WATER QUALITY

Lecture 7

Terminology

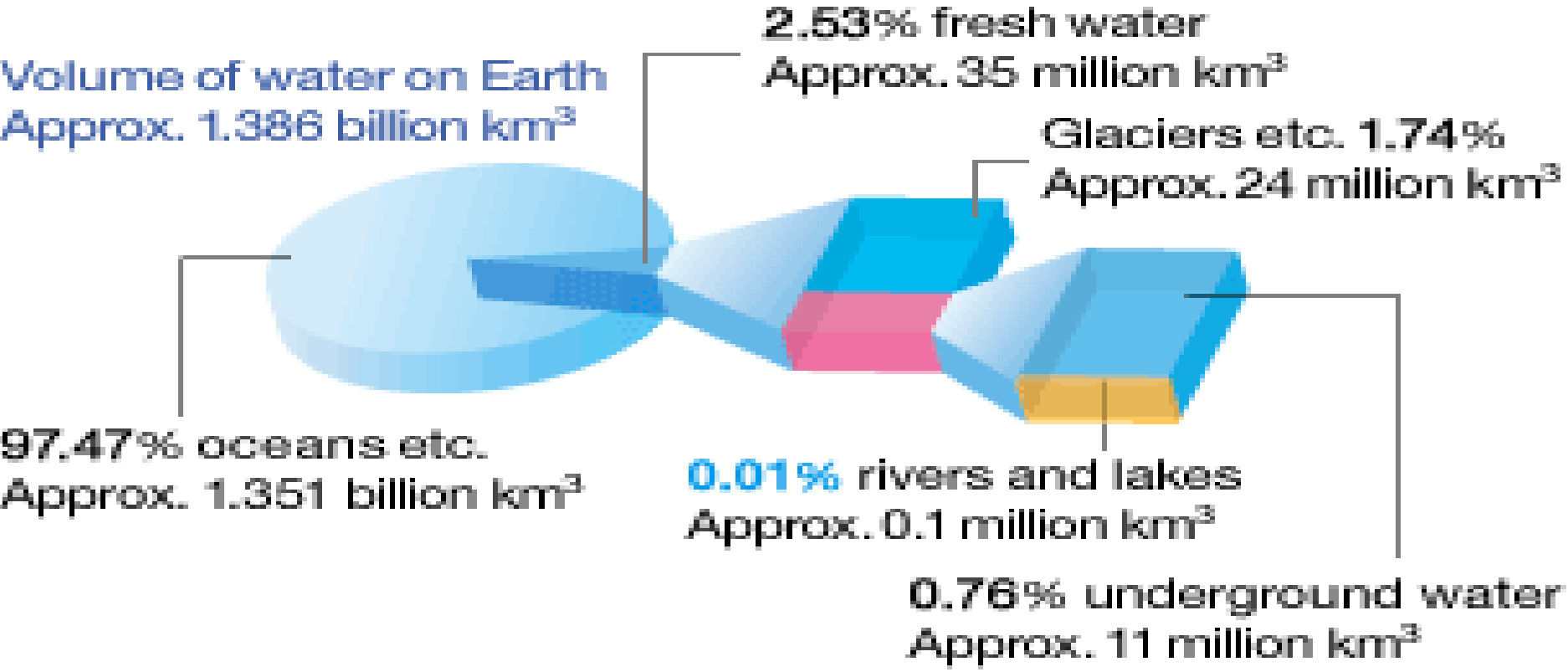
Quality: It is defined as the degree of excellence , a measure of fitness of use.

Drinking Water quality: It refers to the degree of cleanliness and wholesomeness of water .Drinking water quality is judged interms of chemical, physical, and bacteriological content of water.

Potable Water: It is the water which is safe to drink, pleasant top taste and usable for domestic purposes. Thus it has aesthetic appearance and is free from harmful chemicals and diseases causing bacteria.

Polluted/Contaminated Water: Water containing pathogenic microorganisms, harmful chemicals, or sewage is termed as polluted or contaminated water

Only 0.01% of global water resources is fresh water that humans can use



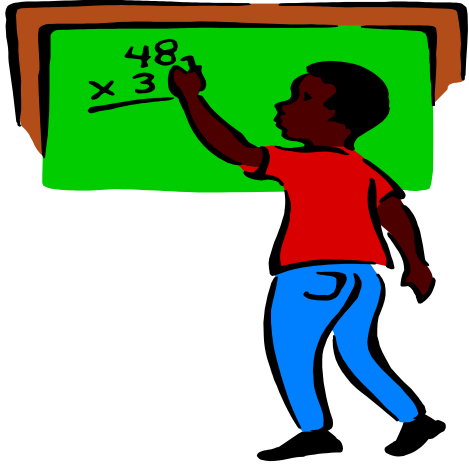
Source: Created from data (water resources of Japan 2011 edition) published by the Ministry of Land, Infrastructure, Transport and Tourism

* Subterranean water of Antarctica is not included.

