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MANAV RACHNA
Vidyanatariksha

ECO & WATER FACTS

COMMUNICATING SCIENCE THROUGH MODEL WATER & ECO HEALTH CLINIC FOR QUALITY OF LIFE

CATALYZED AND SUPPORTED BY
NATIONAL COUNCIL FOR SCIENCE & TECHNOLOGY COMMUNICATION, DST, NEW DELHI
Under Mission ECO Next

Centre for Advance Water Technology & Management

CENTRE FOR ADVANCE WATER TECHNOLOGY & MANAGEMENT

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FOREWORD

WHO and UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) identified inadequate access to safe water and sanitation services, coupled with poor hygiene practices, kills and sickens thousands of children every day, and leads to impoverishment and diminished opportunities for thousands more. Without WASH (water, sanitation and hygiene), sustainable development is impossible. Therefore it was also an important target under Millennium Development Goal (MDG) of UN. Water conservation & literacy are two main global challenges of our time and are directly connected to each other. Available water resources, variability in availability of water, depletion of clean water sources, ecological imbalance and its protection should be known and understood by all. Water resource management & its preservation are thus essential to achieve sustainability goals. Building bridges between clean water, sanitation, health risk reduction and sustainable development is a crucial task.

Commercial markets rarely put a price on the "ecosystem services" and therefore we often fail to adequately protect the crucial ecosystems. Consequently, they are being lost at a rapid rate. Human activities including global warming mean we face a future of falling water tables, shrinking wetlands, vanishing species and a decrease in both the quality and quantity of available fresh water. We must change behavior.
TERI, as an independent reviewer has pointed out that through several agencies are engaged in water quality research in the country but there exist a gross inadequacy in linking the water quality to human health risk and its exposure assessment. Such research outcome has prompted to take up the issue. India being a developing nation, aspire sustainability in growth thus the project will address the water and water related health ecological aspects.

The NCSTC Supported and Catalyzed DST project "Communicating Science through Model Water & Eco Health Clinic for Quality of Life" envisages instituting replicable Model Water & Eco Health Clinics so that science communication can be established with targeted groups of community i.e. students, for improving their overall quality of life by reducing the water related health risk through scientific interventions and IEC. The project wants to educate the students about the water literacy, water quality improvement, sanitation, hygiene conditions through intervention of technology, and the eco health improvement by demand side and supply side water management. The project also envisages developing sustainable local leadership through talent hunt to take forward the science communication within the society.

To partially fulfill the objective of the project the idea of relieving this book originates.I am glad to see the publication on Eco and Water Facts. In many ways, this guide reinforces the messages that have been emerging issues and require some urgent attention. I appreciate the hard work made by Swati Jain under the supervision of Dr A Mukherjee, PI of the project for the compilation of this succinct and useful guide.

16.05.2019

Dr D K Chadha

Place: MRIIRS, Faridabad

CONTENTS

CONTENTS

Compilation:
Prof Arunangshu Mukherjee, PI, CAWTM, MRIIRS
Swati Jain, Research Assistant, CAWTM, MRIIRS
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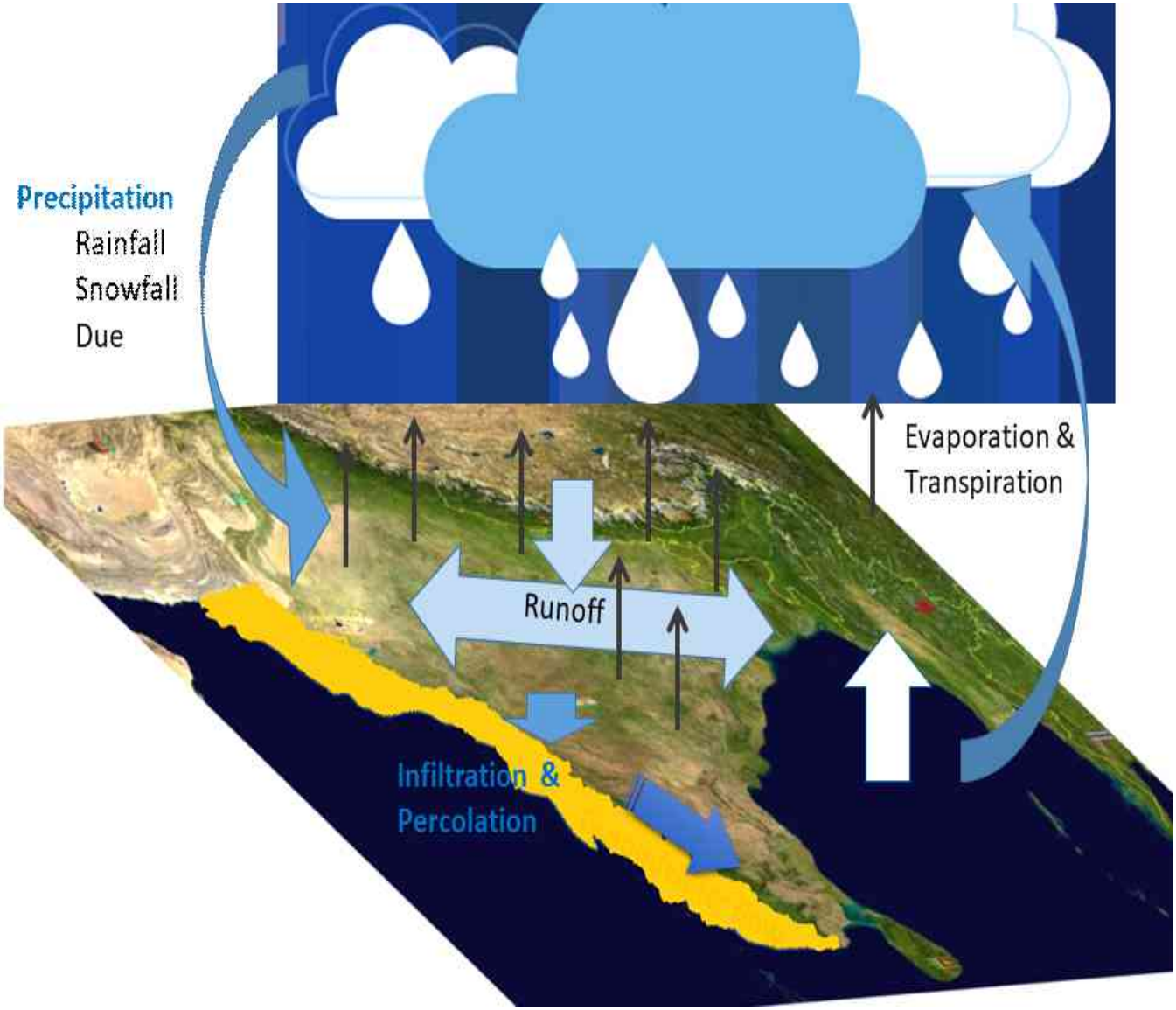
WATER CYCLE



Further Reading:

1. **https://www.usgs.gov/special-topic/water-science school/science/fundamentals-water-cycle?qt-science_center_objects=0#qt-science_center_objects**

2. **https://thewaterproject.org/resources/download/water-cycle-water-crisis.pdf**

DISTRIBUTION OF WATER IN INDIA

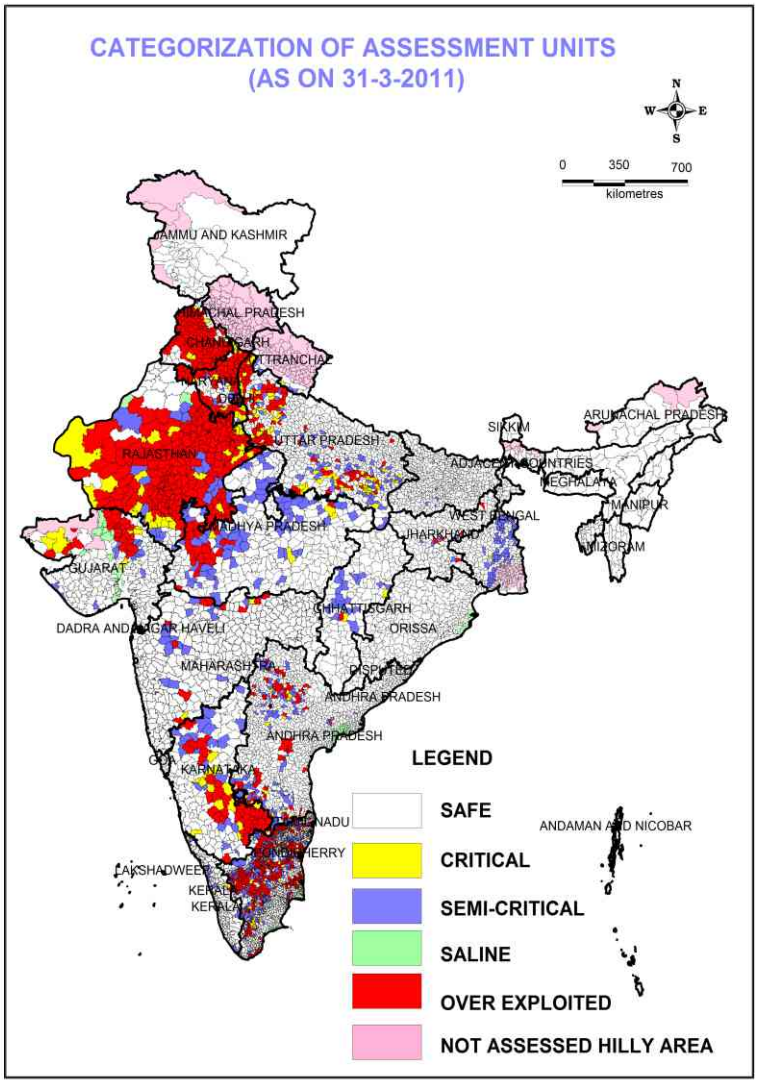


Table- India's Water Resources

Sl. No.	Water Resource at a Glance	Quantity (km^3)	Percent
1	**Annual precipitation (Including snowfall)**	4000	100
2	**Precipitation during monsoon**	3000	75
3	**Evaporation + Soil water**	2131	53.3
4	**Average annual potential flow in rivers**	1869	46.7
5	**Estimated utilizable water resources**	1123	28.1
	Surface water	690	17.3
	Replenishable groundwater	433	10.8
	Storage created of utilizable water	253.381	22.52
	Storage (under construction) of utilizable water	50.737	4.5
6	**Estimated water need in 2050**	1450	129
7	**Estimated deficit**	327	29
	Interlinking can give us	200	17.8

(Source:Water Resources at a Glance 2011 Report, CWC, New Delhi)

It is estimated that some 5000 glaciers cover about 43000 km2 in the Himalayas with total volume of locked water estimated at 3870 km3.

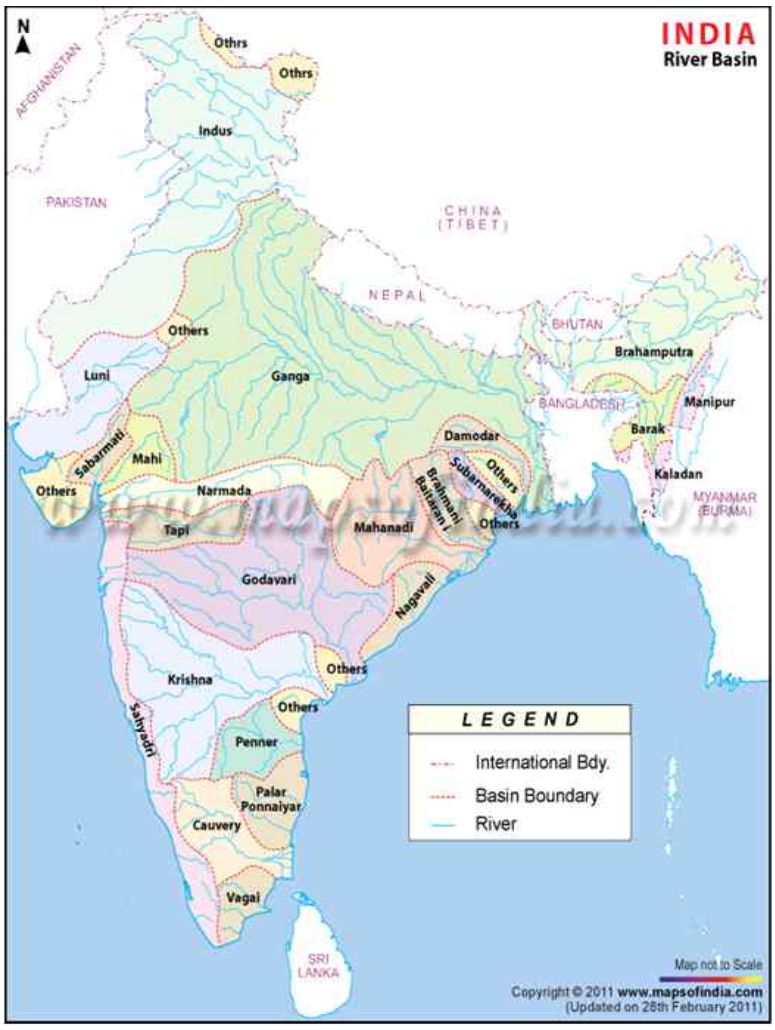
The utilizable water resources of the country have been assessed at 1123 km3 of which 690 km3 is from surface water and 433 km3 from ground water sources.

Further Reading:

1. **https://www.usgs.gov/special-topic/water-science school/science/fundamentals-water-cycle?qt-science_center_objects=0#qt-science_center_objects**

2. **https://thewaterproject.org/resources/download/water-cycle-water-crisis.pdf**

MAJOR RIVER BASINS IN INDIA

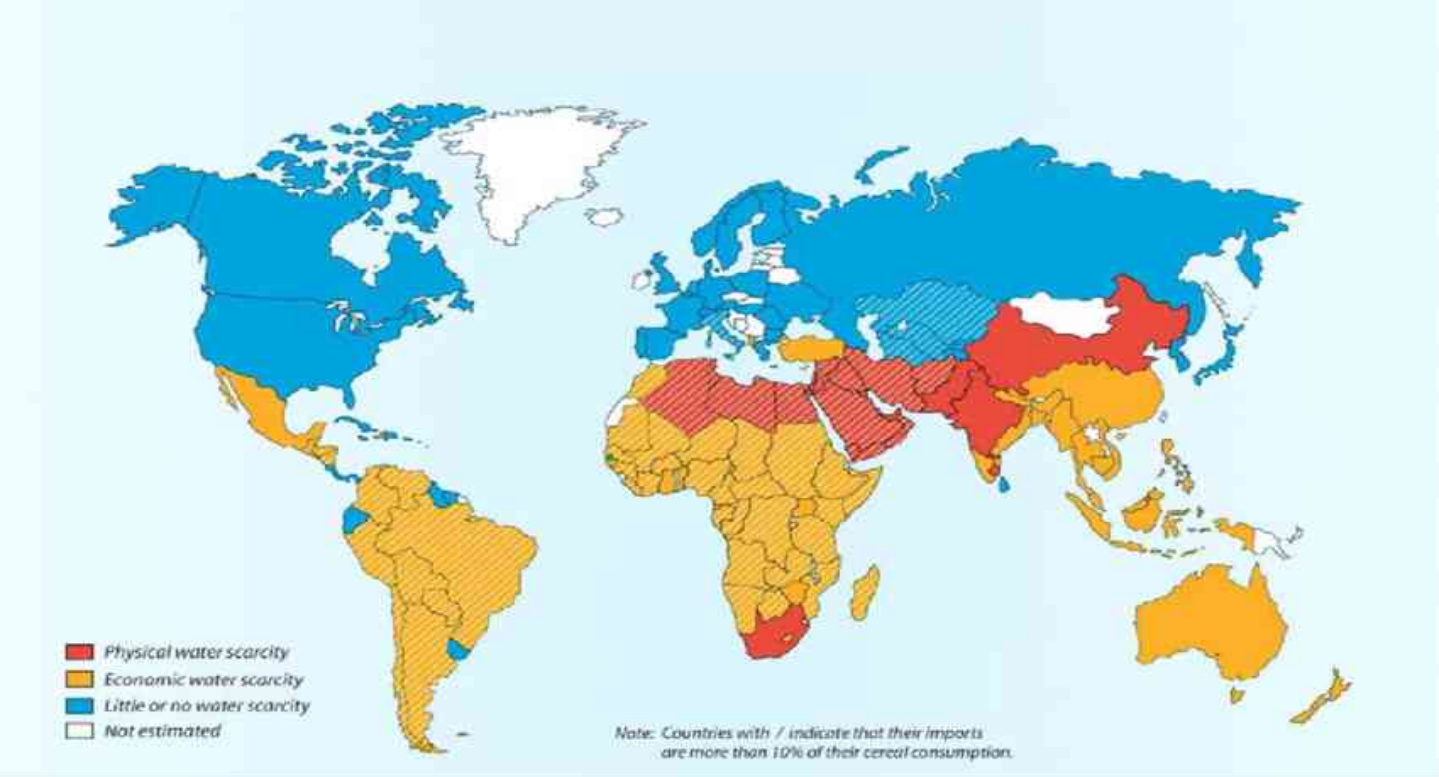


- As many as 13 of them are classified as major rivers whose total catchment area is 252.8 million hectares (m. ha).
- The Ganga-Brahmaputra-Meghna system is the biggest with catchment area of about 110 million hectares (m. ha) which is more than 43 per cent of the catchment area of all major rivers in the country.
- The other major rivers with catchment area more than 10 m. ha are those of the Indus (32.1 m. ha), Godavari (31.3 m. ha), Krishna (25.9 m. ha), and Mahanadi (14.2 m. ha).

