The University of Zambia
School of Engineering
Dept. of Civil & Environmental Engineering

CEE 4412: Environmental Engineering

WATER QUALITY ASPECTS

JMT
AUGUST 2020

Aim

- Introduce students to theoretical and practical aspects of water quality

Outcomes

After this topic, together with the associated laboratory work, you should be able to:

- Carry out water sampling and analysis;
- Characterise water/wastewater;
- Interpret water quality parameters (Physical, Chemical and biological);

Water Quality: Definition

- The condition of the water, including chemical, physical, and microbiological characteristics, usually with respect to its suitability for a particular purpose

Cl: 0.2 – 0.5mg/L

Cl: >1.0mg/L

Water quality: determination

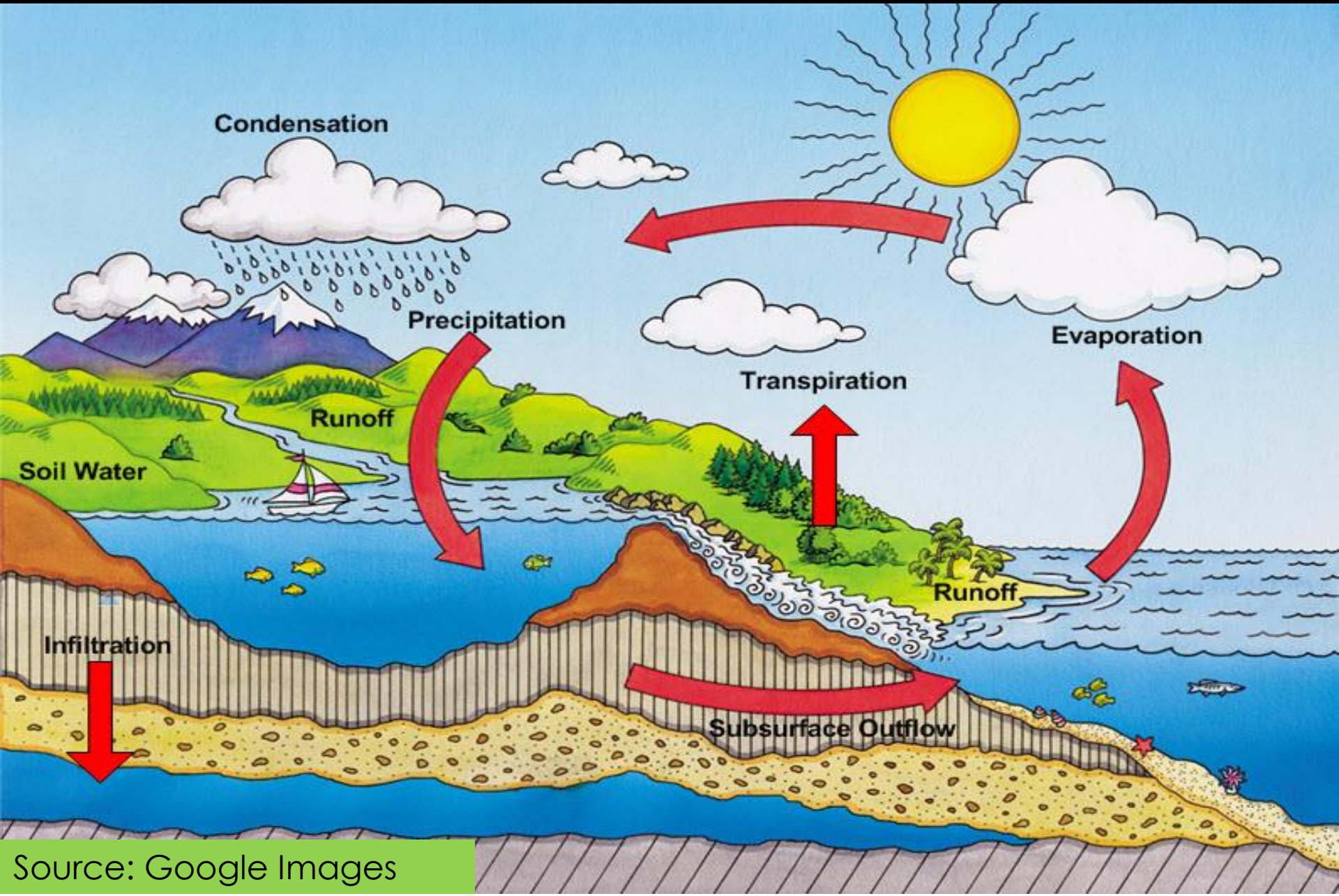
- Through measurement of concentration of parameters like DO, bacteria levels, salinity, turbidity etc.

- What is a water quality Parameter? A constituent of water

What is Water? - Baseline

$$2H + O = H_2O$$

How Does Quality Come In?



Source: Google Images

Parameters collected from each of the Environs

- Atmosphere (CO_2; SO_4)
- Ground surface (Germs, suspended solids, Heavy metals)
- Geology (e.g. Iron, Manganese, Hardness)
- Rivers/streams (industrial Pollutants)

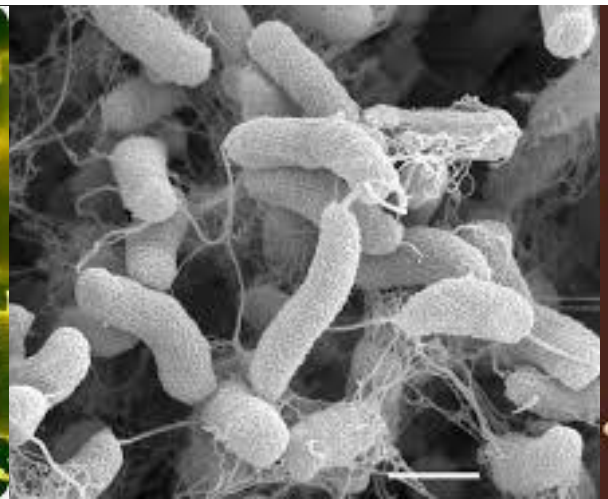
Categories of Water Quality Parameters?

