COURSE ON INTRODUCTION AND APPLICATION OF ENVIRONMENTAL FORENSICS

Environmental Forensics

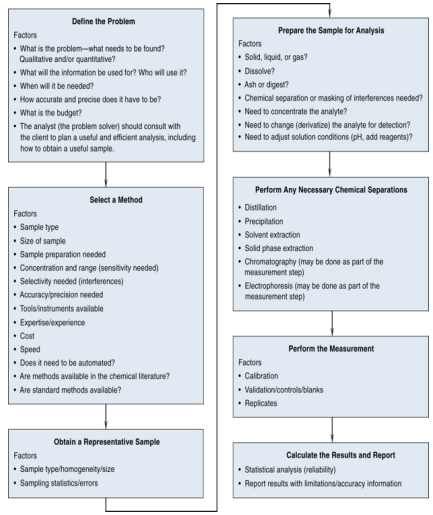
Lecture 1: Introduction of Environmental Forensics

Prof. Dr. Ahmad Zaharin Aris, CEnv, MRSC, FGS
Faculty of Environmental Studies
Universiti Putra Malaysia

An analysis involves several steps and operations which depend on:

- **the particular problem**
- **your expertise**
- **the apparatus or equipment available.**

The analyst should be involved in every step.

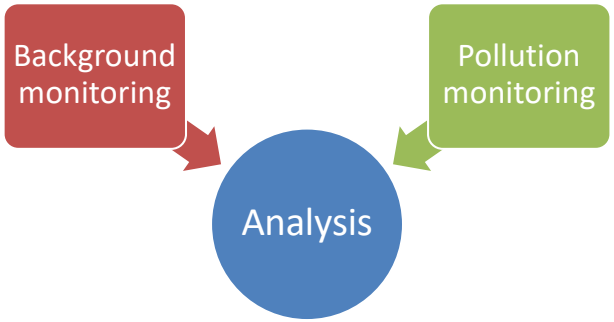


Environmental analysis

The purpose of environmental analysis is two-fold:

- To determine the background and natural concentrations of chemical constituents in the environment
- To determine the concentration of harmful pollutants in the environment

Environmental analysis



Background monitoring

Useful in studies of general environmental processes and for establishing concentrations against which any pollution effects could be assessed

It is however, a fact that pollution has now affected even the most remote areas of the globe, and true background levels of many substances are becoming increasingly difficult to determine

Background monitoring

Objectives of pollution monitoring

- To identify potential threats to human health and natural ecosystems
- To determine compliance with national and international standards
- To inform the public about the quality of the environment and raise public awareness about environmental issues
- To develop and validate computer models (validate simulate process)
- To provide input data (i.e GIS) – aid for expert systems
- To provide inputs to policy making decisions
- To investigate the pollution trend

Environmental analysis

Is often used in EIA studies

- As part of EIA, it is often necessary to establish the baseline concentrations of various substances at the study area
- So that potential impacts may be assessed

Is also integral to environmental forensics

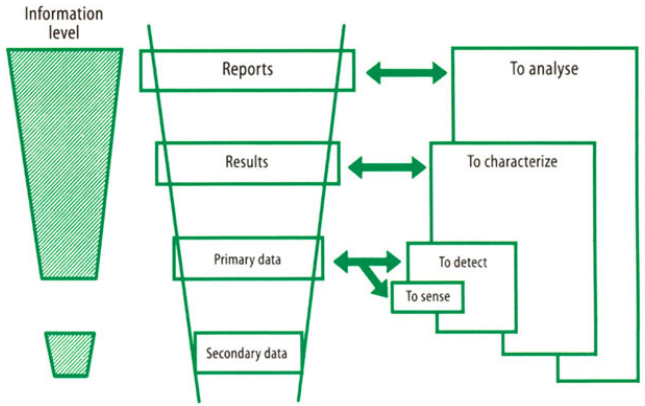
- Forms and important part of environmental law
- Involve fingerprinting pollutant releases to determine the source and cause of contamination

Environmental Forensics

Environmental forensics includes investigating, interpreting and presenting evidence of source, fate, transport, composition, age, and extent of or responsibility for contamination of all environmental media (i.e. air, soil, water or biota).