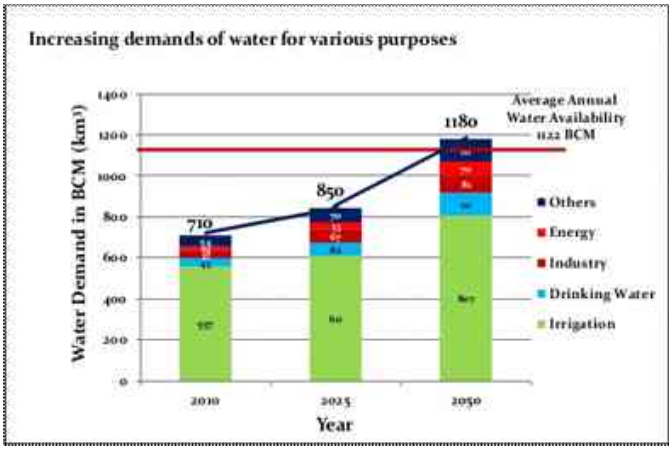
Further Reading:

1. **http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=Basins_of_CGWB**
2. **https://www.indiawaterportal.org/articles/water-level-falls-indias-major-river-basins-cwc**

WATER AVAILABILITY- INDIAN SCENARIO

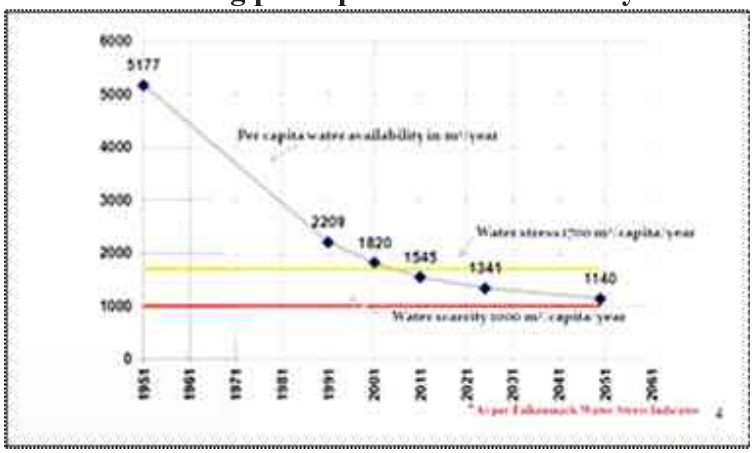


Annual water Availability: 1869 BCM
Utilizable water: 1123 BCM (60%)
- **Surface Water: 690 BCM**
- **Ground water: 433 BCM**
- **GW Utilization: 245 BCM**



As estimated by National Commission for Integrated Water Resources Development (NCIWRD), 1999

Reducing per capita water availability



Further Reading:

1. **https://slideplayer.com/slide/6605459/**

2. **Envi Stats India 2018, supplement on Environmental Accounts , GOI, Ministry of Statistics and Programme Implementation.**

THE WATER RESOURCE POTENTIAL OF RIVER BASINS IN INDIA

S. No.	River Basin	Average Water Resources Potential (In Billion Cubic Meter)	Percentage with respect to total Average Water Resources Potential	Utilisable surface water resources (In Billion Cubic Meter)	Percentage with respect to total Utilisable surface water resources
1	Indus	73.3	3.9	46	6.7
2	Ganga-Brahmaputra-Meghna				
	(a) Ganga	525	28.1	250	36.2
	(b) Brahmaputra	537.2	28.7	24	3.5
	(c) Barak & others	48.4	2.6	-	-
3	Godavari	110.5	5.9	76.3	11.1
4	Krishna	78.1	4.2	58	8.4
5	Cauvery	21.4	1.1	19	2.8
6	Subernarekha	12.4	0.7	6.8	1
7	Brahmani-Baitarni	28.5	1.5	18.3	2.7
8	Mahanadi	66.9	3.6	50	7.2
9	Pennar	6.3	0.3	6.9	1
10	Mahi	11	0.6	3.1	0.4
11	Sabarmati	3.8	0.2	1.9	0.3
12	Narmada	45.6	2.4	34.5	5
13	Tapi	14.9	0.8	14.5	2.1
14	West Flowing Rivers from Tapi to Tadri	87.4	4.7	11.9	1.7
15	West Flowing Rivers from Tadri to Kanyakumari	113.5	6.1	24.3	3.5
16	East Flowing Rivers between Mahanadi and Pennar	22.5	1.2	13.1	1.9
17	East Flowing Rivers between Pennar&Kanyakumari	16.5	0.9	16.5	2.4
18	West Flowing Rivers of Kutch and Saurashtra including Luni	15.1	0.8	15	2.2
19	Area of Inland Drainage in Rajasthan	Negligible	Negligible	--	--
20	Minor Rivers draining into Myanmar (Burma) and Bangladesh	31	1.7	--	--
	Total	**1,869.40**		**690**	

Further Reading:

1. **http://www.wwfenvis.nic.in/Database/StatewiseGroun_4499.aspx**

2. **Reassessment of water Availability in India Using Space Units , Base Planning & Management Organisation, Central Water Commission, November 2018**

AQUIFER SYSTEM IN INDIA

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).

- It is a group of formations that contain sufficient saturated permeable material to yield economic quantities of water to boreholes and springs.
- The various major rock formations of India can be broadly categorized in to 14 Principal aquifer Systems based on their broad hydrogeological properties.
- The Principal Aquifers are further divided into 42 Major Aquifers depending on their distinctive hydrological characteristics and their spatial distribution
- Alluvial Aquifers are the most significant ground water reservoirs which support large scale and extensive development of the country. The Indo-Ganga-Brahmaputra basin having distinctive hydrogeological environment and ground water regime conditions have enormous fresh ground water potential
- Haryana & Delhi consists of Alluvium kind of Aquifers.

Why are aquifer systems important?
Aquifer systems are the storage medium from which groundwater is abstracted.

They should be managed properly and at all times be protected from over-exploitation and contamination.

Further Reading:

1. **Aquifer System of India, Central Ground Water Board, Ministry of Water Resources, GOI Overview of Ground Water in India, Rupal Suhag, PRS**

2. **Ground Water Quality Scenario, Ministry Of Water Resources, River Development & Ganga Rejuvenation**

STATE-WISE AVAILABILITY OF GROUND WATER RESOURCE

Sl. No.	States / Union Territories	Total Annual Replenishable Ground Water Resource (In Billion Cubic Meter)	Percentage with respect to Total Annual Replenishable Ground Water Resource
1	Andhra Pradesh (undivided)	35.89	8.3
2	Arunachal Pradesh	4.51	1
3	Assam	28.52	6.6
4	Bihar	29.34	6.8
5	Chhattisgarh	12.42	2.9
6	Delhi	0.31	0.1
7	Goa	0.24	0.1
8	Gujarat	18.57	4.3
9	Haryana	10.78	2.5
10	Himachal Pradesh	0.56	0.1
11	Jammu & Kashmir	4.25	1
12	Jharkhand	6.31	1.5
13	Karnataka	17.03	3.9
14	Kerala	6.69	1.5
15	Madhya Pradesh	35.04	8.1
16	Maharashtra	33.95	7.8
17	Manipur	0.44	0.1
18	Meghalaya	1.78	0.4
19	Mizoram	0.03	Negligible
20	Nagaland	0.62	0.1
21	Odisha	17.78	4.1
22	Punjab	22.53	5.2
23	Rajasthan	11.94	2.8
24	Sikkim	-	-
25	Tamil Nadu	21.53	5
26	Tripura	2.59	0.6
27	Uttar Pradesh	77.19	17.8
28	Uttarakhand	2.04	0.5
29	West Bengal	29.25	6.8
30	Andaman & Nicobar	0.31	0.1
31	Chandigarh	0.02	Negligible
32	Dadar& Nagar Haveli	0.06	Negligible
33	Daman & Diu	0.02	Negligible
34	Lakshadweep	0.01	Negligible
35	Puducherry	0.19	Negligible
	Grand Total	432.72	100.0

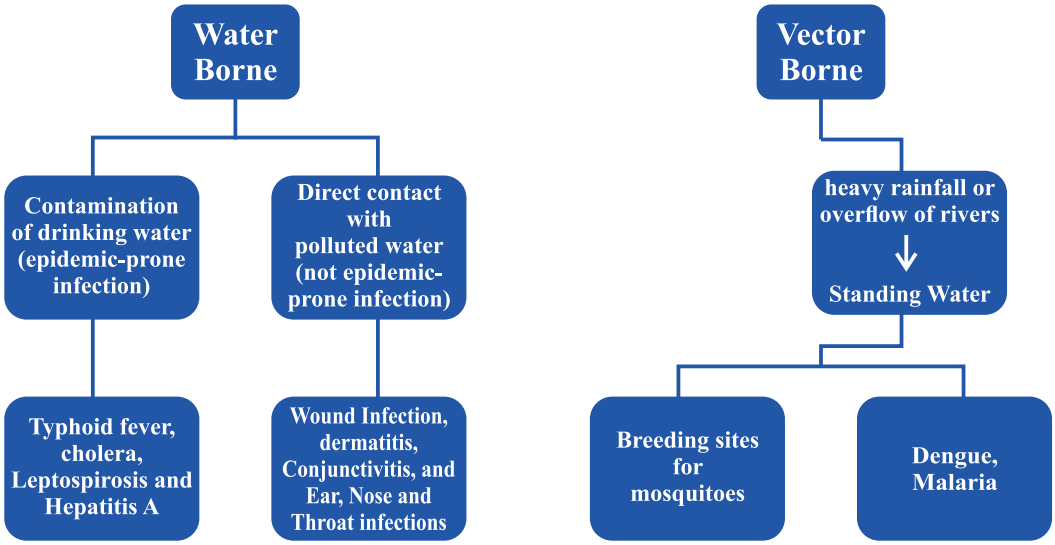
Further Reading:

1. **https://data.gov.in/sector/water-resources**
2. **https://www.indiawaterportal.org/author/ministry-water-resources-mowr**

FLOODS

Floods are common natural disaster occurring worldwide. India is the most flood prone country in the world and accounts for one fifth of global deaths by floods. The main reasons for floods in India are high intensity rainfall in short duration, poor or inadequate drainage capacity of rivers, unplanned reservoir regulation and failure of flood control structures. Floods cause huge losses to lives, properties, livelihood systems, infrastructure, public health and healthcare system.

Disease Risk in Flood Conditions



Prevention of vector borne diseases:

- Chemical Control
- Use of Indoor Residual Spray (IRS) with insecticides recommended under the vector-borne disease control programme
- Use of chemical larvicides like Abate in potable water
- Aerosol space spray during day time
- Malathion fogging during outbreaks
- Personal preventive measures that individuals/communities can take up
- Use of mosquito repellent creams, liquids, coils, mats etc.
- Use of bed nets treated with insecticide (LLIN).
- Wearing clothes that cover maximum surface area of the body

Health education:

- Promote good hygienic practices.
- Ensure safe food preparation techniques.
- Ensure boiling or chlorination of water.
- Increase awareness about early diagnosis and treatment of communicable diseases.

Further Reading:

1. **Health impact of Chennai floods 2015: Observations in a medical relief camp, Nancy Angeline, Suguna Anbazhagan, A Surekha, Sushil Joseph, Pretesh R Kiran. 2017 ,Volume : 5 ,Issue : 2, Page : 46-48,**
2. **Health Risks of Flood Disasters, David L Paterson, Hugh Wright, Patrick N A Harris. Clinical Infectious Diseases, Volume 67, Issue 9, 1 November 2018, Pages 1450-1454**

DROUGHT

Drought is a prolonged dry period in natural climate cycle. It is a slow-onset phenomenon caused by rainfall deficit combined with other predisposing factors.

Drought is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually characterized in terms of its spatial extension, intensity and duration.

Drought causes economic, environmental and social impacts. But Droughts are often predictable: periods of unusual dryness are normal in all weather systems. Advance warning is possible.

CLASSIFICATION

- **Meteorological droughts**- lack of precipitation
- **Hydrological droughts**- lack of moisture in the soil where crops grow
- **Agricultural droughts**- low levels of water in reservoirs

Key Drought Indicators

- Rainfall, storage water levels in reservoirs, surface and ground water levels and sowing in drought conditions

Drought Proofing Measures

- Irrigation has proved to be the most effective drought proofing mechanism
- Construction of storage dam facilitated irrigation by making use of water at proper time of need

Main causes of mortality and morbidity

- Protein-energy malnutrition
- Micronutrient deficiency results in outbreaks of measles, scurvy, beriberi and pellagra
- Lack of water supply and sanitation services increase the risk of infectious diseases such as cholera, typhoid fever, diarrhoea, acute respiratory infections and measles.

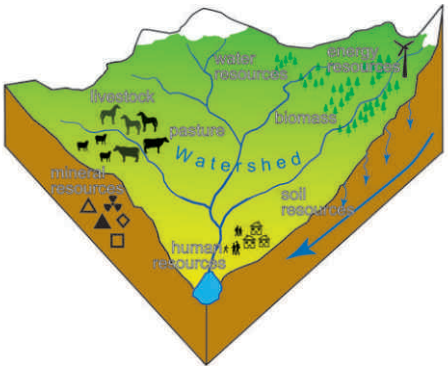
Further Reading:

1. http://mowr.gov.in/brief-drought
2. DROUGHT - Technical Hazard Sheet - Natural Disaster Profiles, World Health Organization

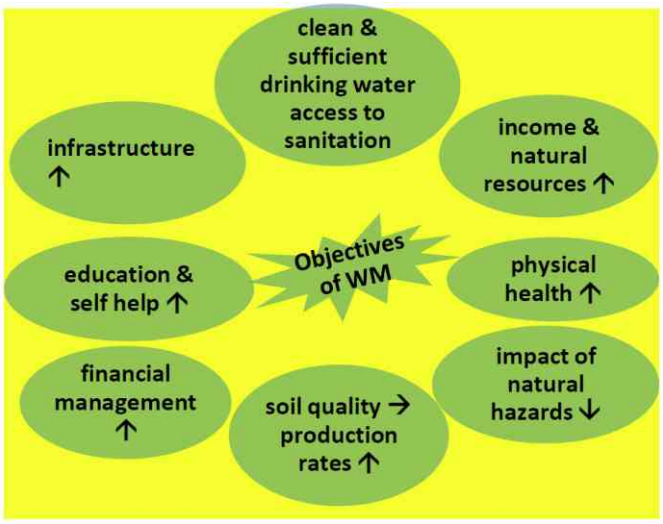
WATERSHED

Watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common point. It is synonymous with a drainage basin or catchment area. A watershed may be only a few hectares as in small ponds or hundreds of square kilometres as in rivers. All watersheds can be divided into smaller sub-watersheds.

A Watershed



Objectives of Watershed Management (WM)



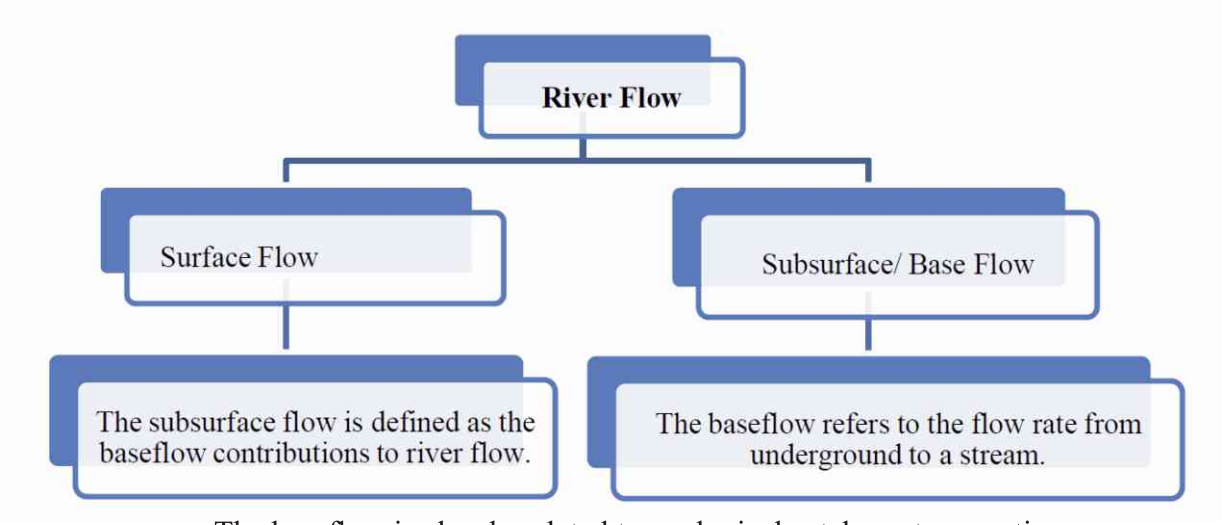
↑improvement, advancement, regeneration, securing
↓reducing
→ resulting in

Farmers	Local community	Larger Society
Increased productivity and higher profits	Lower land development- costs	Reduced risks from floods to downstream cities and farmlands
Improved water availability	Reduced flooding and water logging	Reduced sedimentation in agricultural productive areas and dams
Improved soil quality and better drainage	Reduced soil erosion and land degradation	Better conservation of natural resources
	Increased agricultural productivity	Higher resilience of communities
	Improved livelihoods options	
	Improved land management	
	Less socio-economic conflicts	

Further Readings:

1. https://www.geo.fu-berlin.de/en/v/iwm-network/learning_content/introduction_iwm/benificiaries/index.html
2. http://slusi.dacnet.nic.in/dwainew.html

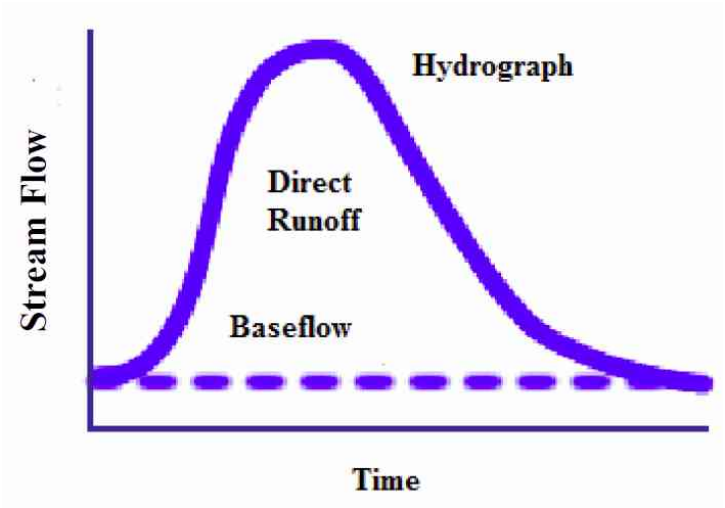
BASEFLOW



• The baseflow is closely related to geological catchment properties.