- *Physical parameters:*
  - Parameters that can be physically removed from the water phase by physical means or those that can be identified through physical means (see, touch, feel, smell etc.).
- *Chemical parameters:*
  - These are parameters that are dissolved in the water and can only be removed or detected through chemical means (Example: Chlorides).

Categories of Water Quality Parameters

❖ *Microbiological parameters:*

- These are parameters which indicate the microbiological quality of water. Examples are bacteria, viruses, protozoa etc. The main interest here is usually on pathogenic (or disease causing) microorganisms present in water


Significance of selected parameters

Suspended Solids

- Constituents associated with water in motion
- Have no effect on health if source is from inorganic matter (e.g. clay, sand)
- Makes water aesthetically unpleasant
- Should be absent in drinking water

Significance of selected parameters

Colloids

- Smaller than SS. Charged –ve
- If inorganic, no health hazard but aesthetic
- If organic in nature associated with micro-organism and stimulate their growth
- May encapsulate microorganism defending them against chlorination
- Act as “vehicle” for attached microorganism
- Measured in NTUs and limit = 5NTU

Significance of selected parameters

Dissolved Oxygen

- Supports Micro and Macro life forms in aquatic system
- At least 3-4mg/l required in distribution system for corrosion and odour control
- Absence indicates pollution
- No direct link to health hence no WHO guideline

Calcium and Magnesium

Calcium and Magnesium

- Ions of Ca^{2+} and Mg^{2+} are the main constituents in formation of water hardness
- In presence of HCO^{-}_{3} they may form precipitates leading to encrustations
- A minimum hardness is important for corrosion control



Significance of selected parameters

- MgH can attack concrete and weaken it
- MgH may cause gastro-intestinal irritation
- TH increases soap consumption
- WHO guideline value for hardness = 500mg/l $CaCO_3$

Significance of selected parameters

Iron and Manganese

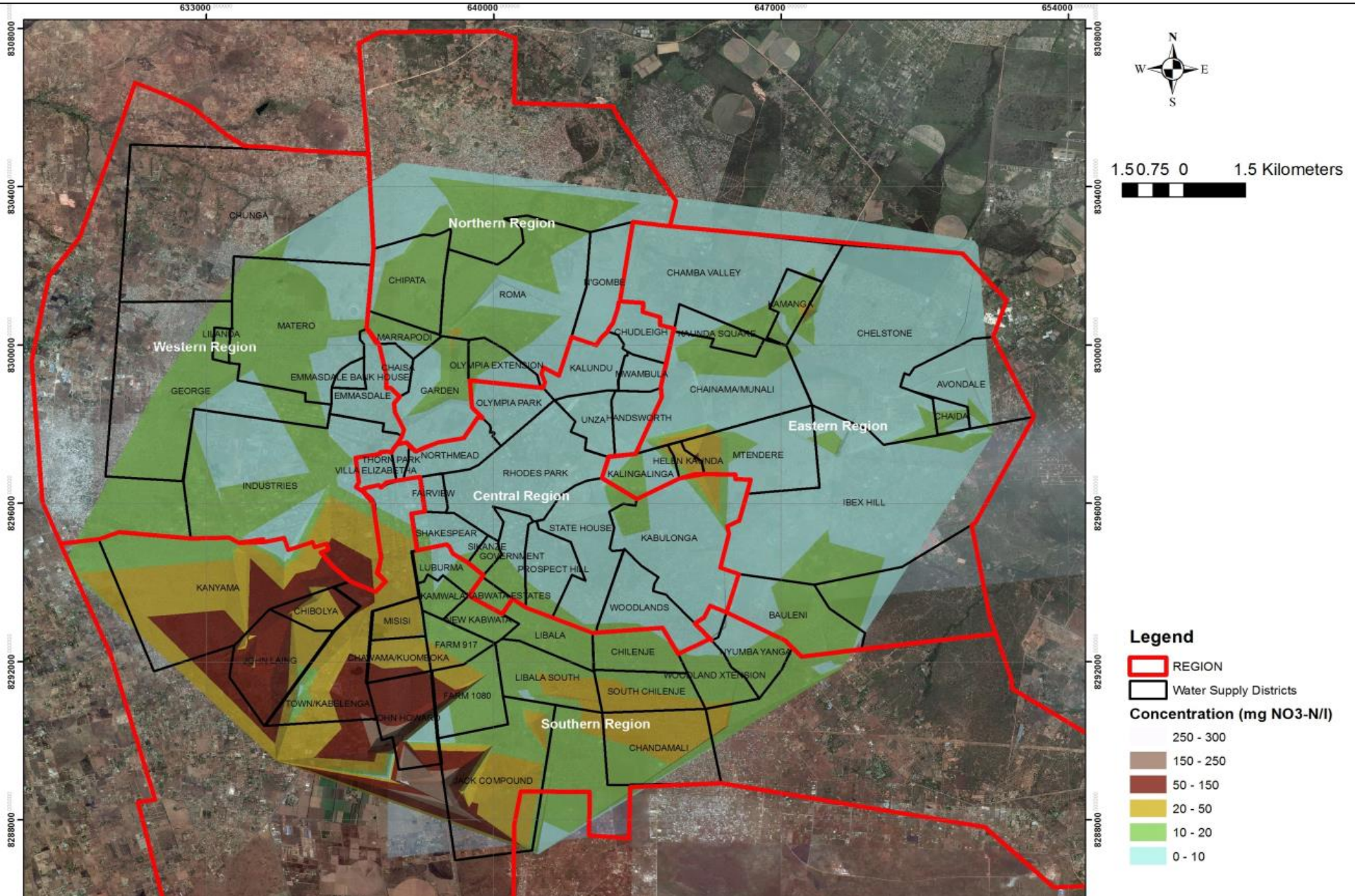
- Normally associated with groundwater
- They cause discolouration of water and turbidity
- Formation of deposits in pipes and other facilities
- Staining of laundry
- Gives water a metallic taste
- High amounts may cause gastro-intestinal irritation
- WHO GV 0.3mg/l Fe, 0.1mg/l Mn