Global Quantities of Water

Total water on earth	1360×10^6 Km^3
Saline water	97.47%
Fresh water	2.53%
North & South pole + Ice caps + Glaciers	1.76%
Ground water	0.76%
Lakes & Rivers	0.007%
Others	0.003%

Some of the Gloomy Arithmetic (Water)

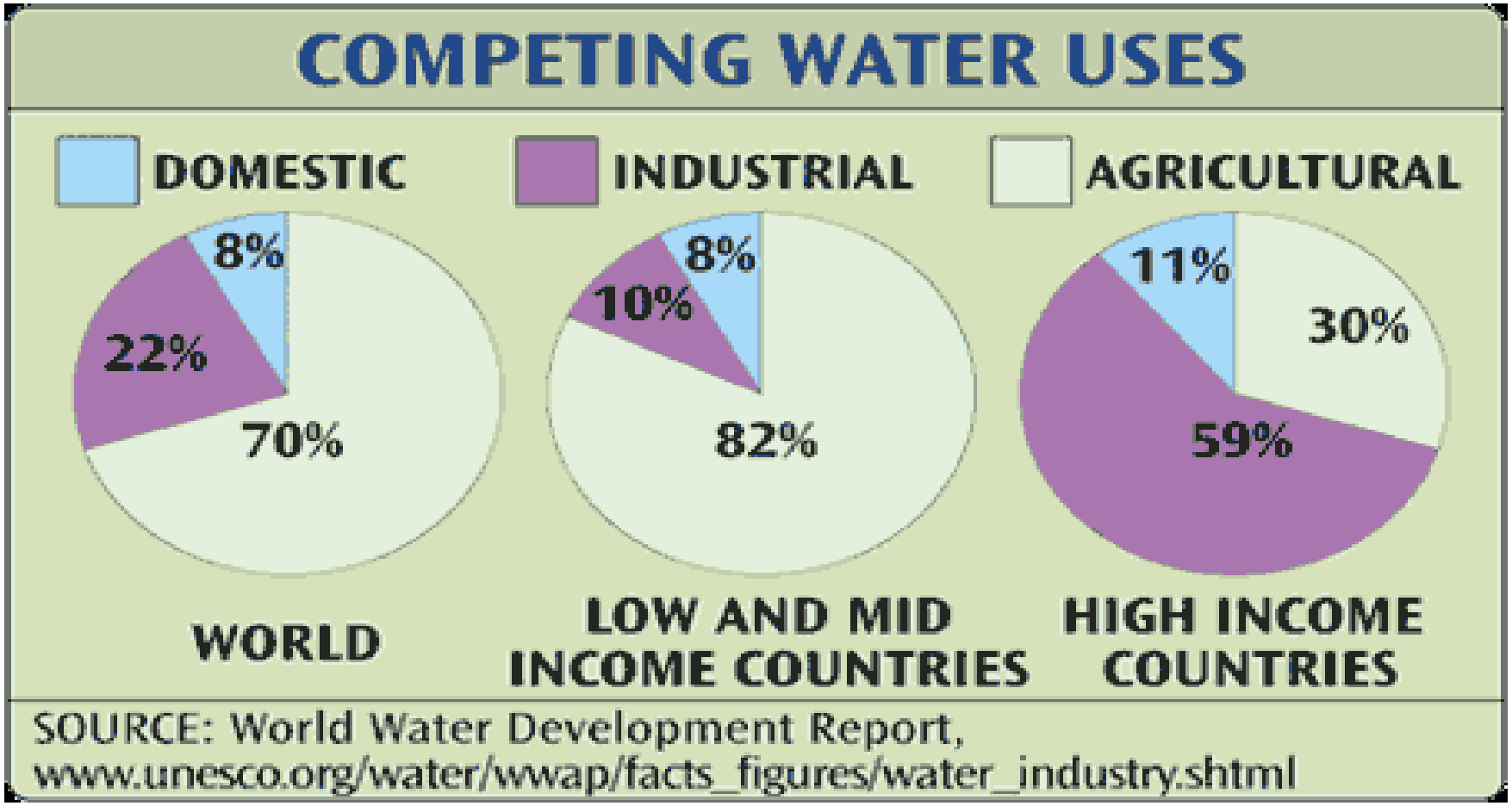


- **1.4 billion people lack safe water**
- **50% of people lack adequate sanitation**
- 20% of freshwater species near extinction
- 76-80% live in water stressed areas most in politically unstable regions
- Past 30 years world water supply has halved
- 80% of diseases carried by water:
    1. 5-7 million people annually:
    2. $125 billion in workday losses/year.
- **Losing irrigated land by 30% in 2025 and 50% by 2050**
- Asia: ***Over two thirds of population live in areas where 80% of rainfall occurs in 20% of the year***

