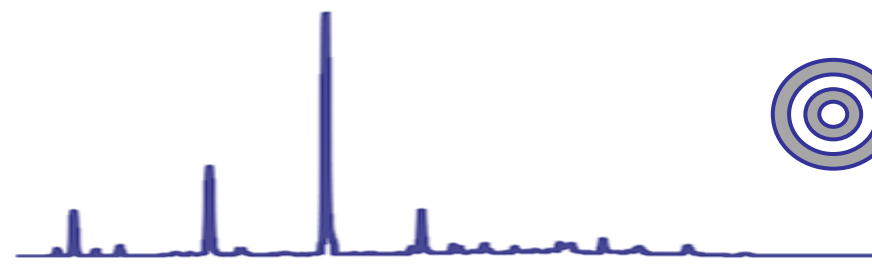
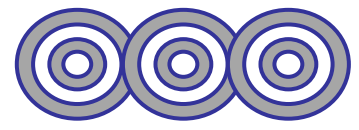


Introduction to Environmental Analysis



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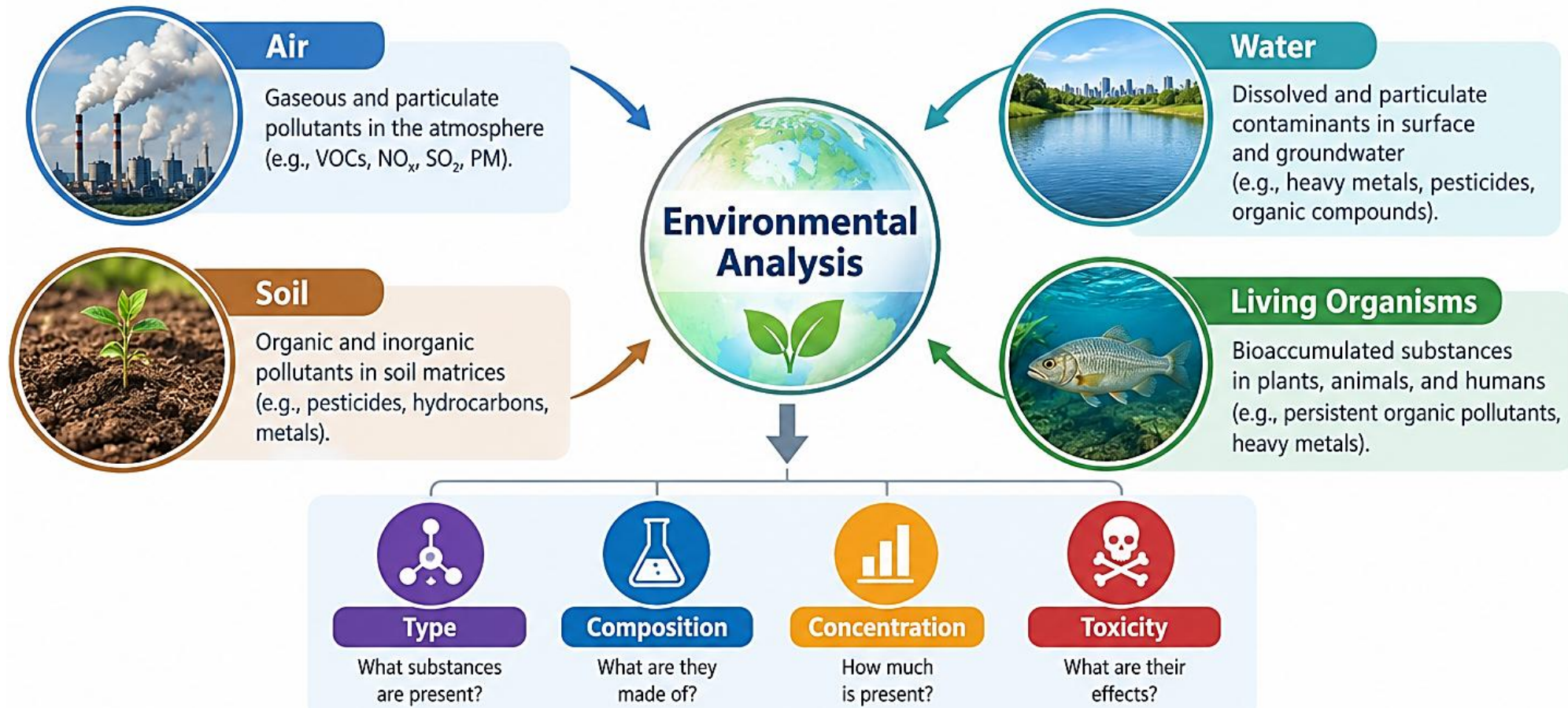


