Analyzer USEPA Methods

ANALYTE	METHOD DESCRIPTION	METHOD NUMBER
Alkalinity	Buffered methyl orange	310.2 (Rev. 1974)
Ammonia	Alkaline phenate with hypochlorite and sodium nitroprusside	350.1, Rev. 2.0 (1993)
Ammonia	Alkaline dichloroisocyanurate with salicylate and sodium nitroprusside	350.1, Rev. 2.0 (1993)
Chloride	Mercuric thiocyanate in the presence of ferric nitrate	SM4500-Cl E
Chlorine	Phosphate buffer DPD	SM4500-Cl G
Chromium VI	Diphenylcarbazide	SM3500-Cr B
COD	Off line dichromate digestion	410.4, Rev. 2.0 (1993)
Conductivity	Eleectrochemical method	120.1
Copper	Bathocuprione	SM3500-Cu C
Cyanide	Chloramine-T and pyridine barbituric acid	335.4, Rev. 1.0 (1993)
Fluoride	SPADNS	SM4500-F D
Hardness (Total)	Calmagite indicator reaction	130.1 (Issued 1971)
Iron (Ferrous)	Phenanthroline	SM3500-Fe B
Iron (Total)	Phenanthroline	SM3500-Fe B
Nitrate+Nitrite	Hydrazine reduction	SM4500-NO3 H
Nitrate+Nitrite	Vanadium reduction	CFR Part 136.3
Nitrate+Nitrite	Enzymatic reduction	N07-0003
Nitrite	Bypass Enzymatic reduction	N07-0003
Nitrite	Sulphanilamide/NEDD	SM4500-NO2 B
Orthophosphate	Acidic molybdate/antimony with ascorbic acid reduction	365.1, Rev. 2.0 (1993)
Orthophosphate	Acidic molybdate/antimony with ascorbic acid reduction	SM4500-P E
pH	Electrochemical method	150.2
Phenol	Buffered KFCN and 4-AAP	420.1 (Rev. 1978)
Silica	Molybdate/Oxalic/Ascorbic	SM4500-SiO2 C
Sulfate	Turbidimetric barium chloride	ASTM D516-11
Sulfide	Acidic DMPD/Ferric chloride	SM4500-S2 D
Thiocyanate	Acidic ferric nitrate	SM4500-CN M
TKN	Alkaline salicylate with hypochlorite and sodium nitroprusside	351.2, Rev. 2.0 (1993)
TKP	Kjeldahl digested sample molybdate/antimony with ascorbic acid reduction	365.4 (Issued 1974)

Environmental Applications: Parallel pH and Conductivity Measurements

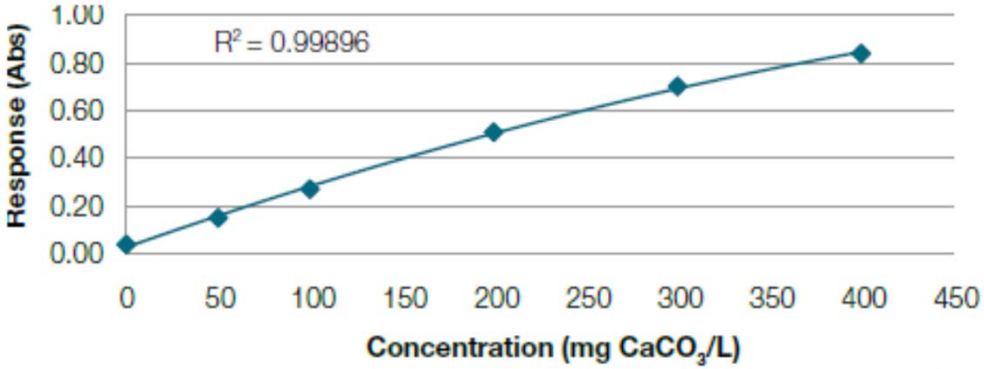
- Integrated Conductivity and pH measurements
- Measuring range for
  - Conductivity 20 µS/cm - 112 mS/cm
  - pH 2 – 12
- Sample types
  - Raw water, ground water, sea water, rain water, municipal water, drinking water and Wastewater
  - Not suitable for DI water or steam condensate