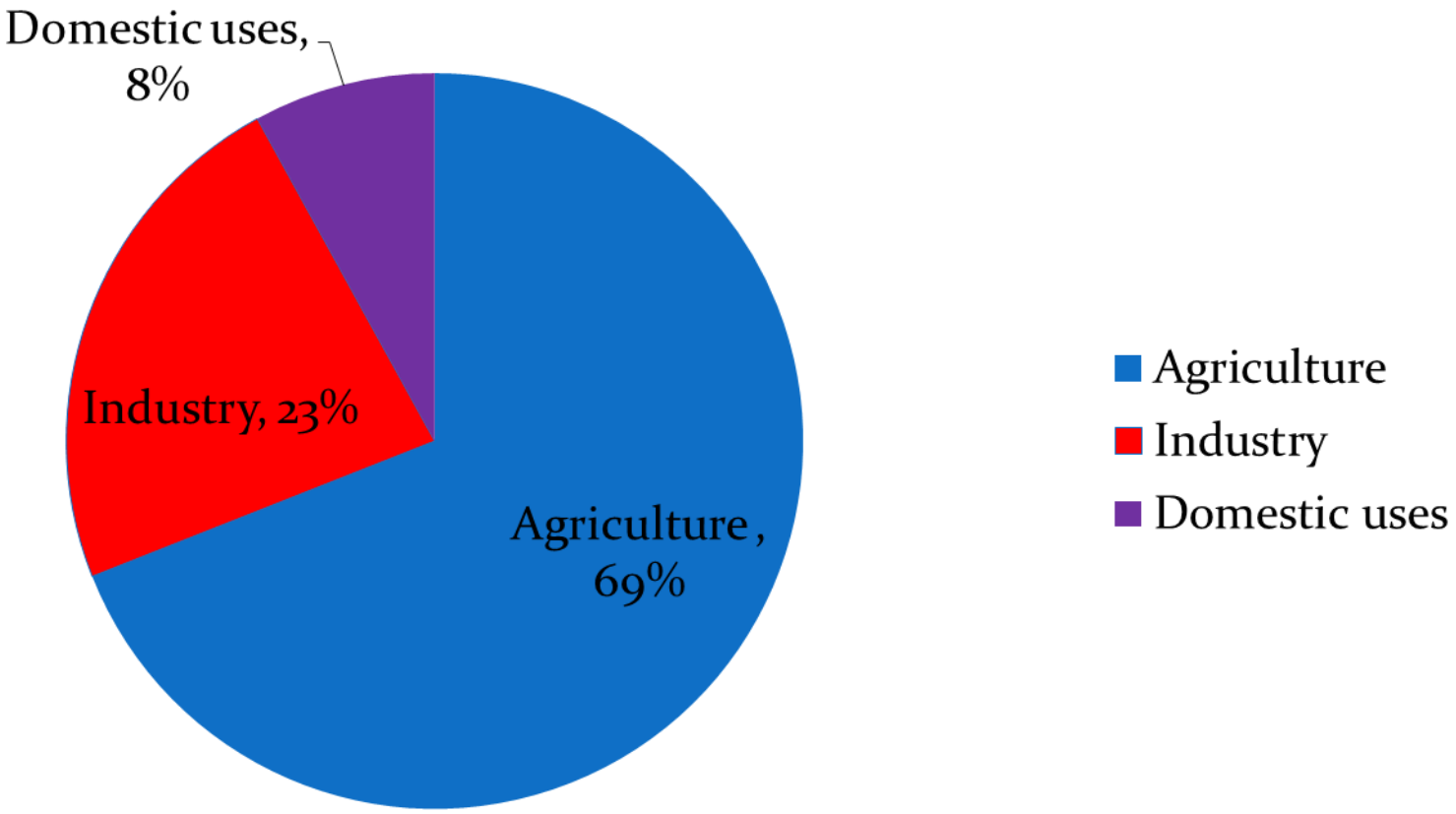
"There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people - and the environment - suffer badly."