Significance of selected parameters

Nitrate

- Comes from geology, decaying organic matter and from fertilizers
- It can serve as an indicator of pollution specially so when other indicator parameters are present
- In excessive concentrations, causes methaemoglobinaemia in infants
- Suspected to be carcinogenic
- WHO guideline value 45mg/l of NO_3^- as NO_3^- or 10mg/l NO_3^- as N

Significance of selected parameters-



Heavy Metals

- Lead, Mercury, Arsenic, cadmium etc….. Toxic and mostly carcinogenic

Microbiological Quality

Quality in terms of presence of microorganisms. It can be determined by microbiological examination of water which poses challenges as follows:

- great number of species to be identified
- time consuming
- The procedures for each one of them is complex and time consuming
- Need for well equipped laboratories
- Need for specialised microbiologists.

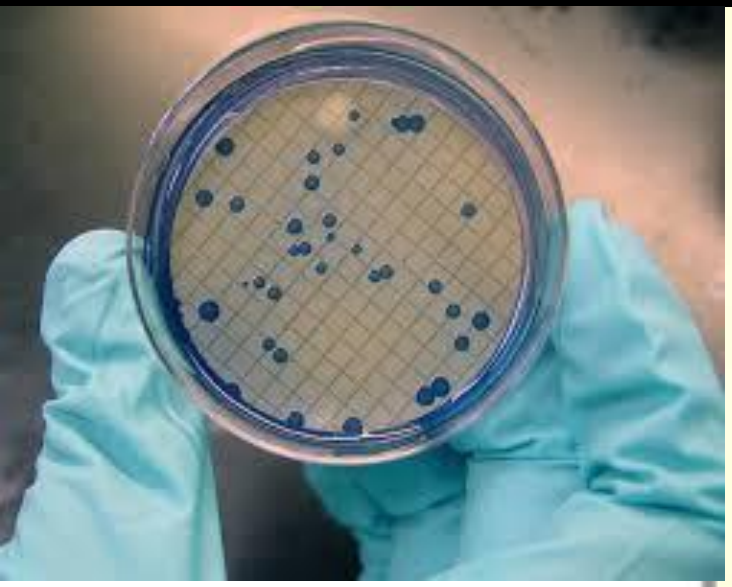
Microbiological Quality

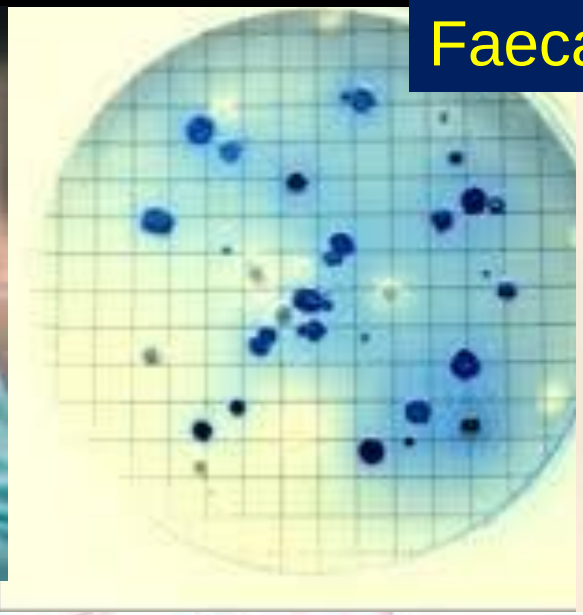
- To circumvent the above challenges, Indicator Microorganisms are used
- These include Faecal Coliforms (FC) and Total Coliforms (TC) which are used as indicators of possible presence of pathogens in water

Why do we use FC and TCs?

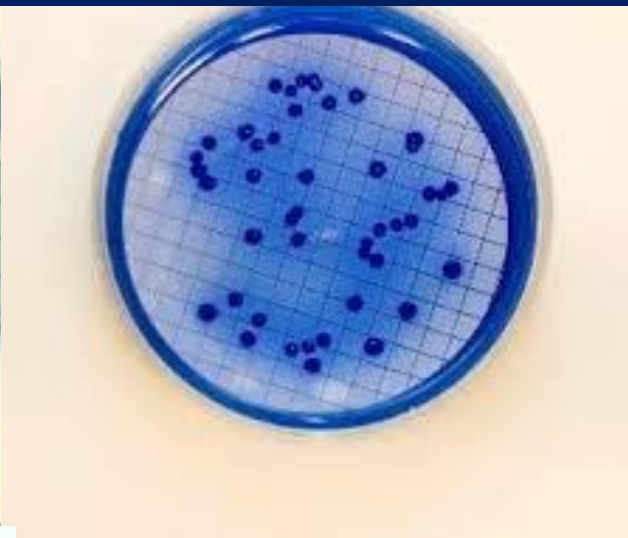
- They can be detected by relatively simple analytical procedures
- The analysis is not time consuming
- It does not require specialized bacteriologists. Every lab technician with some training can do the tests
- Since the number of coliforms is usually much larger than of possible pathogens, there is a great margin of safety provided