In general, river flow is classified into two groups: surface flow and subsurface flow.
It is the Runoff that is not extracted from the land surface by evaporation and transpiration and is delivered to streams, lakes and oceans. Base flow is the Sustained low flow in a river during dry or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from interflow and groundwater discharge. Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater makes a contribution to the baseflow component of river flow. Changes in stream flow over time can be illustrated using a hydrograph (= water picture). The flat portion of the hydrograph is called baseflow and represents inputs to the stream from groundwater. The portion of the hydrograph above baseflow is called direct runoff and indicates the presence of a rain or snow melt event.

Baseflow often influences the surface channel and hyporheic zones that can maintain a river's productivity and biodiversity, habitat availability and aquatic species migration, and influence water quality. The degree of dependency on the baseflow is important for maintaining the biodiversity, habitat connectivity, composition, and function of an aquatic ecosystem.



Further Readings:

1. **Module 2, Lesson 2 Runoff and Infiltration, The Science of Surface and Ground Water Version 2 CE IIT, Kharagpur**
2. **Base flow studies for three rivers between Mahanadi and Godavari Deltas in the Sub-zone 4(A), Indian Institute of Hydrology**

RUNOFF

Runoff can be a significant problem on agricultural land or in turf or ornamental areas. It occurs when water does not move into the soil but instead "runs off" the surface and flows into streams and lakes. Run off may also occur in urban areas when rain washes pesticides applied on lawns into street gutters. The pesticide contaminated water then moves through storm drains, eventually flowing into nearby streams and rivers.

a. Surface Runoff:

It is the portion of rainfall which enters the stream immediately after the rainfall. It occurs when all loses is satisfied and rainfall is still continued and rate of rainfall [intensity] in greater than infiltration rate.

b. Sub-Surface Runoff:

That part of rainfall which first leaches into the soil and moves laterally without joining the water table, to the stream, rivers or ocean is known as sub-surface runoff. It is usually referred is inter-flow.

c. Base flow:

It is delayed flow defined as that part of rainfall, which after falling on the ground the surface, infiltrated into the soil and meets to the water table and flow the streams, ocean etc. The movement of water in this is very slow. Therefore it is also referred a delayed runoff.

Total runoff = Surface runoff + Base flow (including subsurface runoff)

Runoff water also carries eroded soil particles. Any pesticides adsorbed on these particles could contribute to the chemical runoff to surface waters. Pesticides dissolved in the runoff water may move considerable distances offsite.

Further Reading:

1. **http://www.seu.ac.lk/ft/lm/FT0_099/Hydrology/5.0%20Runoff.pdf**
2. **https://www.wcc.nrcs.usda.gov/ftpref/wntsc/H&H/training/runoff-concepts1.pdf**

PALAEOCHANNELS

Palaeochannels are old rivers which were dried up due to various geological and climatological factors in the past. These might be partially or completely buried due to environmental changes like weathering, change in land use pattern etc.

IMPORTANCE OF PALAEOCHANNELS

- Palaeochannels are important sites of mineral deposits
- They are the sites of high ground water potential.
- Palaeochannels are important in understanding climate change and global warming.

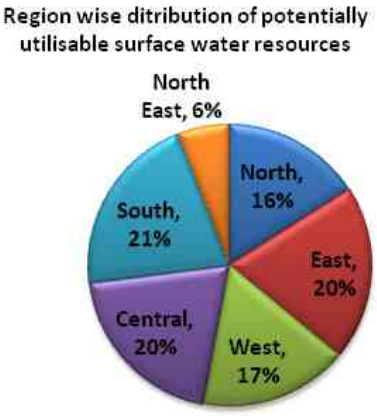
Further Reading:

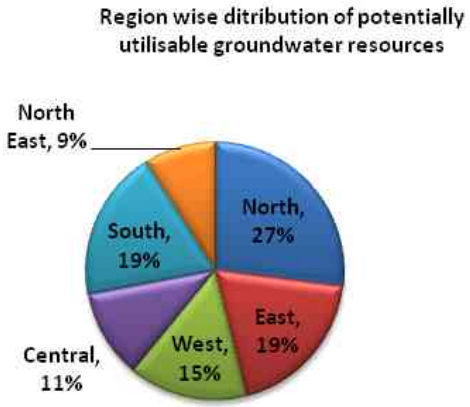
1. **http://shodhganga.inflibnet.ac.in/bitstream/10603/25399/6/06_chapter%201.pdf**

2. **Palaeochannels of North West India: Review And Assessment, Report Of The Expert Committee To Review Available Information On Palaeochannels, 15th October, 2016 New Delhi**

WATER USE PATTERN IN INDIA

	Agricultural Water Demand	Domestic Water Demand	Industrial Water Demand	Energy Production Water Demand
Northern Region % Share in total	93.9	4.8	0.5	0.8
Eastern Region % Share in total	82.5	9.7	5.6	2.2
Central Region % Share in total	91.2	5.6	1.5	1.7
Southern Region % Share in total	82.39	11.69	3.85	2.07
Western Region % Share in total	85.36	9.26	2.78	2.60
North- Eastern Region % Share in total	49.3	41.5	3.5	5.7





Further Reading:

1.Study on Assessment of Water Foot Prints of India's Long Term Energy Scenarios

2.http://mospi.nic.in/sites/default/files/reports_and_publication/statistical_publication/social_statistics/comp_SECTION%206_16mar16.pdf

MAIN SOURCES OF DRINKING WATER IN INDIA

PHYSICAL PARAMETERS OF WATER

Physical characteristics of water (temperature, color, taste, odor etc.) are determined by senses of touch, sight, smell and taste. For example temperature by touch, colour, floating debris, turbidity and suspended solids by sight, and taste and odour by smell.

TEMPERATURE

The temperature of water affects some of the important physical properties of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10 °C. The temperature of water in streams and rivers throughout the world varies from 0 to 35 °C.

Color

Colour in water is primarily a concern of water quality for aesthetic reason. Coloured water give the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, color can indicate the presence of organic substances, such as algae or humic compounds. More recently, color has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water.

Taste and Odor

Taste and odor are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However sweet and bitter tastes are produced by more complex organic compounds. Human detect many more tips of odour than tastes. Organic materials discharged directly to water, such as falling leaves, runoff, etc., are sources of tastes and odour-producing compounds released during biodegradation.

TURBIDITY

Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons.

Further Reading:

1.https://www.researchgate.net/publication/317588226_Which_Physical_Chemical_and_Biological_Parameters_of_water_determine_its_quality

2. https://www.researchgate.net/publication/264822219_Water_quality_assessment_of_Yamuna_River_in_Delhi_region_using_index_mapping

CHEMICAL CHARACTERISTICS OF WATER

The chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. But agricultural runoff, urbanization & industrialization are some anthropogenic activities which contribute to change in chemical properties of water.

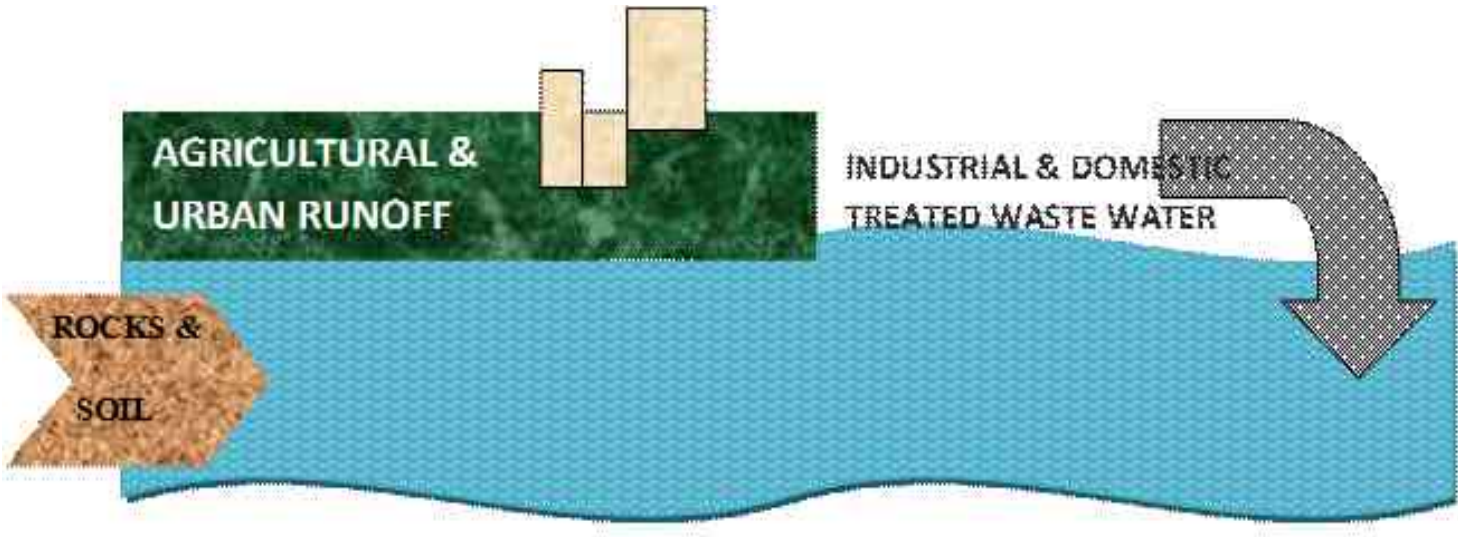


Figure: Activities that contributes to change in chemical properties of water

Runoff causes erosion and weathering of geological formation, rocks and soils as the runoff travels to the surface-water bodies. During this period of contact with rocks and soils the water dissolves inorganic minerals, which enter the natural waters.

Inorganic compounds may dissociate to varying degrees, to cations and anions.

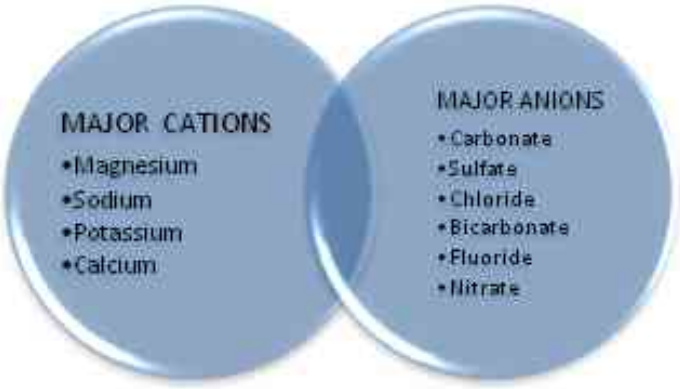


Figure: Major Cations & Anions present in Water

Further Reading:

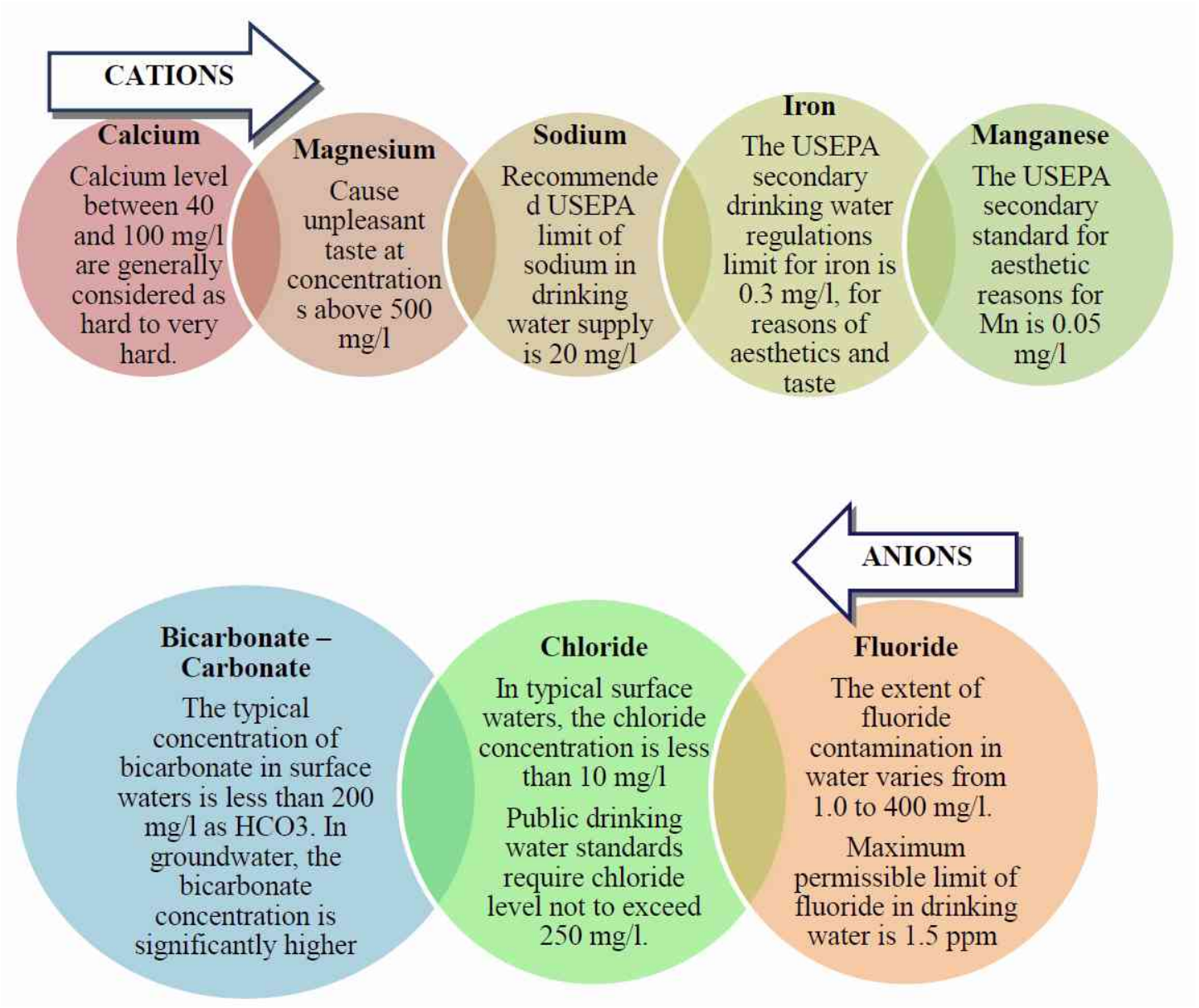
1.https://www.researchgate.net/publication/317588226_Which_Physical_Chemical_and_Biological_Parameters_of_water_determine_its_quality

2.http://echo2.epfl.ch/VICAIRE/mod_2/chapt_2/main.htm

DIVERSITY OF NATURALLY EXISTING WATER

In nature, water always contains chemicals and biological impurities i.e. suspended and dissolved inorganic and organic compounds and micro organisms.

It generally contains calcium, magnesium, sodium and potassium salts of bicarbonate, chloride, sulphate, nitrate, and phosphate as a result of weathering and leaching of rocks. Beside these, some others are present in trace amount such as lead, copper, arsenic, iron and manganese.

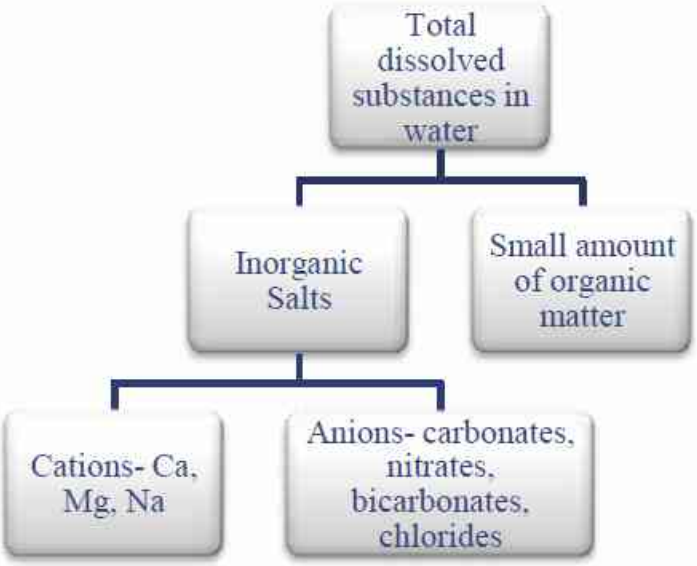


Further Reading:

1. **A review of permissible limits of drinking water. Manoj Kumar and Avinash Puri, IJOEM, 16 (10):40-44, 2012**
2. **Status of water treatment plants in India, CPCB, Ministry of Environment and Forest.**

TOTAL DISSOLVED SOLIDS

Total Dissolved Solids is the total concentration of dissolved substances in water.



- If the elevated TDS is due to calcium and magnesium, a water softener is a good option.
- If the problem is associated with an elevated concentration of nitrate, a reverse osmosis system or distillation unit can be used.
- The best option for dealing with TDS in drinking water should only be determined after analysis of the specific ions contributing to the TDS measurement.

How TDS gets into water:

Further Reading:

1. **https://www.safewater.org/fact-sheets-1/2017/1/23/tds-and-ph**
2. **http://archive.indiawaterportal.org/ask/5305**

PRIMARY WATER QUALITY CRITERIA FOR DESIGNATED BEST USE CLASSES

Total Dissolved Solids is the total concentration of dissolved substances in water.

