Environmental Quality & Pollution Monitoring Techniques

Water Environment

Water Quality

Quantification of Water Characteristics
&
Water Quality Parameters

Dr Vinod Tare
Department of Civil Engineering
IIT Kanpur

Water Quality Parameters

- Water quality is a dimension of water which requires measurement in the precise number is an important concept.
- Though several attempts have been made to implement this concept, its application has been restricted due to difficulties involved in the formulation of a single overall dimensional number. Challenge is similar to making decisions on behalf of Humans i.e. Of Developing Artificial Intelligence Tools or Systems.
- As such various characteristics of water are used to assess water quality.
- Characteristics of water are generally assessed through a number of water quality parameters and these parameters are classified in a number of ways. Most often they are grouped as physical, chemical, and biological. The other way is to classify them in two groups i.e. GROSS & SPECIFIC parameters

Water Quality Parameters – GROSS & SPECIFIC

GROSS PARAMETERS are focused on measuring a common effect, influence or impact due to presence of one or several or many species or substances.

SPECIFIC PARAMETERS on the other hand are necessary when individual physical properties or chemical entities or biological species such as toxic ion or organic compounds or biological species is of concern and, as such, are used to describe water quality as it applies to particular use.

Water – Judgement or Basis of Assessment

Concept of Beneficial Uses of Water

- There are several beneficial uses of water, and since each use of water has an individual set of constraints, an absolute definition of water quality can not be made.
- The basic concern in establishing water quality criteria for various beneficial uses are:
  - (1) Safety,
  - (2) Aesthetic, and
  - (3) Economic.

Water – Beneficial Uses (Domestic) and Quality

- **Safety →**
  - **Biologically Safe →** means absence of disease causing organisms (i.e. Pathogenic Organisms). Examples of organisms which cause some of the commonly known water born diseases.
  - Cholera → *Vibrio coma* or *Vibrio cholera* → Bacterial disease
  - Typhoid → *Salmonella typhosa* → Bacterial diseases
  - Bacillary dysentery → shigellosis → Bacterial
  - Dysentry → Entamoeba hystolytica (Amoebic dysentery) → Protozoan
  - Infectious hepatitis (Jaundice)-----Viral disease
  - Poliomyelitis ----------------------Viral disease

Water – Beneficial Uses (Domestic) and Quality

- **Chemically Safe →** No toxic chemical should be present
  - Example: Heavy metals like Pb, Hg, Cd, Zn, Cu, etc.
  - Radioactive chemicals.
  - Common elements → SO_4^{-2} → in high concentration causes indigestion (laxative effect)
  - NO_3^- If > 100 mg/l → infant illness called methemoglobinemia (in low acidity nitrate reducing bacteria thrive)
  - NO_3 → NO_2 → combines with hemoglobin (competes with O_2) Blue baby disease.
  - Fluoride → mottling of teeth/bones become week → Excessive concentration extracts Ca^{++}).
    → Dental carries, decay → (Low concentration of F^-).
    → Optimum concentration ≅ 1-1.5mg/l.
  - Trihalomethanes → CHX_3, $CHCl_3$, $CHBr_3$, $CHCl_2Br$, $CHBr_2Cl$ → mutagenic.

Water – Beneficial Uses (Domestic) and Quality

- *Aesthetics*: Absence of colour, odour, taste, turbidity → which can be perceived by human senses.
- *Economic*: More hardness → more soap consumption (earlier);
  → scale formation and corrosion.
- More iron → staining of cloths, rusting, clogging, etc.

Water – Beneficial Uses (Industrial) and Quality

- Water is an important raw material.
- Process Water → used in the production of the industry e.g. boiler water→ high quality → scale /corrosion → DO.
- Product Water → food industry → biologically safe
- In Rayon Industry → Fe content → stains the rayon (low grade yarn is produced)
- Tannins → due to tanneries in Kanpur.
- Cooling Water → need not be high quality.
- Service Water → washing, etc.

Water – Beneficial Uses (Agricultural) and Quality

- Concerns
  - Health hazard → workers and consumers (major concern)
  - Soil sickness → chemicals, pH, acidity, etc.
  - Salinity.
- Total concentration of salts → conductivity or TDS.
- Relative proportion of sodium to other ions → sodium hazard to crop → high Na replaces Ca^{++}, Mg^{++}, K^{+}, etc.

