CE 213A
Introduction to Environmental Science

L11: Unit 2: Environmental Pollution
B. Water Pollution

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Schedule : LEC Mon Wed Fri 5:10 – 6 pm

Content

- Basic Concepts
  - water cycle
  - sources of raw water, impurities in water
- Water quality parameters
  - Indicators of water quality
- Cause of concern
  - Pollution in different water bodies
  - Water usage stats
  - Effects of water pollution on health
- Standards for water quality
- Water treatment
  - Sources of polluted water

WATER

A colorless, transparent, odorless, liquid which forms the seas, lakes, rivers, rain and is the basis of the fluids of living organisms.
(Dictionary.com)

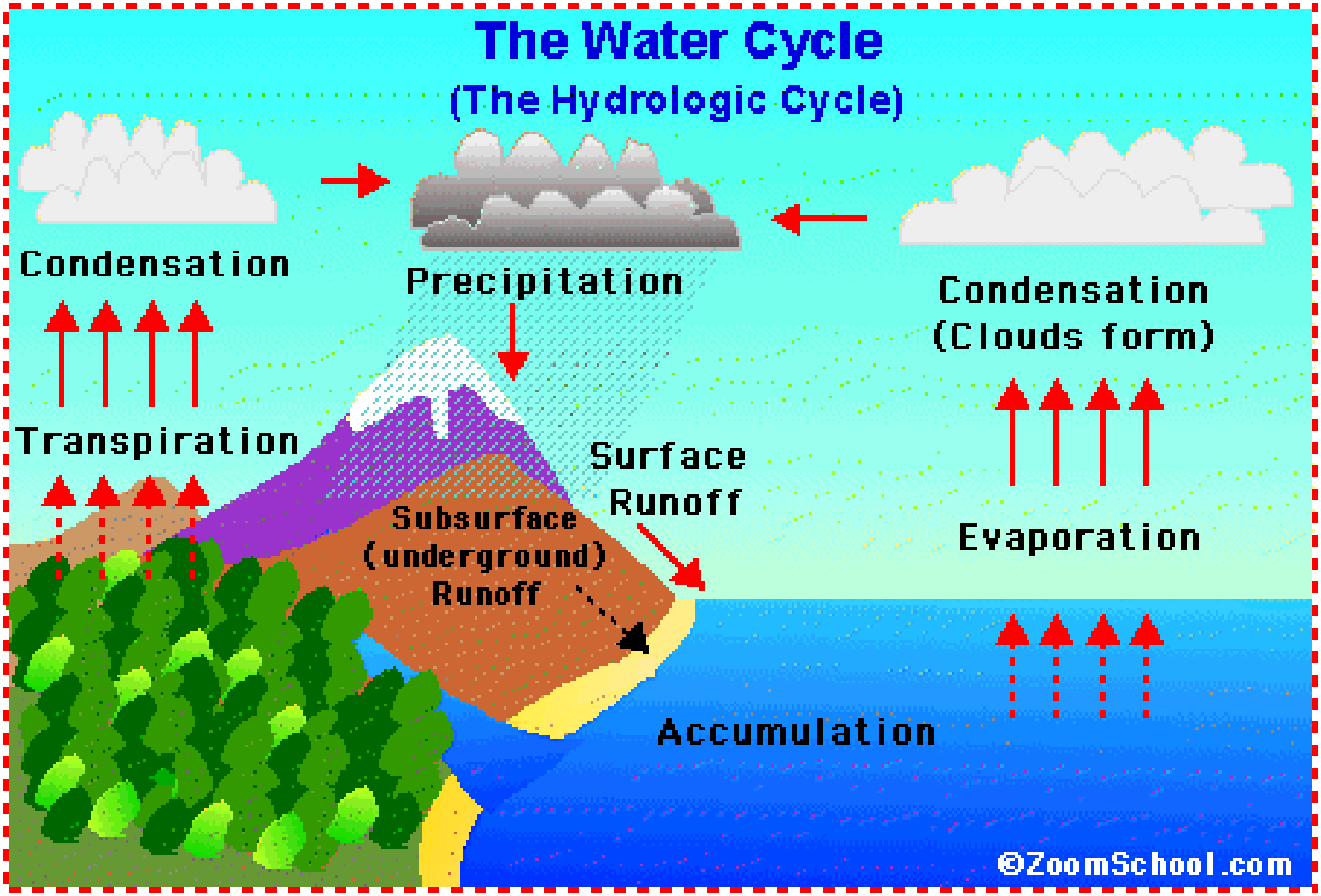
- Forms about 71% of earth surface.
  - 97% salt water (sea)
  - 3% fresh water
    - 87% ice and glaciers, underground, air.
    - 13% surface water (0.4% total water).

- Usage
  - Domestic.
  - Industry.
  - Agriculture.
  - Recreation.

Transparent, odorless, tasteless liquid, a compound of hydrogen and oxygen, H_2O, freezing at 32°F or 0°C and boiling at 212°F or 100°C, that in a more or less impure state constitutes rain, oceans, lakes, rivers, etc. It contains 11.188 percent hydrogen and 88.812 percent oxygen, by weight.
(Dictionary.com)

WATER

- 70% total human body weight.
- 30 – 40% bone mass.
- Body functions:
  - Absorption of oxygen at alveoli.
  - Control of body temperature.
  - Blood component.
  - Digestion in kidneys and intestine.
- Alteration of 10% body content – health problem.
- Alteration of 20% body content – death.