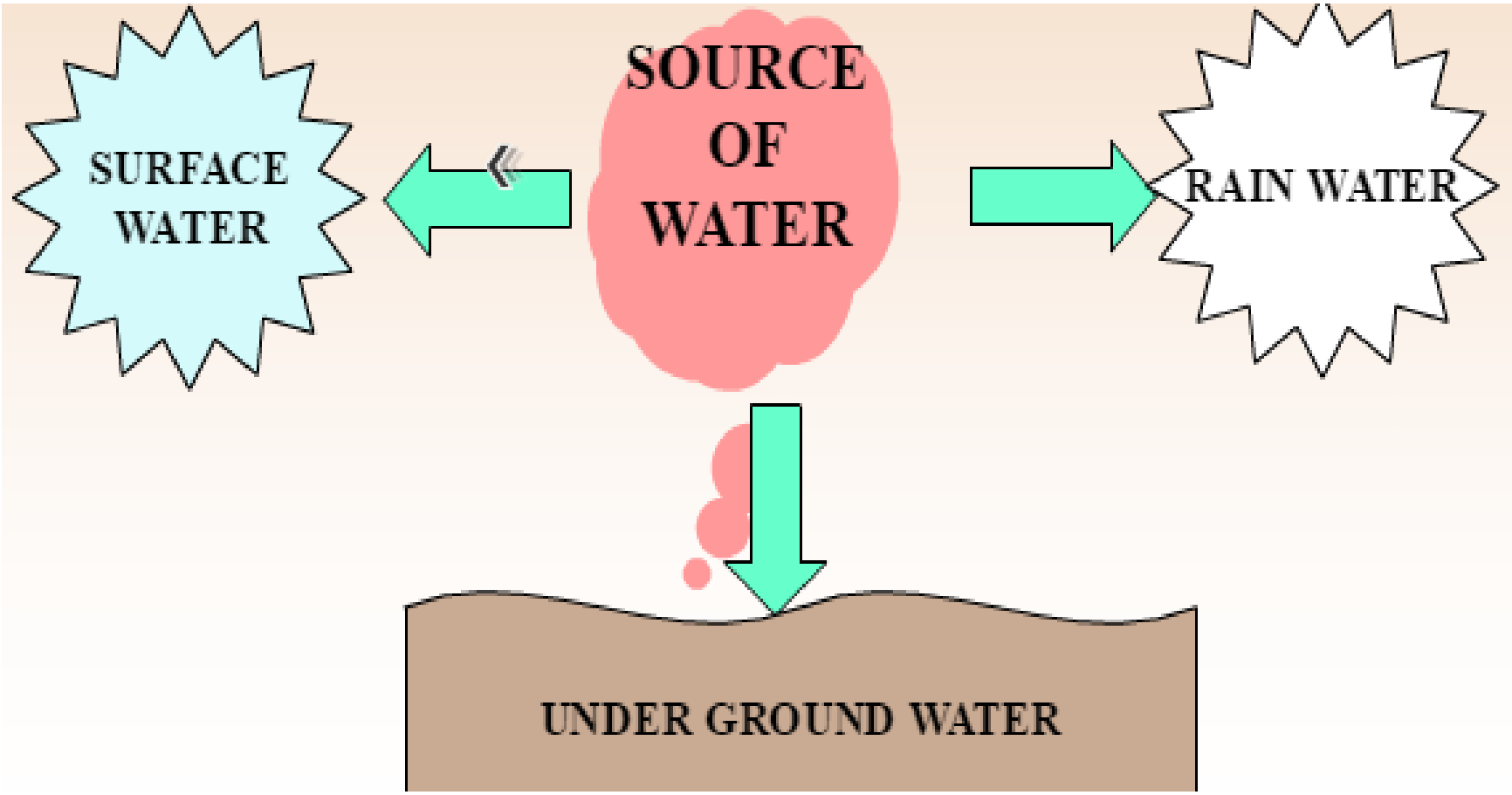
World Water Vision Report

CONSUMPTION PATTERN OF WATER



Consumption Pattern of Water




SOURCE OF WATER
SURFACE WATER
RAIN WATER
UNDER GROUND WATER

Water Resources of Pakistan

Rainfall

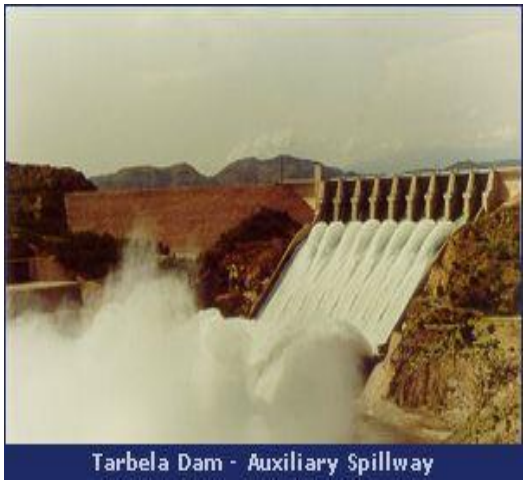
- Annual rainfall (125mm in South-East to 750mm North-West)
- Total water generated by rainfall is around 32 BCM
- Contribution to crops is 10-20%

Groundwater

- Exploitation of Groundwater is 59 BCM
- Over 9,00,000 private tube wells

Surface Water Resources

- Total Inflow is 171 BCM
- Tarbela (10.38 BCM - 485 ft),
- Mangla (5.90 BCM - 380 ft)
- 48 Canals (61000 km), 19 Barrages
- 1,70,000 Watercourses (1.6 Million km)



Tarbela Dam - Auxiliary Spillway

Freshwater Availability Scenario (Per person)