"The application of scientific methods used to identify the origin and timing of a contaminant release"

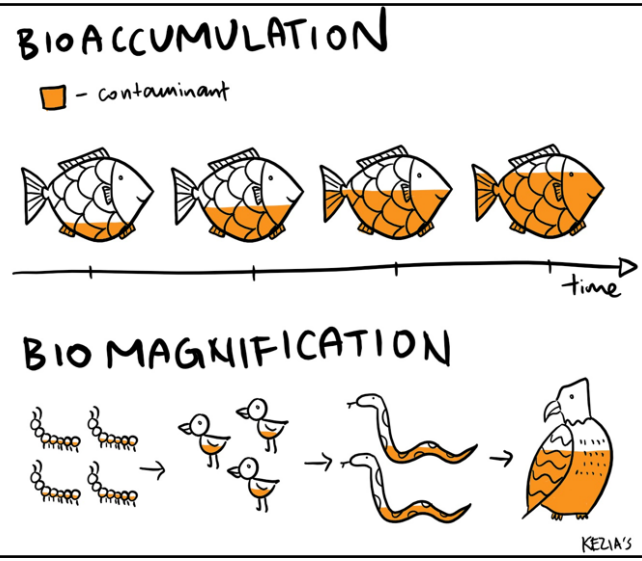
Hierarchies for chemical information



The rank

The rank of the analytical information produced also increases from the term "to sense" to the verb "to analyse":

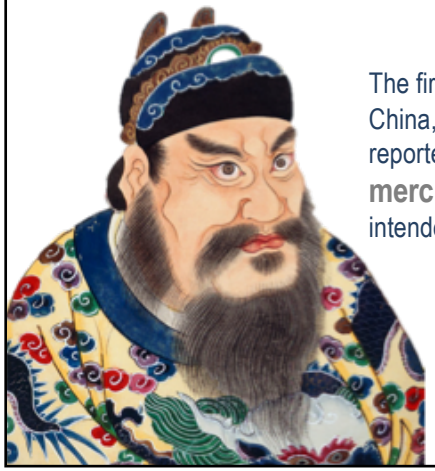
- To sense involves using a device responsive to the presence (and concentration, if applicable) of a (bio)chemical species in a sample.
- To detect involves the direct use of an instrument to acquire or produce a signal and transduce it into a readily measured physical (usually electrical) quantity. This function is served by instruments (e.g. photometers, potentiometers, balances), which produce primary data (e.g. absorbance, electrical potential or mass units). Indirectly, instruments are the basis for sensors.
- To characterize entails establishing distinct features of an object or system in order to define it on the basis of results obtained by mathematical processing of primary data produced by an instrument.
- To analyse involves interpreting - in addition to characterizing - in qualitative, quantitative and structural terms, which entails converting results into reports.



Essentiality and Toxicity of Metals

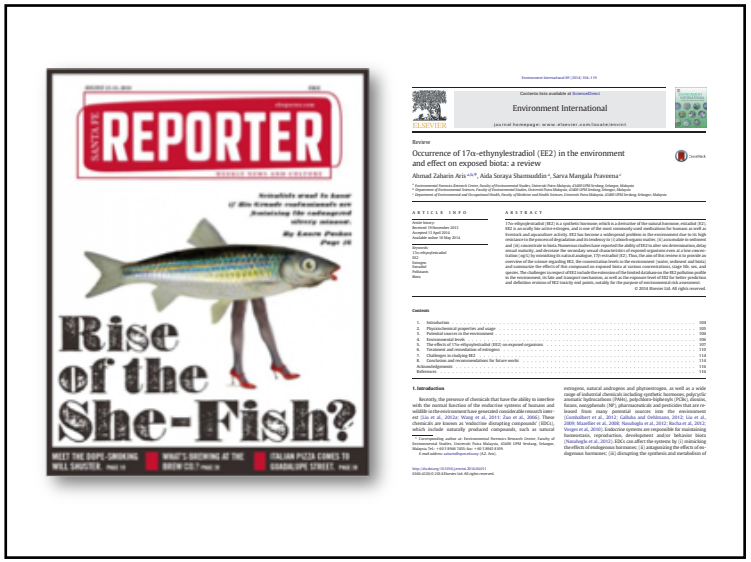
Many metals are of concern because of their toxic properties and some metals are also essential for survival and health of animals and humans.

