



Table of Contents

1	Introduction	1
1.1	What Is Water?	1
1.1.1	Properties of Water	2
1.1.2	Odour and Taste	3
1.1.3	Appearance and Colour	3
1.1.4	Hydrology and Water Distribution on Earth	4
1.1.5	Water Cycle	4
1.2	Water Resources and Related Problems	5
1.2.1	Sources of Freshwater	6
1.2.2	Increasing Water Scarcity	8
1.3	Ecological Implications of Water	9
1.3.1	Climate Change	9
1.4	Properties of Water	9
1.4.1	Physical and Chemical Properties of Water	9
1.4.2	Biological Properties of Water	9
1.5	Conclusion	10
1.6	References	10

2	Water Resources Units	11
2.1	What are the Water Resources?	11
2.1.1	Renewable and Non-renewable Water Resource	13
2.2	Water Measurement Units	14
2.2.1	Conversion Table	16
2.3	Hydrologic Unit Map	16
2.3.1	Classification of the Map	16
2.4	Of Groundwater Recharge From Rainfall	17
2.4.1	Water Level Fluctuation Method	17
2.4.2	Rainfall infiltration Factor (RIF) Method	18
2.4.3	Groundwater Recharge During Monsoon Season	19
2.4.4	Annual Provisions for Groundwater Resources	19
2.4.5	Net Annual Groundwater Availability	19
2.5	Water Quality Units	19
2.5.1	What is a water quality unit ?	19
2.5.2	How does the unit work?	20
2.6	Groundwater resources of INDIA	21
2.6.1	Dynamic Groundwater Resources	21
2.6.2	Groundwater Development	22
2.6.3	Groundwater Utilization	22
2.7	Significant Digits	22
2.7.1	Significant Digit Rules	23
2.7.2	Uncertainty in Calculations	23
2.7.3	Deduction of Significant Figures	24
3	Hydrological Cycle	25
3.1	Different stages of Hydrological Cycle	26
3.2	Water Balance	29
3.3	Water Budget	30
3.4	Different Components of Water Budget	31
3.5	Summary	33
3.6	References	33
4	Precipitation	34
4.1	Introduction	34
4.2	Storms and Its Types	35
4.2.1	Blizzard	35
4.2.2	Bomb Cyclone	35
4.2.3	Coastal Storm	36
4.2.4	Derecho	36
4.2.5	Hail Storm	36
4.2.6	Snowstorm	37
4.2.7	Wind Storm	37

4.2.8	Thunderstorm	37
4.2.9	Firestorm	38
4.2.10	Hurricane	38
4.2.11	Tornado	39
4.3	Measurement of Precipitation	39
4.3.1	Observation Instruments	39
4.3.2	Tipping Bucket Rain Gauge	41
4.4	Average Methods of Precipitation	41
4.4.1	Arithmetic Mean	41
4.4.2	Theissen Polygon Method	42
4.4.3	Isohyetal Method	43
4.5	Precipitation Frequency Analysis	45
4.5.1	IDF Relationship	45
4.6	References	46
5	Evapotranspiration	47
5.1	Introduction	47
5.2	Evaporation	47
5.3	Transpiration	48
5.4	Evapotranspiration (ET)	48
5.5	Evapotranspiration Concepts	49
5.6	Factors Affecting Evapotranspiration	51
5.7	Geographical Pattern of Evapotranspiration	52
5.8	Measurement of Evapotranspiration	52
5.9	Potential Evapotranspiration	55
5.10	Summary	55
5.11	Reference	55
6	Infiltration and Soil Water	56
6.1	Introduction	56
6.2	Infiltration	56
6.2.1	Problems Concerning the Poor Functioning of the Infiltration	57
6.2.2	Factors Affecting Infiltration	58
6.2.3	Solutions for the Problems of Infiltration	59
6.3	Soil Water	60
6.3.1	The Soil Composition	60
6.3.2	Soil Profile	61
6.3.3	Soil Structure	61
6.3.4	Soil Moisture Content and Saturation	62
6.3.5	Field capacity and Permanent Wilting Point	62
6.3.6	Soil Water Retention	63
6.3.7	Soil Water Retention and Organism	63
6.3.8	Soil Retention and Organism	64