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What is Environmental Analysis?

Environmental analysis is the process of investigating and assessing the **type**, **composition**, **concentration**, and **toxicity** of chemical substances within various environmental matrices like **air**, **water**, **soil**, and **living organisms**.



Environmental analysis applies analytical chemistry to **identify, measure, and evaluate** chemical substances in environmental samples.

Environmental analysis provides qualitative and quantitative information about pollutants, contaminants, nutrients, and naturally occurring species.



Qualitative information



Quantitative information



Pollutants



Contaminants



Nutrients



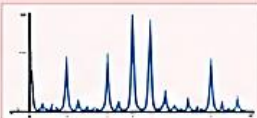
Naturally occurring species

Central Questions



What is present?

Which substances are in the sample?



- Identify
- Characterize
- Confirm



How much is present?

What are the concentrations or levels?



- Quantify
- Compare
- Assess



Where is it present?

In which locations and matrices?



- Spatial distribution
- Source tracking
- Transport



How reliable is the measurement?

Are the results accurate, precise, and defensible?



- QA/QC
- Method validation
- Uncertainty

Objectives of Environmental Analysis

1. Detect and identify environmental contaminants.

2. Quantify pollutants at relevant concentration levels.

3. Assess air, water, and soil quality.

4. Identify pollution sources and contamination pathways.

5. Evaluate spatial and temporal changes in environmental quality.

6. Compare measured concentrations with standards and guideline values.

7. Generate defensible data for environmental management and decision-making.

Results of environmental analysis support



Environmental Monitoring

Track changes over time
and space



Pollution Assessment

Identify sources
and extent



Risk Assessment

Evaluate potential
human and ecological risks



Regulatory Compliance

Meet legal standards
and guidelines



Treatment

Remove or reduce
contaminants



Remediation

Restore environmental
quality

Major Environmental Sample Types

Air	Water	Soil and sediment	Waste	Biological samples
Gases, vapors, aerosols, particulate matter	Drinking water, surface water, groundwater, wastewater	Minerals, organic matter, metals, organic contaminants	Municipal, industrial, hazardous, solid wastes	Plants, tissues, microorganisms, biomonitoring samples

Major Classes of Environmental Pollutants

Inorganic pollutants	Organic pollutants	Emerging contaminants	Particulate pollutants
Heavy metals, metalloids, nutrients, and toxic inorganic ions	VOCs, pesticides, PAHs, PCBs, and petroleum compounds	Pharmaceuticals, PFAS, endocrine disruptors, and microplastics	PM10, PM2.5, aerosols, and suspended solids

What Do Environmental Analysts Measure?

Environmental analysts measure chemical substances, chemical properties, physical properties, and biological indicators to characterize environmental quality and assess contamination.