Water – Beneficial Uses (Agricultural) and Quality

- Excessive bicarbonate (HCO_3)→ Precipitation of Ca, Mg in the root zone of crops
  - Residual Sodium Bicarbonate (RSB) = $[CO_3] + [HCO_3] - [Ca] - [Mg]$; meq/l
- Toxic chemicals → Boron content.

Water – Beneficial Uses (Live Stock) and Quality

- Drinking water for animals →Biologically and chemically safe → Human and animal Safety
  - Disease transmission → TB
- Economic loss if cattles are not healthy.
- Aesthetic → Not much important →Turbidity and colour → Not a problem
- Test should not be bad.

Water – Beneficial Uses (Fish Culture) and Quality

- Concerns
  - Temperature
  - DO > 5 mg/l
  - Turbidity →Photosynthesis is affected → Less food for fish → affects the food chain
  - Toxic chemicals

Water – Beneficial Uses (Recreational Use) and Quality

- Concerns
  - Aesthetic → Very important
  - Disease causing
    - organisms → skin diseases → mainly fungal.
    - Chemicals → Irritation of nose and eyes.

Water

Water Sources

- The two principal sources are ground or surface water. Depending on the hydrology of a basin, the levels of human activity in the vicinity of these source, and other factors, a wide range of water quality parameters can be encountered. One major distinction is based on the level of the dissolved salts (Total Dissolved Solids, TDS)
  - Fresh waters are those sources with TDS < 1000 mg/l
  - Brackish waters are those which have TDS > 1000 mg/l and can be used under special circumstances for specific uses with adequate treatment up to (say) 10,000 mg/l
  - Finally the most abundant source, the Ocean or Sea water, contains approximately 35,000 mg/l dissolved salts and consequently requires demineralization prior to use.

Water Quality Measures or Parameters

GROSS MEASURES or GROSS PARAMETERS are focused on measuring a common effect, influence or impact due to presence of one or several or many species or substances.

SPECIFIC MEASURES or SPECIFIC PARAMETERS on the other hand are necessary when individual physical properties or chemical entities or biological species such as toxic ion or organic compounds or biological species is of concern and, as such, are used to describe water quality as it applies to particular use.

Understanding Water Quality Parameters

- What or Definition or Concept
- Why or Significance or Importance
  - From the Point of View of Beneficial Use → Aesthetic, Safety and Economic Considerations
  - From the Point of View of Conveyance & Treatment
- How or Principle and Method/Technique or Procedure

Water Quality Parameters

$pH = -\mathrm{Log}_{10}[H^+]$

- What ?
- Why ?
- How ?

Dr Vinod Tare
Department of Civil Engineering
IIT Kanpur

Water Quality Parameters

- Many liquids are essential in our daily life.
- They may include water, beverages, dairy products, chemicals, acids and bases, or pharmaceutical products.
- The quality of these liquids, including water, is determined by their characteristics. To assess these characteristics, various principles of measurement are used.
- One of these principles is pH measurement, according to the potentiometric principle.

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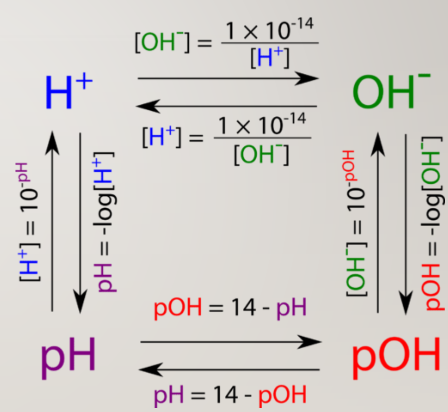
Water Quality Parameters

- The principle of pH can be traced back to 1909.
- ***Danish chemist*** Soren Peder Lauritz Sorensen (S P L Sorensen) introduced the hydrogen ion exponent pH, to describe the concentration of hydrogen ions in a solution.
- This is the basis for the development of the conventional pH scale.

pH i.e. Negative of Logarithm of Hydrogen Ion Activity in Moles Per Litre

- **pH**, is a quantitative measure to indicate whether in a liquid solution H^+ ions are more or equal or less than OH^- ions and does not indicate acidity or basicity of aqueous or other liquid solutions.
- The term, widely used in chemistry, biology, agronomy, and many other fields.
- pH translates the values of the concentration of the hydrogen ion - which ordinarily ranges between about 1 and 10^{-14} Moles per litre - into numbers between 0 and 14.