Water Cycle- The cycle of processes by which water circulates between the earth's oceans, atmosphere, and land, involving precipitation as rain and snow, drainage in streams and rivers, and return to the atmosphere by evaporation and transpiration

Potable (Drinking) water vs. Wastewater

- Potable water is water which is fit for consumption by humans and other animals. It is also called drinking water, in a reference to its intended use.
  - Water may be naturally potable, as is the case with pristine springs, or it may need to be treated in order to be safe.
  - In either instance, the safety of water is assessed with tests which look for potentially harmful contaminants.

- Wastewater is water containing wastes from residential, commercial, and industrial processes.
  - Municipal wastewater contains sewage, gray water (e.g., water from sinks and showers), and sometimes industrial wastewater. Large industries, such as refineries, also generate wastewater.
  - Wastewater requires treatment to remove pollutants prior to discharge.

Raw Water Sources

The various sources of water can be classified into two categories:

1. Surface sources
   - Ponds and lakes;
   - Streams and rivers;
   - Storage reservoirs; and
   - Oceans, generally not used for water supplies, at present.

2. Sub-surface sources or underground sources
   - Springs;
   - Infiltration wells ; and
   - Wells and Tube-wells.

Impurities in various sources of water…..[1/2]

- Rain water is obtained as a result of evaporation from the surface water.
  - Probably it is the purest form of natural water.
  - However, during its downward journey through the atmosphere it dissolves organic and inorganic suspended particles and considerable amount of industrial gases like (CO_2 , NO_2 , SO_2 etc.).
  - Rain water is expensive to collect and is irregular in supply.

- Underground water is free from organic impurities and is clearer in appearance due to the filtering action of the soil.
  - But it contains large amount of dissolved salts.

Impurities in various sources of water…..[2/2]

- **River water** contains **dissolved minerals** like chlorides, sulphates, bicarbonates of sodium, magnesium, calcium and iron.
  It also contains **suspended impurities** of sand, rocks and organic matter.
  - The composition of river water is not constant.
  - The amount of dissolved impurities in it depends on its contacts of the soil. Greater the duration of contact, more soluble is the minerals of soil in it.

- **Lake water** has high quantity of organic matter present in it but lesser amount of dissolved minerals.
  - Its chemical composition is also constant.

Water pollution may be defined as the presence in water of impurities in such quantity and of such nature as to impair the use of he water for a stated purpose.
Thus the definition of water quality is predicted on the intended use of the water, and a gross determination of the quantity of suspended and dissolved, impurities, while useful in some cases, is not sufficient to completely define water quality.

Water Quality Assessment

WATER QUALITY PARAMETERS

Need for Water Quality Assessment

- Water quality assessment provides the **base line** information on **water safety**.

Detailed description

http://www.cotf.edu/ete/modules/waterq3/WQassess1.html

Handout 10 – Water Quality Assessment Monitoring
UNICEF 2010

Water Quality Parameters

- *Water quality* is *determined* by assessing three classes of attributes: physical, chemical, and biological.

- There are *standards* of *water quality* set for each of these three classes of attributes.

Physical Parameters

- Colour
- Taste and Odour
- Turbidity
- Temperature
- Conductivity

Chemical Parameters:

- pH
- Acidity
- Alkalinity
- Hardness
- Solids
- Harmful Chemicals
  - Chlorides
  - Sulphates
  - Iron
  - Nitrates and more…….

Bacteriological Characteristics:

Bacterial examination of water is very important, since it indicates the degree of pollution.

Water polluted by sewage contain one or more species of disease producing pathogenic bacteria.

Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as *E.Coli*, a member of coliform group, also live in the intestinal tract of human beings.

Major Indicator – Coliform group

Coliform itself is not a harmful group but it has more resistance to adverse condition than any other group.

So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.

Methods to estimate the bacterial quality of water

Membrane Filter Technique

- ✓ Standard Plate Count Test
- ✓ Most Probable Number (MPN)

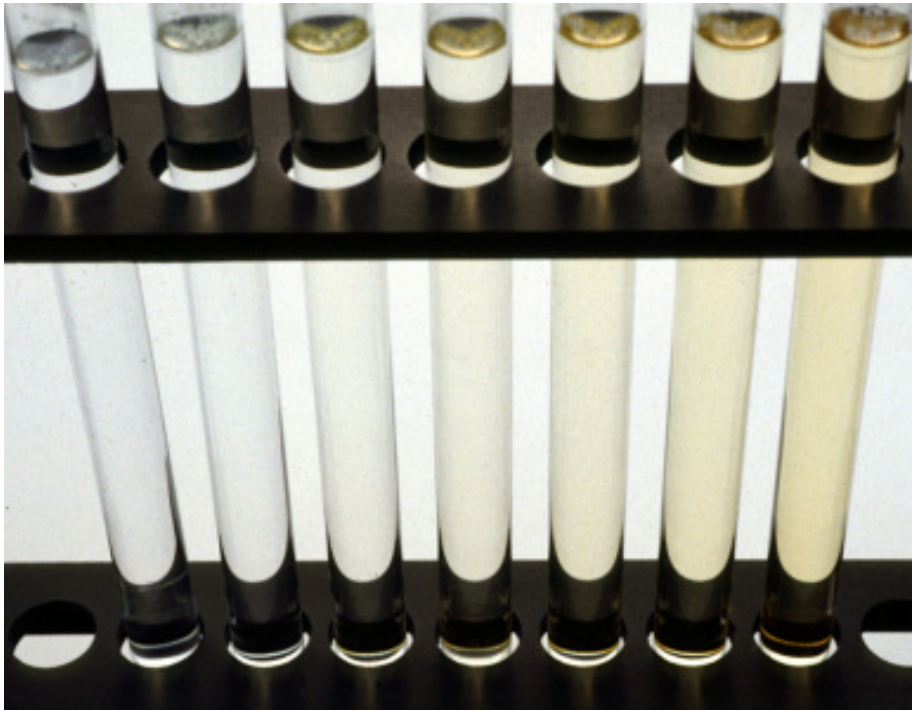
Physical Parameters of Water Quality assessment