Environmental Applications: Alkalinity

Chemistry: Bromophenol Blue and phthalate buffer pH 3.5

Sample matrix: Drinking, ground, surface, waste and saline water

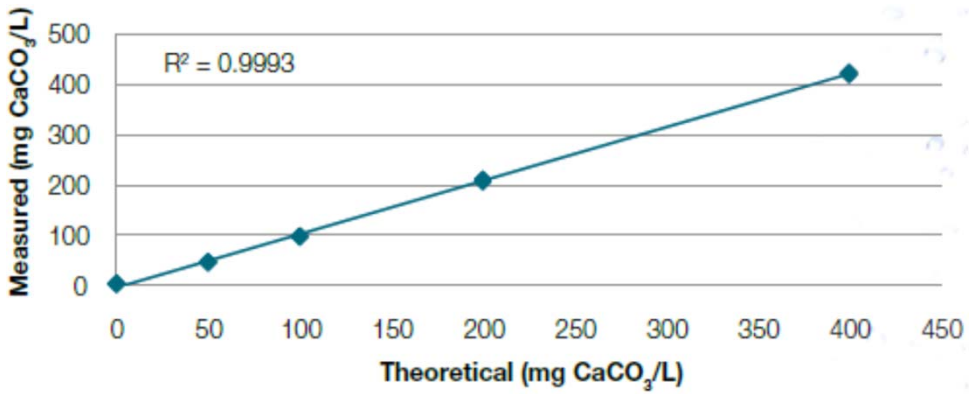


Method Detection Limit (MDL)

Application	Sample	n	Average (mg $CaCO_3$/L)	SD	MDL (mg $CaCO_3$/L)
Alkalinity	blank	7	3.07	1.077	3.4[1]
	blank	50	3.16	0.735	5.4[2]

[1]MDL = 3.14 × SD (blank sample, n=7)
[2]MDL = 3 × SD + average (blank sample, 3 batches, n=30)

	Lake Water (mg $CaCO_3$/L)		Tap Water (mg $CaCO_3$/L)		Lake water (mg $CaCO_3$/L)	
	N	49	N	50	N	50
	Mean	28.8	Mean	32.5	Mean	177.7
	SD	CV %	SD	CV %	SD	CV %
Within	0.725	2.5 %	0.849	2.6 %	1.287	0.7 %
Between	0.626	2.2 %	0.196	0.6 %	4.462	2.5 %
Total	0.958	3.3 %	0.871	2.7 %	4.644	2.6 %



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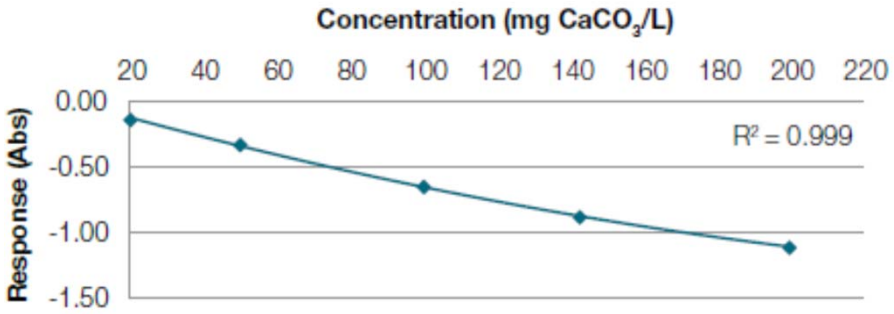
Environmental Applications: Total Hardness

Chemistry: Calmagite

Sample matrix: Drinking, ground, surface, waste and saline water

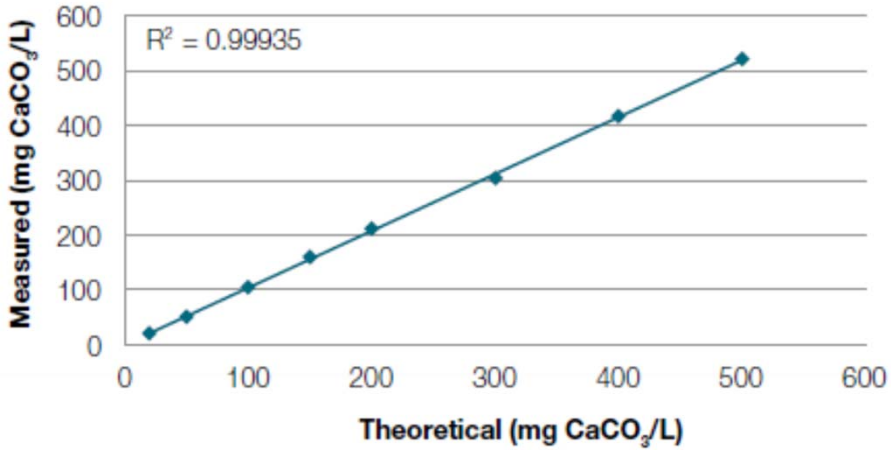


Method Detection Limit (MDL)