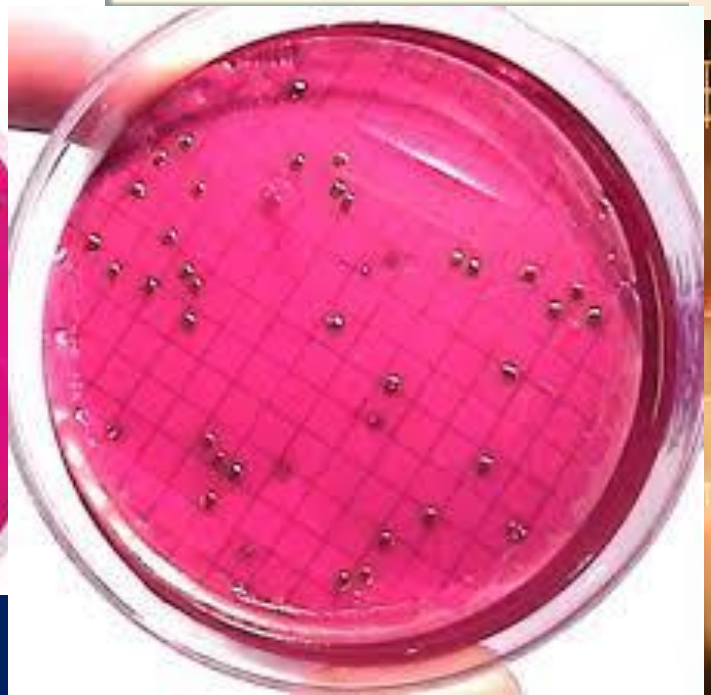
Why do we use FC and TCs?





Faecal Coliforms?





Total Coliforms?

Expression of Concentration of WQ Parameters

- Expression is in a number of ways depending on the nature of the parameter.
- For most physical and chemical parameters, the units are mass per unit volume of water.
- Examples: Kg/m^3; g/m^3; g/L; mg/L and so on
  - Determinant = concentration of the parameter
  - Very small concentrations = micrograms/litre (µg/L) or even nanograms per litre (пg/L).

Expression of Concentration of WQ Parameters

- Example: 0.0035mg/l = 3.5µg/l = 3500 ng/l.

WHAT TO KNOW

- conversion factors for units on mass/volume. (e.g. 1kg = 1000g; 1g=1000mg; $1m^3$=1000l; 1l =1000cm^3 etc.)
- Other expressions:
  - Microbiological parameters = No. CFU/unit volume,
  - Turbidity = Nephelometric Turbidity Units (NTU)
  - Electrical conductivity = Siemens/cm

Expression of Concentration of WQ Parameters

- Example: Express 200g/m^3 in terms of mg/l

Water Quality and Standards

PARAMETER	ZAMBIAN STANDARD (ZS 190)	WHO Guideline
pH	6.5 – 8.0	6.5 – 8.5
Turbidity (NTU)	5	5
Conductivity (mMhos/cm)	1500	1500
Total Dissolved Solids (mg/l)	1000	1000
Total Suspended Solids (mg/l)	-	-
Sulphates (mg/l)	400	250

How is Water Quality Determined? (Level of concentration of parameter)

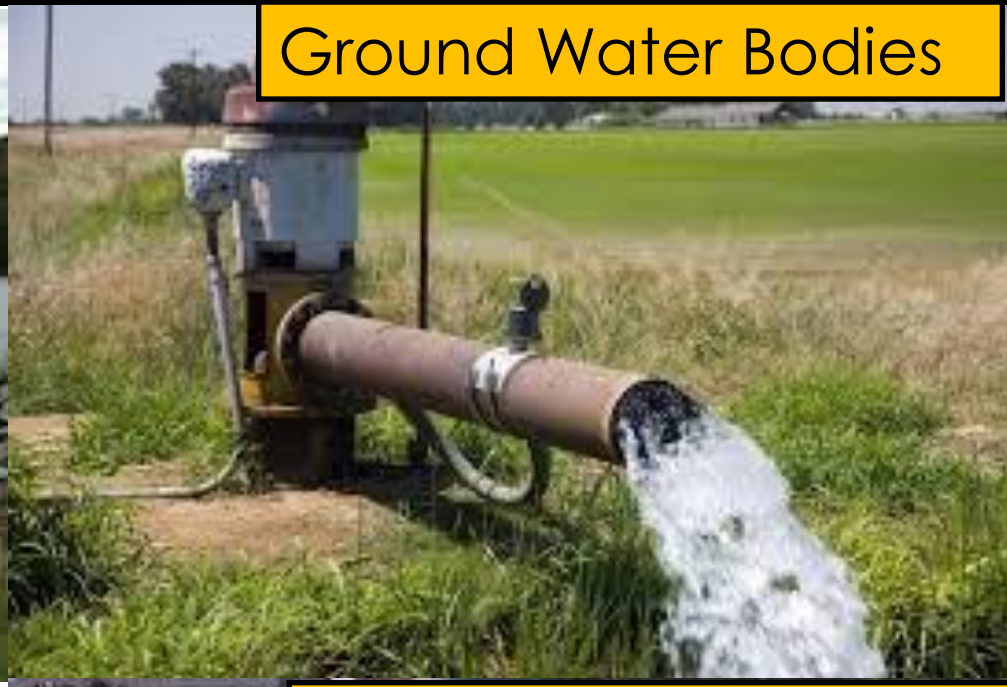
Through laboratory or field water analyses involving