First ever recorded case – toxicity of metals and forensics evidence



The first emperor of unified China, Qin Shi Huang, it is reported, died of ingesting **mercury** pills that were intended to give him eternal life.

7 February 260 BC - 10 August 210 BC (age 50)

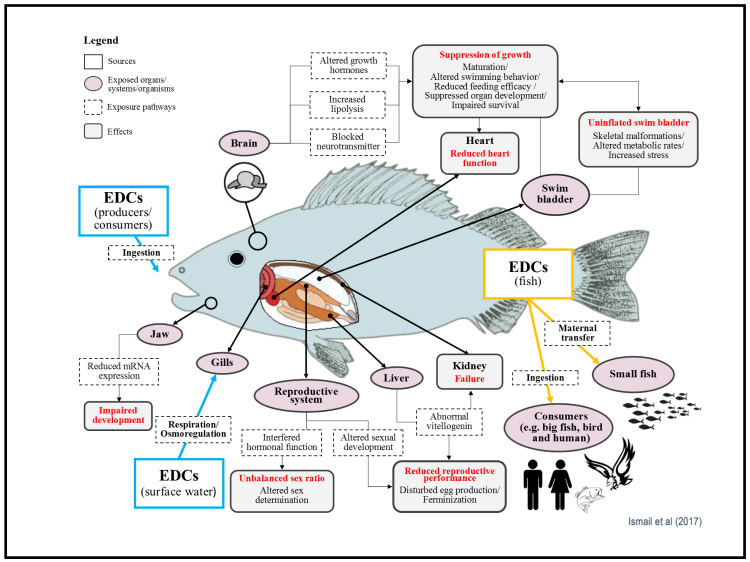


Environment International

Review

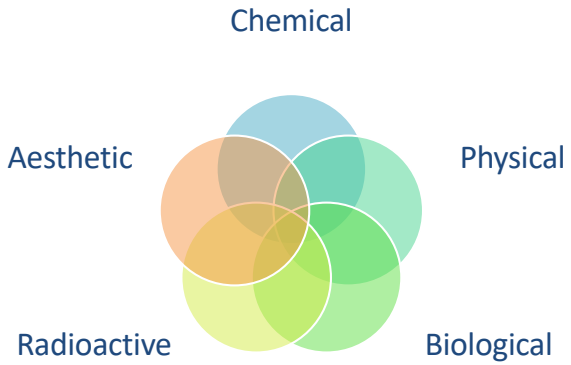
Occurrence of 17α-ethynylestradiol (EE2) in the environment and effect on exposed biota: a review

Ahmad Zaharin Aris, Aida Soraya Shamsuddin, Sarva Mangala Praveena



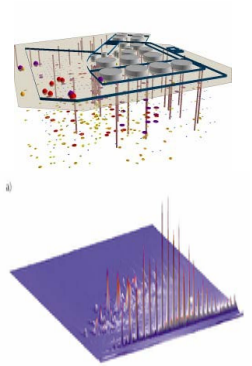
Types of pollution

Different types of pollution



Components of an Environmental Forensics Project

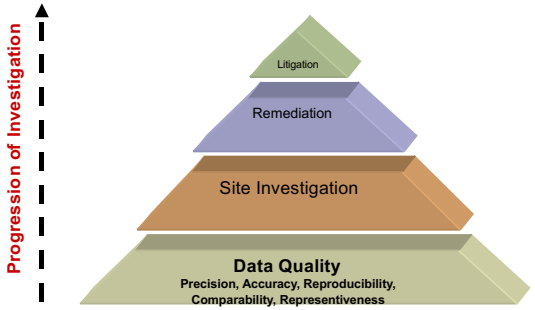
- Compilation of historical information
  - Chemical
  - Physical (satellite maps, GIS, geological features)
- Collection of site specific data and of current data
- Interpretation (data analysis, modelling)
- Visualization



Disciplines in Environmental Forensics

- Chemistry
- Statistics
- Environmental Engineering
- Microbiology
- Hydrogeology
- Soil Science
- Toxicology
- Biology
- Ecology
- Litigation Experience
- And others….