- pH, pOH & pKw
- H & OH, and pH & pOH Relation



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Water Quality Parameters

- In 1889 Nernst formulated an equation for the first time, that related electrical voltage to ion concentration, now know by his name as Nernst Equation.
- The Nernst equation derived for pH is the physical basis for pH measurement, according to the potentiometric principle.

Nernst Equation

$$E = E^0 - \frac{RT}{zF} \ln Q$$

E = reduction potential

E^0 = standard potential

R = universal gas constant

T = temperature in kelvin

z = ion charge (moles of electrons)

F = Faraday constant

Q = reaction quotient

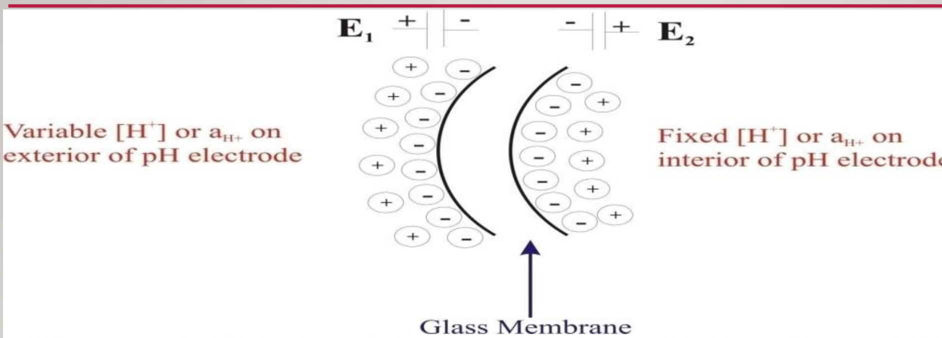
Electrolyzers (alkaline ionizers) produce H_2 gas at the negative cathode by reducing (adding electrons to) H^+ ions to H_2 gas using electricity. The following equation describes the reduction of H+ ions to H2 gas:

$$2H^+ + 2e^- \rightarrow H_2$$

The Nernst equation is used to predict reduction potentials (ORP). The form of the Nernst equation used for dissolved hydrogen gas is:

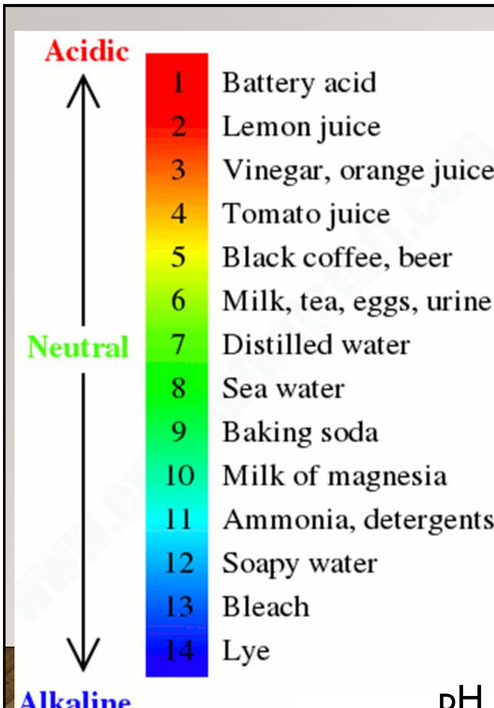
$$E_{mv} = E^0 - \left(\frac{RT}{nF}\right) \ln \frac{[H_2]}{[H^+]^2}$$

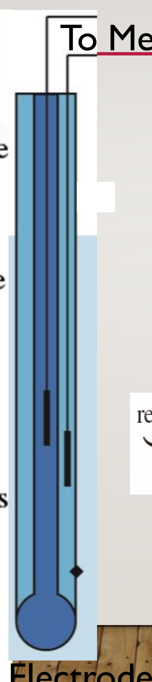
Nernst Equation

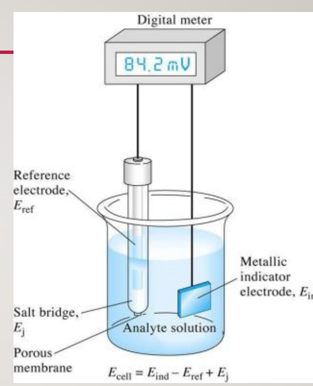


$$E_{mv} = E^0 - \left(\frac{RT}{nF}\right) \ln \frac{[H_2]}{[H^+]^2}$$

The Nernst equation derived for pH is the physical basis for pH measurement, according to the potentiometric principle.