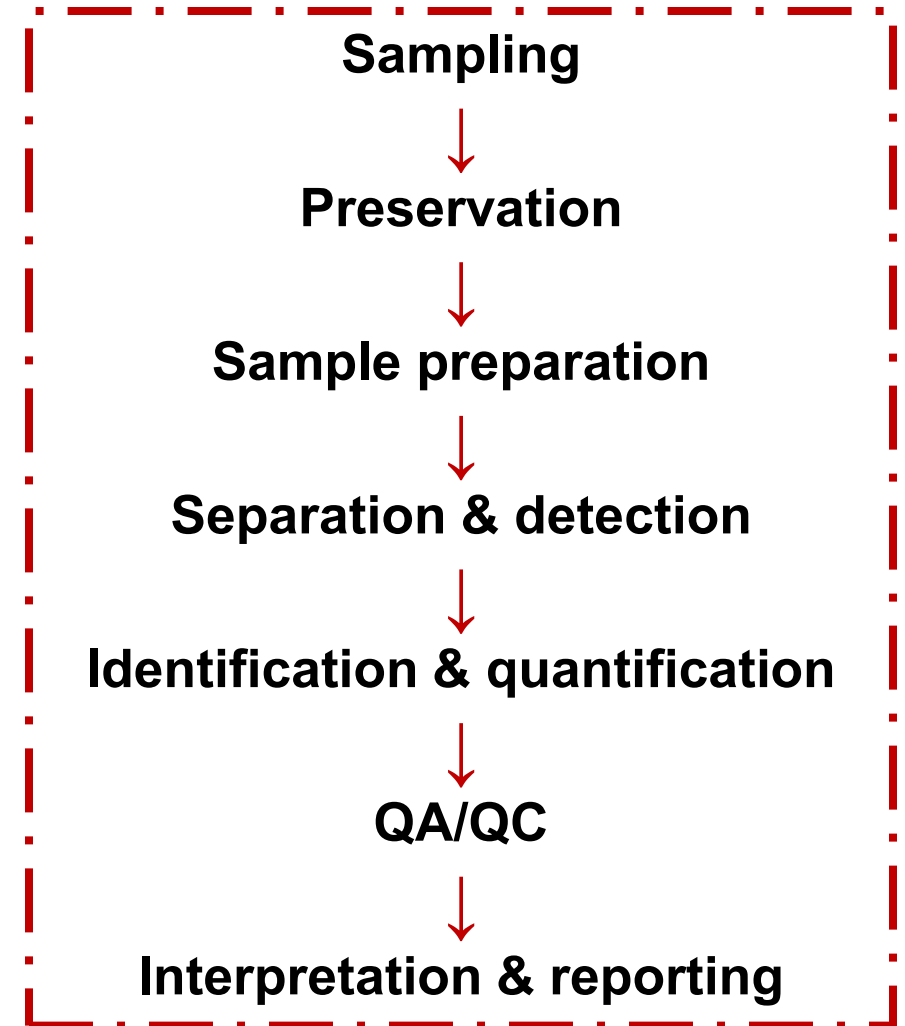
Chemical Substances	Identify and quantify pollutants, contaminants, nutrients, and naturally occurring chemical species. Examples: heavy metals, metalloids, cyanide, fluoride, pesticides, PFAS, nitrate, phosphate, VOCs, PAHs, hydrocarbons, pharmaceuticals, minerals.
Physical Properties	Measure physical characteristics that describe the condition and quality of environmental matrices. Examples: temperature, turbidity, color, conductivity, total suspended solids, particle size, particulate matter.
Chemical Properties	Determine chemical characteristics that describe the composition and behaviour of environmental samples. Examples: pH, acidity, alkalinity, dissolved oxygen, hardness, salinity, chemical oxygen demand, oxidation-reduction potential, organic carbon.
Biological Indicators	Assess organisms, biological responses, or biological substances that indicate environmental quality or contamination. Examples: microorganisms, algae, chlorophyll biomarkers, bioaccumulated contaminants.

The Environmental Analytical Workflow

The environmental analytical workflow is a systematic sequence of steps used to collect, prepare, analyze, and interpret environmental samples/matrices (chemical or biological pollutants) to obtain reliable information about chemical substances and contaminants.

