QUALITY OF GROUNDWATER

Prepared By
KUNWAR BIJENDRA PRATAP RAHI
GUEST FACULTY, DEPT. OF GEOLOGY
PATNA UNIVERSITY, PATNA

Quality for Domestic use
Quality for Irrigation use
Quality for Industrial use

- Quality for Domestic use
  - Free from turbidity.
  - Should be colourless, odourless, tasteless.
  - Without any harmful micro-organisms and radioactivity

SOURCES OF SALINITY

- Salt content ranges from < 25ppm in a groundwater of quartzite spring to more than 300,000ppm in brine.
- Increase in salt concentration of dissolved salts may be brought about in the soil zone due to a high evaporation rate.
- A further increase in the salts may occur as the water infiltrated through the materials in the zone of aeration by dissolution of soluble material, especially carbonates of calcium and magnesium.
- Salts are added to groundwater passing through soils by soluble products of soil weathering and erosion by rainfall and flowing water.
- salinity varies with specific surface area of the aquifer materials, solubility of minerals and contact time.
- Salinity generally increases with depth.
- Unweathered igneous rocks which are relatively insoluble, contributing little amount of salt to groundwater whereas sedimentary rocks contain more soluble minerals.

Constituents	Maximum desirable (ppm)	Highest permissible (ppm)
pH	7.85	6.5 – 9.2
TDS	500	1500
Hardness	< 100	500
Calcium	75	200
Magnesium	50	150
Sodium	50	200
Carbonate and Bicarbonate	800	800
Sulphate	200	400
chloride	200	600
Iron	0.3	0.3
Manganese	0.1	1
Zinc	5	15
Nitrate	45	45
Copper	1	1.5

• Presence of some Toxic elements beyond their permissible limit makes the water unsuitable.

constituents	Permissible limit (ppm)	Impacts on human health
Fluoride	1.5	Fluoride is essential in small quantities for the prevention of dental caries, especially in children. Excessive consumption leads to: •Skeletal Fluorosis: Deposits of Fluoride on the bones, making them stiff and rigid with a crippling effect. •Dental Fluorosis: Discolours teeth, makes teeth brittle and eventually makes them fall out. •Blood Disorders
Lead	0.01	Lead can affect almost every organ and system of the body. The most sensitive is the central nervous system, particularly in children. Lead also damages kidneys and the reproductive system.

constituents	Permissible limit (ppm)	Impacts on human health
Arsenic	0.01 (WHO) 0.05 (BIS)	•Consuming high levels of inorganic arsenic can result in death. •Small levels of arsenic can cause nausea and vomiting. •Arsenic ingestion can cause blood disorders. •Ingesting or breathing low levels of inorganic arsenic for a long time can cause skin problems.
Chromium	0.05	Ingesting large amounts of chromium can cause stomach upsets and ulcers, kidney and liver damage, and even death.
Mercury	0.001	Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys. Effects on brain functioning may result in irritability, tremors, changes in vision or hearing, and memory problems.

constituents	**Permissible limit (ppm)**	**Impacts on human health**
Cadmium	0.003	Long-term exposure to cadmium in water is associated with kidney disease. Other long-term effects are lung damage and fragile bones. May have carcinogenic properties.
Selenium	0.01	the toxic effects of long-term selenium exposure are manifested in nails, hair and liver.
DDT and other pesticides	0.01 (DDT, BIS) 0.0005 (Pesticides)	DDT affects the nervous system. Pesticides affects in Central Nervous system and interferes with the chromosomal set up.