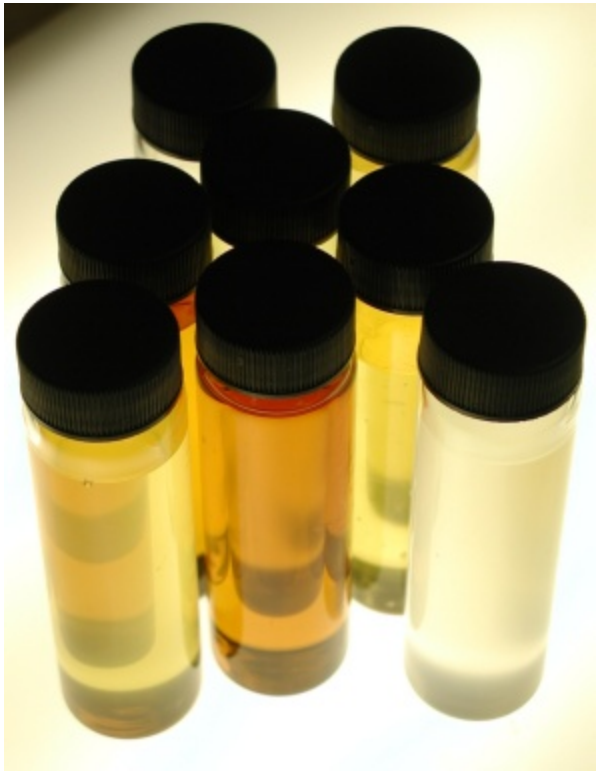
- Colour
- Odour
- Turbidity
- Temperature
- Conductivity

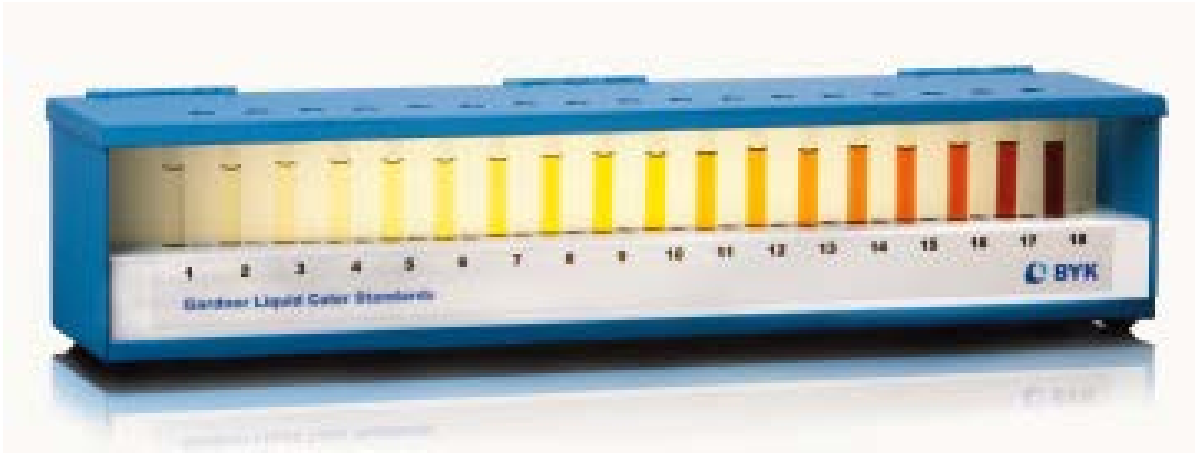
Colour

- Aesthetically displeasing
- May be due to the Presence of organic matter, metals (iron, manganese) or highly coloured industrial waste
- Desirable that drinking water be colourless

- Colour is measured by **colorimetric technique**
  - Desirable limit 5 Hazen Unit
  - Permissible limit 25 Hazen Unit



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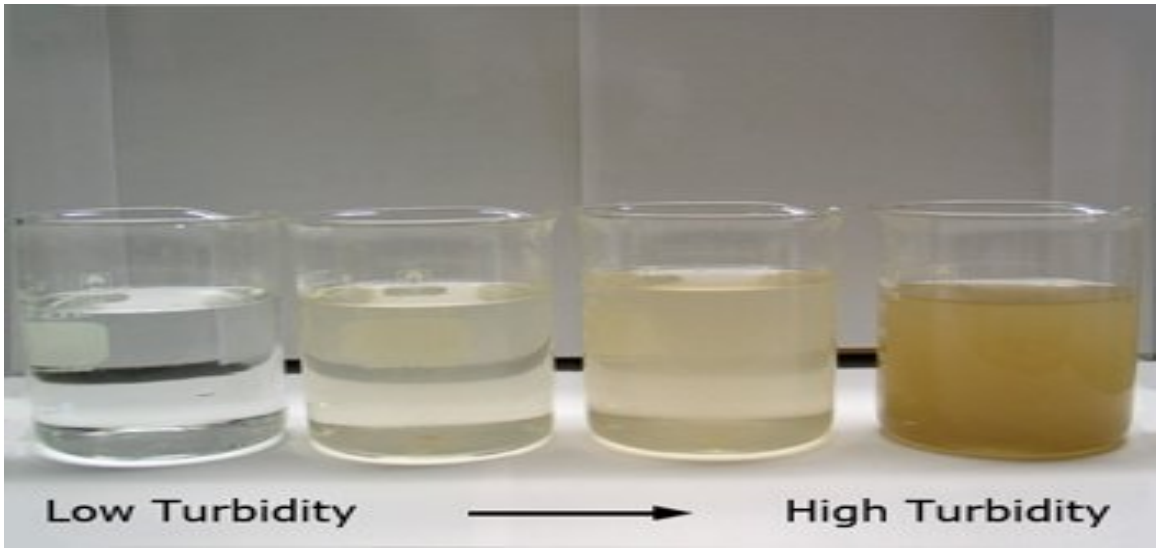
Taste and Odour

- Mainly due to organic substances, Biological activity, industrial pollution
- Taste buds in the oral cavity specially detect inorganic compounds of metals like magnesium, calcium, sodium, copper, iron and zinc
- Water should be free from objectionable taste and odour.

