Water

Introduction

Water is a vital resource. Pure water is usually tasteless, Odorless, Colorless & a liquid in its pure state at ambient Temperature. Water is one of the best solvents, and dissolves almost every substance to some degree.

When rainwater flows through the land to reach rivers, lakes & subsoil, it leaches dissolves solids, gases and other Liquids & get contaminated.

During its flow, the water gets mineral rich or contaminated with the solid, Liquid & gaseous.

The Water Treatment starts from here.

To design a perfect plant, water chemistry knowledge is very important & essential.

Source of Water

- Surface Water - Rivers, Lakes, Dam and Sea
- Ground Water – Well and Tube Well

- Conventional Water cycle - Water from Water Bodies across earth evaporates to form vapours, which create clouds.

- The clouds condense to generate rains and make water bodies across earth.

Impurities

Undissolved Impurities	Water on its way or the discharges in the same carries load of Undissolved solids. The same are termed as Total Suspended Solids. Some of the alike charged particles which doesn't settle in water remains in the suspension, is called Turbidity.
Dissolved Impurities	Some salts also get dissolved in water which are called Total Dissolved Solids (TDS). Based on some discharges by Industries, City waste few toxic / organic compounds also get dissolved in water source, The same are analysed using parameters like Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Organic Carbon (TOC) etc.

Water Parameters - Effects & Removal

Parameters	Effects	Removal
Turbidity, TSS, Grit & Colloidal Particles	• Can clog the Pipelines & Equipments • Can interfere in Biological Treatment • Can clog Membranes & Resins in Softener & DM Plant	• Coagulation, Flocculation & Clarification • Media Filtration • Microfiltration & Ultrafiltration
Oil & Grease	• Forms a layer on anything it comes in contact with • Can develop Anaerobic conditions	• Oil & Grease Traps • Dissolved Air Floatation system • CPI/TPI • Oil & Grease Skimmers
Temperature	• Varies the Dissolved Solid Conc. across the year • Increase/decrease solubility in water	-
Colour	• Visual Impact • Indication of organics / impurities	• Coagulation, Flocculation & Clarification • Using proprietary chemicals • Activated Carbon Filter • Oxidation
Organic Matter	• Can foul Ion Exchange Resins & Membranes • Can be detrimental for water bodies	• Coagulation, Flocculation & Clarification • Activated Carbon Filter • Oxidation • Biological Treatment systems
Bacteria	• Can create health Issues • Can Foul the Membranes	• Chlorination • UV • Oxidants like H_2O_2, Ozone & NaOCl
Iron	• Detrimental to Aquatic Life in case of high concentration • Can foul media and Membranes	• Aeration • By Precipitation using Lime • Iron Removal Resins

Parameters	Effects	Removal
pH	• Lower pH leads to corrosion • Higher pH with Hardness results in Scaling • Interference in Biological systems	• Neutralisation with Acid & Alkali
Total Hardness - Salts of Calcium & Magnesium	• Keep soap undissolved & can create skin irritation • Scale the Pipeline & Equipments	• Lime-Soda Softening • Ion Exchange Softener
Sodium	• Affects soil with high concentration • causes corrosion in boilers under certain conditions	• Reverse Osmosis • Demineralisation Process
Total Alkalinity - Bicarbonates, Carbonates & Hydroxides	• Lower pH leads to Corrosion • Higher pH with hardness can scale & tends to foam	• Reverse Osmosis • Lime precipitation • Demineralisation Process
Free Mineral Acids	• Corrosion	• Neutralisation • Reverse Osmosis • Demineralisation Process
Carbon Dioxide	• Corrosion in water Lines	• Aeration / Deaeration • Neutralisation
Sulphates	• Can irritate when in excess Concentration • Can form scales with Calcium	• Reverse Osmosis • Demineralisation Process
Chlorides	• Pitting of metal surfaces / Piping	• Reverse Osmosis • Demineralisation Process
Nitrates	• Health Issues with the Pregnant Ladies • Infants – Blue Baby Syndrome • Affect the Aquatic Life • Algal growth in water bodies	• Reverse Osmosis • Demineralisation Process • Denitrification
Fluorides	• cause of mottled enamel in teeth • Can Cause bone defects	• Reverse Osmosis • Demineralisation Process • Fluoride Filters
Silica	• Scaling & Deposition	• Reverse Osmosis • Demineralisation Process
Hydrogen Sulfide	• Corrosion • cause of "rotten egg" odor • Interference in Biological systems	• Aeration / Scrubber
Oxygen	• Corrosion	• Reducing agent
Ammonia	• Detrimental for Copper • Can create health issues when consumed water with Ammonia	• Air/Steam Stripping • Aerobic systems
Free chlorine	• Health Hazard	• Reducing agent
Heavy Metals	• Scale Membranes • Health Hazard	• Precipitation @ high/Moderate pH