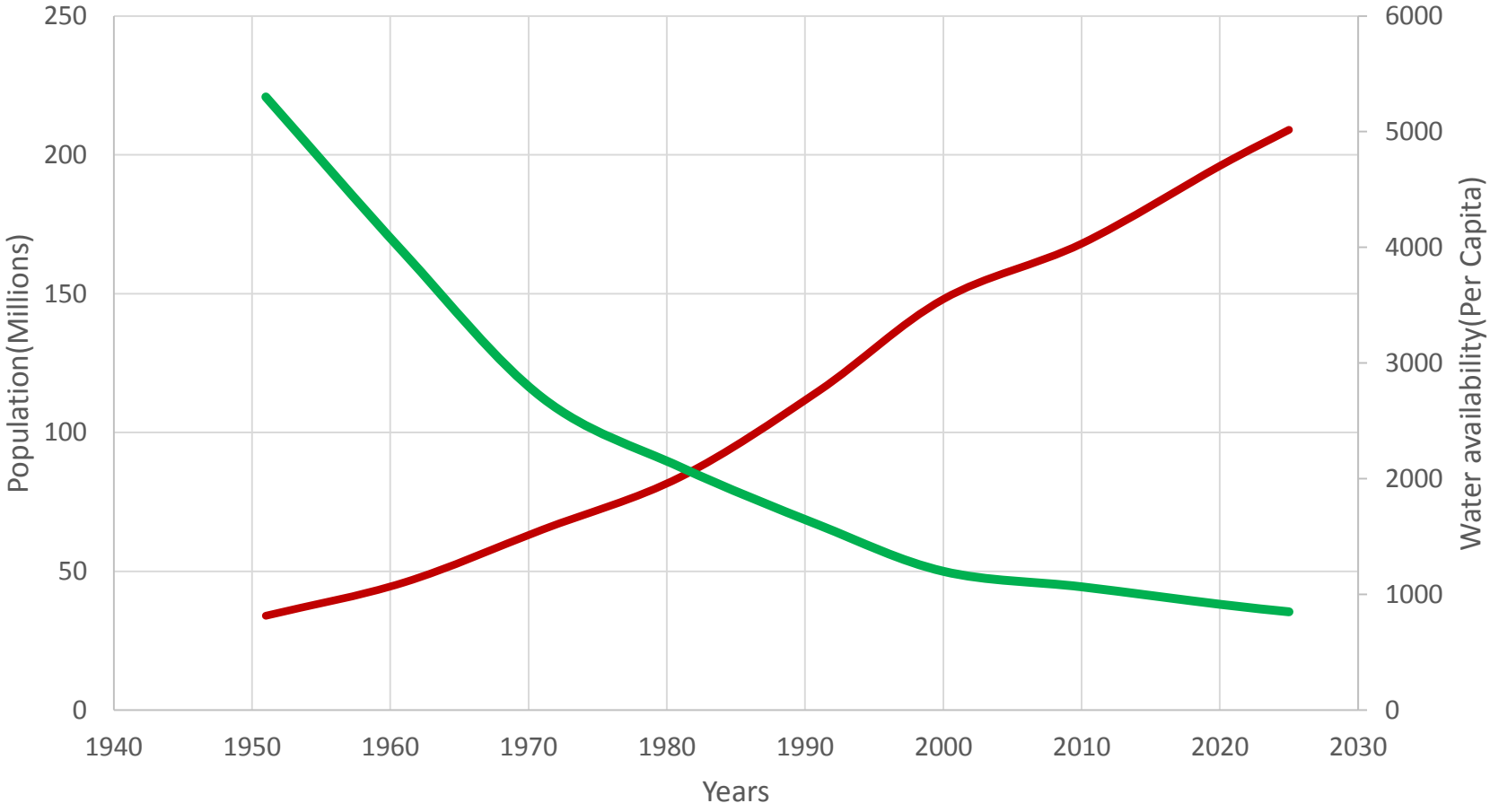
- Global
  - 1950 – 16,800 cubic meters per annum
  - 2000 – 6,800 cubic meters per annum
  - Reduction: 60 % in 50 years
- Pakistan
  - 1950 – 5,300 cubic meters per annum
  - 2000 – 1,200 cubic meters per annum
  - Reduction: 77 % in 50 years

- Critical limit 1,000 cubic meters per person per annum

Future Water Scenario

Year	Population (million)	Water availability (per capita,m3)
1951	34	5300
1961	46	3950
1971	65	2700
1981	84	2100
1991	115	1600
2000	148	1200
2010	168	1066
2020	196	915
2025	209	850

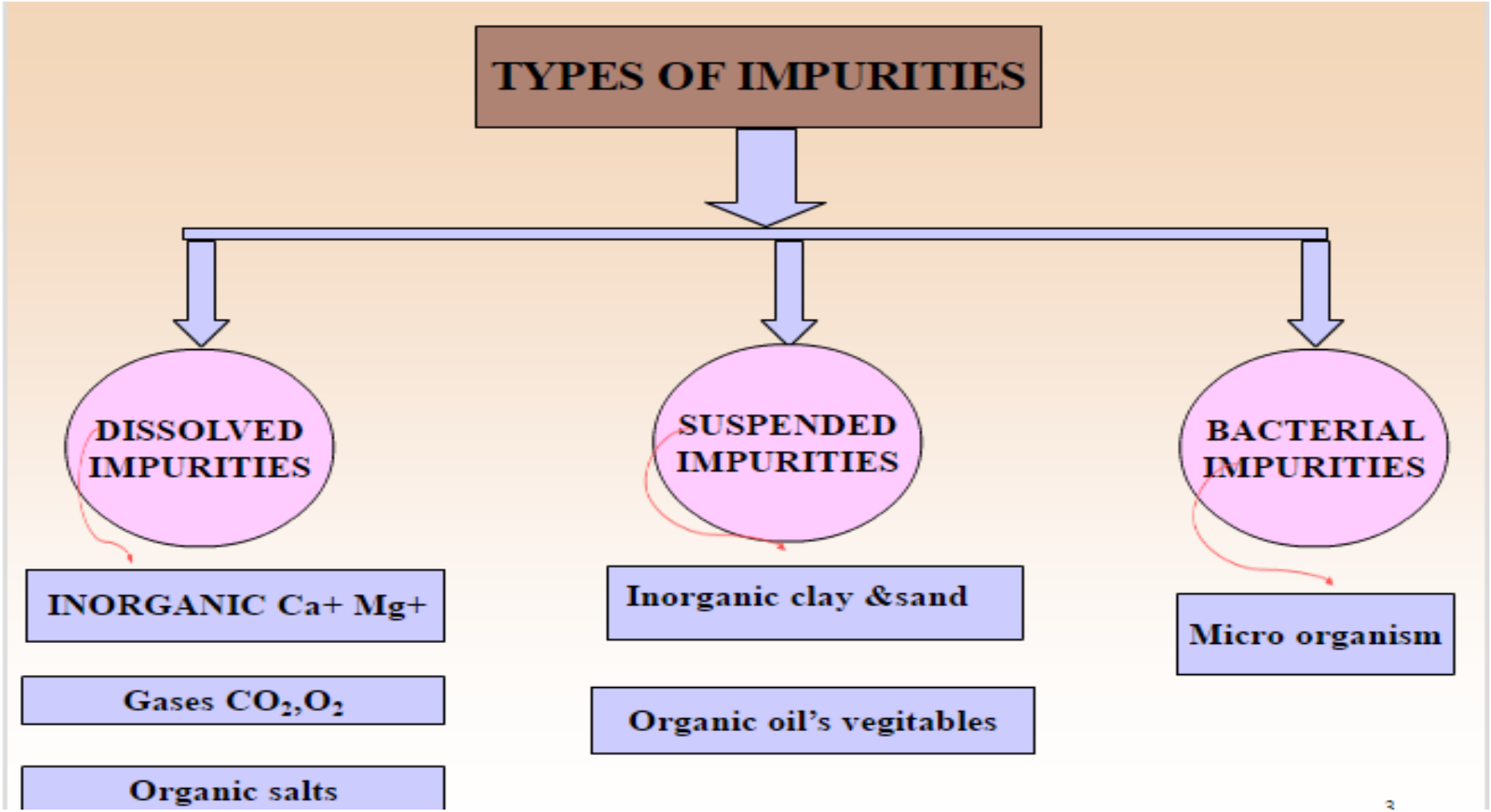
Future Water Scenario (Per-Capita Water Availability)