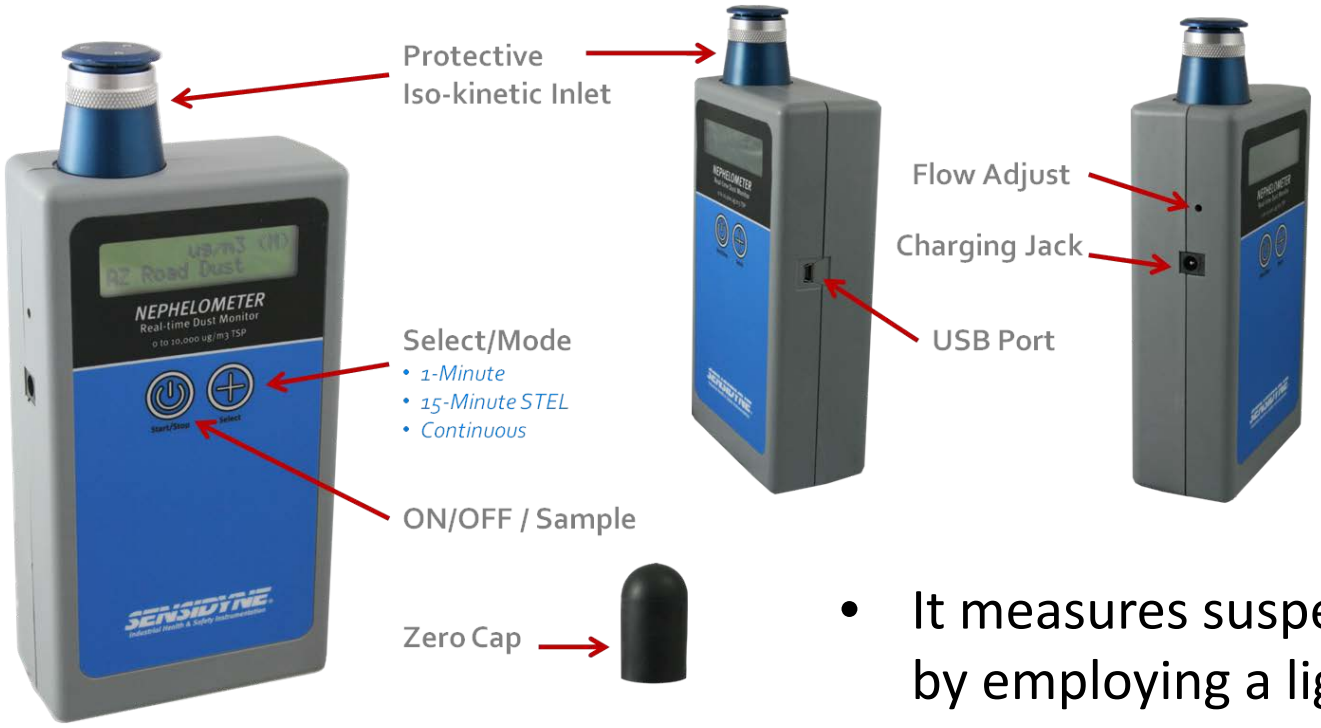
Turbidity

- Turbidity is a measure of how clear the water is.
- Caused by suspended matter
- Measured in Nephelometric Turbidity Units (NTU)



Nephelometer

- A *nephelometer* is an instrument for measuring concentration of suspended particulates in a liquid or gas colloid.



- It measures suspended particulates by employing a light beam (source beam) and a light detector set to one side (often 90°) of the source beam.

Turbidity (NTU)

Water Samples:

Why do we measure Turbidity?

- High level turbidity shield and **protect bacteria** from the action of **disinfecting agents.**

- High turbidity can lower the amount of dissolved oxygen (DO) in the water and reduce the sea grasses that juvenile organisms need.

- Suspended solids (particles floating in the water) can **block the sun's light** from reaching the underwater sea grasses that baby organisms use for protection.

- Suspended solids can also raise water temperature which reduces the content of Dissolved Oxygen (DO).