S.No	Designated Best Use	Class	Criteria
1.	Drinking water source without conventional treatment but after disinfection	A	1. Total Coliform organism MPN/100 ml shall be 50 or less 2. pH between 6.5 and 8.5 3. dissolved Oxygen 6 mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0, 2 mg /l or less
2.	Outdoor bathing (organized)	B	1. Total Coliform organism MPN/100 ml shall be 500 or less 2. pH between 6.5 and 8.5 3. dissolved Oxygen 5 mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0, 3 mg /l or less
3.	Drinking water source after conventional treatment and disinfection	C	1. Total Coliform organism MPN/100 ml shall be 5000 or less 2. pH between 6 and 9 3. dissolved Oxygen 4 mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0, 3 mg /l or less
4.	Propagation of wild life and fisheries	D	1. pH between 6.5 and 8.5 2. dissolved Oxygen 4 mg/l or more 3. Free ammonia (as N) 1.2 mg/l or less
5.	Irrigation, industrial cooling, controlled waste disposal	E	1. pH between 6.5 and 8.5 2. Electrical conductivity at 25^0 C micrp mhos/cm Max. 2250 3. Sodium adsorption ratio max 26 4. Boron max. 2 mg/l

Further Reading:

1. **https://greencleanguide.com/earths-water-distribution-and-indian-scenario/**
2. **Status of water treatment plants in India, CPCB, Ministry of Environment and Forest**

GENERAL QUALITY CRITERIA FOR RAW WATER CONCERNING SUBSTANCES UNDESIRABLE BEYOND ACCEPTABLE LIMITS

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Remarks
1	Colour, Hazen units, *Max*	5	15	Extended to 15 only, if toxic substances are not suspected in absence of alter- nate sources
2	Odour	Agreeable	Agreeable	a) Test cold and when heated b) Test at several dilutions
3	*p*H value	6.5-8.5	No relaxation	—
4	Taste	Agreeable	Agreeable	Test to be conducted only after safety has been established
5	Turbidity, NTU, *Max*	1	5	—
6	Total dissolved solids, mg/l,	500	2 000	—
7	Ammonia (as total ammonia-N), mg/l, *Max*	0.5	No relaxation	—
8	Calcium (as Ca), mg/l, *Max*	75	200	—
9	Chloride (as Cl), mg/l, *Max*	250	1000	
10	Fluoride (as F) mg/l, *Max*	1.0	1.5	
11	Iron (as Fe), mg/l, *Max*	0.3	No Relaxation	Total concentration of man- ganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l
12	Magnesium (as Mg), mg/l, *Max*	30	100	
13	Nitrate (as NO_3), mg/l, *Max*	45	No Relaxation	
14	Sulphate (as SO_4) mg/l, *Max*	200	400	May be extended to 400 pro- vided that Magnesium does not exceed 30
15	Total hardness (as $CaCO_3$), mg/l, *Max*	200	600	
16	Cadmium (as Cd), mg/l, *Max*	0.003	No Relaxation	
17	Lead (as Pb), mg/l, *Max*	0.05	No Relaxation	
18	Total arsenic (as As), mg/l, *Max*	0.01	0.05	

Further Reading:

1. **Status of water treatment plants in India, CPCB, Ministry of Environment and Forest**

2. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482709/**

INDICATORS OF QUALITY WATER

Inorganic Indicators

Hardness is correlated with TDS (Total dissolved solids). It represents total concentration of Ca2+ and Mg2+ ions, and is reported in equivalent CaCO3. Other ions (Fe2+) may also contribute. Hardness expressed as mg/L CaCO3 is used to classify waters from "soft" to "very hard".

S.No.	Hardness as mg/L CaCO3	Classification	Utilization	Impact on Health
1.	0 – 60	Soft (treated water in which the only ion is sodium.)	Drinking and all other chores	Not suggested for those with heart , circulatory problems, or others with low sodium diet.
2.	61 – 10	Moderately hard		
3.	121 – 180	Hard (water that contains an appreciable quantity of dissolved minerals, like calcium and magnesium).	Bathing, doing dishes, laundry, general cleanup	Diabetes, digestive health, kidney stones, Alzheimer's disease
4.	>180	Very hard		

Organic Materials

Organic chemicals are made up of carbon (C), hydrogen (H), as well as nitrogen (N) and oxygen (O). Organic compounds are derived from living organism as well as industrial sources.

Organic compounds in water also affect the water quality. Organic chemicals cause disagreeable tastes and odors in drinking water. Vinyl chloride, benzene and other organic contaminants are known carcinogenic agents, while chloroform is a cancer-suspect agent.

Further Reading:

1. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775162/**
2. **https://www.lcra.org/water/quality/colorado-river-watch-network/Pages/water-quality-indicators.aspx**

FALLING UNDER GEOGENIC CONTAMINATION

High arsenic in ground water

Occurs in isolated patches in spreading over 79 blocks in eight districts namely, Malda, Murshidabad, Nadia, North 24 Paraganas, South 24- Paraganas to the east and Haora, Hoogly and Bardhaman to the west of Bhagirathi/ Hoogly river.

Eastern part of Bhagirathi/ Hoogly river is much more affected than the western part. Deeper aquifers (> 100 mbgl) in the same area are generally free from arsenic. Ground water in arsenic affected area is characterized by high iron, calcium, magnesium, bicarbonate with low chloride, sulphate and fluoride.

High fluoride in ground water

Occurs in 105 blocks of 12 districts of West Bengal. After the assessment, the final scenario regarding the high fluoride concentration in ground water of West Bengal has been observed in 43 blocks of 7 districts, namely Bankura, Birbhum, Purulia, Malda, Uttar Dinajpur, Dakshin Dinajpur and South 24 Parganas.

In West Bengal highest concentration of fluoride in groundwater has been reported from Khyarasol block (15.9mg/lit) and Rampurhat-I block (17.9mg/lit) of Birbhum district.

High salinity

Brackish to saline and fresh water bearing aquifers have been deciphered in the different depth zones in Kolkata Municipal Corporation area, South 24 Parganas and in parts of North 24 Parganas, Haora and Purba Medinipur districts.

High iron

In some isolated patches of Medinipur, Haora, Hugli and Bankura iron content is somewhat higher than 1 ppm and sometimes it exists more than 2 ppm in Haora and parts of Hugli districts.

Likewise, in the Himalayan foothills in the districts of Darjeeling and Jalpaiguri ground water in near surface aquifers have iron as high as more than 3 ppm at places.

Further Reading:

1. **Towards Better Management of Ground Water Resources in India B.M.Jha & S.K.Sinha**

2. **Concept note on Geogenic Contamination of Ground Water in India, CGWB, Ministry of Water Resources, GOI**

E.COLI - WAYS OF ACCESS & PROTECTION

E. coli bacteria live in the digestive systems of humans and warm-blooded animals.

Coliform bacteria may not cause disease, but can be indicators of pathogenic organisms that cause diseases. The latter could cause intestinal infections, dysentery, hepatitis, typhoid fever, cholera and other illnesses.

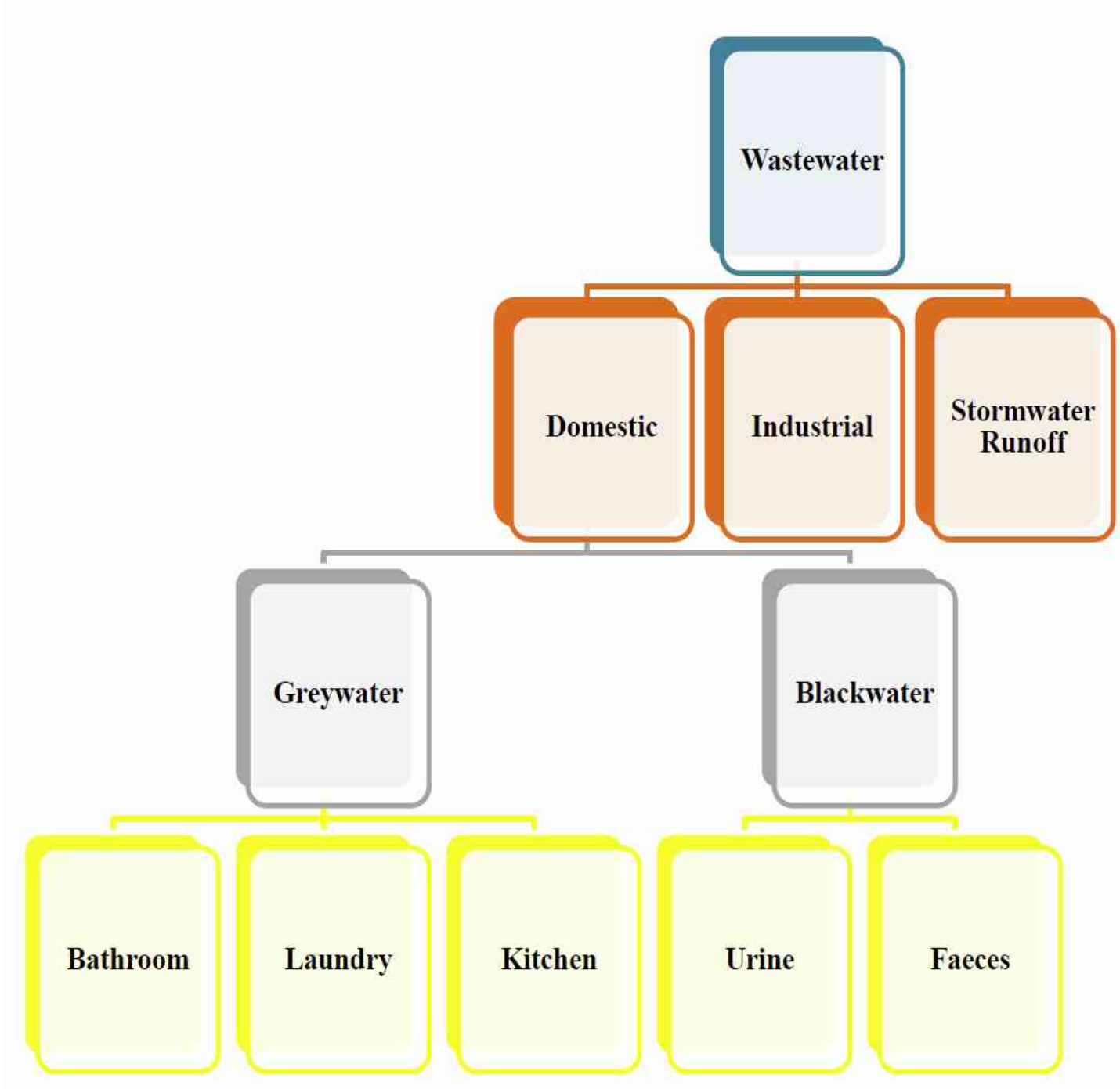
HOW CAN I PREVENT GETTING E. COLI O157:H7 (Most common disease causing strain of E.COLI)?

- Avoid swallowing lake or pool water while swimming, especially pool water in public swimming facilities.
- Drink municipal water that has been treated with chlorine or other effective disinfectants.
- Make sure that persons with diarrhea, especially children, wash their hands carefully with soap after going to the bathroom to reduce the risk of spreading infection, and that persons wash hands after changing soiled diapers.
- Wash fruits and vegetables thoroughly, especially those that will not be cooked.
- Avoid unpasteurized milk.

Further Reading:
1. The Role of Alkalinity Citizen Monitoring

2. SDWF, Detailed Escherichia Coli

TYPES OF WATER WASTE



Further Reading:

1. **Impact of Wastewater on Surface Water Quality in Developing Countries: A Case Study of South Africa By Joshua N. Edokpayi, John O. Odiyo and Olatunde S. Durowoju, January 18, 2017, Intech Open**
2. **https://www.researchgate.net/publication/275097499_Wastewater_as_a_Resource**

WATER BORNE DISEASES

Here is a list of the five most dangerous water-related diseases that occur in India, which are described as follows:

1) Cholera
Cholera is a water-related disease, and is diarrhoeal in nature. It can kill in hours if left unattended. Cholera strikes when one ingests water that is infested with the Vibrio Cholerae bacterium.

2) Diarrhoea
Diarrhoeal infection is spread through food and drinking water that has been contaminated.
A diarrhoeal attack can last up to 2 weeks and leave the person completely dehydrated.

3) Malaria
Malarial fever is spread by the Plasmodium parasite mosquito that breeds in water bodies like lakes, paddy fish and stagnant water.
Malaria can kill a child who does not have the immunity against the disease.

4) Typhoid
Fluctuating high fever, exhaustion, sleepiness, diarrhoea etc are signs of typhoid.
The infection spreads through contaminated food and water or through close contact with an infected person.

5) Filariasis
Filariasis is a parasitic disease and affects people who live near unsanitary water bodies or sewages.
Filariasis is spread by mosquitoes that breeds in fresh and stagnant water bodies and is the host of the filarial nematode worm. This worm affects humans and leads to Elephantitis.

Further Reading:

1. **https://www.cdc.gov/ncezid/dfwed/waterborne/index.html**

2. **https://globalhydration.com/waterborne-disease/common-waterborne-disease-bacteria-viruses-cysts/**

WATER BORNE DISEASES

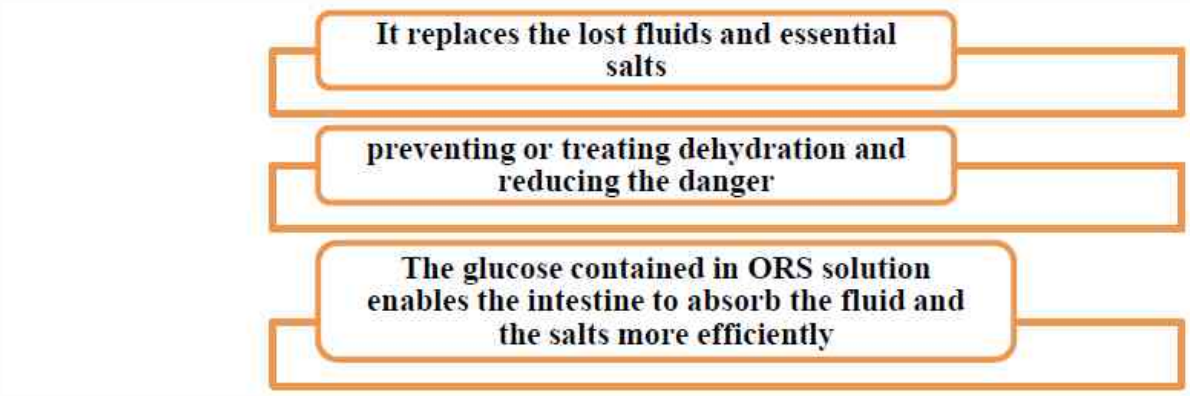
1. **Diarrhoea**

- Acute diarrhoea normally only lasts a few days.

Prevention: Oral Rehydration Solutions (ORS)

ORS does not stop the diarrhoea.

What does ORS do?



- ORS alone is an effective treatment for 90-95% of patients suffering from acute watery diarrhoea, regardless of cause. This makes intravenous drip therapy unnecessary in all but the most severe cases.

2. **Cholera**- an acute diarrhoeal infection cause by ingestion of food or water that is contaminated with bacterium Vibrio cholera.

3. **Dysentery**- Dysentery is bloody diarrhoea

VIRAL HEPATITIS

Viral hepatitis A and E are water borne

While sporadic cases of hepatitis E are reported throughout the year, epidemics occur as a result of contamination of piped water supply.

Almost all outbreak of viral hepatitis in India are due to hepatitis E virus as by age five most individuals develop immunity through natural infection against Hepatitis A.

Further Reading:

1. **https://www.apollohospitals.com/patient-care/health-and-lifestyle/diseases-and-conditions/dysentery**
2. **https://www.ndmc.gov.in/departments/Departments/Health/Vector_Borne_Action_plan-2017.pdf**

EFFECT OF SEWAGE POLLUTION ON SURFACE WATER BODIES

Organic Pollution

All organic materials or wastes can be broken down or decomposed by microbial and other biological activity (biodegradation). This category of pollution becomes a problem when the oxygen required for biodegradation due to organic pollution is greater than the available oxygen in the water body. Natural systems do have a limited capacity to accommodate self-purification through biodegradation by employing re-oxygenation processes.

Effect of Nutrients

Here the primary focus is on fertilizing chemicals such as nitrates and phosphates. While important for plant growth, too much of nutrients encourage the overabundance of plant life and can result in environmental damage called eutrophication. Nitrates and phosphates contributed through anthropogenic sources such as sewage, agricultural run-off and run-off from un-sewered residential areas.

Effect of High Dissolved Solids (TDS)

The amount of dissolved solid is important consideration in determining its suitability for irrigation, drinking and industrial uses. In general, waters with a total dissolved solids

Effect of Toxic Pollutants on Water Quality

The toxic Pollutants are mainly heavy metals, pesticides & other industrial xenobiotic pollutants. Arsenic, cadmium, chromium, lead, mercury poses risk to carcinogenicity and other severe health disorders.

Ecological Health

A large number of areas in our aquatic environment support rare species and ecologically very sensitive. Since, the Water Act, 1974 provides for maintenance and restoration of ?wholesomeness? of aquatic resources, which is directly related to ecological health of the water bodies, it is important that ecological health of the water bodies is given first priority in the water quality goal.

Further Reading:

1. **http://www.cpcbenvis.nic.in/cpcb_newsletter/sewagepollution.pdf**

2. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4144270/**

EFFECTS OF WATER POLLUTION ON HUMAN HEALTH

Health risk associated with polluted water includes different diseases such as respiratory disease, cancer, diarrheal disease, neurological disorder and cardiovascular disease.

Poor people are at greater risk of disease due to improper sanitation, hygiene and water supply.

Contaminated water has large negative effects in those women who are exposed to chemicals during pregnancy; it leads to the increased rate of low birth weight as a result fetal health is affected.

Bacterial diseases

1. Untreated drinking water and fecal contamination of water is the major cause of DIARRHOEA.

Fever, abdominal pain, nausea, headache are major symptoms of diarrhoea.

2. Disease CHOLERA is caused by the contaminated water.

The symptoms of this disease are watery diarrhea, nausea, vomiting and watery diarrhea leads to dehydration and renal failure.

Viral diseases

HEPATITIS

It infects the liver. Jaundice, loss of appetite, fatigue, discomfort and high fever are symptoms of hepatitis.

Vaccine is available for hepatitis

Parasitic disease

CRYPTOSPORIDIOSIS

symptoms are diarrhea, loose or watery bowls, stomach cramps and upset stomach.

Parasitic disease

GIARDIASIS / TRAVELERS' DISEASE

symptoms are bloating, excess gas, watery diarrhea and weight loss.

Water pollution is a global issue, we should together fight against it.

Further Reading:

1. **Environmental Risk Assessment and Remediation (2017) Volume 1, Issue 3, July 13, 2017, Allied Academics**

2. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2610176/**

SYNTHETIC ORGANICS: PLASTICS

Plastics are synthetic organic compounds, mostly derived from petroleum.

Plastic you put in the bin ends up in landfill.

Rainwater and wind carries plastic waste into streams and rivers, and through drains.

Single Use Plastic is the main culprit

Plastic is often blown away because it's so lightweight. From there, it can eventually clutter around drains and enter rivers and the sea this way.

Microfibres are even released into waterways when we wash our clothes in the washing machine. They are too small to be filtered out by waste water plants and end up being consumed by small marine species, eventually even ending up in our food chain.