Existing Situation

- Surface water largest source of irrigation in Pakistan (31% as a single source)
- 79% access to piped /hand pump water supply
- 30% of diseases & 40% deaths –water borne
- 90% exposed to unsafe drinking water
- BOD Ravi=300mg/l(80mg/l)

Types of Impurities in Drinking Water



Types of Impurities in Drinking Water

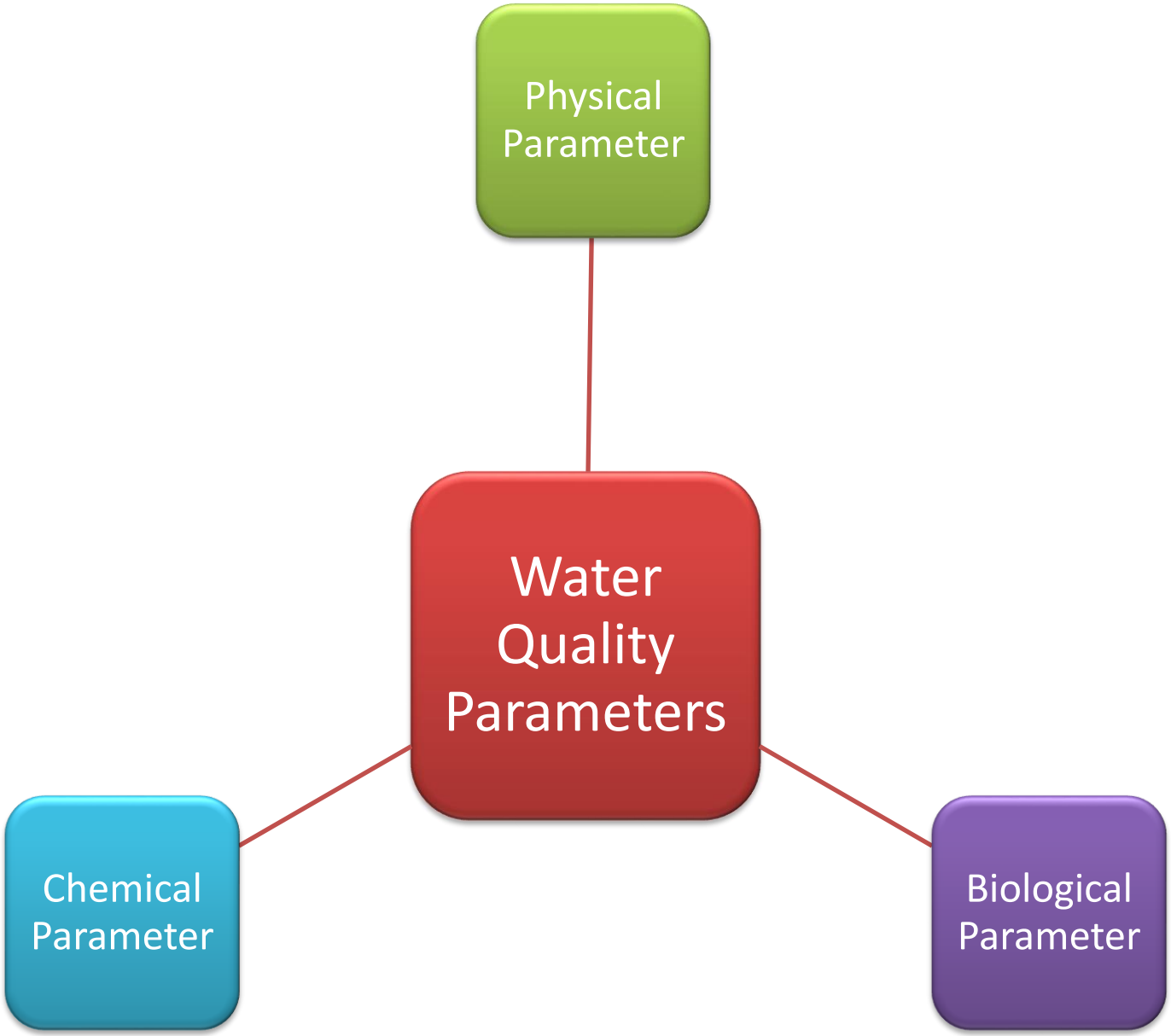
	Impurities	Health & Other Impacts
1.	**Suspended Impurities**	
	❑ **Bacteria**	Some cause diseases
	❑ **Algae ,Protozoa**	Color, taste, odour, turbidity, diseases
	❑ **Silt, Clay**	Turbidity
2.	**Dissolved Impurities**	
	(a) Salt	
	❑ **Fe ,Ca , Mg**	Hardness, corrosiveness
	❑ **Na**	With Chloride causes taste
	❑ **SO_4**	Laxative effect
	❑ **Fe , Mn**	Color , hardness, taste
	❑ **Fluoride**	Dental fluorosis
	❑ **Vegetable dyes**	Color , Odour
	❑ **Pb**	Neurological disorder,
	❑ **Iodide**	Causes goiter if <0.1mg/l
	❑ **NO^{-3}**	Methemoglobinemia in infants