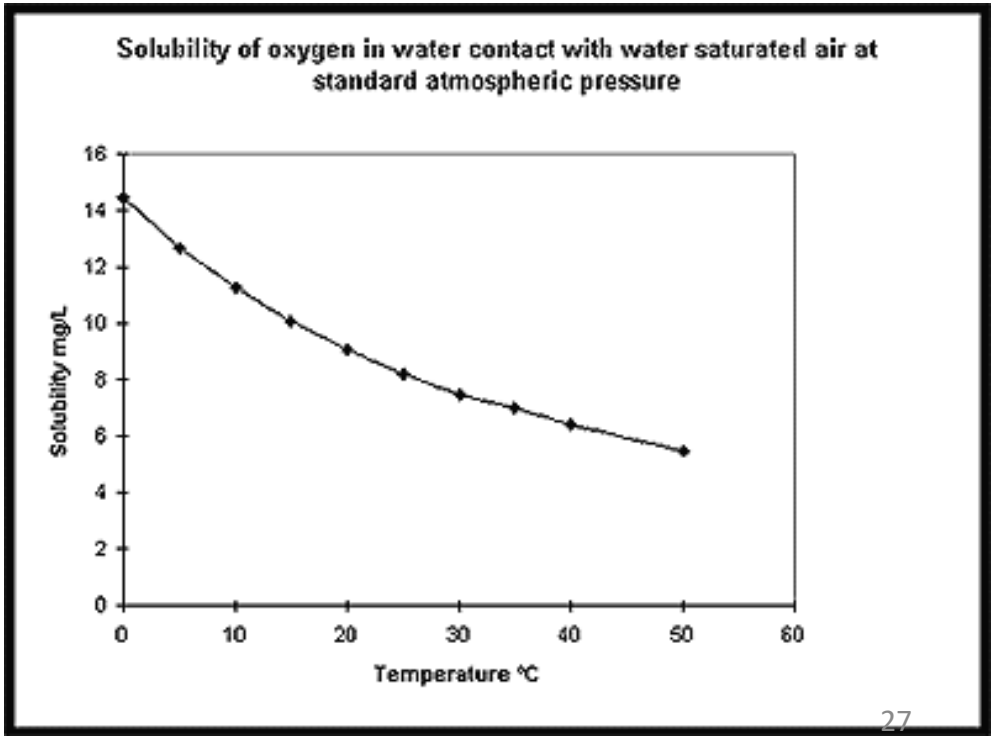
Temperature

- Temperature is a measure of the kinetic energy of an object (how fast its particles are moving).

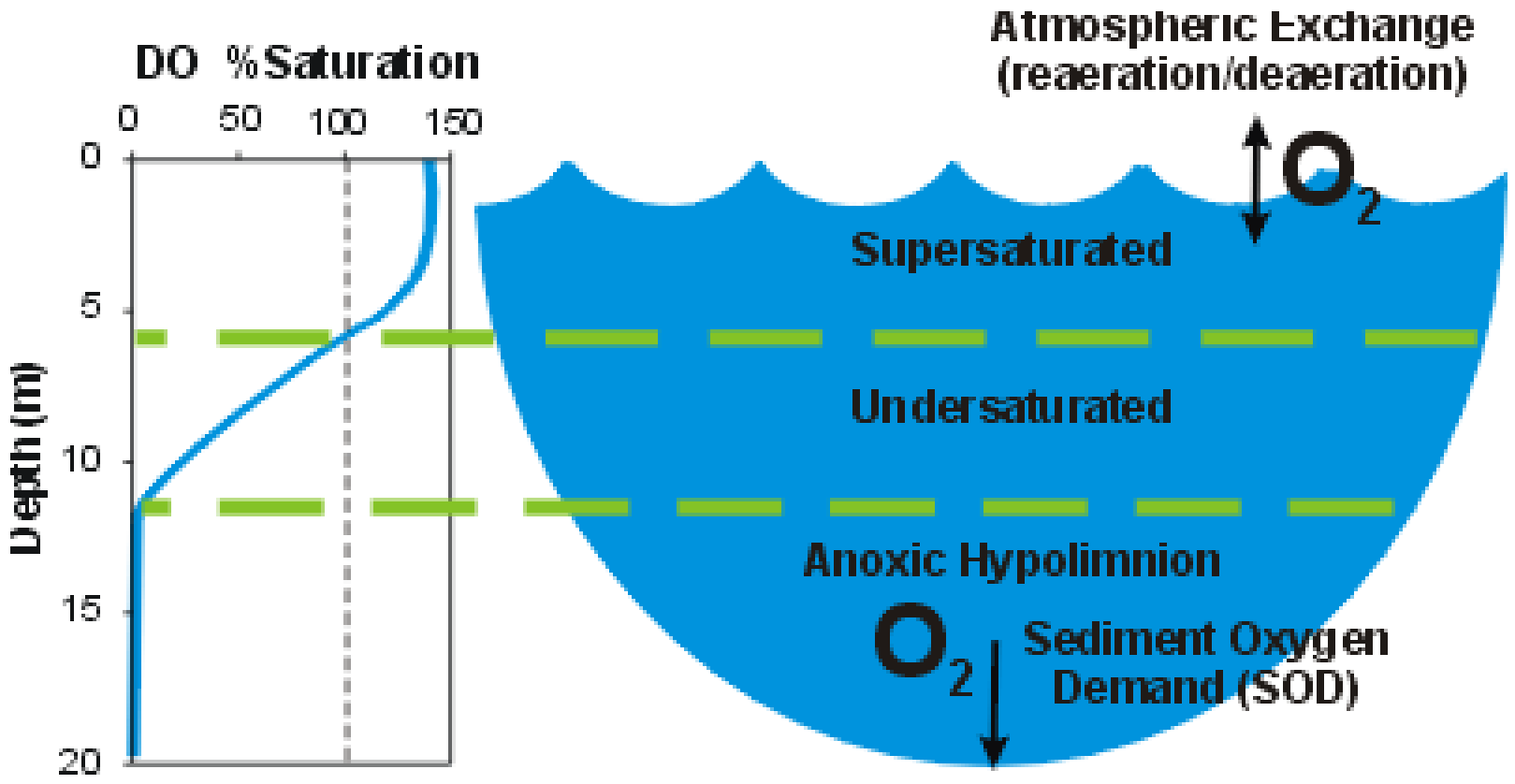
- Temperature has a big effect on the **amount of DO** in the water
  - The higher the temperature the less DO because the gas particles escape from the surface of the water.
  - Higher temperatures can **increase plant growth** which is good, but when there is too much plant growth it causes a **decrease in DO when the plants die**.
  - DO is maximum at 4^0 C temperature

- The water heats up and cools down much slower than the land does.