6.3.9	Retention of Soil Water, Water Balances, and other Components.	64
6.3.10	Types of Soil Water	64
6.3.11	Soil Water Evaporation Process	65
6.4	Conclusion	66
6.5	Reference	66
7	Ground Water	67
7.1	An Aquifer	69
7.2	An Overview of the Water Cycle	70
7.3	Groundwater Flow	71
7.3.1	Preferential Flow of Water	72
7.3.2	Subsurface Flow of Water	72
7.3.3	Eco-hydrology	72
7.3.4	Equation of Continuity and the Law of Darcy under steady-state Condition	74
7.4	Effects of a Well	75
7.4.1	Potential Effects in the Health of a Human	75
7.5	Flow Net	76
7.6	Reference	77
8	Watershed Management	78
8.1	Watershed.	78
8.2	Water Yield.	80
8.2.1	Assessment of Water Yield	80
8.2.2	Advantages of Assessing Water Yield.	82
8.2.3	Perspective of Water Management and Assessment.	82
8.2.4	Impact of Afforestation on Water Yield.	83
8.3	Streamflow Pattern.	84
8.3.1	Discharge Measurement.	84
8.3.2	Stream Flow Measurement by Pre-Calibrated Structures.	85
8.3.3	Approaches for Determining the Characteristics of Streamflow	87
8.4	Forest (vegetation) Management.	88
8.5	Snowpack Management.	88
8.5.1	Measurement of Snowfall.	89
8.5.2	Snow Surveys.	89
8.6	Urban Watershed Management	89
8.7	Reservoir Watershed Management.	91
9	Introduction to Water Quality	92
9.1	Water Quality Definitions	92

9.2	Sources of Water Pollution	97
9.2.1	Other Sources of Water Pollution	98
9.3	Magnitude of the Water Quality Problem	101
9.4	Soil Quality	102
9.5	References	103
10 Physical Characteristics of Water		104
10.1	Introduction	104
10.2	Turbidity	105
10.3	Odor	107
10.4	Total Dissolved Solids (TDS)	108
10.5	Total Suspended Solids	110
10.6	Color	111
10.7	Temperature	111
10.8	Conductivity	112
10.9	Concluding Words	113
11 Chemical Characteristics of Water		114
11.1	What is Water?	114
11.2	Common Chemical Characteristics of Water	114
11.2.1	Inorganic Minerals	115
11.2.2	pH value of Water	116
11.2.3	Hardness of Water	117
11.3	Organic Indicators of Water Quality	119
11.3.1	Biological Oxygen Demand (BOD)	119
11.3.2	Chemical Oxygen Demand (COD)	120
11.4	Dissolved Gases	120
11.4.1	Solubility of Gases	121
11.4.2	Dissolved Oxygen (DO)	122
11.5	Microscopic and Bacterial characteristics of water	122
11.6	Chemical Constituents of Water	122
11.6.1	Sampling Method for Analysis	124
12 Biological Characteristics of Water		128
12.1	Water Quality	128
12.2	Biological Characteristics of Water.	130
12.2.1	Plankton	130
12.2.2	Macro Invertebrates	132
12.2.3	Macrophytes.	134
12.2.4	Pathogens in Water.	135
12.2.5	Bioassays.	136
12.3	References	139

13 River Water Quality 140

13.1	Introduction	140
13.2	Physical Process in River	141
13.2.1	Erosion	141
13.2.2	Transportation	142
13.2.3	Deposition	142
13.3	Biological Characteristics of River	142
13.3.1	Autotrophic Organisms	143
13.3.2	Microbes and Protista	144
13.3.3	Macro Invertebrates	144
13.3.4	Adaptation and Characteristics of Aquatic Insects.	145
13.4	Chemical Characteristics of River	146
13.4.1	Dissolved Oxygen and Aquatic Life	147
13.4.2	How to Measure Dissolved Oxygen?	148
13.5	Conclusion	148
13.6	Reference	148