Annexure A: Conversion as CaCO3

For calculating the ionic load of the Water constituents and bring it to one platform, the concentration of the ions is calculated & expressed as 'as CaCO3'. For making the conversion simpler, arbitrarily CaCO3 was chosen, as its Molecular weight is 100 & Equivalent weight is 50. Following are the Molecular Weights, Equivalent Weights & Conversion Factors of major Ions in Water.

Ions	Ions	Mole. Wt	Valency	Eq. Wt	as CaCO3
Cations					
Calcium Ca++	Ca+2	40.08	2	20.04	2.50
Magnesium Mg++	Mg+2	24.31	2	12.15	4.12
Iron as Fe+++	Fe+3	55.85	3	18.62	2.69
Aluminium Al+++	Al+3	26.98	3	8.99	5.56
Arsenic Ar+++	As+3	74.92	3	24.97	2.00
Chromium Cr+++	Cr+3	52.00	3	17.33	2.89
Iron as Fe++	Fe+2	55.85	2	27.92	1.79
Barium Ba++	Ba+2	137.33	2	68.67	0.73
Manganese as Mn++	Mn+2	54.94	2	27.47	1.82
Copper Cu++	Cu+2	63.55	2	31.77	1.58
Zinc Zn++	Zn+2	65.4	2	32.70	1.53
Cadmium Cd++	Cd+2	112.4	4	28.10	1.78
Selenium Se++	Se+2	79.0	2	39.48	1.27
Lead Pb++	Pb+2	207.2	2	103.60	0.48
Cobalt Co++	Co+2	92.9	2	46.47	1.08
Potasium as K+	K+1	39.1	1	39.10	1.28
Sodium as Na+	Na+1	23.0	1	22.99	2.18
Ammonium as NH4+	NH4+1	18.0	1	18.04	2.77
Nickel	Ni+2	58.7	2	29.35	1.71
Boron	B+1	10.8	1	10.81	4.63
Anions					
Ions	**Ions**	**Mole. Wt.**	**Valency**	**Eq. Wt.**	**as CaCO3**
Bicarbonate $HCO3^-$	HCO3 -1	61.02	1	61.02	0.82
Carbonate $CO3^{--}$	CO3 -2	60.01	2	30.00	1.67
Hydroxyl as OH^-	OH-1	17.00	1	17.00	2.94
Sulphates as $SO4^{--}$	SO4 - 2	96.06	2	48.03	1.04
Chlorides as Cl^-	Cl 1	35.45	1	35.45	1.41
Nitrate as $NO3^-$	NO3-1	62.00	1	62.00	0.81
Fluorides as Fl^-	Fl 1	19.00	1	19.00	2.63
Phosphate $PO4^{---}$	PO4 -3	95.00	3	31.67	1.58
Nitrite as $NO2^-$	NO2 1	46.01	1	46.01	1.09
Bromides as Br^-	Br 1	79.90	1	79.90	0.63