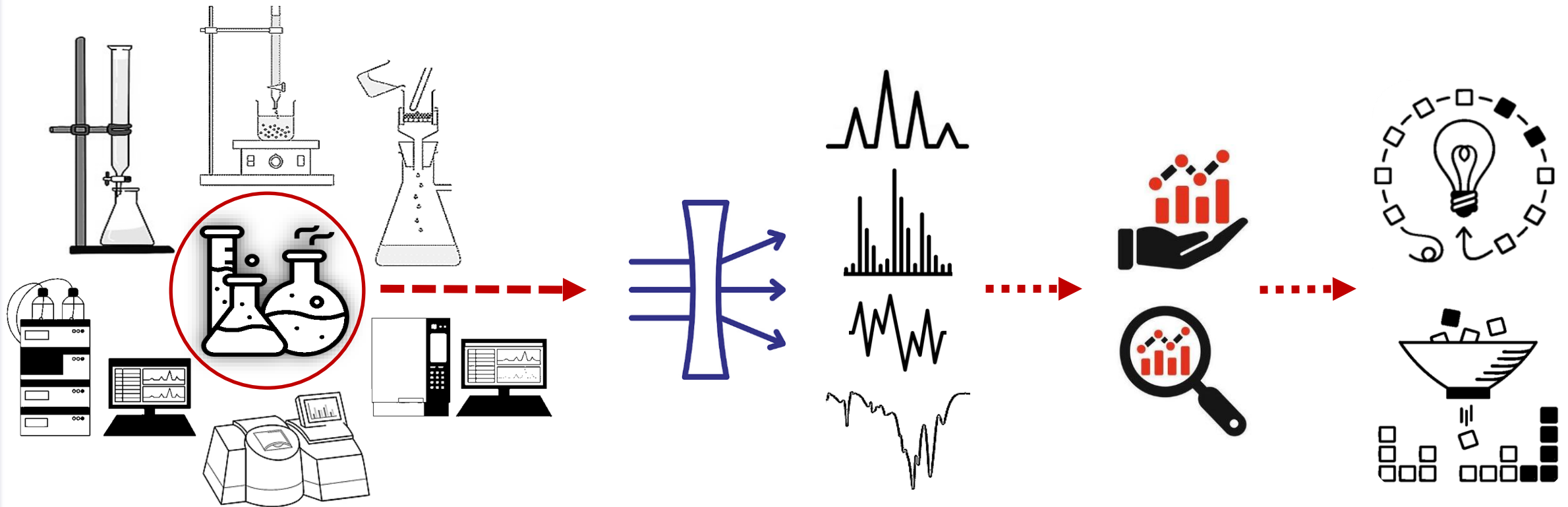
Every stage can introduce uncertainty, contamination, analyte loss, challenges, or bias.

Reliable environmental data depend on the complete workflow - not only on the analytical instrument.



Chemical Analysis

A branch of chemistry focused on the **qualitative** and **quantitative** determination of chemical components in materials, as well as the development of tools and methods used to analyze **chemical composition**.