1. Water Sampling
2. Sample Transportation
3. Sample Analysis

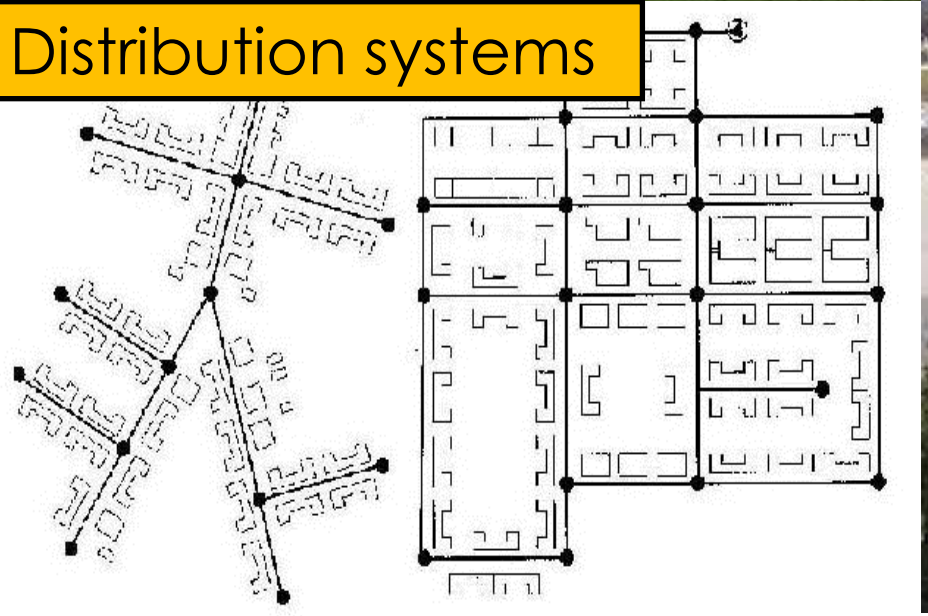
Sources of Samples and Characterisation

Surface Water Bodies

Ground Water Bodies



Distribution systems



Treatment Facilities

Importance of Water Quality Determination

- In drinking water, to
  - Ensure water meets standards for drinking water
  - Monitor treatment efficiency of units (In Treatment Plants)
  - Ensure water supplied meets stipulated guidelines (In distribution system)
- In wastewater treatment, to
  - monitor treatment efficiencies of treatment units
  - ensure effluent quality meets stipulations for discharge into surface water bodies

SAMPLING

REQUIREMENTS

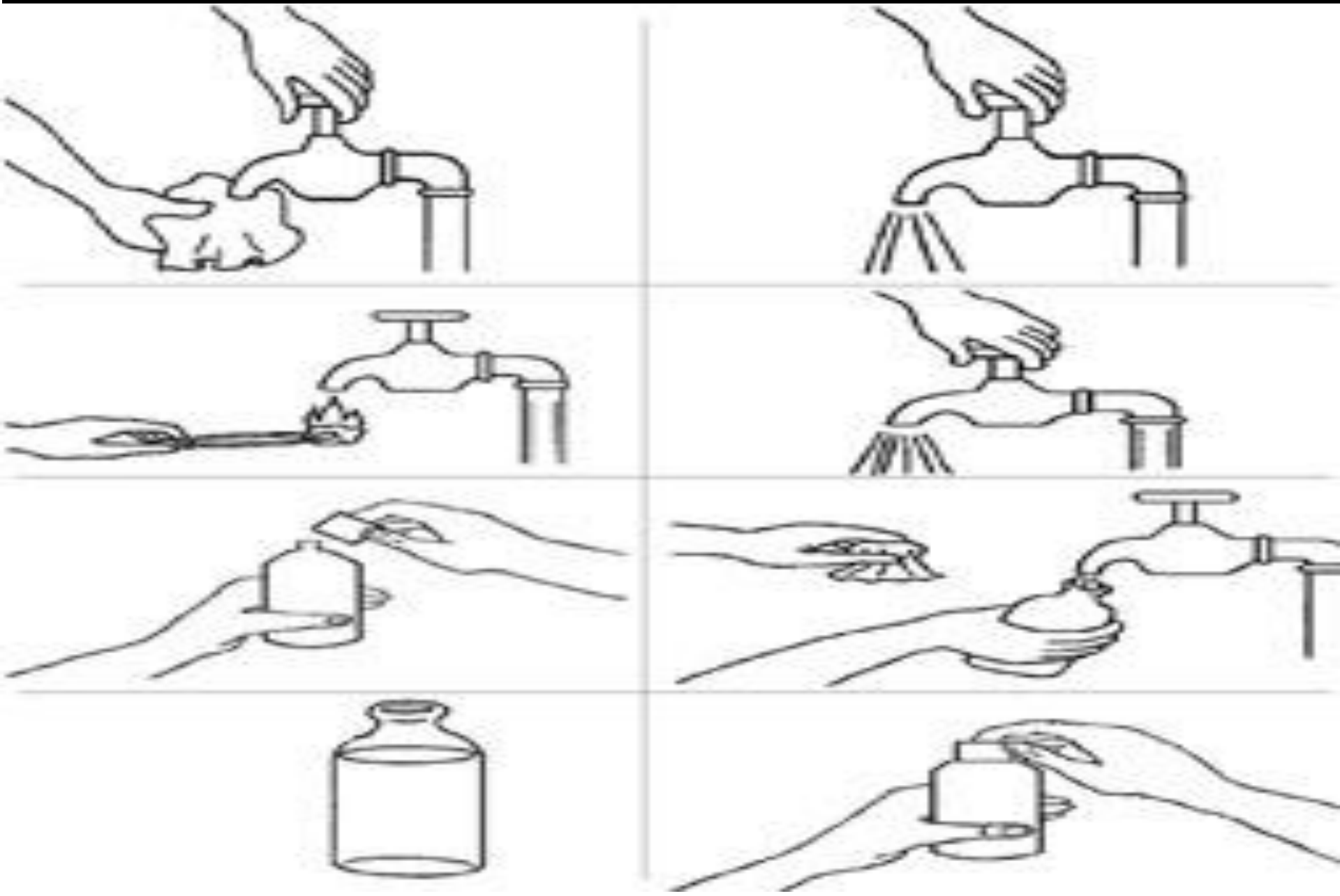
- Representativeness
  - Sample handled in a manner that will not lead to deterioration or contamination
  - Sample is giving picture of general quality

- Types
  - Hence depending on conditions, either sample to be “grab” or “composite”
  - Sampling can be for microbiological or physical chemical analysis