Application	Sample	n	Average (mg/L $CaCO_3$)	SD	MDL (mg/L $CaCO_3$)
THardness	blank	7	7.6	0.637	2[1]
	blank	50	7.7	0.612	10[2]

[1]MDL = 3.14 × SD (blank sample, n=7)
[2]MDL = 3 × SD + average (blank sample, 5 batches, n=50)

	Tap water (mg $CaCO_3$/L)		Spiked tap water (mg $CaCO_3$/L)		Ground water (mg $CaCO_3$/L)	
	N	50	N	50	N	50
	Mean	52	Mean	157	Mean	82
	SD	CV %	SD	CV %	SD	CV %
Within	0.762	1.5 %	1.668	1.1 %	0.835	1.0 %
Between	0.620	1.2 %	2.494	1.6 %	1.348	1.6 %
Total	0.983	1.9 %	3.001	1.9 %	1.586	1.9 %



References: EPA 130.1

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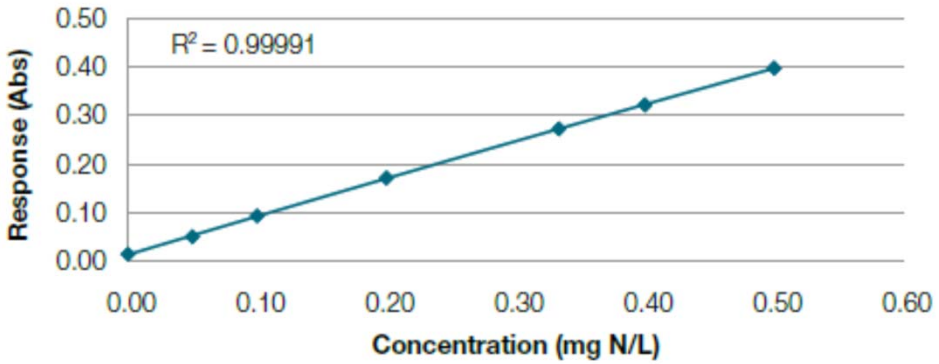
Environmental Applications: Total Oxidized Nitrogen (TON Enzymatic)

Chemistry: Nitrate reductase
Sample matrix: Drinking, ground, surface, waste and saline water



Method Detection Limit (MDL)

Application	Sample	n	Average (µg/L)	SD	MDL (µg/L)
TON Enz	Blank	7	0.075	0.112	0.351[1]

[1]MDL = 3.14 × SD (blank sample, n=7)

References: ASTM D7781-14, EPA 40 CFR Part 141

- A rapid, non-toxic alternative
  - Sample preparation is simplified
  - Detection range is flexible
  - Reduce costs in reagent usage and waste disposal

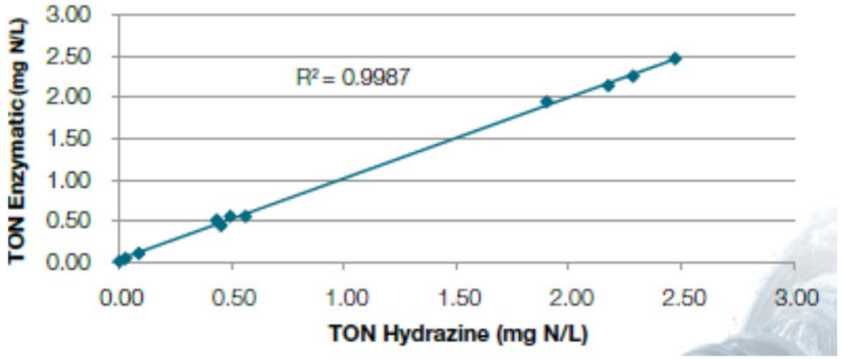
Environmental Applications: Total Oxidized Nitrogen (TON Enzymatic)

Chemistry: Nitrate reductase
Sample matrix: Drinking, ground, surface, waste and saline water