Chemicals,
apparatus,
equipment, &
instruments

Numbers,
units, &
concentration
expressions

Chemical
calculations,
stoichiometry,
& equilibrium

Errors in
chemical
analyses &
measurements

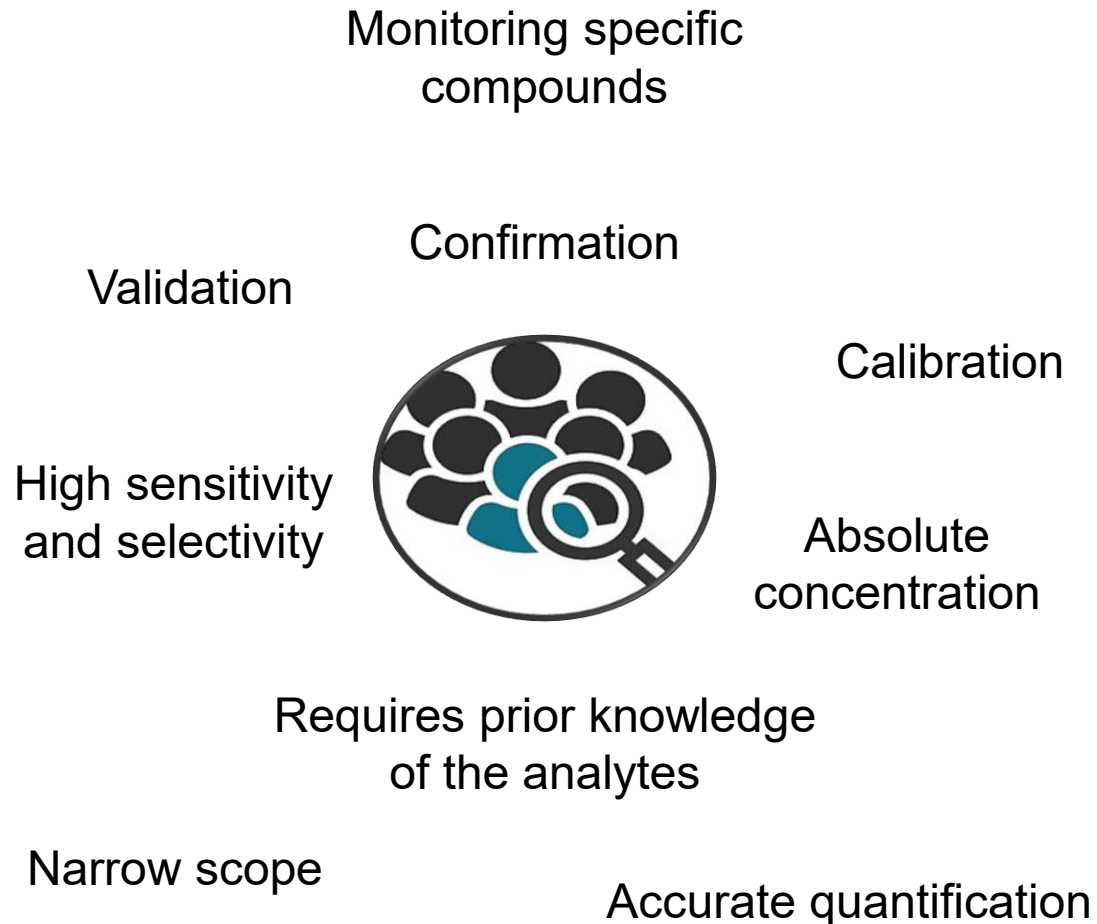
Sampling,
standardization,
& calibration