S.No	*Potential plastic additives*	*Adverse effects on human body*
1.	Lead, cadmium, and mercury	Affects multiple body systems; damage to kidneys, lungs and bones; cause cancer
2.	Diethylhexyl phthalate (DEHP)	- Reproductive malformations -Developmental disorders -Pulmonary system effects including asthma and allergies -Direct toxicity
3.	Bisphenol-A	Chemical that interferes with human hormonal function, endocrine disruptor

Further Reading:

1. **https://www.wwf.org.uk/updates/how-does-plastic-end-ocean**
2. **https://www.maine.gov/dacf/php/integrated_pest_management/school-ipm-curricula/high/documents/PTS_plastics2.pdf**
3. **https://www.greenbiz.com/article/5-innovations-could-end-plastic-waste**

Most Harmful Effects of Some Elements Present In Polluted Water

ARSENIC

Long terrn exposure to arsenic causes cancer of the skin, I ungs, urinary bl adder and kidney

FLUORIDE

Immediate Symptoms include digestive disorders skin diseases, dental fluorosis, and skeletal floorosis.

LEAD

Affects multiple body systems and is particularly harmful to young children.

HEXAVALENT

Carcinogen and a reproductive toxicant for both males and females. In addition to cancer and reproductive harm.

IRON

Hemochromatosis, a severe disease that can damage the body's organs.

NITRATE

Mathemoglobinemia or blue-baby syndrome, is a condition caused by the inability of the blood to deliver enough oxygen to the body.

Further Reading:

1. **Heavy Metal Poisoning, Rare Disease Database, NORD**

2. **Nitrates and Nitrites in Drinking Water Groundwater and Surface Waters, water Research Centre**

POLLUTION: OUT OF SIGHT, OUT OF MIND?

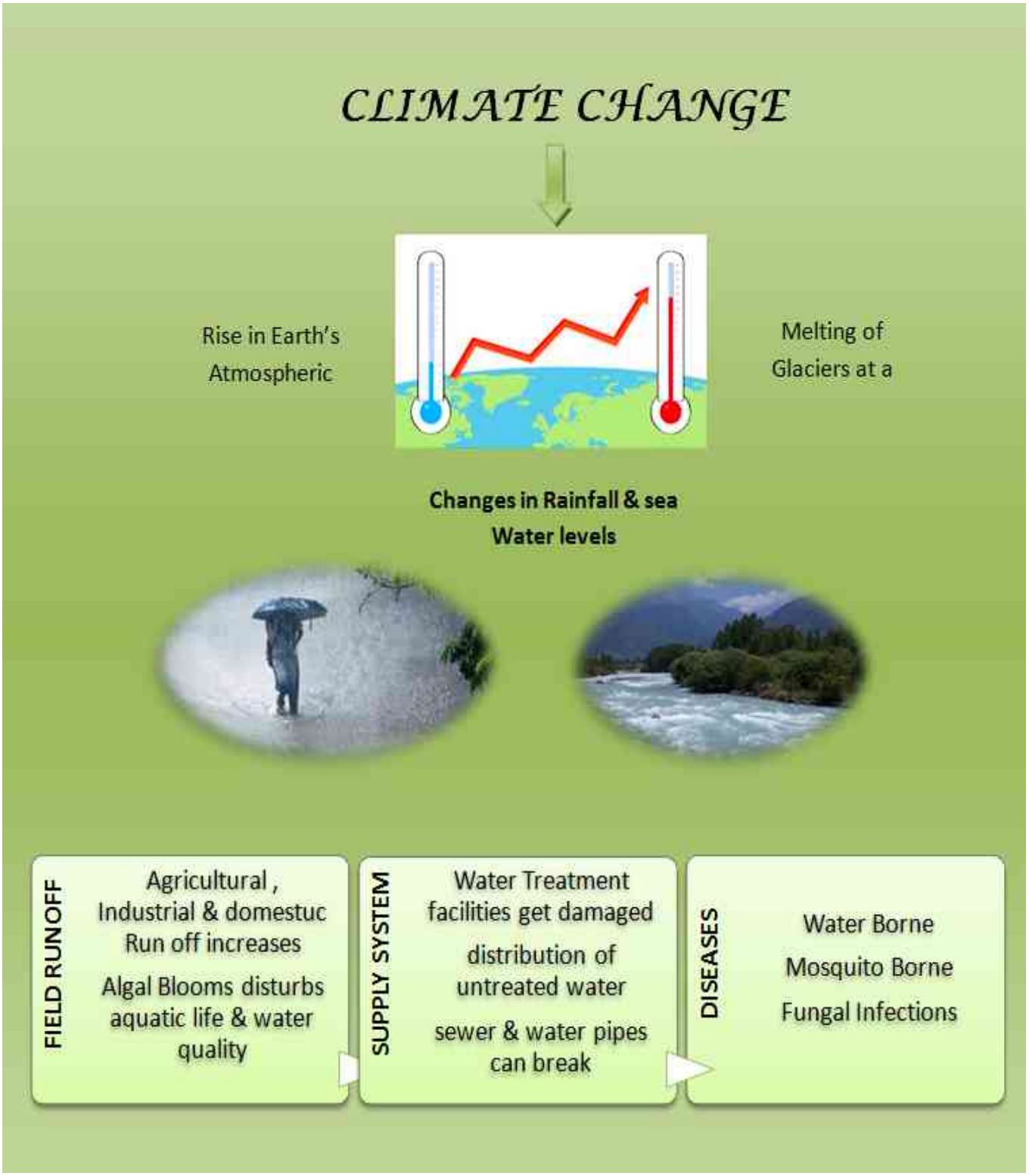
- Nitrogen and phosphorus are natural minerals, but 80 percent of nitrates, and 75 percent of phosphates that are found in lakes and rivers are added by humans.
- Farming accounts for the largest amounts of sediment pollution, but construction sites and strip mined areas (where there is bare earth) can lose up to 15,691 tonnes of sediment per square kilometre per year (which is 15 times higher than the normal cropland erosion rate).
- Fertilizer use is more than 15 times higher than it was in 1945. Homeowners typically use 10 to 50 times more fertilizer than is required for healthy plants.
- In developing countries, 70 percent of all industrial waste is dumped, untreated, into water sources. (2003 International Year of Freshwater Facts and Figures)
- One drop of oil can make up to 25 litres of water unfit for drinking. (Government of Canada: Water and the environment;
- One gram of 2,4-D (a common household herbicide) can pollute 10 million litres of water. (Government of Canada: Water and the environment
- One gram of PCBs can make up to one billion litres of water unsuitable for aquatic life. (Government of Canada: Water and the environment
- One gram of lead can pollute 20,000 litres, and make it unfit for drinking. (Government of Canada: Water and the environment
- Acid rain has a pH of 3.6, which is 100 times more acidic than normal rainwater, which has a pH of 5.6.
- 80 percent of diseases in developing countries are water-related.

Further Reading:

1. **EPA; https://www.epa.gov/**

2. **https://www.canada.ca/en/environment-climate-change/services/water-overview.html)**

WATER QUALITY & CLIMATE CHANGE



Further Reading:

1. Climate Change Impacts on Hydrology and Water Resources of Indian River Basins

2. Umesh Kumar Singh and Balwant Kumar, ISSN: 0973-4929, Online ISSN: 2320-8031

SEWER WORKERS

- The working conditions of the sanitary workers have remained virtually unchanged for over a century. Using only a stick broom and a small tin plate, the sanitary workers clear faeces from public and private latrines onto baskets or other containers, which they then carry on their heads to dumping grounds and disposal sites. A few, however, are provided with wheelbarrows or carts by the municipal authorities.
- Apart from the social atrocities that these workers face, they are also exposed to certain health problems by virtue of their occupation. These health hazards include exposure to harmful gases, cardiovascular degeneration, musculoskeletal disorders, infections, skin problems and respiratory system problems.
- The workers are commonly exposed to gases like hydrogen disulfide, methane, ammonia and carbon monoxide.

Further Reading:

1. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2796749/**
2. **Why India's sanitation workers are nobody's priority, Hindustan Times**

PERSONAL LEVEL MEASURES TO CONTROL WATER POLLUTION

- Reduce the waste of water by turning off taps immediately after use. This prevents shortages and helps in reducing the volume of polluted water to be treated.
- Properly dispose paints, chemicals, cleaning solvents, nail polishes and oils.
- Fix leaky faucets and shower heads to reduce water use.
- Run washing machines and dishwashers when full, not before.
- Decrease water resistant surfaces such as cement around homes to reduce surface runoff. Vegetation, porous materials, gravel, wood decking etc. can be used instead of cement.
- With the help of community members, monitor and identify pollutants in your nearby water resources and help in cleanup programs.
- Do not dispose non-degradable products such as plastic wrappers down the drain. They end up as litters on beach shores and impede sewage treatment process.
- Avoid flushing pills and liquid medications into the toilet.
- Avoid throwing garbage into lakes, rivers and streams and help in cleaning litter around water resources.
- Reduce the use of pesticides, fertilizers and other chemicals to maintain your garden.
- Wash your automobiles at carwashes instead of washing it yourself. The wastewater from these carwashes are drained into the sewer and treated which reduce the amount of pollutants in the water.

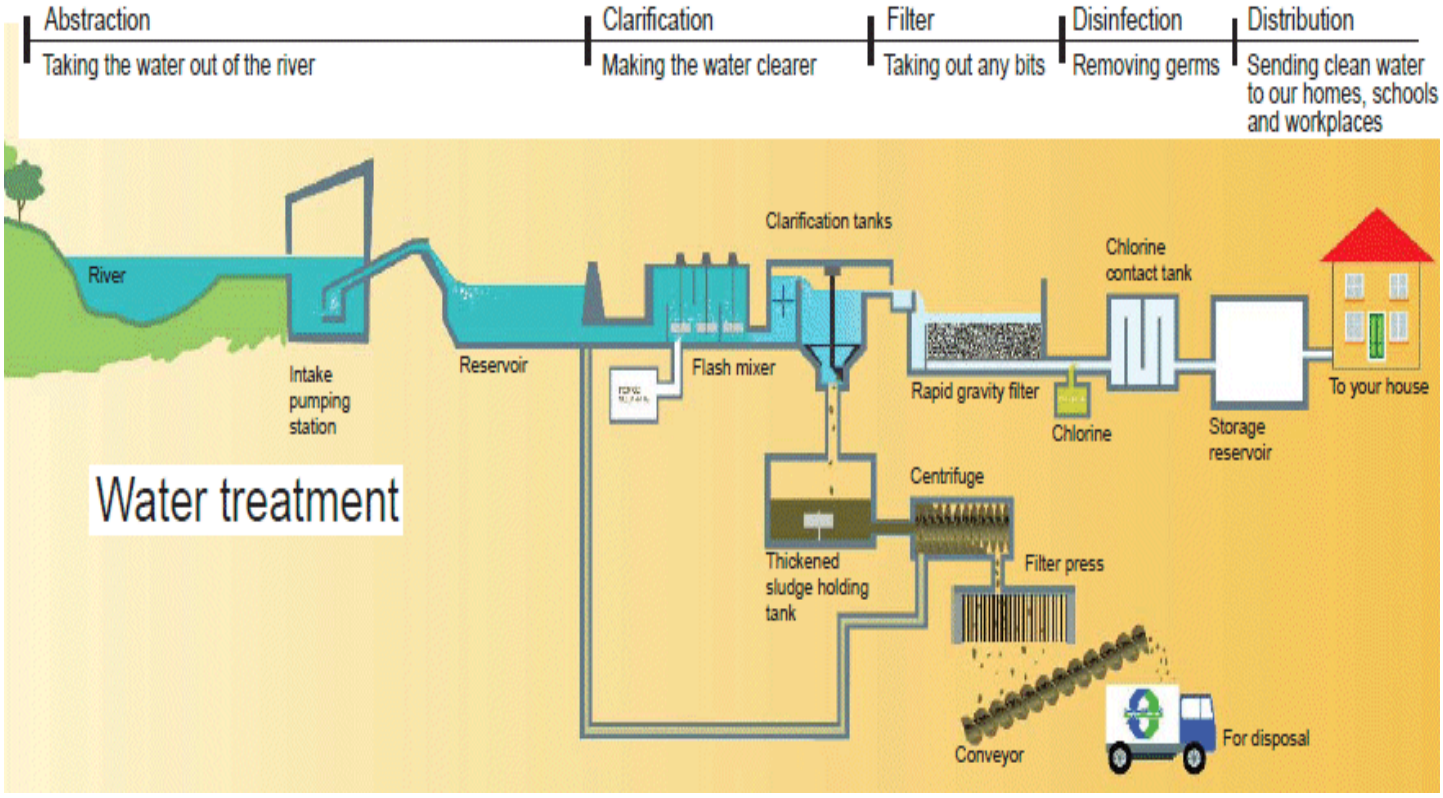
Further Reading:

1. **https://www.sciencetopia.net/pollution/water/prevention-solutions**

2. **http://cpcbenvis.nic.in/water_pollution_control.html#**

HOW WATER IS SUPPLIED TO OUR HOMES

- The water we use in our homes is rainwater from reservoirs, wells or rivers.
- Before this water can be pumped to our homes, it must be cleaned at the waterworks.



- First, particles of sand, mud and grit sink and settle in a tank and then the water passes to filter beds where any remaining dirt and some of the bacteria are removed.

- Next, chlorine gas is bubbled through the cleaned water to kill any remaining bacteria.
- Fluoride may be added to the water to help prevent tooth decay.
- The clean water is then pumped through pipes to storage tanks and finally to our homes.

Further Reading:

1. **https://jalshakti-ddws.gov.in/**

2. **http://web.worldbank.org/archive/website01291/WEB/0__CO-20.HTM**

USAGE IS NOT THE CONCERN, WASTAGE IS. .

Quality of used water gets deteriorated and ultimately all this used water drains into rivers which increases the amount of treatable water and the risk of unidentified contamination also increases. .

PREVENTION MEASURES AND POSSIBLE SOLUTIONS OF WATER POLLUTION

Implement existing environmental laws

Water quality laws regulate the amount of water pollutants released into water and restrictions on the degradation of physical, biological and chemical properties of water resources.

Use fertilizers wisely and give preference to native plants

Natural fertilizers such as peat, compost, manure should be preferred while gardening and farming. Indigenous plants-those are native to your location-help in reducing water use and are economic as well.

Proper use and dispose of chemicals

Chemicals from pesticides, fertilizers, cleaning products etc. reach groundwater with surface runoff. So these materials should never be dumped into sinks, drains and toilets. Use detergents with low or no phosphate because high phosphate content in lakes can harm fishes.

Control of sediments and erosion from construction sites

Erosion from construction sites can be maintained by mulching. It is a process of layering the surface of soil with a permanent or temporary material to improve soil quality. Sediment can be controlled by installing sediment basins that capture washed off soil and consequently prevent pollution of nearby water resources.

Control storm water runoff

Storm water runoff is created when water from rainfall and snow flow over ground and are not absorbed. As the storm water runoff flows over impervious surfaces, it collects debris, sediments, chemicals and other pollutants which can have negative effects on the quality of water if the runoff is left untreated.

It can be controlled by applying management practices such as washing automobiles at car wash instead of streets, removing impervious surfaces such as cement around homes etc.

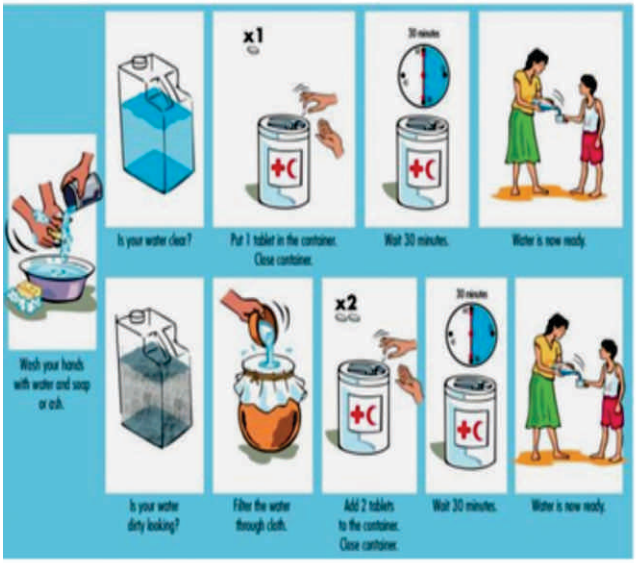
Further Reading:

1. **https://www.sciencetopia.net/pollution/water/prevention-solutions**

2. **http://cpcbenvis.nic.in/water_pollution_control.html**

HOUSEHOLD WATER TREATMENTS

1. CHLORINATION



2. FLOCCULANT/DISINFECTANT POWER

3. SOLAR DISINFECTION

4. CERAMIC FILTRATION

Further Reading:

1.https://www.cdc.gov/healthywater/drinking/index.html

2.https://www.cdc.gov/safewater/household-water.html

ROOFTOP RAIN WATER HARVESTING

Rain water may be harvested in areas, having rainfall of considerable intensity, spread over the larger part of the year e.g. the Himalayan areas, northeastern states, Andaman Nicobar, Lakshadweep islands and southern parts of Kerela and Tamil Nadu

Rain water is bacteriologically pure, free from organic matter and soft in nature.

Easy to Maintain, reducing Water Bills, Suitable for Irrigation, Reduce demand on Ground Water, Reduces the cost for pumping of ground water, the rooftop rain water harvesting is less expensive, In saline or coastal areas, rain water provides good quality water

Panchsheel Park Colony about 1000 residents pooled in Rs 4.5 lakh to harvest more than 170 million litres of water annually.

Rainwater harvesting methods are site specific and hence it is difficult to give a generalised cost. But first of all, the major components of a rainwater harvesting system - rain and catchment area - are available free of cost. A good proportion of the expenses would be for the pipe connections. By judiciously fixing up the slopes of roofs and location of rainwater outlets, this could be brought down considerably. However the cost varies widely depending on the availability of existing structures like wells and tanks which can be modified and used for water harvesting.