Temp °C	Solubility of Oxygen mg/l
0	14.6
20	9.08
25	8.24
40	6.41
50	5.49



DO in Surface Water



Conductivity

- Solids can be found in nature in a dissolved form. Salts that dissolve in water break into positively and negatively charged ions.

- Conductivity is the ability of water to conduct an electrical current, and the dissolved ions are the conductors.

- It **indicates the presence of dissolved solids** in water, but does not provide information about a specific chemical.

- Its change might indicate a water quality problem that requires further investigation.

Contributors to Conductivity

- The major **positively charged ions** are sodium, (Na+) calcium (Ca^{2+}), potassium (K^{+}) and magnesium (Mg^{2+}).

- The major **negatively charged ions** are chloride (Cl^{-}), sulfate (SO_4^{2-}), carbonate (CO_3^{2-}), and bicarbonate (HCO^{3-}).

- Nitrates (NO_3^{2-}) and phosphates (PO_4^{3-}) are **minor contributors to conductivity**, although they are very **important biologically**.

Water characteristics

Characteristic	Surface Water	Ground Water
Turbidity	high	low
Dissolved minerals	low-moderate	high
Biological content	high	low
Temporal variability	very high	low

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CHEMICAL PARAMETERS & INDICATORS OF WATER QUALITY

Chemical Parameters for Water Quality assessment

pH
Acidity
Alkalinity
Hardness
Solids
Harmful Chemicals
- Chlorides
- Sulphates
- Iron
- Nitrates
- Heavy Metals
- Pesticides

Solids

- Both dissolved and suspended materials are called solids.
- Total ***solids*** include any material left in a container after the water is removed by evaporation, usually at 103-105°C.
- Total solids can be separated into total ***suspended solids*** (solids that are retained on a 2.0 micron filter) and total ***dissolved solids.***

pH

- pH is a measure of how acidic or basic (alkaline)the water is.
- pH is defined as the negative logarithm of hydrogen ion concentration.

$$pH = - \log [H^+]$$

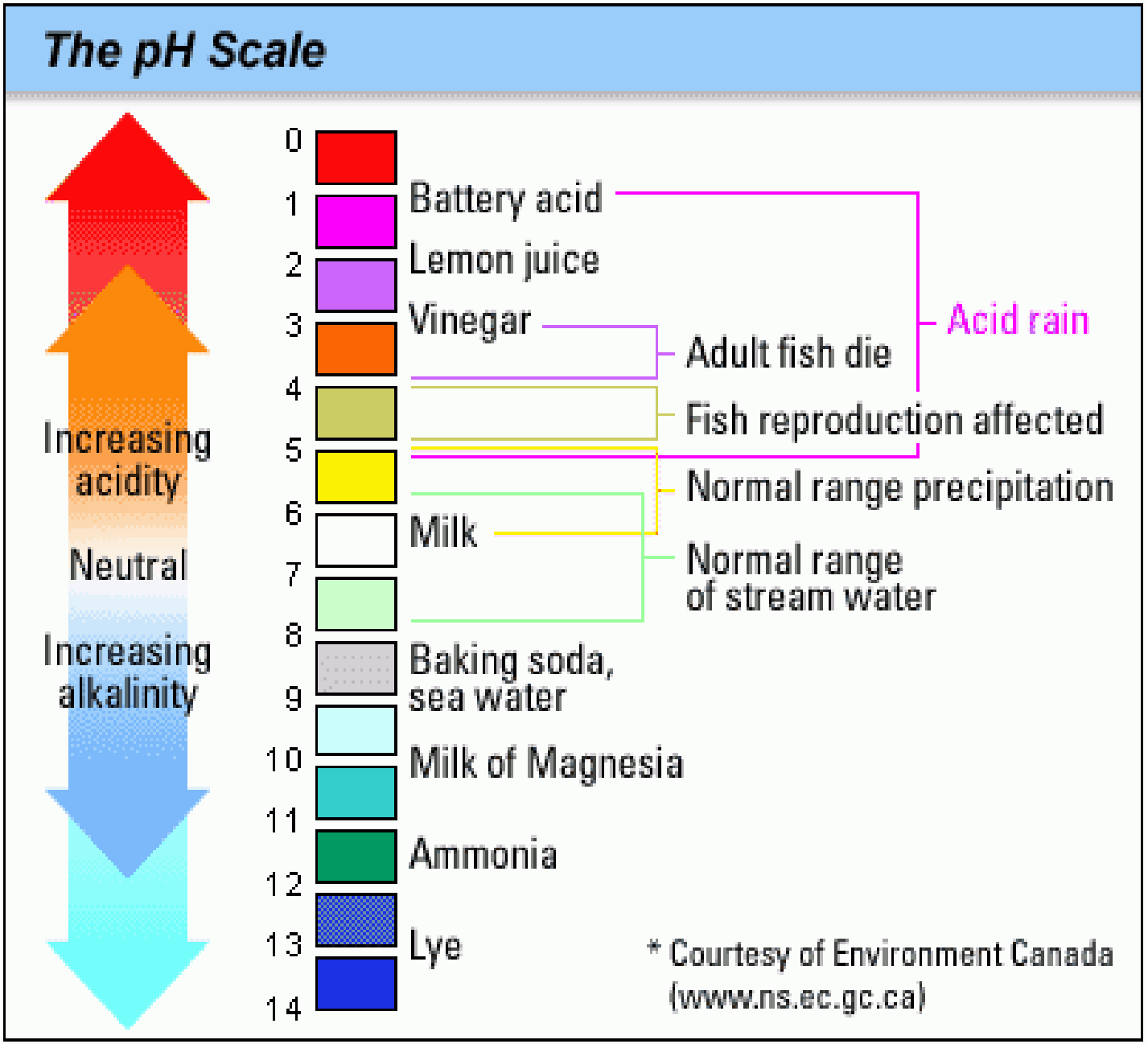
$$pH + pOH = 14$$

- The pH scale goes from 1 to 14 with 7 being neutral.
  - In neutral solution pH = pOH = 7
  - The lower the number the more acidic the water is.