The Foundation of All Environmental Investigations



Lifecycle of Forensics Project

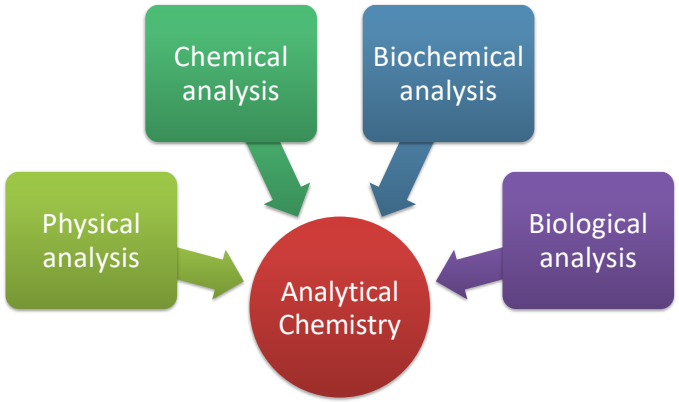
- Review available data to **determine goals of investigation**
- Field sampling, investigation, data gathering, sampling strategy, QA-QC
- Choose laboratory with appropriate analyte list (non-routine)
- Develop QA-QC for external laboratory evaluation
- Data analysis and statistical assessment
- Data compilation and development of conclusion

Forensics work is not completed in the same fashion as routine environmental investigations.

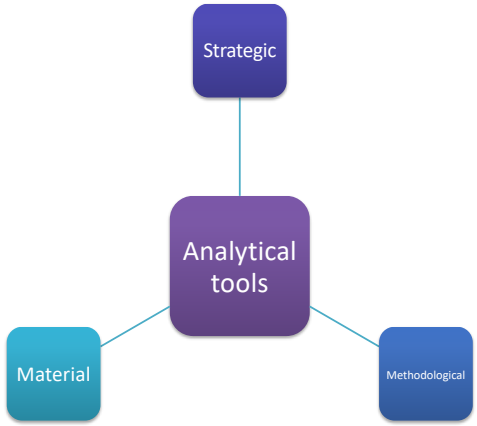
Analytical chemistry

"Analytical chemistry is a metrological science that develops, optimizes and applies measurement processes intended to derive quality (bio)chemical information of global or partial type from natural or artificial objects or systems in order to solve analytical problems"

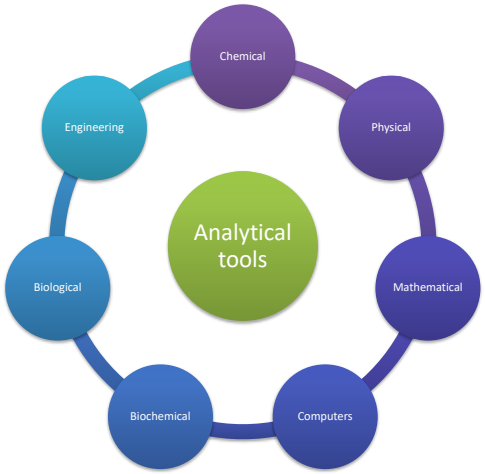
Placement of analytical chemistry



Types of the analytical tools



Nature of the analytical tools



Analytical chemistry: tools

- **Chemical**: reagents, chemical reactions
- **Biochemical**: immobilized enzymes, immunoassay reagents
- **Physical**: laser sources, apparatuses, instruments, balances
- **Mathematical**: statistical treatment of primary data
- **Computers**: software for data acquisition and processing
- **Biological**: animal and plant tissues for building sensors
- **Engineering**: large-scale processes adapted for micro scale implementation (e.g. supercritical fluid extraction, freeze drying)