Methods
development
& validation

Statistical
data
treatment &
evaluation

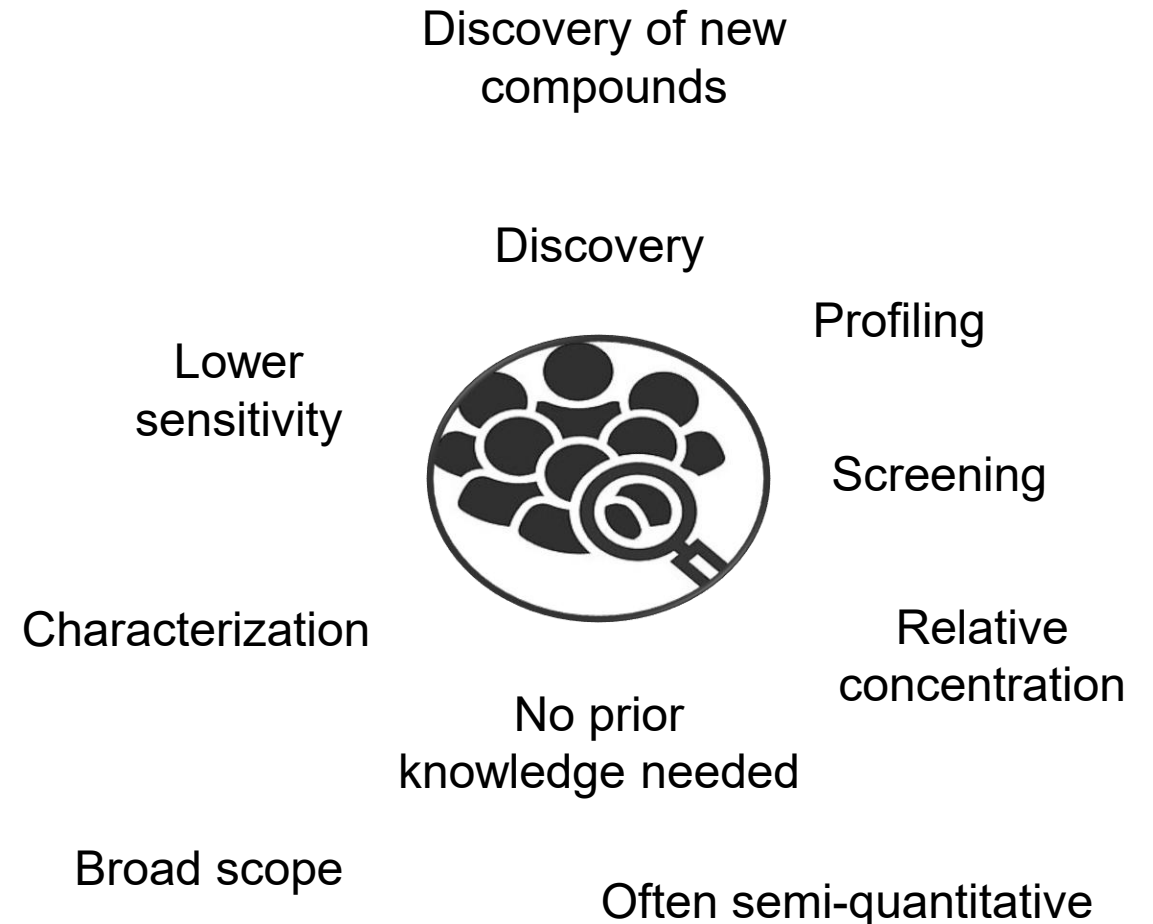
Targeted Analysis

To measure a specific, pre-defined set of specific and known compounds



Untargeted Analysis

To detect all measurable compounds in a sample, even those that are unknown



Main Analysis Steps

1 Sample Collection

Obtain representative samples from the environment using appropriate sampling methods and containers.



Water



Soil



Air



Biota

- Plan sampling strategy
- Use clean, appropriate containers
- Avoid contamination
- Record metadata (location, time, etc.)

2 Sample Pretreatment

Prepare the sample to isolate, concentrate, and remove interferences before analysis.



Filtration

Extraction

SPE

- Filtration / separation
- Extraction (e.g., LLE, SPE, SPME)
- Concentration
- Cleanup (remove matrix effects)

3 Instrument Detection

Analyze the prepared sample using suitable analytical instruments and techniques.



GC-MS



HPLC



ICP-MS

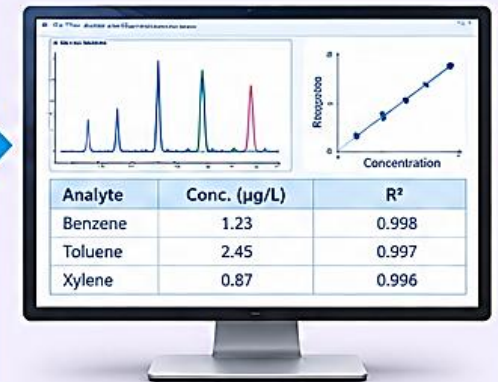


AAS

- Select appropriate technique
- Optimize instrument conditions
- Ensure proper calibration
- Acquire high-quality data

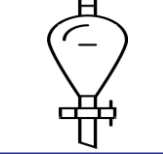
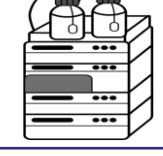
4 Data Processing

Evaluate and interpret the results to obtain the concentration, identity, and quality of analytes.