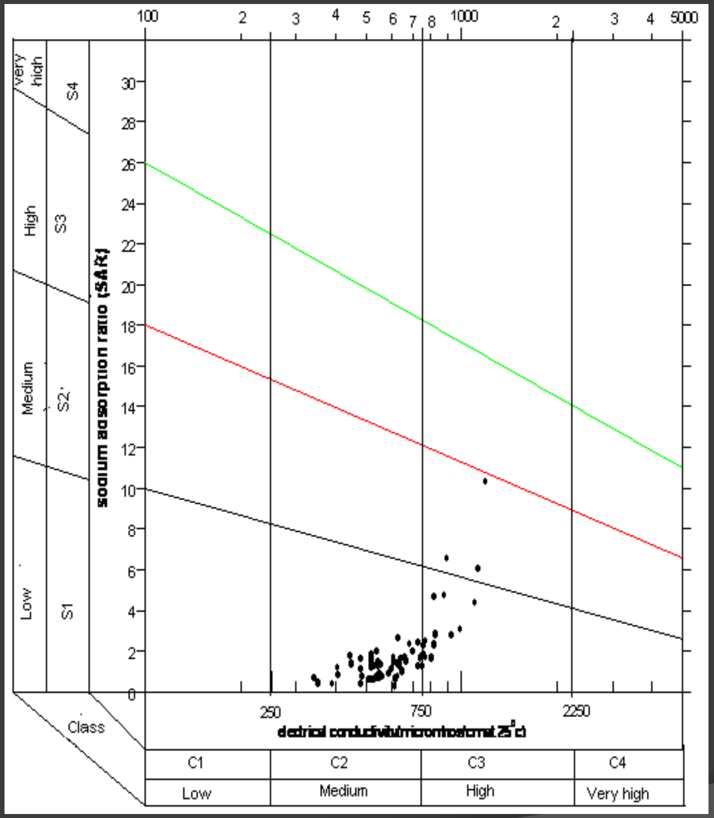
❑Quality for Irrigation Use:

- Plant growth may be harmed by the effect of excess salts within the soil and presence of toxic substances.
- An important factor allied to the relation of crop growth to water quality is drainage.
- Sodium reacts with soils reduces the permeability. Soils containing sodium with carbonate or bicarbonate as predominant anion are termed as Alkali Soils, those with Chloride and sulphate are Saline Soils.
- Sodium content is usually expressed in terms of Percent Sodium.

$$\%Na = \frac{(Na + K)100}{Na + K + Ca + Mg}$$

- The classification of irrigation waters with respect to Salinity hazard and Sodium hazard is given by US salinity laboratory.
- Sodium Adsorption Ratio (SAR):

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$



USSL diagram

- Boron is necessary in very small amount for normal growth of plants. Quantities needed vary with the crop type.

Quality classification for Irrigation(after wilcox)

Water class	**%Na**	**Specific conductance(μs/ cm)**	**Boron**		
			Sensitive Crops	Semi tolerant	Tolerant crops
Excellent	<20	<250	<0.33	<0.67	<1.00
Good	20-40	250-750	0.33-0.67	0.67-1.33	1.0-2.00
Permissible	40-60	750-2000	0.67-1.00	1.33-2.00	2.00-3.00
Doubtful	60-80	2000-3000	1.00-1.25	2.00-2.50	3.00-3.75
Unsuitable	>80	>3000	>1.25	>2.50	>3.75

Quality for Industrial use

- Salinity, hardness and silica are three parameters that usually are important for industrial water.
- Adequate groundwater supply with suitable quality often become a primary consideration in selecting new industrial plant location.

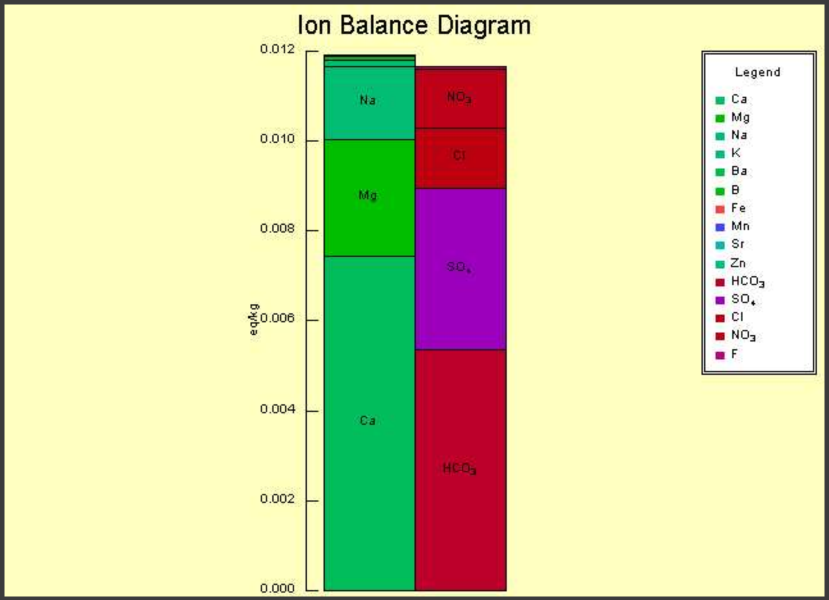
changes in Chemical composition:

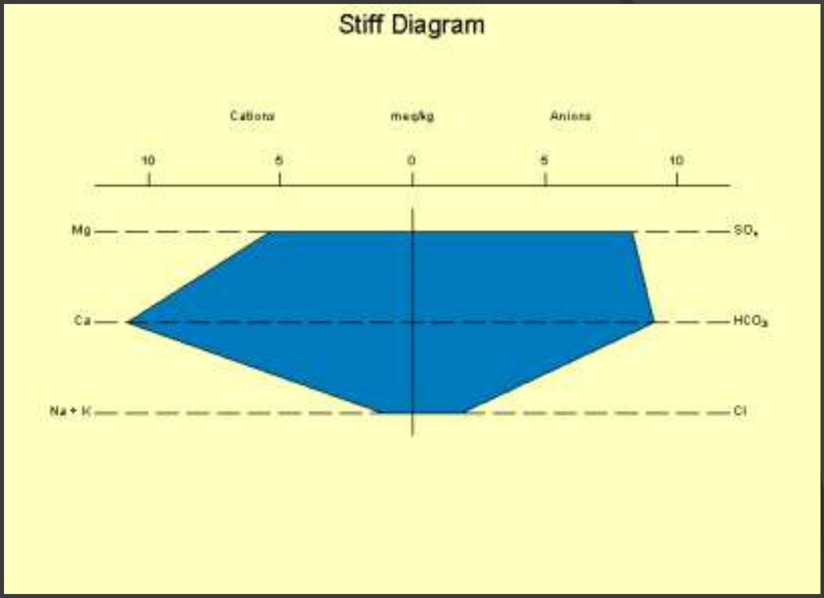
- Chemical precipitation may remove ions in solution by forming insoluble compounds.
- Ion exchange involves the replacement of ions principally cations, the process is called base or cation exchange.
- Certain bacteria reduces the sulfur contents.

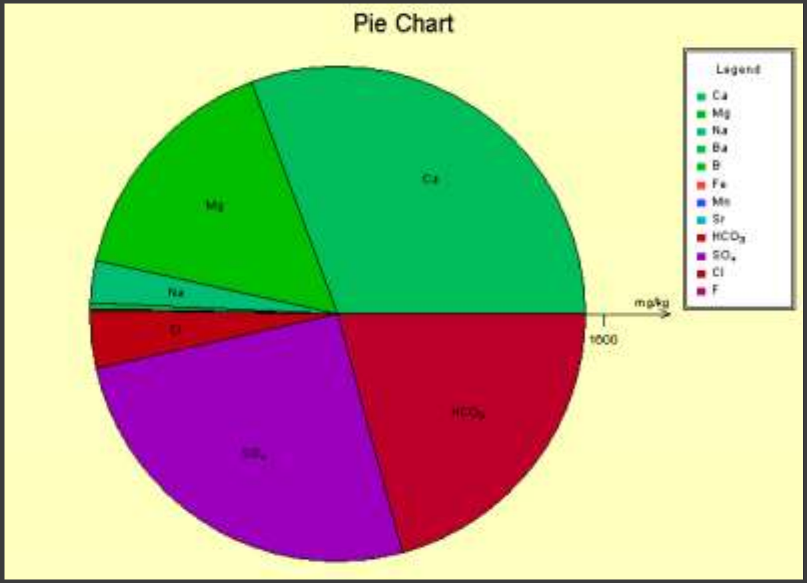
Graphical representations:

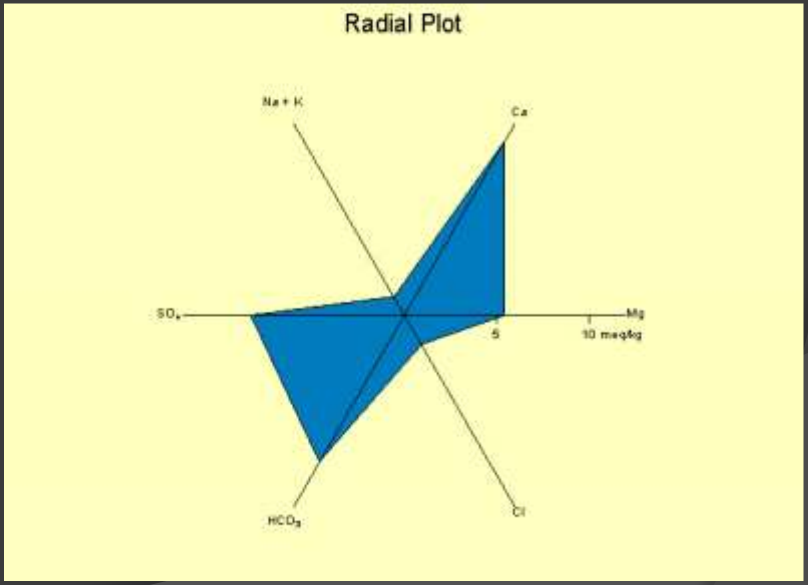
Used for easier and quick interpretation of distribution of anion and cation.

- **Collins Bar diagram:** Total concentration in epm is represented by the height of vertical bars.
- **Stiff's polygon of epm:** Stiff's (1951) system used parallel horizontal axes and one vertical axis.
- **Pie diagram:** the total concentration is represented by the area of a circle which is divided into sectors to give percentage composition.
- **Radial vectors:** Mancha's (1940) use radial vectors, the length of each vector represents in epm of the constituents.
- **Piper trilinear diagram:** consists of two triangular fields for representing cations and anions and one diamond shaped field . The overall characteristic of the water is represented in the diamond shaped field by projecting the position from the triangular field.
- **Schoeller semilogarithmic diagram:** here concentrations are plotted on six equally spaced logarithmic scale. The points are joined by straight lines.

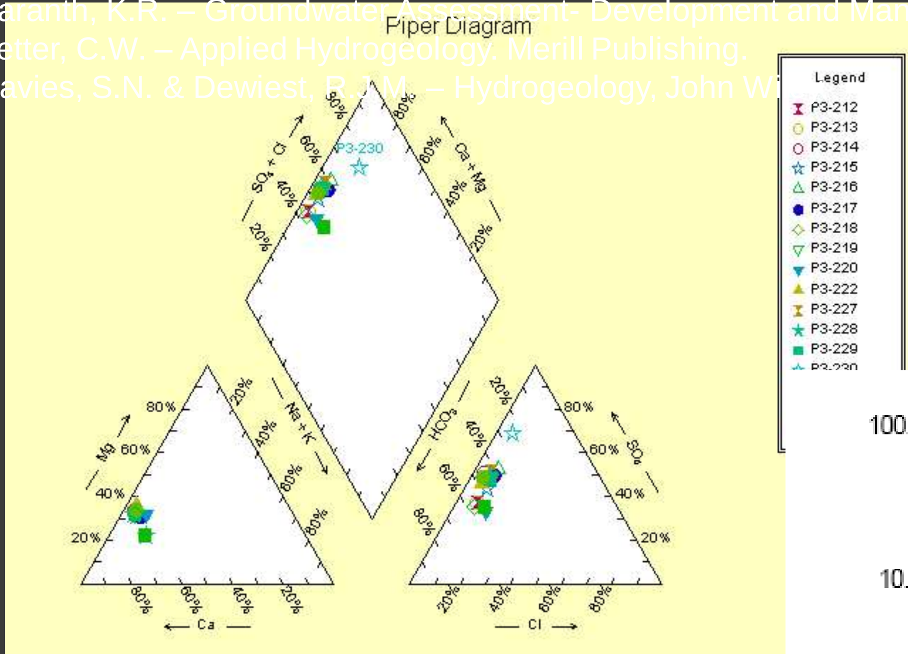

Ion Balance Diagram
0.012
0.010
0.008
0.006
0.004
0.002
0.000
eq/kg
Na
Mg
Ca
NO3
Cl
SO4
HCO3
Legend
Ca
Mg
Na
K
Ba
B
Fe
Mn
Sr
Zn
HCO3
SO4
Cl
NO3
F