Analytical chemistry: information produced

- **Chemical**: the presence or concentration of inorganic or organic species; the structure of a material; changes in the properties of the material surface (e.g. by effect of corrosion)
- **Biochemical**: the presence, concentration or activity of biochemical species such as enzymes or nucleic acids
- **Biological**: the presence or concentration of microbes or allergens

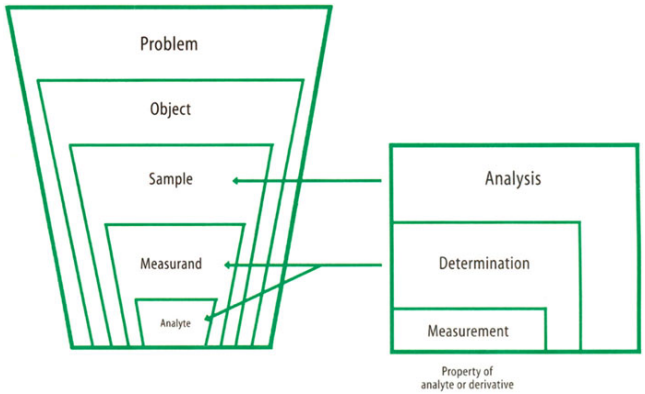
Types of analysis

The chemical substance being determined in a sample is called an analyte (i.e atom, ion). Samples are "analysed" whereas analytes are "determined"

Chemical analysis

May also be categorized with respect to the type of substance being analyzed.
Inorganic analysis - concerned with the determination of atoms and inorganic compounds
Organic analysis – involves the determination of organic compounds

Hierarchies topped by problem



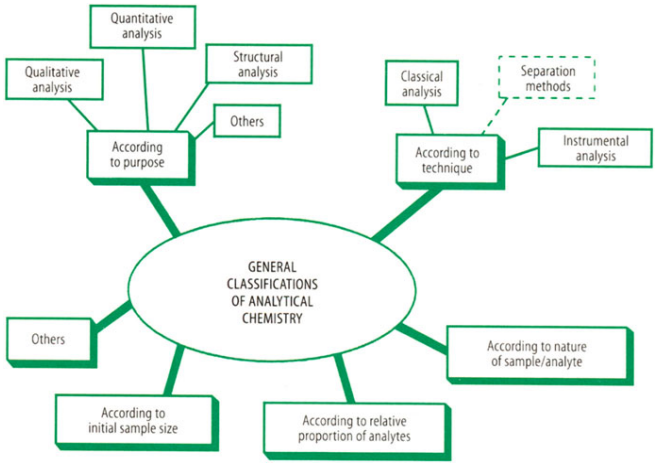
Quantity, measurand and analyte

Quantity : An attribute of phenomenon object or substance that can be distinguished qualitatively and determined quantitatively

Measurand : A quantity that is measured via a comparison that provides the required information. It is equivalent to quantity in the physical domain.

Analyte : A chemical species (element, ion, molecule, radical) that can be identified (and its amount or concentration determined) via a chemical measurement process.

Classifications



Types of analysis

Qualititative analysis

Quantitative analysis

Qualitative analysis and Quantitative analysis

Qualitative

Concerned with the identification (i.e determining the nature) of a chemical substance

Quantitative

Concerned with the quantification (i.e determining the amount) of a chemical substance

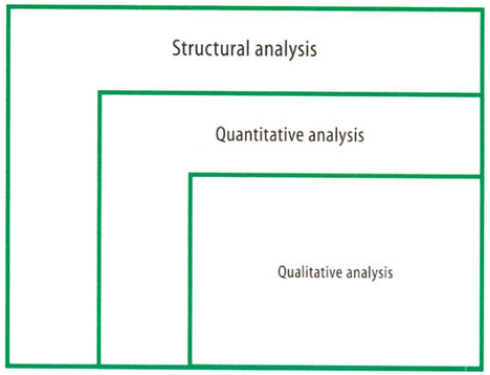
The former answers the question:

"Which substance is present ?"

while the later answers the question:

"How much is present ?"