Relationships – Some of the basic Formulae & Relations

pH	$-\log_{10}(H^+)$
POH	$-\log_{10}(OH^-)$
PH+POH	14
M. Alkalinity	Total Alkalinity (Bicarbonates + Carbonates + Hydroxide) ppm as CaCO3
P. Alkalinity	½ Carbonates + Hydroxides, ppm as $CaCO_3$

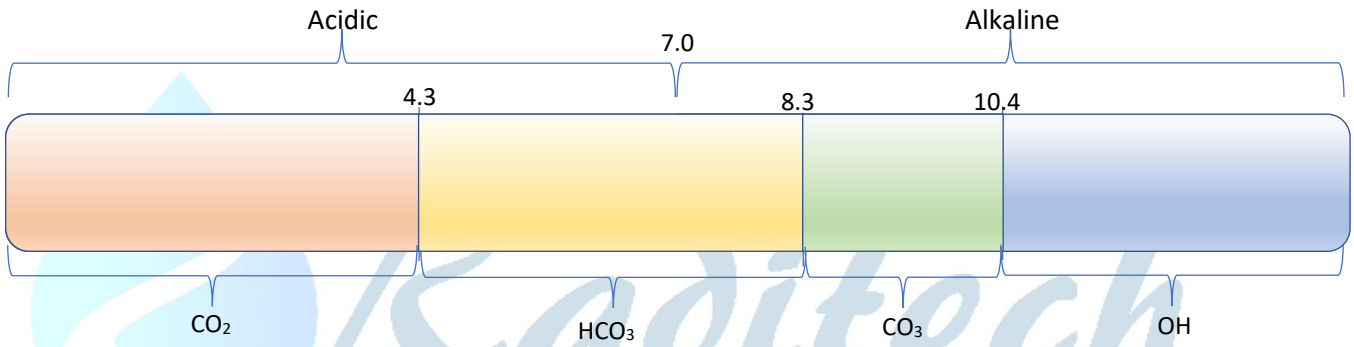
Total Hardness	Calcium (Ca^{+2}) + Magnesium (Mg^{+2}), all as $CaCO_3$
Total Alkalinity / M. Alkalinity	Bicarbonates (HCO_3^{-1}) + Carbonates (CO_3^{-2}) + Hydroxides (OH^{-1}), all as $CaCO_3$
P. Alkalinity	½ Carbonates + Hydroxides, all as $CaCO_3$
Equivalent Mineral Acidity (EMA)	Chlorides (Cl^{-1}) + Sulfates ($SO4^{-2}$) + Nitrates ($NO3^{-1}$), all as $CaCO_3$
Calcium Alkalinity	Ca Hardness or TA, whichever is smaller
Magnesium Alkalinity	Mg Hardness, if Alk> TH Alk – Calcium Hardness, if Alk< TH
Sodium Alkalinity	Zero, when TH>TA TA-TH, When TH<TA
Ca Noncarbonate Hardness	Ca Hardness – Ca Alkalinity
Mg Noncarbonate Hardness	Mg Hardness – Mg Alkalinity

TH – Total Hardness as CaCO3, TA – Total Alkalinity as CacO3

M. Alkalinity & P. Alkalinity Relations (M & P)		
	M. Alk	P. Alk
If P = 0	HCO_3 as $CaCO_3$	-
If P < ½ M	H CO_3 + CO_3	½ CO_3
If P = ½ M	CO_3	½ CO_3
If P > ½ M	CO_3 + OH	OH + ½ CO_3
If M = P	OH	OH

M - M. Alkalinity, P- P. Alkalinity

pH-Alkalinity Scale



Dear Readers,

Hope above Topic covers all the related points. Our attempt behind making this topic available to you is to create more awareness about Water & Wastewater Chemistry and respective Case Studies. Please mail us your feedback on this topic or any other topic of your interest which you want us to include in the Library on amit@raditechsolutions.com.