Sampling for Microbiological Examination

- Special Bottles to be used
- Special sampling techniques to be used
- Time between sampling and analysis <24hrs
- Samples to be kept cool during transportation

Sampling from a tap

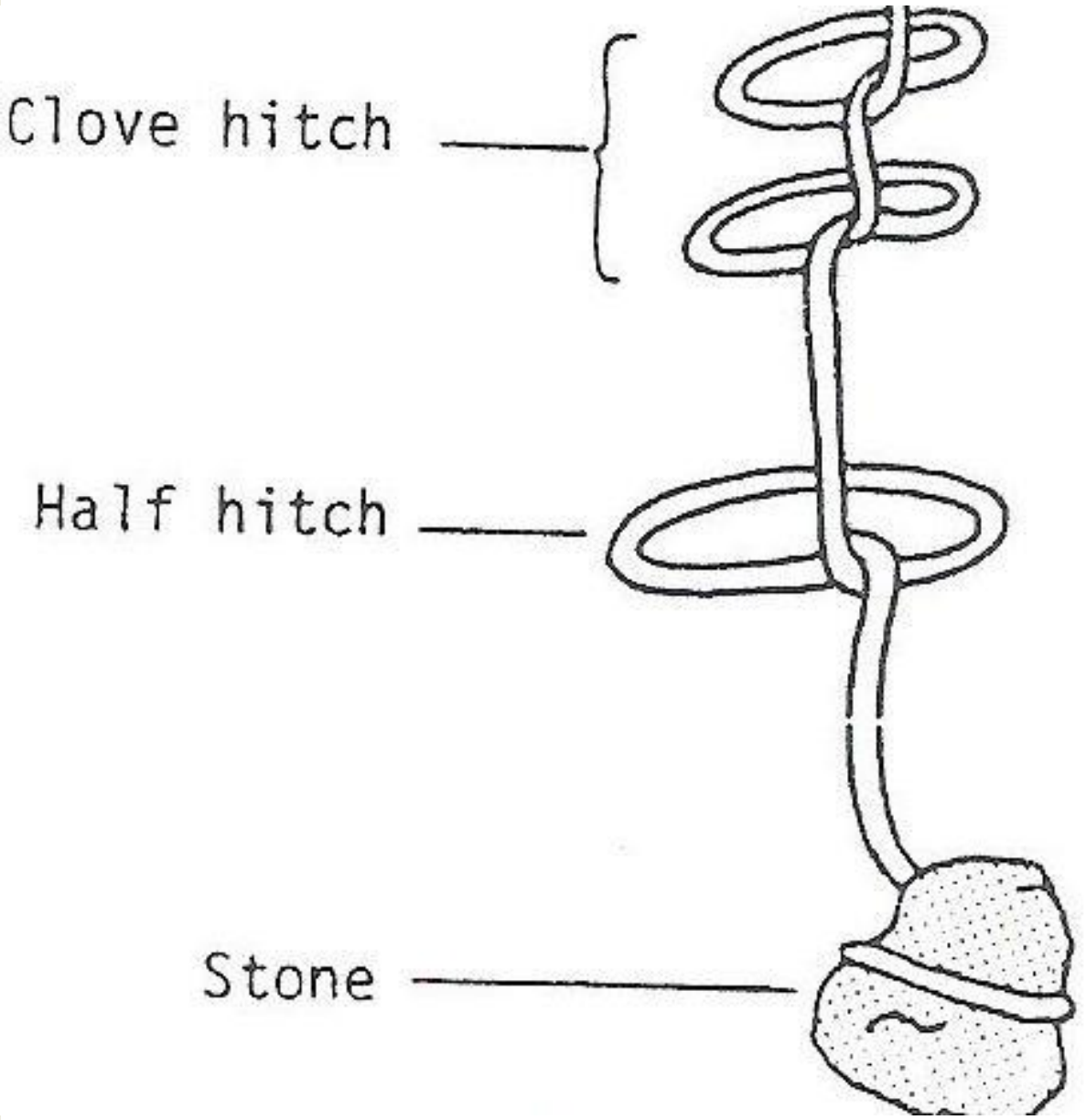


Sampling from a Borehole

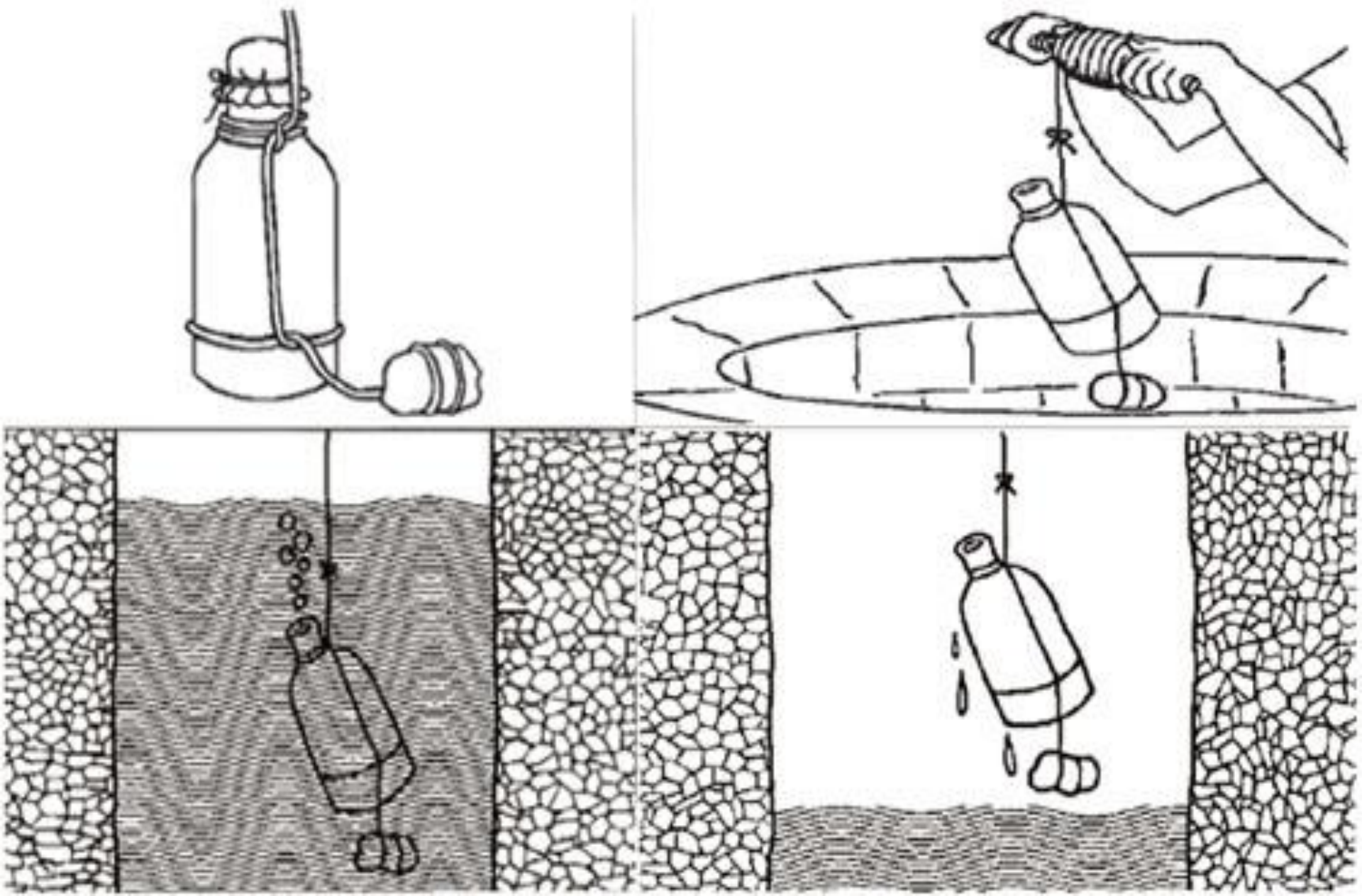
- Adequate flushing required before samples are collected
- Collection is as above on handling of bottle