- Process chromatograms / spectra
- Identify compounds (libraries, standards)
- Quantify using calibration
- Assess data quality
- Report and interpret results

Steps in Chemical Analysis

Target	Define the problem, what is the problem, what we need to found, qualitative and/or quantitative, objectives, what will the information be used for and who will use it, when will it be needed, how accurate and precise does it have to be, what is the budget, ...etc.	
Method	Select a method, sample type, size, sample preparation needed, concentration, range, sensitivity needed, selectivity, interferences, accuracy, precision, tools, instruments, expertise, experience, cost, speed, manual or automated, literature, standard, regulations that need to be followed, ...etc.	
Sampling	Sample collection, obtain a representative sample, sample type, homogeneity, size, statistics and errors, physical state, solid, liquid, gas, dissolve, ash or digest, ...etc.	
Preparation	Sample preparation and extraction, separation and avoiding matrix effect needed, need to concentrate the analyte, preconcentration, need to change and derivatize the analyte, need to adjust solution conditions, pH, add reagents, ...etc.	
Separation	Perform any necessary separations, distillation, precipitation, extraction, solid phase extraction, chromatography, electrophoresis, ...etc.	
Instrument	Perform the measurement (instrument), calibration, validation, controls, blanks, replicates, ...etc.	
Data	Analyzing data and interpreting results, statistical analysis, reliability, critically evaluate results, validation, report results with limitations/accuracy information, interpret carefully for intended audience, ...etc.	