Why do we measure pH ?

- Every increase of one on the scale is actually an increase of 10 times more acid.
  - A pH of 5 is 10 times more acid than a pH of 6.

- **Most plants and animals cannot survive in water that has a pH less than 5.** It's too acidic.


The pH Scale
Increasing acidity
Neutral
Increasing alkalinity
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
Lemon juice
Vinegar
Milk
Baking soda, sea water
Milk of Magnesia
Ammonia
Lye
Acid rain
Adult fish die
Fish reproduction affected
Normal range precipitation
Normal range of stream water
* Courtesy of Environment Canada (www.ns.ec.gc.ca)

Alkalinity

- Capacity to neutralize acid
- Presence of carbonates, bi-carbonates and hydroxide compounds of Ca, Mg, Na and K

Alkalinity

- Alkalinity measures the **buffering capacity** of the water against changes in pH.

- Water that has **a high alkalinity** can accept large doses of acids ***or*** bases without altering the pH significantly.

- Waters with **low alkalinity**, such as rainwater or distilled water, can experience a drop in the pH with only a minor addition of an acid or base.

- **In** natural waters much of the alkalinity is provided by the **carbonate/ bicarbonate buffering system**.

- Alkalinity is determined by measuring the amount of acid needed to lower the pH in a water sample to a specific endpoint; the results are usually reported in standardized units **as** milligrams $CaCO_3$ per liter.

- Carbon dioxide dissolves in water to form carbonic acid , which dissociates and is in equilibrium with bicarbonate and carbonate ions.

$$CO_2\ (gas) \longleftrightarrow CO_2\ (dissolved)$$

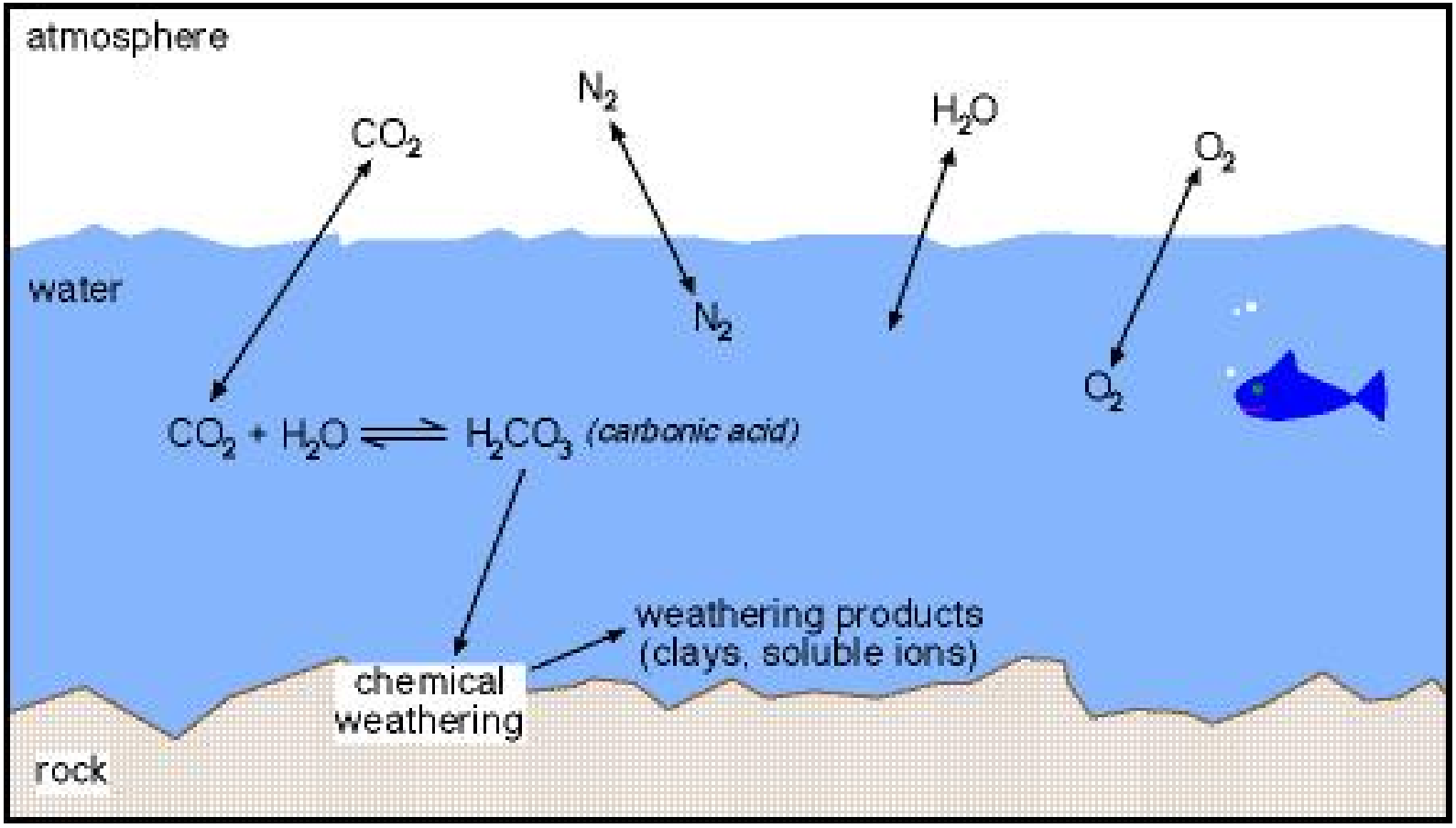
$$CO_2(dissolved) + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

$$HCO_3^- \longleftrightarrow 2H^+ + CO_3^{2-}$$

- Carbon dioxide dissolves in water to form **carbonic acid** , which dissociates and is in equilibrium with **bicarbonate and carbonate** ions.
- ***Buffering mechanism***:

  If an acid is added to the water, the hydrogen ion concentration is increased, and this combines with both the carbonate and bicarbonate ions, driving the equilibrium to the left, releasing carbon dioxide into the atmosphere.

Carbonate cycle in water



Hardness

- Capacity of water for reducing and destroying the lather of soap
- **It is total concentration of calcium and magnesium ions**

- Types
  - Temporary – Bicarbonates of Calcium and Magnesium
  - Permanent – **Sulphates , chlorides and nitrates** of calcium and magnesium

- Impact
  - Causes encrustations in water supply structures

Total Hardness

- **Total Hardness**: total concentration of metal ions expressed in terms of mg/L of equivalent $CaCO_3$.
- Primary ions are Ca^{2+} and Mg^{2+}.
  - also iron and manganese.
- **Total Hardness approximates total alkalinity.**

Alkalinity vs. Hardness

Possibility of 3 cases

- Alkalinity = Hardness
  - Ca and Mg salts are present
- Alkalinity > Hardness –
  - presence of basic salts, Na, K along with Ca and Mg
- Alkalinity < Hardness –
  - neutral salts of Ca & Mg present

Iron

- One of the earth's most plentiful resource
- High iron causes brown or yellow staining of laundry, household fixtures
- Metallic taste, offensive odour, poor tasting coffee
- Cause iron bacteria
- Acceptable limit – 0.3 mg / l

Chloride

Occurs in water due to:

- Dissolution of salt deposit
- Discharge of effluents
- Intrusion of sea water

- Regarding irrigation – most troublesome anion
- Acceptable limit - 250 mg/l
- IMPORTANT - Not harmful to human beings

Nitrate

Increasing level of nitrate is due to

- Agricultural fertilizers, manure,
- animal dung, nitrogenous material ,
- sewage pollution

- Health impact : (blue baby diseases to infants)

- Maximum permissible limit 45 mg / l

Fluoride

- Occurs naturally
- Long term consumption above permissible level can cause –
  - dental fluorosis (molting of teeth)
  - Skeletal fluorosis
- Acceptable limit – 1 mg / l
- Maximum permissible limit – 1.5 mg / l
- Remedy – 1) Deflouridation
  2) Mixing Fluoride free water
  3) Intake of vitamin C,D, calcium, antioxidants

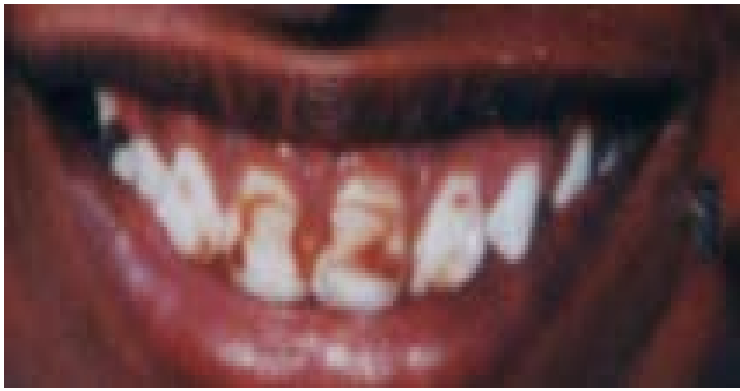
Fluoride causes Fluorosis

Three types of Fluorosis

1.Dental Fluorosis

2. Skeletal Fluorosis

3. Non-skeletal Fluorosis



Phosphates

•Phosphates are also essential for plant growth but, just like nitrates, too many phosphates is a bad thing.

•Too many phosphates can cause too much algal blooms.

- Phosphates are found in fertilizers, rocks, and soil.

- IMPACT: Phosphates can
  - increase temperature,
  - decrease DO

Arsenic

- Occur in ground water from arseniferous belt

- Industrial waste, agricultural insecticide
- High arsenic causes
  - various type of dermatological lesions,
  - muscular weakness, paralysis of lower limbs,
  - can also cause skin and lung cancer

- Acceptable limit : 0.05 mg / l

Heavy Metals

- Present as mineral in soil and rocks of earth

- Human activities

Battery	–	Lead & Nickel
Textile	–	Copper
Photography	–	Silver
Steel production	–	Iron

Pesticides

- Can cause
  - Cancer
  - Birth defects
  - Blood disorder
  - Nervous disorder
  - Genetic damage

Common problems

Visible effects	Reasons
water turns black, smell	Waste water
Acidic taste	Low pH
Alkaline taste	High pH
Boiled Rice hard and yellow	High Alkalinity
White deposits on boiling	Hardness

Visible effects	Reason
Iron taste, change in color after exposure to atmosphere, change in colour of clothes & utensils Oily appearance on top of water body	Iron
Soap not lathering	hardness
Brownish black streaks on teeth	Fluride
Growth of Algae	Nitrate, phosphate
Fish kills	Low pH, less DO
Salty taste	chloride