Types of Impurities in Drinking Water

	Impurities	Health & Other Impacts
2.	<u>Dissolved Impurities</u> (b) Gases	
	❑ O_2	Corrosive to metals
	❑ CO_2	Corrosive, produces acidity
	❑ H_2S	Odour
	(c) Radioactive ❑ It is the disintegrating of some unstable atomic nuclei. It is accompanied by emissions of alpha or beta particles(it happens when a neutron is converted into proton with the emission of an electron). ❑ The permissible concentration of unknown radioactive alpha or beta emitter is expressed in terms of BECQUEREL per liter(Bq/l) ❑ 1 Bq =1 radioactive decay (disintegration)per second	

Waterborne Diseases

Sr.No	Diseases	Bacteria
1.	Typhoid	Salmonella Typhi
2.	Para typhoid	Salmonella Para Typhi
3.	Gastroenteritis	Viral disease
4.	Dysentery	Amoebic Dysenteria Shigella Dysenteria
5.	Hepatitis	Viral disease
6.	Poliomylitis	Viral disease
7.	Cholera	Vibrio Cholera


Physical Parameter
Water Quality Parameters
Chemical Parameter
Biological Parameter

Water Quality Parameters

1.Physical Parameters		
1.	**Taste & Odour**	May be caused in water by organic compounds, inorganic salts or dissolved gases. Drinking water should be free from objectionable taste and odour.
2.	**Color**	Color in drinking water may be caused by vegetable dyes or presence of iron and manganese. Its presence in aesthetically objectionable.
3.	**Turbidity**	Turbidity is due to the presence of colloidal solids in water sample. Turbid waters are of cloudy appearance which makes them aesthetically unattractive.
4.	**Conductivity**	Conductivity is a measure of electrolyte content of a water and is related to dissolved mineral salts in water.
5.	**Total dissolved solids**	TDS in drinking water imparts taste and consist mainly of inorganic salts and small amounts of organic matter. TDS present in water indicate the suitability of water for domestic use. A TDS content of less than 500 mg/l is most desirable for such purposes.

Water Quality Parameters

2.Chemical Parameters		
1.	**Alkalinity**	It is the capacity of a water sample to neutralize strong acids . Alkalinity is expressed in terms of mg/l as $CaCO_3$.
2.	**Acidity**	It is the capacity of water sample to neutralize strong bases. Acidity in water is generally caused due to dissolution of CO_2. $H_2O + CO_2 \rightarrow H_2CO_3$ Acidity is measured in term of $CaCO_3$ needed to neutralize the carbonic acid. It is expressed in terms of mg/l as $CaCO_3$.
3.	**pH**	It is expressed as the common logarithm of the reciprocal of the hydrogen ion $[H^+]$ concentration i.e. $pH = - \log[H^+]$ pH test determines the strength of an acid or base while the chemical test for acidity or alkalinity determines the amount of acid or base.

Water Quality Parameters

2.Chemical Parameters		
4.	**Hardness**	It is the property of preventing lather formation with soap. Hardness also produces scale in hot water systems. Hardness is caused by divalent metallic ions in water which react with soap to form precipitate. These ions are most commonly associated with bicarbonates, sulphates, and chlorides in water.
5.	**Metals and Others**	❑Arsenic: Carcinogenic, skin cancer ❑Chromium: Carcinogenic, skin allergy, impairs kidneys ❑Cyanide: Affects thyroid and nervous system ❑Fluoride: Dental caries, fluorosis ❑Lead: General toxicants, toxic to nervous system, ❑Mercury: Impairs kidneys , affects brain ❑Nitrates: Causes metheoglobinemia in infants. ❑DDT: Carcinogenic to animals, toxic to human

Calculating pH

Problem 1: Determine the pH of a sample of rainwater that has a hydrogen-ion concentration, $[H^+]$, of 1.00×10^{-4} mol/L.