Time Taken for a Typical Analysis

Sample collection



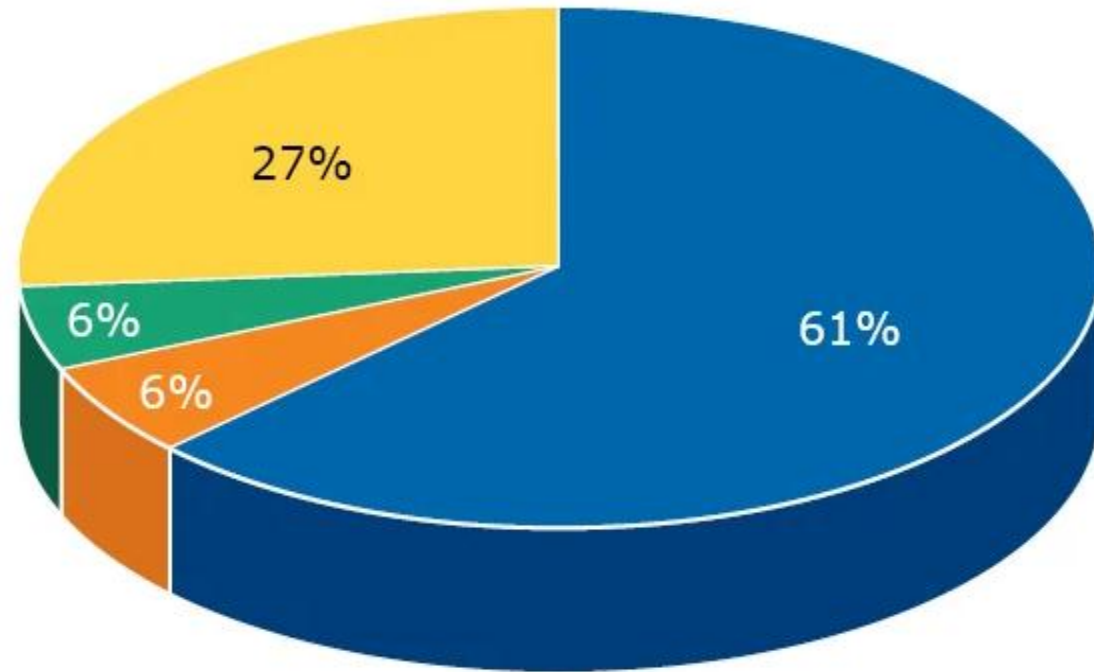
Sample preparation



Sample analysis

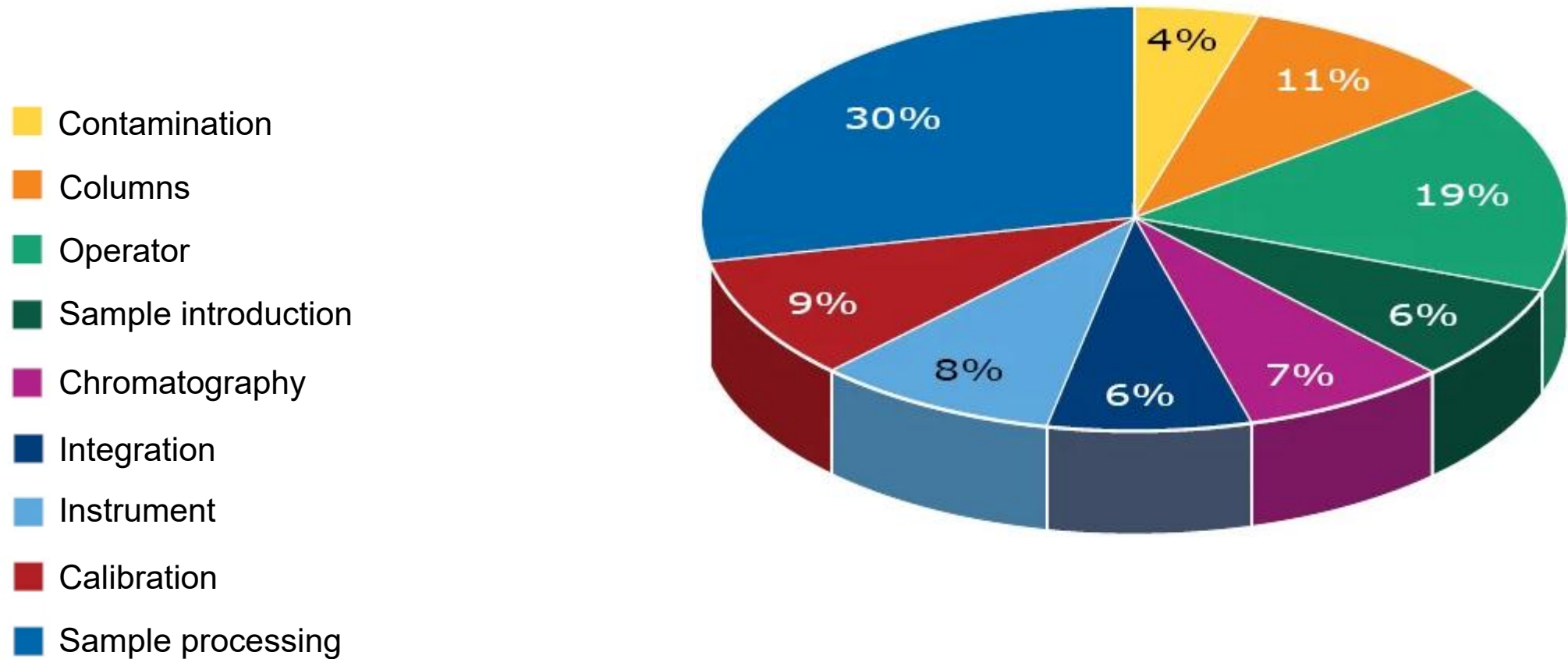


Data processing



- Sampling and sample collection
- Sample preparation and extraction
- Sample analysis
- Data processing management

Sources of Error Generated During Typical Chromatographic Analysis



The Most Common Analytical Challenges

Challenge Area	Common Problem	Effect on Analysis
Sampling and sample collection	-Obtaining a representative sample -Sample contamination -Analyte loss or degradation	-Non-representative data -Biased data -Poor analytical precision
Sample preparation and extraction	-Matrix interferences -Sample size -Contamination -The targeted analytes at trace levels -Time-consuming & laborious processes	-Signal suppression or enhancement -Low accuracy, interference -Poor recovery, variability -Loss of analyte -Matrix interference
Instrumentation (measurement)	-Instrument calibration errors -Low instrument sensitivity -Instrument drift or malfunction	-Noise, baseline drift, signal distortion -Quantitation errors -Poor resolution -False peaks, low recovery -Instrument instability
Data analysis	-Inappropriate statistical analysis -Lack of proper quality assurance & control -Managing large, complex datasets	-Misinterpretation -Incorrect conclusions -Wrong identity -Poor statistics -Low confidence

Thank You!