Scope



- **Qualitative analysis identifies a property of the analyte (or its reaction product), quantitative analysis measures it in numerical units and structural analysis interprets it.**

Quantitative

- Results of quantitative analysis are generally expressed in terms of concentration
- Concentration is quantity of analyte (g, kg, mg/l etc)
- Obviously – involves identification as well as quantification since a numerical value must be ascribed to a particular substance

For example

- Qualitative analysis may simply tell us whether Hg is present in a sample of waste effluent, whereas quantitative analysis will tell us exactly how much mercury is present in the effluent.

Quantitative analysis categories

Complete analysis

- Each and every constituent of the sample is determined

Ultimate analysis

- Each and every element in the sample is determined without regarding to the compounds present

Partial analysis

- The amount of one or several, but not all, constituents in a sample is determined

Desctructive analysis

- The use of method, or technique, which destroy the substance in question during analysis (e.g. dissolution of solid sample into acid)

Non Desctructive analysis

- Does not destroy the sample during analysis (e.g X-Ray fluoresence) and the sample may be re-used for other analyses

Speciation

- Determination of all the different forms of a class of compounds in a sample. (e.g speciation of mercury)

Categorizing

Another way of categorizing types of analyses is according to the level of the substance in the sample

Macroanalysis

- The determination of major constituents present at high concentration (%)

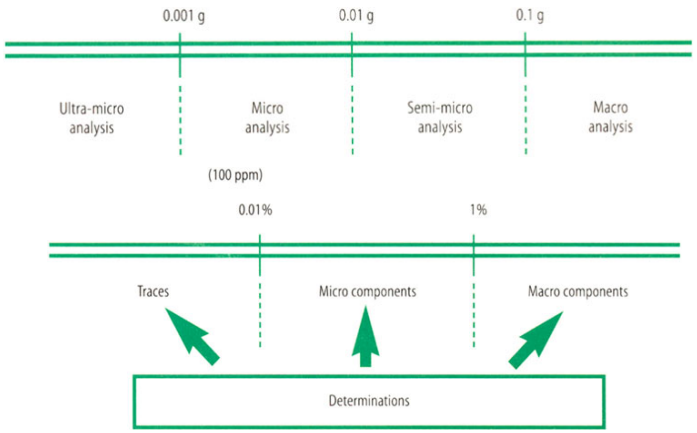
Microanalysis / Trace analysis

- The determination of constituents present in very small quantities (0.1 ppb – 100 ppm)

Ultra trace analysis

- The determination of constituents present at levels lower than in trace analysis (< 0.1 ppb)

Types of (bio)chemical determination



Different methods provide a range of precision, sensitivity, selectivity, and speed capabilities.

Method	Approx. Range (mol/L)	Approx. Precision (%)	Selectivity	Speed	Cost	Principal Uses
Gravimetry	$10^{-1}-10^{-2}$	0.1	Poor–moderate	Slow	Low	Inorg.
Titrimetry	$10^{-1}-10^{-4}$	0.1–1	Poor–moderate	Moderate	Low	Inorg., org.
Potentiometry	$10^{-1}-10^{-6}$	2	Good	Fast	Low	Inorg.
Electrogravimetry, coulometry	$10^{-1}-10^{-4}$	0.01–2	Moderate	Slow–moderate	Moderate	Inorg., org.
Voltammetry	$10^{-3}-10^{-10}$	2–5	Good	Moderate	Moderate	Inorg., org.
Spectrophotometry	$10^{-3}-10^{-6}$	2	Good–moderate	Fast–moderate	Low–moderate	Inorg., org.
Fluorometry	$10^{-6}-10^{-9}$	2–5	Moderate	Moderate	Moderate	Org.
Atomic spectroscopy	$10^{-3}-10^{-9}$	2–10	Good	Fast	Moderate–high	Inorg., multielement
Chromatography–Mass Spectrometry	$10^{-4}-10^{-9}$	2–5	Good	Fast–moderate	Moderate–high	Org., multi-component
Kinetics methods	$10^{-2}-10^{-10}$	2–10	Good–moderate	Fast–moderate	Moderate	Inorg., org., enzymes

THANK YOU

"We have made clear to you the signs;
perhaps you will understand."

(57:17)

H_2O

Water Research

http://research.upm.edu.my/hydro