Problem 2: Calculate the hydrogen-ion concentration, $[H^+]$ in a shampoo with a pH of 5.72.

- If the H+ concentration is 0.00001mol/l.What is the OH- concentration.
- What is the pH of a solution that contains 1.32 grams of nitric acid dissolved in 750 ml of water
- What is the pH of solution that contains 25 grmsof HCL dissolved in 1.5 litres of water

Calculating pH

Problem 3: Determine the missing values

sample	$[H^+]$	pH
Rainwater	1.00×10^{-4}	?
Shampoo	?	5.72
HCl	0.5	?
Acetic acid	1.31×10^{-3}	?
Soil solution	?	4.7

Water Quality Parameters

3.Bacteriological Parameters		
1.	**Coliforms**	This group consists of : **Aerobactor Aerogenes:** These are mostly found in soil, plants, grains and to some extent in the faeces of man and animal. **Fecal Coliforms :** Refers to all those coliforms which are present in faeces. They are also named as thermo tolerant coliform bacteria. • All coliforms ferment lactose with the formation of gas at 35°C. • Only fecal coliforms can sustain at 44.5°C to ferment lactose to produce gas. It has been found that pathogenic bacteria in water will die away at least as rapidly as coliform bacteria Therefore , they are used as indicator of faecal pollution **Total coliform:** Refers to all types of coliforms present in water sample.

Water Quality Parameters

4. Radiological Parameters		
1.	Alpha and Beta activity	Radio active material concentrations in drinking water are largely due to naturally occurring radionuclide in the uranium and thorium decay series. These radio nuclides are present in soil.

Drinking Water Quality

1. Criteria

- Drinking water quality criteria specify the conditions to provide long term protection to human health.
- Based on the latest scientific knowledge, criteria prescribe limits on concentrations of specific constituents in drinking water which, if not exceeded , will not have the adverse impact on the health of the consumers.
- They are mostly based on health effects, but may take into consideration technological and economical capacity to achieve the required criteria.
- Criteria provide a logical basis and reasoning for setting a standard.

Drinking Water Quality

2. Standard

- Standard refers to any rule principle or measure established by an authority or that has an official backing. Thus standards are fixed by law.
- Standards are set according to national priorities and taking into consideration the economic and technical capabilities.
- Drinking water quality standards form the legal basis for the protection of public health. They impose limits on the concentration of hazardous substances which may be present in drinking water
- Standards achieve nothing unless they are measured implemented and enforced.

Drinking Water Quality

3. WHO Drinking Water quality Guidelines

- The primary aim of guidelines for drinking water quality is the protection of public health. They are of advisory nature and based on scientific research. They are not intended for absolute and direct application in every country.
- The guidelines are intended to be used as the basis for the development of national standards.
- WHO guidelines address bacteriological quality of all waters intended for drinking treated water entering the distribution system
- Guidelines values have been prescribed for inorganic and organic chemicals, pesticides, disinfectants and radioactive constituents of health significances. Values have also been provided for various parameters in drinking water that may give rise to complaints from consumers.

Drinking Water Quality Monitoring

- Drinking water quality monitoring refers to collecting the water supply samples on regular basis and analyzing them to ensure compliance with the enforced standards/guidelines in accordance with the frequency and procedures prescribe.
- Monitoring ensures that water treatment and distribution comply with the given objectives and regulations.
- Effective water supply monitoring requires the support of appropriate legislation, regulations, standards an code of practices.

Drinking Water Quality Monitoring

Surveillance

- It is defined as the continuous and vigilant public health assessment of the safety and acceptability of drinking water services.
- It is concerned with all aspects of water supply which influence health e.g., coverage, quality and availability.

Drinking Water Quality Monitoring

Sanitary Inspection

- Sanitary inspection are among the essential elements for an effective water quality surveillance programme.
- It is a systematic inspection of an installation or supply system designed to identify risk of contamination. Water quality analysis must be accompanied by sanitary inspection.
- Sanitary inspection is assisted by the use of standards forms.

Drinking Water Quality Monitoring

Sampling Frequency

- The following sampling frequencies for drinking water in the distribution systems are recommended for monitoring purposes.

Population served	Samples to be taken monthly
< 5000	1
5000-100,000	1 for each 5000 population
>100,000	1 for each 10,000 population + additional samples

Water quality Legislation/Regulations

- The legislative framework is a vital component in the provision of safe drinking water and for smooth operation of water supply system. Legislation is likely to be a collection of acts, code of practices and regulation.
- The legislation should make provisions for the establishment of drinking water quality standards
- Legislation should make provisions for delineating minimum treatment requirements, monitoring programme for water supply agency, initiation of legal action to ensure adequate water supply service quality.

Water quality Legislation/Regulations

- Under the legislation , codes of practice are developed for selecting and protecting water source, treatment process and distribution system.
- Under the regulations, procedures are developed for conducting sanitary inspection of the source, treatment plant and the distribution system for selecting deficiencies
- Regulations specify for water supply agency, the minimum number of samples to be taken in an area according to the population served for monitoring purposes. They also specify the standardized analytical methods for testing the quality of drinking water.
- Regulations require water supply agency to maintain records on the quality of water supplied and keep them open to public.