Sampling from a Well

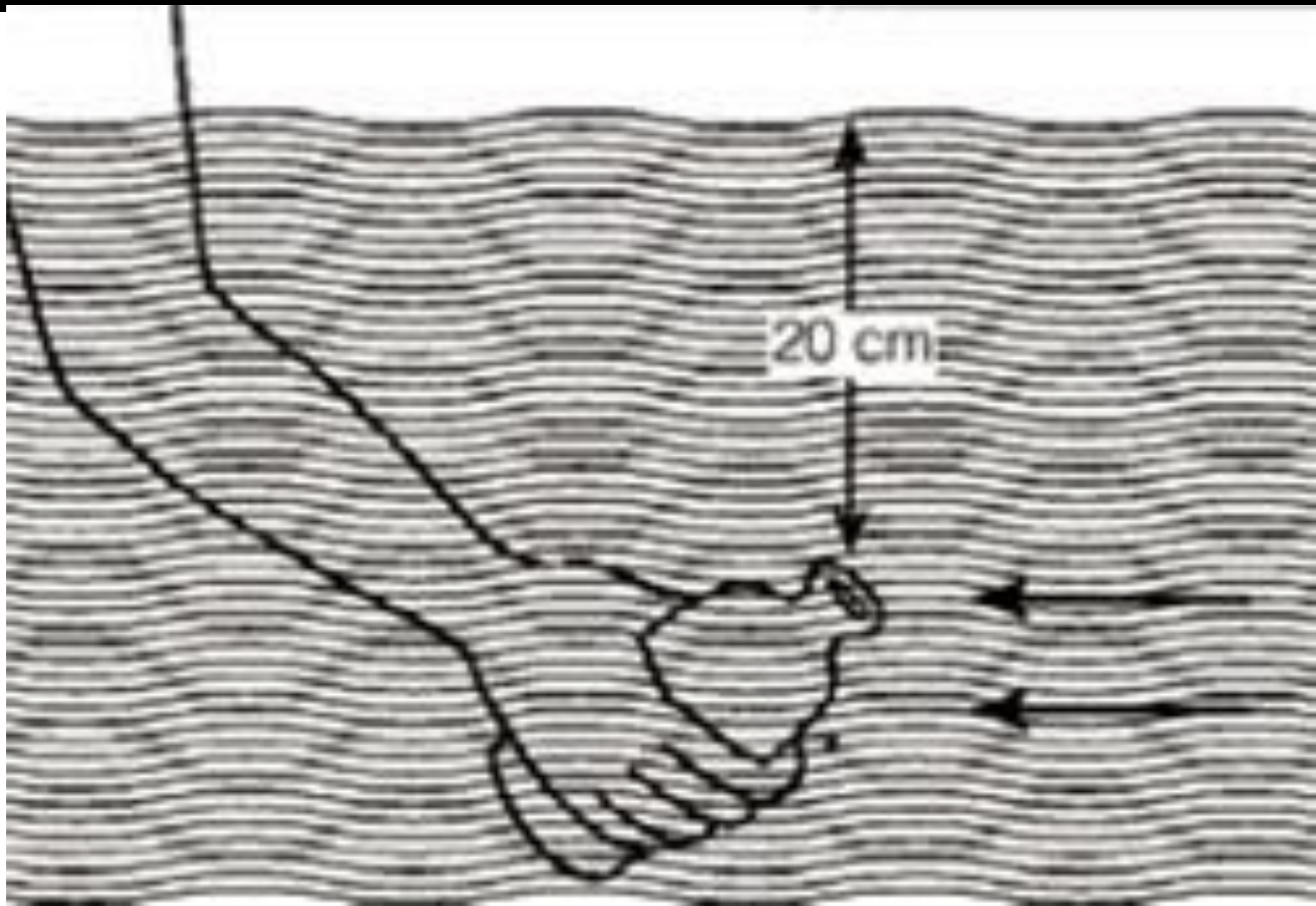
- Prepare the bottle with a piece of string and attach a clean weight to the sampling bottle



Sampling from a Well cont’



Sampling from a surface water body



Sampling Bottles

Bottles for microbiological sampling

- To be sterile.
- Important that the mouth of the bottle is not touched to avoid contamination.
- Hence after sterilization, sampling bottle covered with foil paper on the lid.