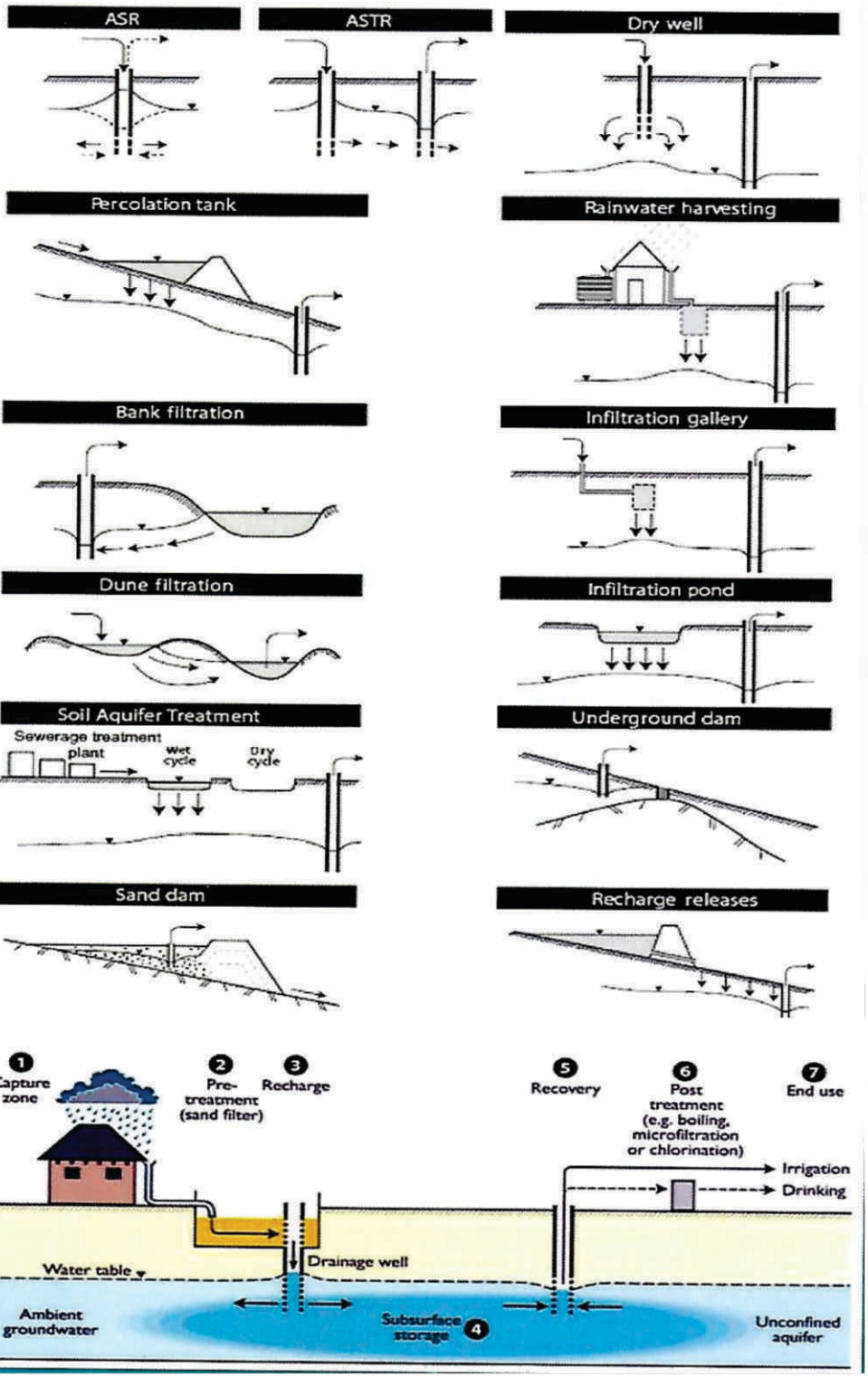
Typically, installing a water harvesting system in a building would cost between Rs 2,000 to 30,000 for buildings of about 300 sq. m. The cost estimate mentioned above is for an existing building.

For instance, water harvesting system in the CSE building in Tughlakabad Institutional Area, Delhi, was set up with an investment of Rs 30,000 whereas those in the model projects ranged between Rs 70, 000 and Rs 8 lakh. The costs would be comparatively less if the system were incorporated during the construction of the building itself.

Further Reading:

1. **http://cgwb.gov.in/documents/AR/Roof%20Top%20Rain%20Water%20Harvesting.pdf**
2. **https://www.cseindia.org/rainwater-harvesting-1272**

ROOFTOP RAIN WATER HARVESTING CONCEPTS



- Rain water may be harvested in areas, having rainfall of considerable intensity, spread over the larger part of the year e.g. the Himalayan areas, northeastern states, Andaman Nicobar, Lakshadweep islands and southern parts of Kerala and Tamil Nadu.
- Rain water is bacteriologically pure, free from organic matter and soft in nature.
- Easy to Maintain, Reducing Water Bills, Suitable for Irrigation, Reduce demand on Ground Water, Reduces the cost for pumping of ground water. The rooftop rain water harvesting is less expensive, in saline or coastal area, rain water provides good quality water.

ASR- Aquifer Storage and Recovery

ASTR- Aquifer Storage Transfer &

Further Reading:

1. **http://cgwb.gov.in/documents/AR/Roof%20Top%20Rain%20Water%20Harvesting.pdf**
2. **https://www.cseindia.org/rainwater-harvesting-1272**

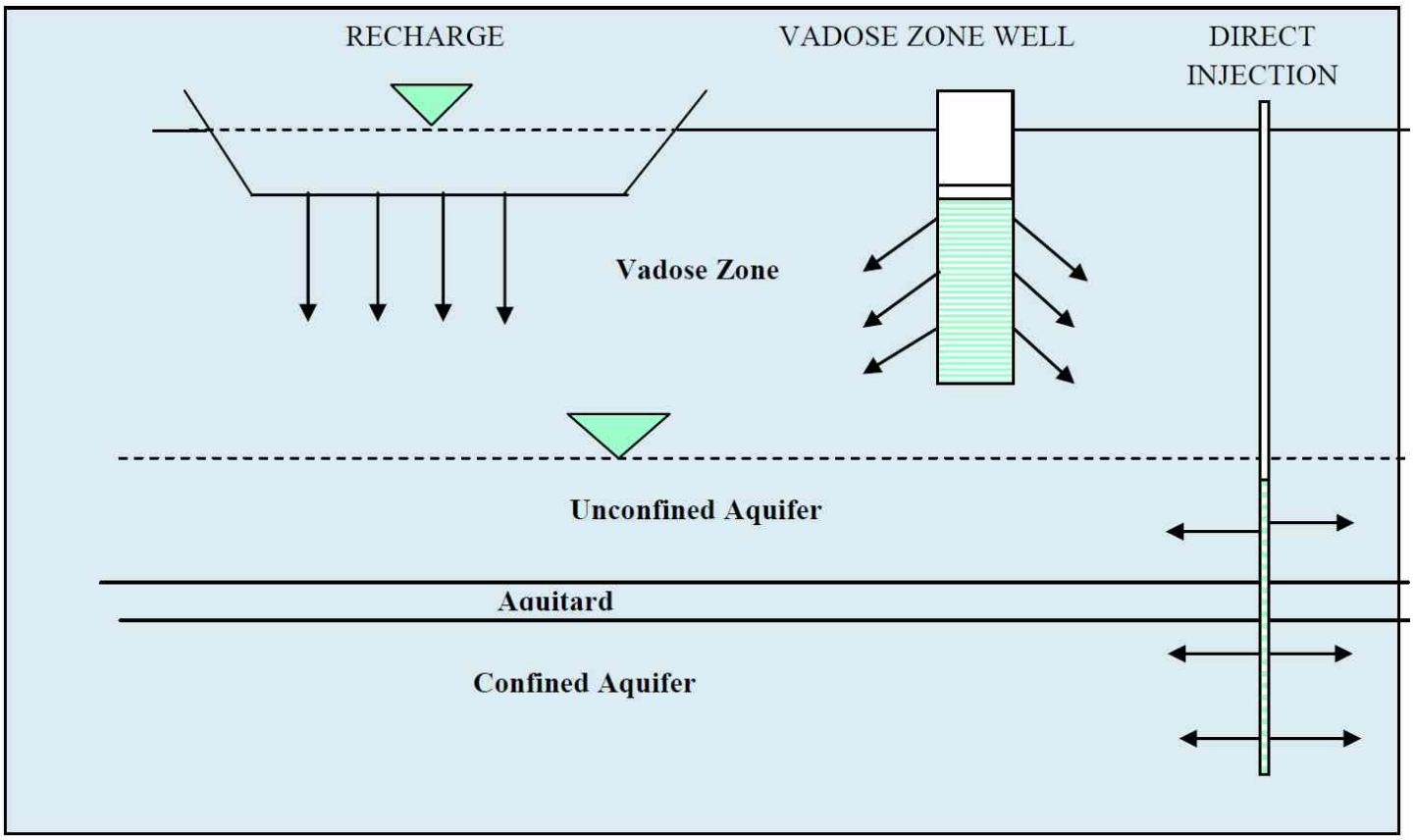
ARTIFICIAL RECHARGE

Artificial Recharge (AR)
Recharge at a greater rate than natural recharge, resulting from deliberate actions of man.

Description
A process by which water is induced into the subsurface by means of injection boreholes or increased infiltration e.g. from flood spreading, streams, lakes or basins.

Why is artificial recharge important?
It is a form of water conservation and is useful in arid areas where surface storage would incur unacceptable evaporation losses. Artificial recharge is also important to remedy effects of pollution and enhance water yielding capacity of an aquifer.

Figure: Method of Aquifer Recharge



Further Readings:
1. https://www.indiawaterportal.org/sites/indiawaterportal.org/files/S.K.Sharma_GWE.pdf

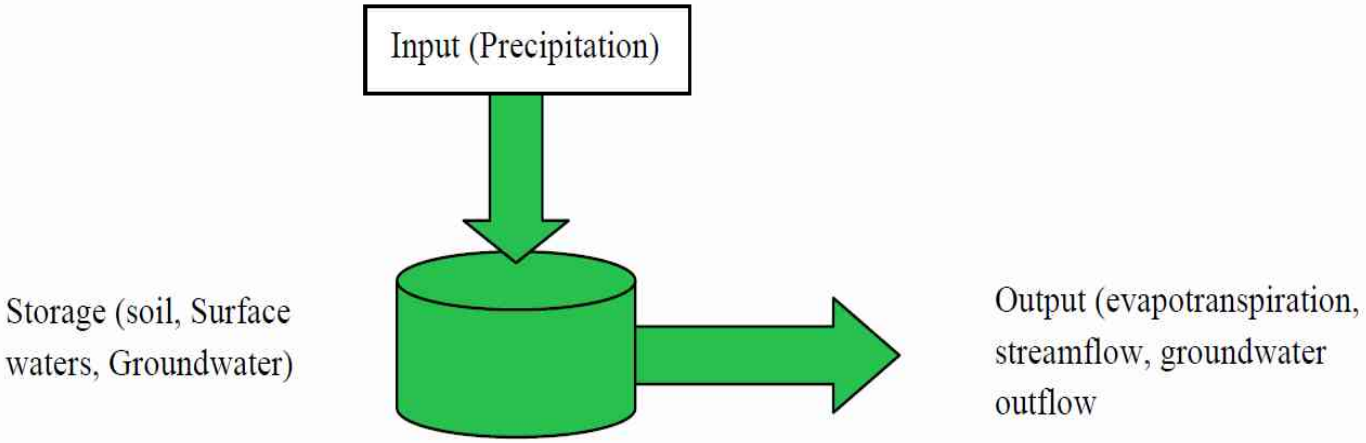
2. The Groundwater Recharge Movement in India

WATER BUDGET

Water budgeting (also known as, water accounting, water balancing, stocks and flows) is founded on the principle of conservation of water mass, or, if we assume the density of water to be constant, the conservation of water volume.

Mass balance: Input- Output= Change in Storage

Mass balance: Input- Output= Change in Storage



Total rainfall input = Surface water flows + Groundwater recharge + Evapotranspiration

Water Balance Equation= P-Q-E-ΔS= 0

In Earth's water budget, precipitation is the income. Evapotranspiration and runoff are the expenses. The water budget of Earth as a whole is balanced because the amount of precipitation is equal to the amount of evapotranspiration and runoff. However, the water budget of a particular area, called the local water budget, is usually not
balanced.

Factors That Affect the Water Budget

1. Include temperature, vegetation, wind, and the amount and duration of rainfall.
2. The factors that affect the local water budget vary geographically.
3. The local water budget also changes with the seasons in most areas of Earth.

Further Reading:

1. **http://waterbudget.sustainablesources.com/**
2. **http://schoolwires.henry.k12.ga.us/cms/lib08/GA01000549/Centricity/Domain/3377/Chapter%2015.1%20Notes%20-%20Earth%20Systems.docx**

INDOOR WATER BUDGET

Indoor and outdoor water budgets are the calculated amount of water a household will require based on the size of the family, number and types of fixtures, and landscape needs. The landscape needs are based on turf water requirements only. Some items in the indoor budget could be added to the home after the homeowners move in. Use average water amounts for fixtures that are not in place. This helps the homeowner decide whether to add a fixture or appliance that is more conserving than the average because they can see how it can affect the total.

INDOOR WATER BUDGET EXAMPLE

Fixtures and appliances in this home have the Following flow rates:

Toilets	1.6 gallons per flush
Showers	2.5 gallons per minute
Washing Machine	The family will buy a model using 35 gal. per load
Dishwasher	8.5 gal. per load
Faucets	This amount is fixed at 8.5 gallons
Baths	Average use

Family size: 3
CALCULATION :
Multiply the second column times the third column then times the
Fourth column (this is the number of persons in the household).
The subtotal for each item is entered in the fifth column.
The figures in the fifth column are added up to show the amount of
water used each day. This total can be multiplied by 365 (days) to
give the amount of water that would be consumed in one year.

ITEM	USE RATE	FLOW RATE	No of PERSONS	TOTAL
Toilet	4.0 flushes per person per day	1.6	3	19.2
Shower	4.8 minutes per person per day	2.5	3	36
Washing Machine	0.30 loads per person per day	40 gal per load (avg.)	3	36
Dishwasher	0.17 loads per person per day	8.5	3	4.34
Faucets			N/A	8.5 estimated
Baths	0.14 baths per person per day	50 gal. per bath (avg.)	3	21
TOTAL				125.04

Daily total (125.04) times 365 days equals 45,639.6 gallons per year

Further Readings:

1. https://www.indiawaterportal.org/sites/indiawaterportal.org/files/S.K.Sharma_GWE.pdf

2. The Groundwater Recharge Movement in India

USES OF WATER BUDGET

In addition to protecting sources of drinking water, water budgets can be used for a number of land use and water use developments including: Permit to Take Water applications; landfill site approvals; residential or industrial development; municipal water supplies; aggregate extraction; dam construction; storm water management; and irrigation.

- To set water allocation targets and recharges rates within local watersheds
- As a decision-making tool to evaluate land and water uses such as restoration and rehabilitation projects
- Evaluate the cumulative effects of land and water uses within watersheds
- To provide a watershed scale framework for site scale studies (e.g. evaluation of a sewage & water system plan)
- To help make informed decisions about the design of environmental monitoring programs
- To assist in setting targets for water conservation.

Further Reading:

1 . https://conservationontario.ca/fileadmin/pdf/policypriorities_section/IWM_WaterBudgetOverview_PP.pdf

2. Water Budgeting, NABARD

WATER RECYCLING

- agriculture
- landscape
- public parks
- golf course irrigation
- cooling water for power plants and oil refineries
- processing water for mills, plant0073
- toilet flushing
- dust control,
- construction activities
- concrete mixing
- artificial lakes

Suggested Water Recycling Treatment and Uses

Primary Treatment: Sedimentation	**Secondary Treatment:** Biological Oxidation, Disinfection	**Tertiary / Advanced Treatment:** Chemical Coagulation, Filtration, Disinfection	
No uses Recommended at this level	Surface irrigation of orchards and vineyards Non-food crop irrigation Restricted landscape impoundments Groundwater recharge of non potable aquifer Wetlands, wildlife habitat, stream augmentation Industrial cooling processes.	Landscape and golf course irrigation Toilet flushing Vehicle washing Food crop irrigation Unrestricted recreational impoundment.	Indirect potable reuse: Groundwater recharge of potable aquifer and surface water reservoir augmentation.

Further Reading:

1. **Water Reuse and Recycling: Community and Environmental Benefits Water Reuse and Recycling: Community and Environmental Benefits, https://www3.epa.gov/region9/water/recycling/**

2. **Water Recycle and Reuse - A Case Study of NMIMS University Campus, Ishwar P. Patil , Prof. Hemant D.Wagh and Prof.(Dr.) Arun Kumar Dwivedi, September 2013. IJESI.**

BENEFITS OF WATER RECYCLE & RESUSE

The use of gray water at decentralized sites (see definition) for landscape irrigation and toilet flushing reduces the amount of potable water distributed to these sites, the amount of fertilizer needed, and the amount of wastewater generated, transported, and treated at wastewater treatment facilities.

Environmental Benefits
By providing an additional source of water, water recycling can help us find ways to decrease the diversion of water from sensitive ecosystems. Recycled water can also be used to create or enhance wetlands and riparian habitats.

Water Recycling Can Decrease Diversion of Freshwater from Sensitive Ecosystems
The lack of adequate flow, as a result of diversion for agricultural, urban, and industrial purposes, can cause deterioration of water quality and ecosystem health. People who reuse water can supplement their demands by using a reliable source of recycled water, which can free considerable amounts of water for the environment and increase flows to vital ecosystems.

Water Recycling Decreases Discharge to Sensitive Water Bodies
In some cases, the impetus for water recycling comes not from a water supply need, but from a need to eliminate or decrease wastewater discharge to the ocean, an estuary, or a stream.

Water Recycling Can Reduce and Prevent Pollution
Recycled water may contain higher levels of nutrients, such as nitrogen, than potable water. Application of recycled water for agricultural and landscape irrigation can provide an additional source of nutrients and lessen the need to apply synthetic fertilizers.

Recycling Water Can Save Energy
Recycling water on site or nearby reduces the energy needed to move water longer distances or pump water from deep within an aquifer. Tailoring water quality to a specific water use also reduces the energy needed to treat water. The water quality required to flush a toilet is less stringent than the water quality needed for drinking water and requires less energy to achieve. Using recycled water that is of lower quality for uses that don't require high quality water saves energy and money by reducing treatment requirements.