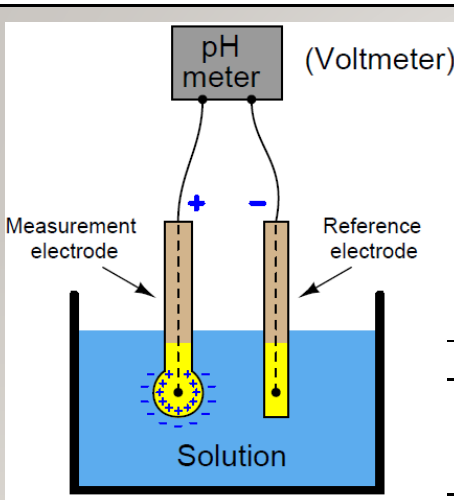




$$\underbrace{\text{reference electrode}}_{E_{ref}} \,|\, \underbrace{\text{salt bridge}}_{E_j} \,|\, \text{analyte solution} \,|\, \underbrace{\text{indicator electrode}}_{E_{ind}}$$

$$E_{cell} = (E_{ind} - E_{ref}) + E_j$$

For most electroanalytical methods, the junction potential is small enough to be neglected



Common Reference Electrodes

i) Calomel Electrodes (Hg in contact with Hg_2Cl_2 & KCl)

ii) Silver/Silver Chloride Electrode

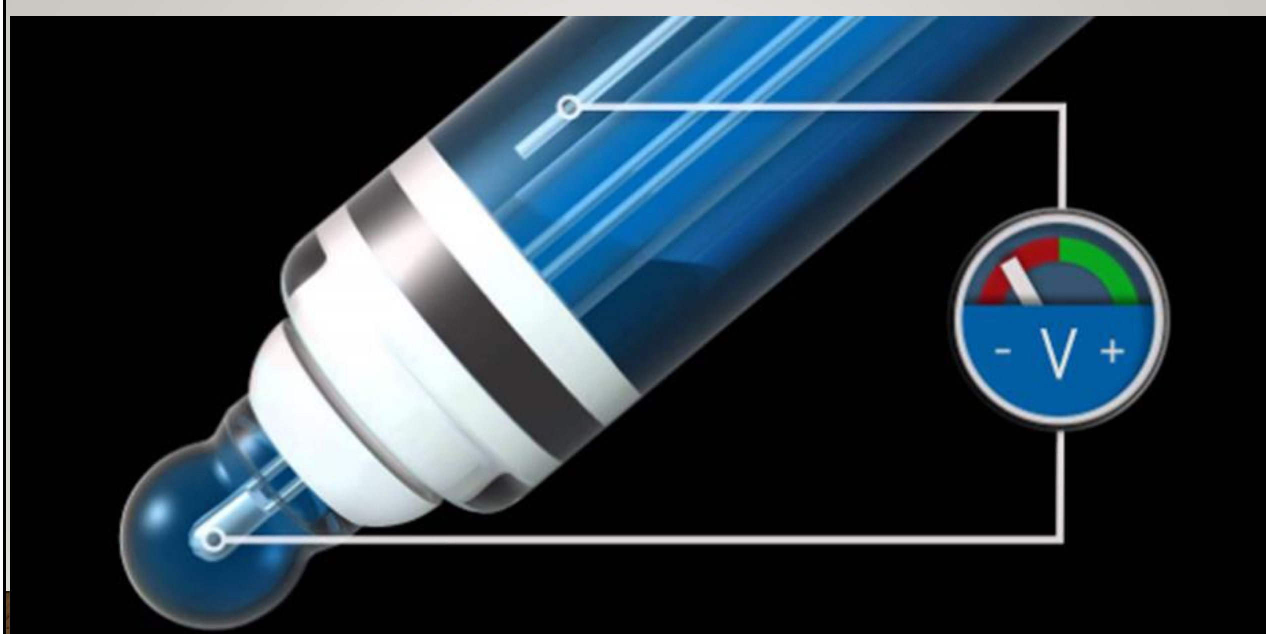
Measurement or Indicator Electrodes

- Detects or Responds to Presence of Analyte
- Ideal indicator electrode responds *rapidly and reproducibly* to changes in the concentration of an analyte ion (or groups of analyte ions)
- Three Common Types:

a) Metallic Indicator Electrodes

b) Membrane Indicator Electrodes
   - Crystalline Membrane Electrodes
   - Non-crystalline Membrane Electrodes

c) Ion selective Electrode (field effect transistor) ISFET

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