14 Lakes and Reservoir Water Quality 149

14.1	Factors That Impact Water Quality	150
14.1.1	Pollution	150
14.1.2	Acid Rain	151
14.1.3	Harmful Algal Blooms	153
14.1.4	Eutrophication	154
14.2	Biological and Chemical Characteristic of Lakes	155
14.2.1	Homogenous Lakes	158
14.2.2	Stratified Lakes	159
14.2.3	Lake Restoration	159
14.3	Summary	159
14.4	References	160

15 Soil and Ground Water Quality 161

15.1	Introduction	161
15.2	Characteristics of Land Water	163
15.2.1	Hydrological Characteristics	163
15.2.2	Lakes and Reservoirs	164
15.3	Rivers	166
15.3.1	Tropical Rivers	166
15.4	Ground Water and its Characteristics.	168
15.4.1	Aquifer's Types	169
15.4.2	Quality of Water	170
15.5	Process that Impact the Quality of Water	170
15.6	Human Health and Water	171
15.7	References	171

16 Best Management Practices	172
16.1 Introduction	172
16.2 Stormwater Management	173
16.2.1 Stormwater Management BMPs	173
16.2.2 Using Stormwater BMPs in Urban Areas	174
16.2.3 Application of Urban Stormwater BMPs	175
16.3 Agricultural Practices	176
16.4 Silvicultural Practices	177
16.4.1 Goals of Silvicultural Practices	179
16.5 References	179
17 Water Laws, Regulations and Standards	180
17.1 Crisis which Arise of Water Rights.	181
17.2 Quality of the Water	183
17.3 Federal Rules and Regulations for the Quality of Water	187
17.3.1 Strategy to Control Pollution	187
17.3.2 Standards-based on Technology	188
17.3.3 Standards-based on Water Quality	188
17.4 Water Quantity	188
17.5 References	190
18 Water Policy	191
18.1 Introduction	191
18.2 Policy Formulation	193
18.2.1 Identification of the Problem	194
18.2.2 Establishing a Program or an Agenda	195
18.2.3 Making a Decision	195
18.2.4 Preparation of a Budget	195
18.2.5 Implementing the Program	195
18.2.6 Evaluation of the Program	195
18.3 Water Availability and Use	196
18.3.1 Sources of Water	196
18.3.2 Uses of Water	197
18.4 International Water Policy	198
18.5 Water and Environmental Justice	198
18.5.1 Globalization	200
18.6 Water and Environmental justice	200
18.7 Sustainable Water Management	201
18.8 Concluding Words	203
18.9 Reference	204
19 Water Economics	205
19.1 Introduction	205

19.2	The Water Market	206
19.2.1	Conditions for Trading In Water Market	206
19.2.2	Issues in Water Trading Markets	208
19.3	Demand for Water	209
19.3.1	Types of Water Demand	210
19.3.2	Factors affecting the rate of demand for water	211
19.4	Supply of Water	212
19.4.1	Factors Affecting or Influencing Effective Supply of Water	213
19.4.2	Trade Barriers	214
19.5	Supply and Demand	215
19.6	Elasticity	215
19.6.1	1. Perfectly Elastic Water Demand ($E_p = \infty$)	216
19.6.2	2. Perfectly Inelastic Demand ($E_p = 0$)	216
19.6.3	3. Unitary Elastic Demand ($E_p = 1$)	216
19.7	Water Externalities	216
19.8	Costs of Production	217
19.8.1	Elements of Costs of Production	217
19.8.2	Calculation of Cost of Production	218
19.8.3	Steps to Calculate the Cost of Production	218
19.9	More on Efficiency	218
19.9.1	Types of Efficiency	219
19.10	Economic Policy Analysis	220
19.10.1	Goals and Objectives of Economic Policies	220
19.10.2	Types of Economic Policy	220
19.11	Water Pricing	221
19.11.1	Contents of Water Pricing	222
19.12	Cost-Benefit Analysis	223
19.12.1	Steps of Cost-Benefit Analysis	224
19.13	Direct and Indirect Economic Effects	225
19.13.1	Types of Economic Effects	225
19.13.2	Water and Economic Effects	225
19.14	Conclusion	226
19.15	Reference	226