Further Readings:

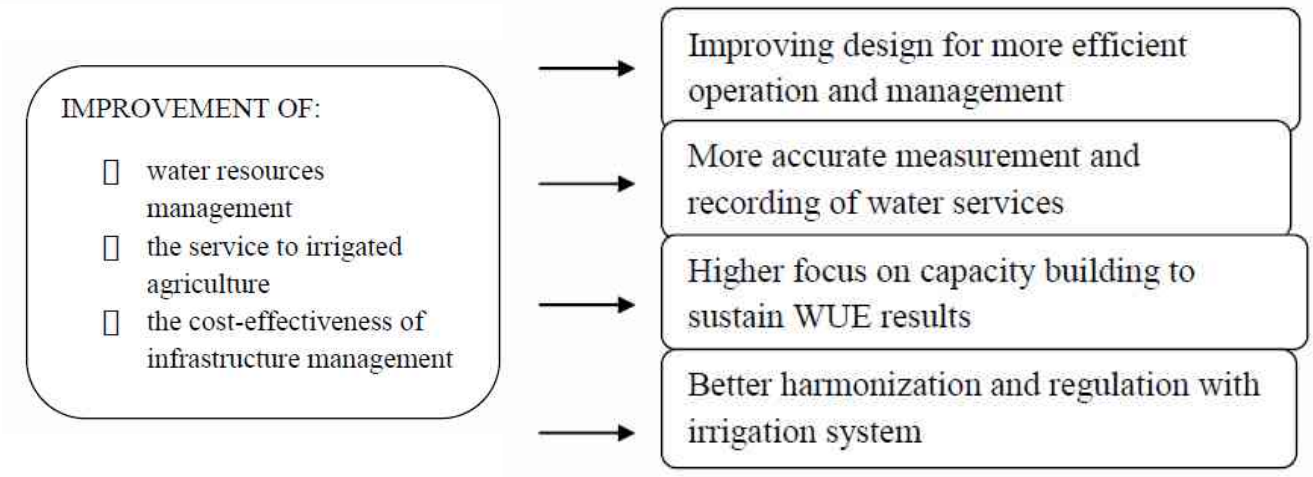
1. **https://www3.epa.gov/region9/water/recycling/**

2. **https://www.lacsd.org/waterreuse/benefits.asp**

WATER USE EFFICIENCY

Water Use Efficiency (WUE) is the ratio between effective water use and actual water withdrawal. It characterizes, in a specific process, how effective is the use of water.

Water uses	Quantity*	Present level of efficiency (%)^	Full achievable efficiency (%)@	Scope for increase	Quantum of water likely to be saved for full efficiency	Quantum of water likely to be saved by 20%increase or full efficiency	Relative weight for 20% increase
Irrigation							
Surface water	339	30	60	30	102	68	0.53
Ground water	218	55	75	20	44	44	0.34
Drinking water							
Urban water	33	60	90	30	10	7	0.05
Rural water	10	70	90	20	2	2	0.02
Industries including for power	56	80	95	15	8	8	0.06
Others	54	-	-	-	-	-	-
Total	710				166	129	



Further Reading:

1. **Guidelines for improving water use efficiency in Irrigation, Domestic & Industrial sector. Central Water Commission, Ministry of Water Resources, Gov. of India**
2. **https://www.livemint.com/Opinion/Cbw6kcycrx0QtCPLKneAHP/India-needs-to-focus-on-water-efficiency.html**

WATER FOOTPRINT

The water footprint concept is an indicator of water use in relation to consumer goods. The concept is an analogue to the ecological and the carbon footprint, but indicates water use instead of land or fossil energy use. **The water footprint of a product is the volume of freshwater used to produce the product, measured over the various steps of the production chain.**

The three water footprints:

Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products.

Blue water footprint is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.

Grey water footprint is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources.

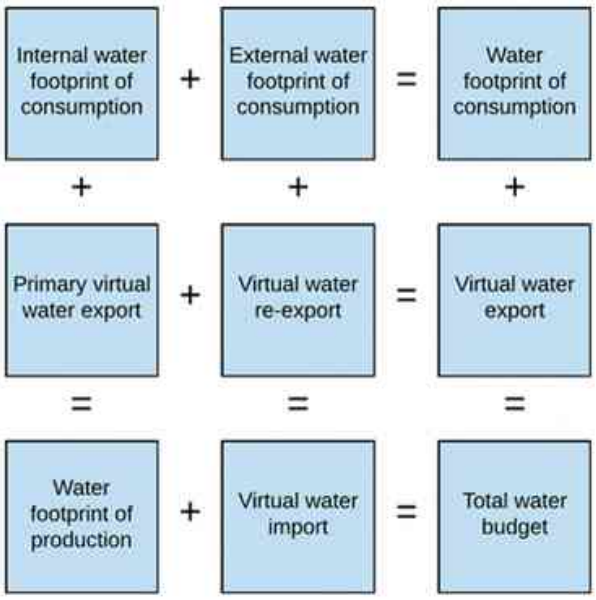


Fig: The water footprint accounting scheme for a spatial unit like a municipality, province, state, nation or river basin, showing the relation between the water footprints of production and consumption and virtual water trade (from Hoekstra et al. 2011)

Virtual Water

Virtual water is the amount of water that is embedded in food or other products needed for its production. Trade in virtual water allows water scarce countries to import high water consuming products while exporting low water consuming products and in this way making water available for other purposes [World Water Council].

Showing people the 'virtual water' content of various consumption goods will increase the water awareness of people.

Further Reading:

1. **The Water Footprint: The Relation Between Human Consumption and Water Use, Arjen Y. Hoekstra**

2. **Water Footprint of India and its Implications for International Trade in Food Products, Kriti Bardhan Gupta, South Asia Economic Journal, 9:2 (2008): 419-433**

WATER & CIVILIZATION

The Indus Valley Civilization was an ancient civilization located in what is Pakistan and northwest India today, on the fertile flood plain of the Indus River and its vicinity. Evidence of religious practices in this area date back approximately to 5500 BCE. Farming settlements began around 4000 BCE and around 3000 BCE there appeared the first signs of urbanization. By 2600 BCE, dozens of towns and cities had been established, and between 2500 and 2000 BCE the Indus Valley Civilization was at its peak

Indian Geography - Himalayas - Indus River o 1st civilization = Harappans (2300 - 1700 BC) o 2nd civilization = Aryans (2000s BC)

The Indus Valley Civilization flourished around 2500 BCE. Water was vital for the civilization and was used primarily for human personal use and irrigation. The most important structure in the city of Mohenjodaro was the Great Bath, which had water channels leading to and from it (Majumdar et al. 1978). Its remains can still be seen today. The Indus Valley civilization gave way to Indo-European invaders who were initially less settled in their lifestyles.

It is true that almost all the civilizations appeared on the banks of the big rivers. It shows how vital water is for our survival. But for the Hindus, water is more important. Their entire life is based on water, from birth to death, and all the ceremonies use water. Hindu or Indian civilization grew slowly on the soil of holy Ganga and expanded to holy Sindhu and Sarasvati regions. The order of rivers in the Nadhi Sukta (RV 10-75) clearly shows this east ward march of Indian civilization.

At its peak, the Indus Valley Civilization may have had a population of over five million people. The Indus cities are noted for their urban planning, a technical and political process concerned with the use of land and design of the urban environment.

They are also noted for their baked brick houses, elaborate drainage systems, water supply systems, and clusters of large, non-residential buildings.

Further Reading:

1. **https://www.ancient.eu/Indus_Valley_Civilization/**

2. **https://www.khanacademy.org/humanities/world-history/world-history-beginnings/ancient-india/a/the-indus-river-valley-civilizations**

CULTURE, RELIGION & WATER IN INDIA

In Indian culture water is linked to every social aspect of life. Divine water is consumed in the temple after puja worship rituals; idols of worship are sprinkled with water (abhishekam); and a plantain leaf kept for a meal is cleaned with water and a prayer.

The Holy River Ganges is mythologically linked to Lord Shiva as the fountain that flows through the Himalayan terrain, reaching first Haridwar and then Benares. All over India people throng for a dip in the holy river to wash away their sins, for the Holy River Ganges is the Hindu symbol for purification of the soul and rejuvenation of the mind.

The river Cauvery is linked closely to the culture, tradition, and history of the state of Tamilnadu. The Aadi Perukku festival (Adi means a Tamil month, Perukku means swelling) is celebrated in mid-July when the river is in full flow; and the Mettur Dam is built across it, storing water to release for the cultivation of wet lands.

The river Cauvery and all rivers are worshipped as mother, for the river water sustains life for agriculture, the main source of revenue for farmers and the government.

River Ganges- pilgrims taking a holy dip in the river

Gange cha Yamune chaiva Godavari
Sarasvati Narmadhe Sindho Kaveri
Jalesmin Sannidhim Kuru
Ahnika Sutravai, Verse 106

"In this water, I invoke the presence of divine waters from the rivers Ganga, Yamuna, Godavari, Saraswati, Narmada, Sindhu and kaveri. These rivers are considered as goddesses and I pray to them for considering me for their blessings.

The beauty in the above hymn is that the Hindus considered the whole country from north to the south, from east to west as one country. It shows how integrated the country was before foreigners invaded in wave after waves.

Further Reading:

1. **The role of water in Indian Culture, 2018. Hektoen International**

2. **https://en.wikipedia.org/wiki/Water_and_religion.**

WATER LAWS

Constitution generally follows the scheme introduced in the Government of India Act (1935), where water is a state subject. States have the exclusive power to regulate water supplies, irrigation and canals, drainage and embankments, water storage, water power and fisheries

While the Constitution does not recognize a fundamental right to water, court decisions deem such a right to be implied in Article 21 (right to life) (Muralidhar 2006). The right to water is arguably implied in the recognition of the right to a clean environment. In Subhash Kumar v. State of Bihar (1991), the Supreme Court recognized that the right to life 'includes the right of enjoyment of pollution free water and air for full enjoyment of life'.
In the Sardar Sarovar case, the Supreme Court directly derived the right to water from Article 21, stating that water is the basic need for the survival of the human beings and is part of right of life and human rights as enshrined in Article 21 of the Constitution of India (Narmada Bachao Andolan v. Union of India 2000, 274).

The National Green Tribunal Act, 2010 that came into being as a law in June 2010 for the first time vests the power in a Tribunal to provide for 'relief and compensation to the victims of pollution and other environmental damage', 'for restitution of property damaged' and 'restitution of environment' (Section 15).

The Schedule appended to the Act makes it clear that the National Green Tribunal shall have jurisdiction over cases and violations under the Water (Prevention and Control of Pollution) Act, 1974. Thus the Act creates an enforceable right to claim damages and compensation for all victims of water pollution. This is a sharp departure from the provisions under the existing Water (Prevention and Control of Pollution) Act, 1974 where apart from closing down a polluting industry, cutting its water and power supply, and criminal punishment for those responsible for running it there was simply no right available to the victims of water pollution.

The National Green Tribunal Act, 2010 introduces such an enforceable right. The Tribunal is likely to become functional later this year and the way it shapes law and jurisprudence in this area remains to be seen.

Further Reading:

1. **S. Muralidhar, "The Right to Water: An Overview of the Indian Legal Regime" in Eibe Reidel & Peter Rothen eds., The Human Right to Water (Berlin: Berliner Wissenschafts-Verlag, 2006), p. 65-81.**

2. **http://www.ielrc.org/activities/workshop_0612/content/d0607.pdf**

WATER POLICY OF INDIA

The 'National Water Policy (2012) adopted by the Government of India regards water as a scarce natural resource, fundamental to life, livelihood, food security and sustainable development.

The main emphasis of National Water Policy 2012 is to treat water as economic good which the ministry claims to promote its conservation and efficient use. This provision intended for the privatization of water-delivery services is being criticized from various quarters

The policy also does away with the priorities for water allocation mentioned in 1987 and 2002 versions of the policy. The policy was adopted with a disapproval from many states.
National Water Policy is formulated by the Ministry of Water Resources of the Government of India to govern the planning and development of water resources and their optimum utilization. The first National Water Policy was adopted in September, 1987. It was reviewed and updated in 2002 and later in 2012.

The major provisions under the policy are:
Envisages to establish a standardized national information system with a network of data banks and data bases .

1. Resource planning and recycling for providing maximum availability.
2. To give importance to the impact of projects on human settlements and environment.
3. Guidelines for the safety of storage dams and other water-related structures.
4. Regulate exploitation of groundwater .
5. Setting water allocation priorities in the following order: Drinking water, Irrigation, Hydropower, Navigation, Industrial and other uses
6. The water rates for surface water and ground water should be rationalized with due regard to the interests of small and marginal farmers.
7. The policy also deals with participation of farmers and voluntary agencies, water quality, water zoning, conservation of water, flood and drought management, erosion etc.

Further Reading:

1. Ministry of Water Resources (2012). National Water Policy. New Delhi: Government of India.
2. Report Of The Ground Water Resource Estimation Committee (GEC-2015), Ministry of Water Resources, River Development & Ganga Rejuvenation Government of India NEW DELHI October, 2017
3. https://en.wikipedia.org/wiki/National_Water_Policy

WHAT MORE YOU CAN DO TO PROTECT SOURCES OF WATER

- Minimize the waste you produce - reduce, reuse, recycle and compost.

- Do not use the toilet as a wastebasket.

- Properly dispose of products, such as cleaners that contain toxic chemicals, pesticides, paints, solvents, gasoline, and flammable liquids.

- Read the labels to learn how to use and dispose of the products safely. Do not dump these products into sewers, on the ground, in the toilet, or in the garbage can. Take these products to your local household hazardous waste depot.

- Use non-toxic cleaning products. Purchase products from businesses that produce environmentally safe products. Check company websites to learn about their environmental practices and products. Remember, white vinegar is a great 'all-in-one cleaner' and it is a natural organic bi-product of fruits, vegetables and grains. It is, therefore, edible and biodegradable.

- To reduce air pollution emissions, use public transit, carpool, cycle or walk.

- Become energy efficient, and practice energy conservation.

- Minimize the waste you produce - reduce, reuse, recycle and compost.

Further Reading:

1. **Modern India Can Learn a Lot from These 20 Traditional Water Conservation Systems by Sanchari Pal, July 15, 2016**

2. **Easy Things You Can Do To Protect Drinking Water Sources, EPA**

ECOSYSTEM " ENGINEERS": FOUNDATION SPECIES

- Foundation species play a major role in creating or maintaining a habitat.
- They cause physical changes in the environment that affects community structure.
- Beaver Dams can transform landscapes on a very large scale.
- Corals are a key example of a foundation species across many islands in the South Pacific Ocean.

Foundation species create or enhance their habitats which benefit others. Foundation alters habitat.

Species as Ecosystem Engineers
The Beaver

- Behaviors of such species may influence succession and increase species richness
- Sometimes identical to the keystone species, while other times serves as a counterbalance
- Examples: elephants, kelp, eastern hemlock, mussels

Further Reading:

1 . https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Foundation_species.html

KEYSTONE SPECIESKEYSTONE SPECIES

Keystone species play critical roles in their Ecosystem:

→ Keystone Species

- Have a large effect on the types and abundances of other species
- Can play critical roles in helping sustain ecosystems
- Pollination
- Top predators

Benefits of Keystone species

Keystone species have a large effect on types and the abundance of other species

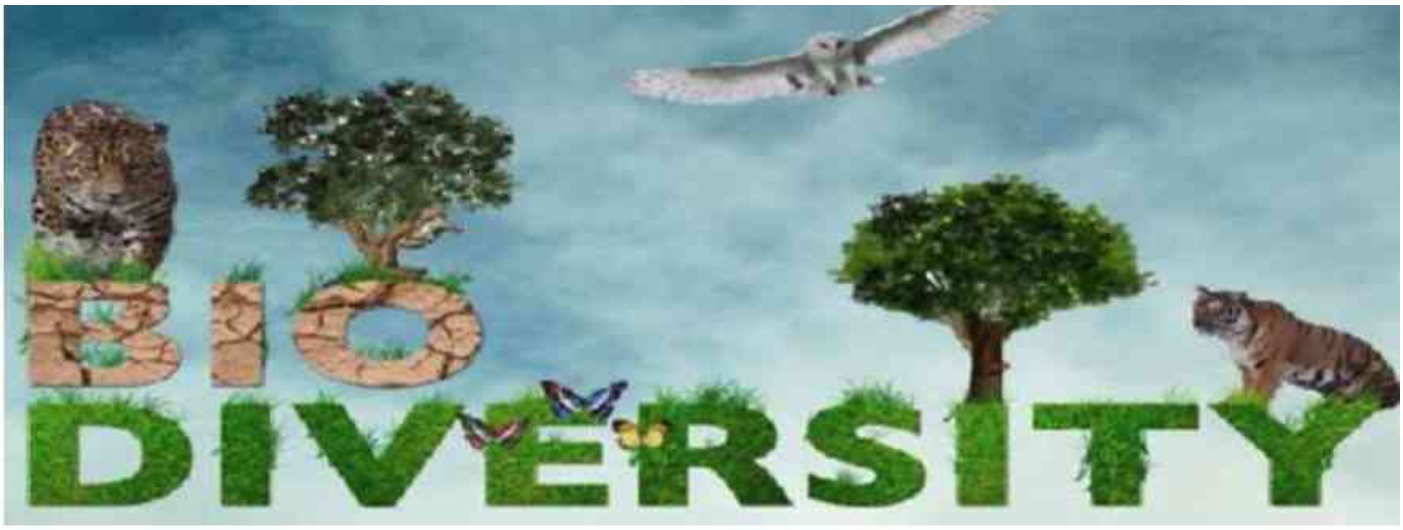
Keystone influences function

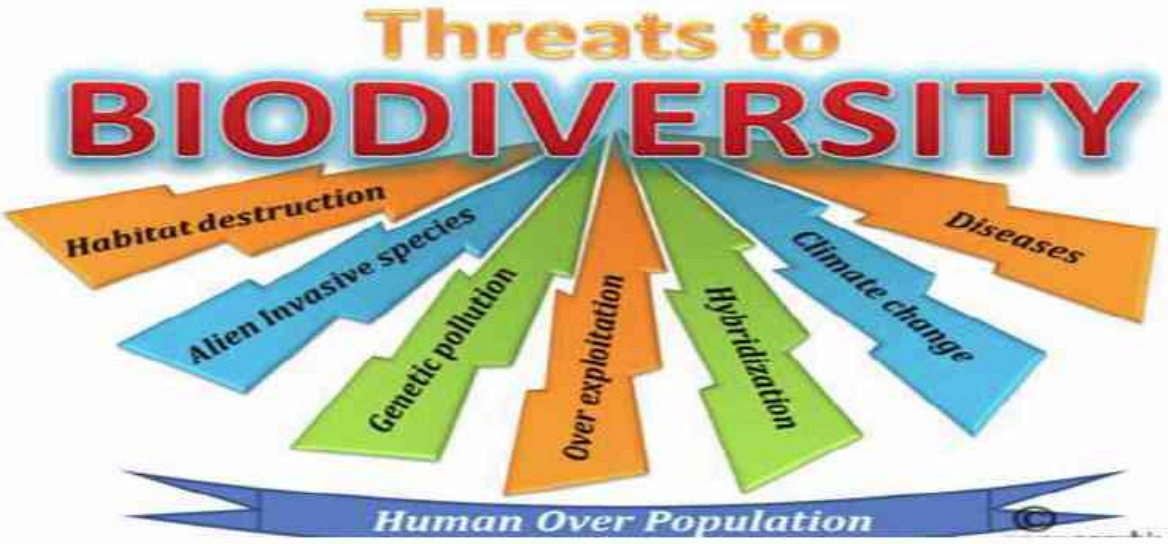
A loss of this species may cause ripple effect felt across the entire ecosystem