Other Considerations

- If ice is not available, transportation time <2hrs
- Samples to be kept in the dark and cooling to be rapid.
- If these conditions are not met, the samples to be discarded;
- Box for sampling to be cleaned and disinfected after each use
- Never Mix Wastewater with Drinking Water Samples

Sampling for Physical/Chemical Parameters

Bottles for physical physical/chemical analysis

- Need not be sterile but should be clean (adequately rinsed with distilled water).

Other Consideration

- Type of sampling bottle (i.e. Plastic/Glass)
- Cooling
- Holding time – dependent on parameter

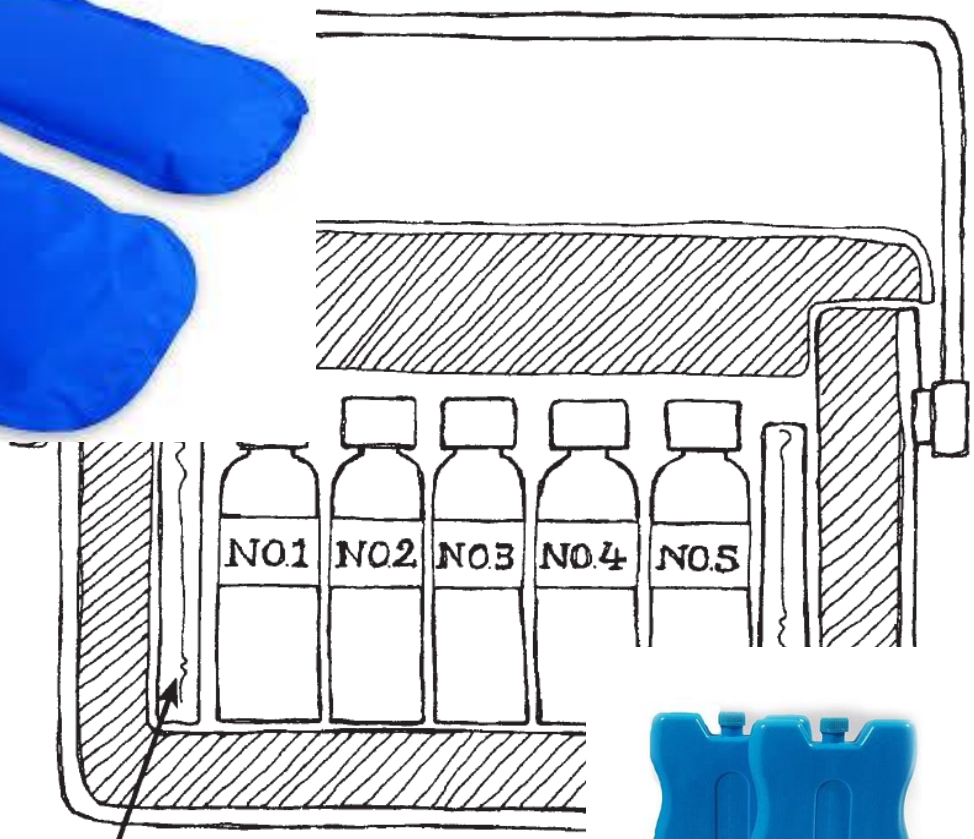
Sample Preservation

Parameter	Container	preservative	Max. allow. Storage time
Alkalinity	P, G	Refrigerate	24 hours
Acidity	P, G	Refrigerate	24 hours
Boron	P	HNO_3 to pH >2	28 days
Chlorine, Total, Residual	P, G	Analyse immediately	0.25hours
Colour	P, G	Refrigerate	48 hours
Fluoride	P	None required	28 days
Hardness	P, G	Add HNO_3 or H_2SO_4 to pH>2	6 months
Metals (General)	P, G (rinsed with HNO_3	For dissolved metals, filter immediately, add HNO_3 to pH>2	6 months

(Source: Standard Methods for the Examination of Water and Wastewater, 1998).

Sample Transportation

- Samples to be Cooled during transportation hence the need for cooler boxes and ice packs



Laboratory Analysis

- According to standards: Standard Operating Procedures (SOP)

Sample Tracking

- Sometimes referred to as Chain of Custody

- Connecting source to result which is done by:

  - Writing details of the sampling point on the sampling bottle or

  - Use bottles with identification numbers.

Required Details

- Full description of the sampling point (e.g. place, type: Kafue river,)
- Sanitary conditions
- Climatic conditions
- Date and time of sample collection;
- Person collecting;
- Parameters for which sample is being collected (e.g. microbiological; and
- Preservatives used, if any.

Example

SAMPLE ID	BOTTLE No./IDENTITY	DESCRIPTION	PRESERVATIVES	DATE/TIME OF SAMPLING	FIELD RESULTS	CONDITIONS	SAMPLED BY
Goma Lakes	X	BACTERIOLOGICAL	Nil	12/07/2019; 14:35 HRS	pH; Temp	Wet; Dry	JMT

Quality Control and Quality Assuarance

- Quality Assurance: A set of activities that determine the procedures and standards to develop a product.

- What is Quality Control: Activities and techniques to verify that the developed product is in conformance with the requirements. The ultimate output of both processes is to deliver a quality product.

END

THANK YOU