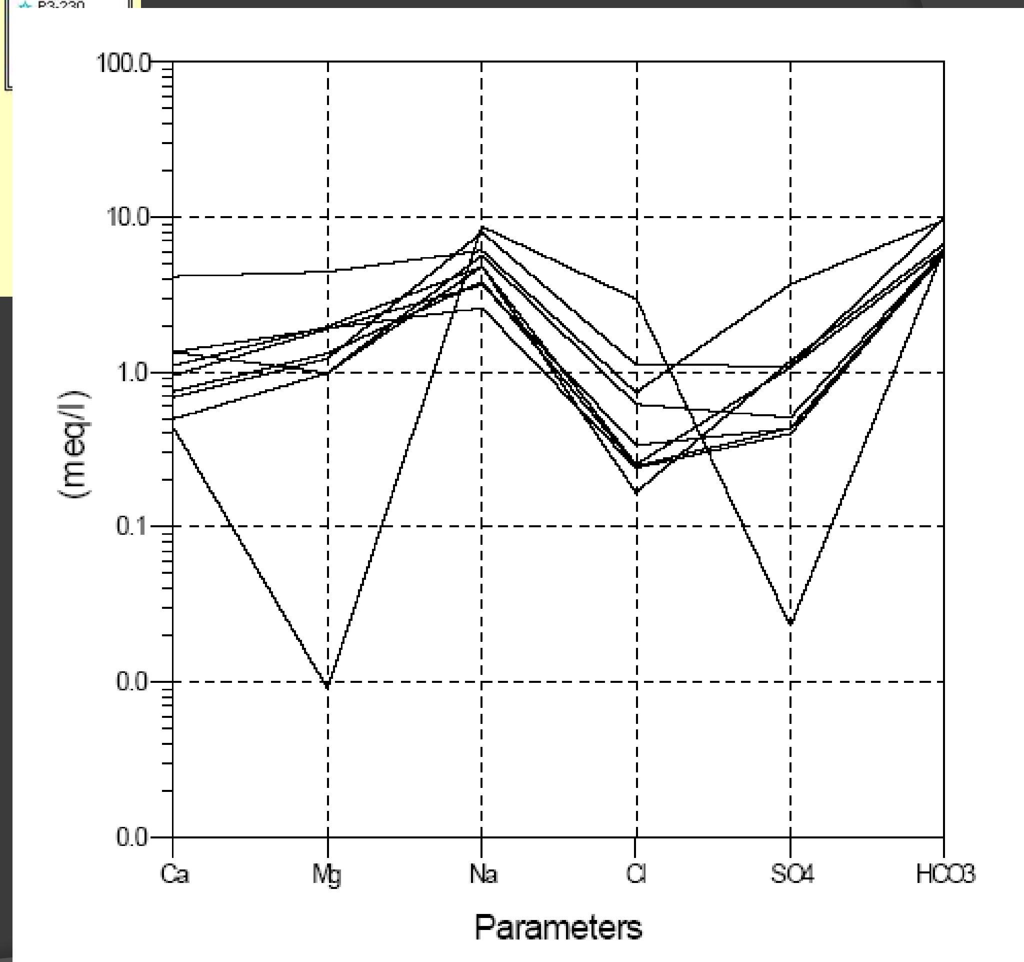

Stiff Diagram
Cations
meq/kg
Anions
10
5
0
5
10
Mg
Ca
Na + K
SO4
HCO3
Cl


Pie Chart
Ca
Mg
Na
Cl
SO4
HCO3
mg/kg
1000
Legend
Ca
Mg
Na
Ba
B
Fe
Mn
Sr
HCO3
SO4
Cl
F


Radial Plot
Na + K
Ca
SO4
Mg
5
10 meq/kg
HCO3
Cl

Raghunath, H.M. – Ground Water. New Age International Publishers
Karanth, K.R. – Groundwater Assessment- Development and Management. Tata Mc. Graw Hill.
Fetter, C.W. – Applied Hydrogeology. Merill Publishing.
Davies, S.N. & Dewiest, R.J.M. – Hydrogeology. John Wi





REFERENCES:

Todd, D.K. and Mays L.W., Groundwater hydrogeology. John Wiley.

Raghunath, H.M. – Ground Water. New Age International Publishers

Karanth, K.R. – Groundwater Assessment- Development and Management. Tata Mc. Graw Hill.

Fetter, C.W. – Applied Hydrogeology. Merill Publishing.

Davies, S.N. & Dewiest, R.J.M. – Hydrogeology, John Wiley.