Measuring range

Application	Range	Extended measuring range (dil. 1+4)
TON Enz	*- 0.5 mg N/L	Up to 2.5 mg N/L

Method Comparison: TON Hydrazine



Resource: Automated nutrient analysis and water quality monitoring

Green Workflow – Consolidated Water Analysis

Why Gallery Analyzer

- Walkaway solution
- Reduced cost per analysis
- System uptime and reliability
- Ease of use

---------- How ----------

Speed of analysis
- Parallel pH and conductivity measurements
- Integrated analytics – multiparameter by single instrument

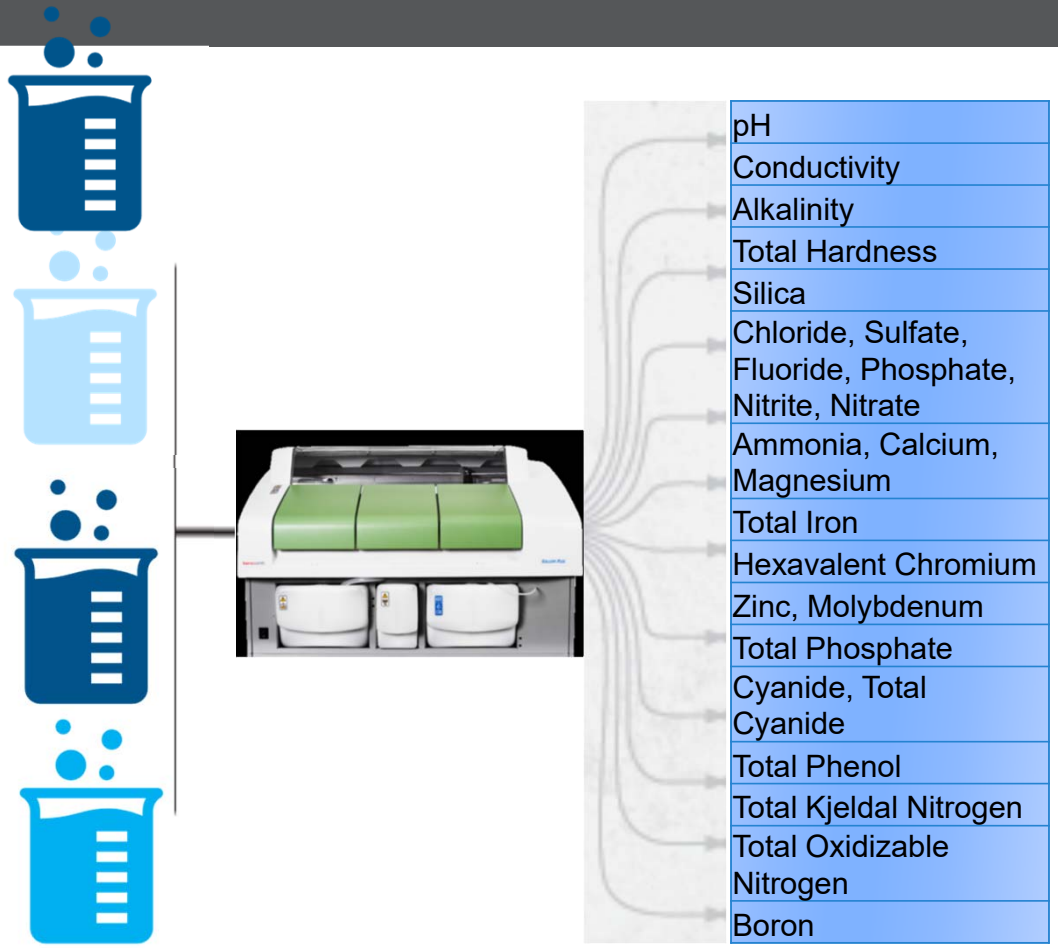
Get more done with less
- Very low sample volume
- Reduced reagent consumption - 1/100th to 1/1000th compared to traditional wet chemistry
- Reduced waste disposal cost

Robust instrument
- No cross contamination due to disposable cuvettes
- Long life Xenon source lamp

Workflow based operation
- Don’t need skilled operator
- Built in barcode reader
- Bi-directional LMS

Consolidate Your Water Analysis

Special Limited Time Offer



Single Instrument – Many Parameters

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Thank You

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