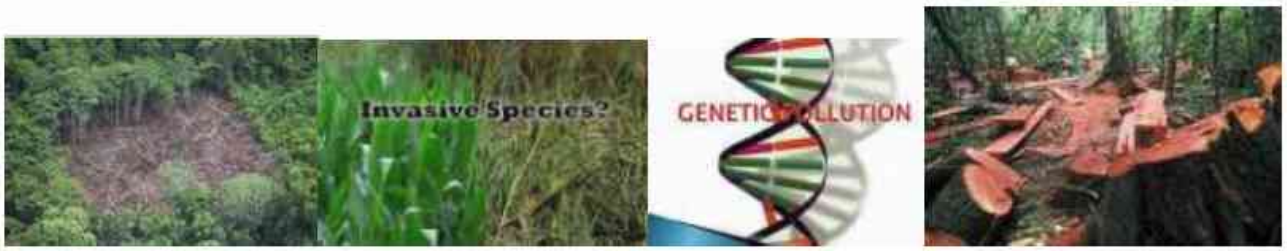
Further Reading:

1. **https://www.nationalgeographic.org/encyclopedia/keystone-species/**

THREATS TO BIODIVERSITY







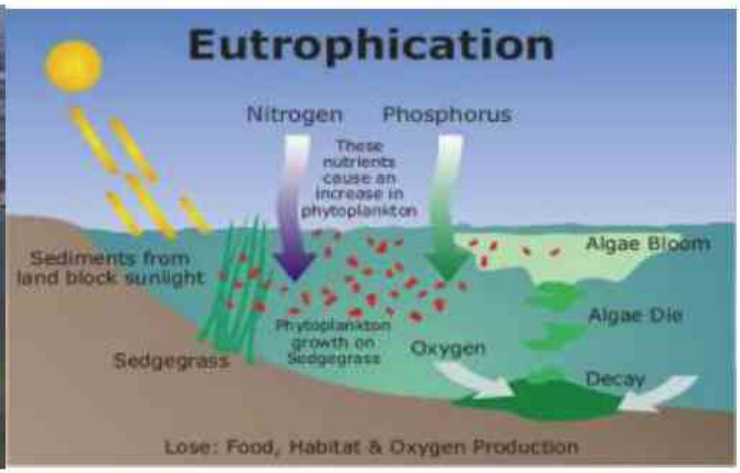
Scientist believes that all species that have ever lived are 99 percent extinct.

Further Reading:

1 . http://www2.ca.uky.edu/Forestry/FOR230/LEC%208%20Biodiversity%20Threats%20FOR%20230%20FA%2015.pdf

EUTROPHICATION ALGAL BLOOMS

- An algal bloom or marine bloom or water bloom is a rapid increase in the population of algae in an aquatic system.
- Algal blooms m ay occurs in freshwater as well as marine environments.
- Tiny Organisms with a Toxic Punch



What are the dangers?

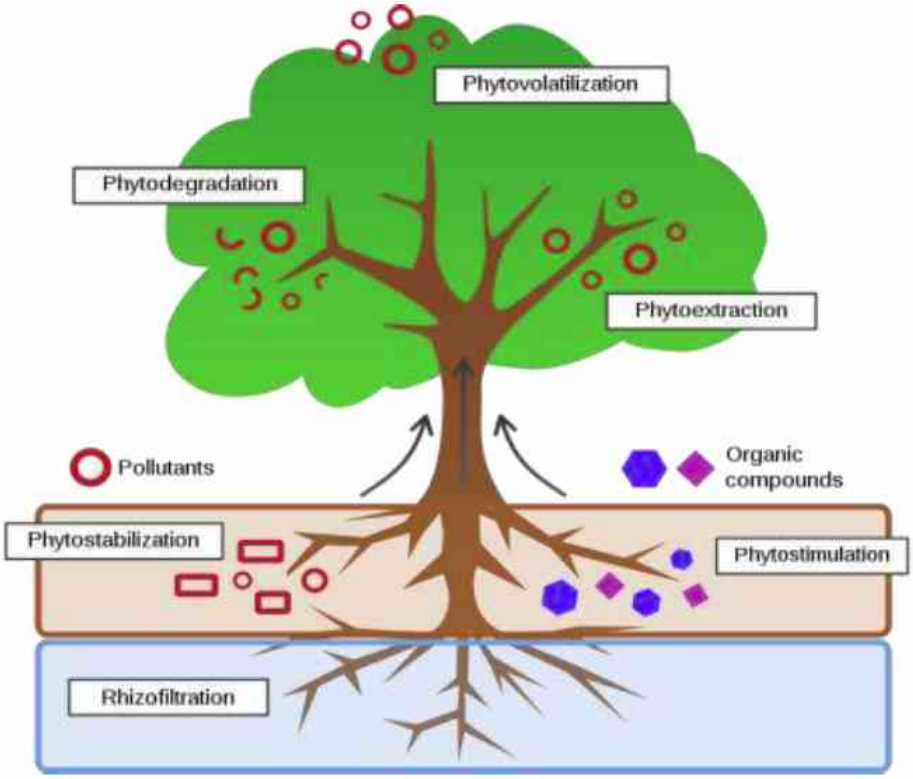
HABs can…

- Cause drinking water to taste and smell bad
- Kill fish by decreasing oxygen levels
- Can contain cyanobacteria, which are poisonous to humans and deadly to livestock and pets

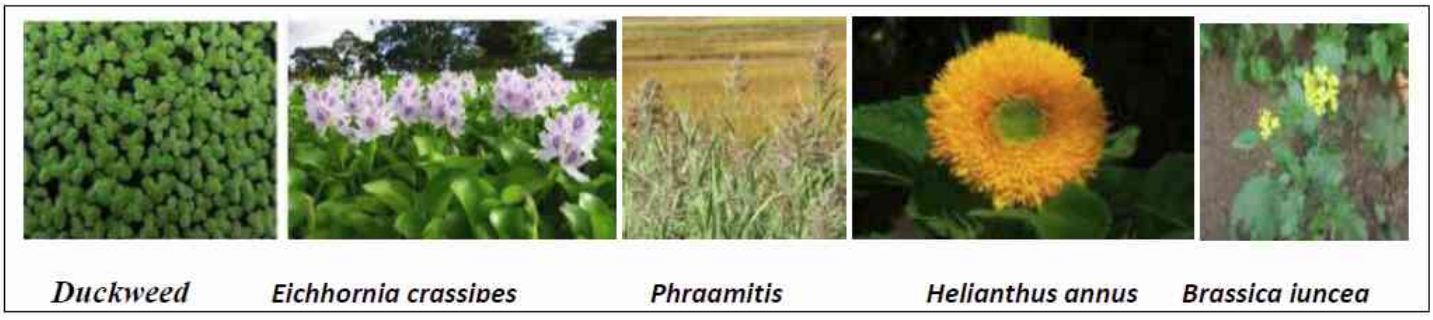
Further Reading:

1. **https://oceanservice.noaa.gov/hazards/hab/**
2. **https://www.regions.noaa.gov/great-lakes/index.php/project/harmful-algal-blooms/**

PHYTOREMEDIATION - AN ECO-FRIENDLY AND SUSTAINABLE METHOD



Phytoremediation term is derived from two generic terms including 'phyto' means plant and 'remediation' means impeding environmental damage. Phytoremediation is an assembly of technologies, using a group of plants for remediation of soils, water, sludge which get sediment with different types inorganic and organic contaminants.

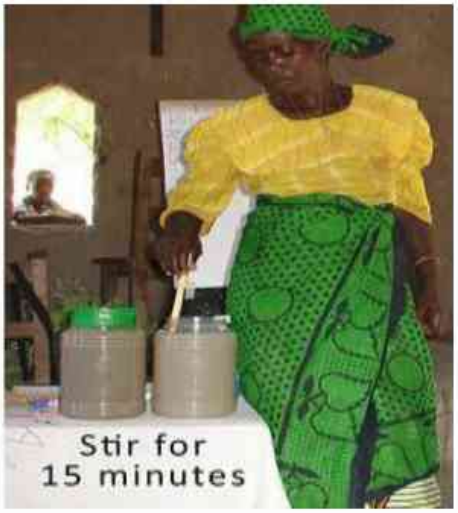


Further Reading:

1. **http://www.unep.or.jp/ietc/publications/freshwater/fms2/1.asp**

MORINGA OLEIFERA: SEEDS AS WATER PURIFIER

Moringa oleifera seeds treat water on two levels, acting both as a coagulant and an antimicrobial agent. It acts as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, bacteria, toxins etc.). This can be a more efficient water purification process than conventional synthetic materials in use today.



Further Reading:

1. **Francis Kweku Amagloh and Amos Benang (2009). Effectiveness of Moringa oleifera seed as coagulant for water purification. African Journal of Agricultural Research Vol. 4 (1), pp. 119-123**

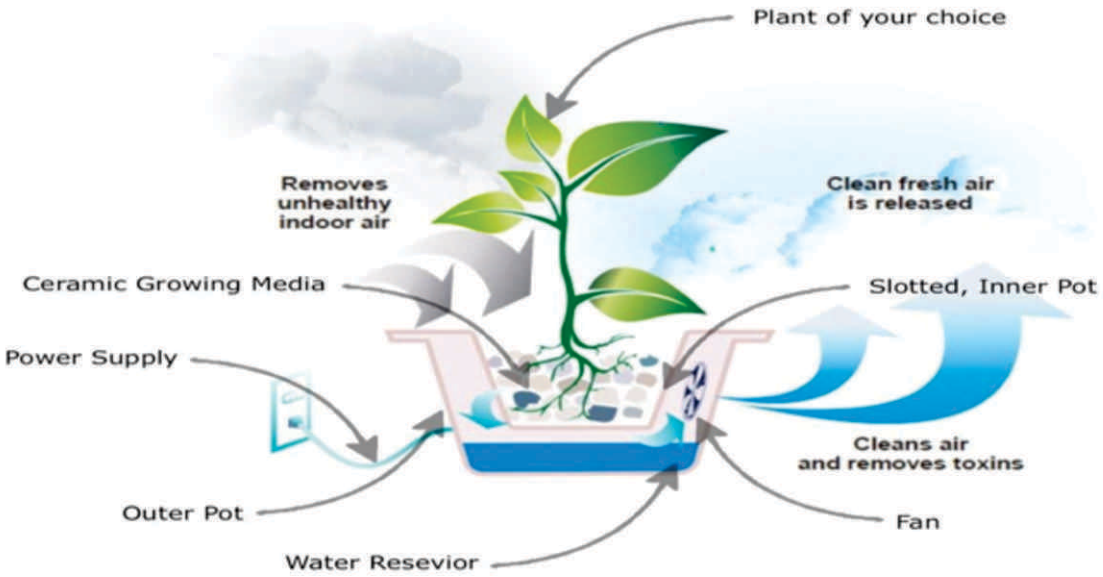
PLANTS TO THE RESCUE: INDOOR PLANTS AS AIR PURIFIER

Plants are the earth's natural solution for cleaning and repairing the air by removing harmful airborne pollutants. According to Clean Air Study by NASA researchers some indoor plants are effective at removing benzene, formaldehyde, and trichloroethylene, xylene, and ammonia from the air—chemicals that have been linked to health effects like headaches and eye irritation.

Golden Pothos

Peace Lily

Spider Plant



IT'S NOT MAGIC. IT'S SCIENCE

Reference

1. **Plant Air Purifier (cleanest and greenest solution for air repair, category winner 2013)**

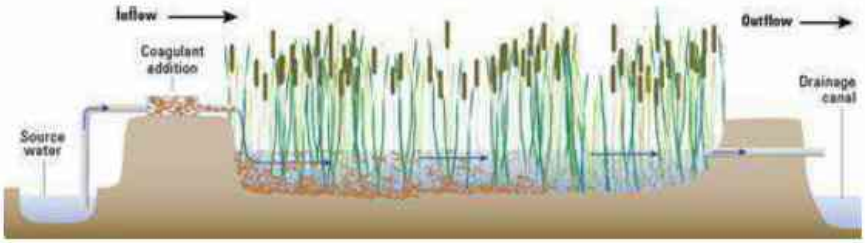
WETLANDS: KIDNEY'S OF NATURE

- Natural wetlands have been used to treat waste for hundreds of years
- Wetlands are areas where water covers soil all or part of the time. These are ttransitional areas between land and water.
- Typically occur in low lying areas that are inundated by surface and groundwater.
- Wetlands are important because they protect and improve water quality, provide fish and wildlife habitats, store floodwaters and maintain surface water flow during dry periods.
- World Wetlands Day occurs on February 2.
- Convention on Wetlands is called the Ramsar Convention
- Retaining additional nutrients and treating non-point source pollutants help give natural wetlands the affectionate nickname of "Earth's Kidneys."

Further Reading:

1. **https://www.ramsar.org/**

WETLANDS: KIDNEY'S OF NATURE



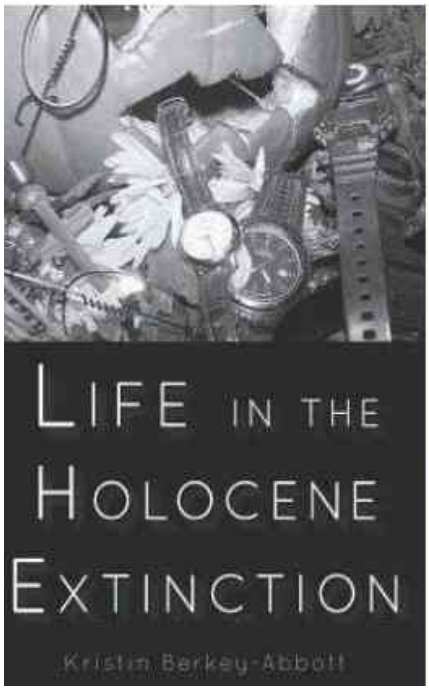
- Constructed wetlands (CWs) are man-made, artificial or treatment wetlands or ''engineered systems, designed and constructed to utilize the natural functions of wetland vegetation, soils and their microbial populations to treat contaminants in surface water, groundwater or waste streams" (ITRC, 2003).

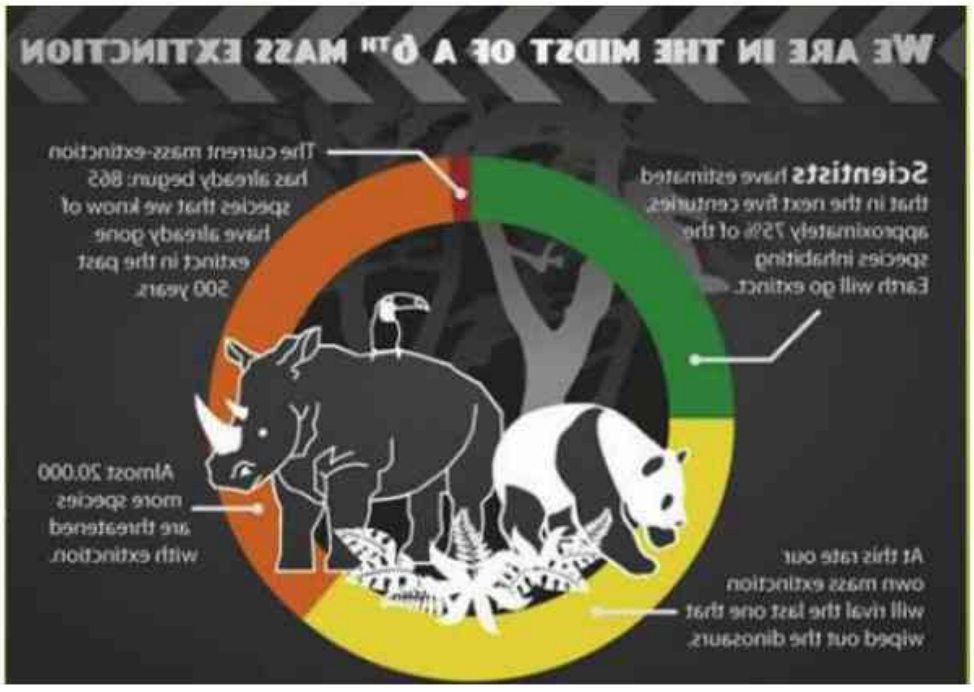
Further Reading:

1. **Guiding Principles for Constructed Treatment Wetlands: Providing Water Quality and Wildlife Habitat (2000)**

THE SIXTH EXTINCTION

- We are in a biodiversity crisis — the fastest mass extinction in Earth's history, largely due to: human destruction of ecosystems overexploitation of species and natural resources human overpopulation the spread of agriculture pollution.
- Also known as Holocene Extinction.
- The Sixth Extinction would seem to be the first recorded global extinction event that has a biotic, rather than a physical, cause.





Further Reading:

1. **The Sixth Extinction: Patterns of of Life and the Future of Humankindby Richard Leakey and Roger Lewin (Doubleday and Company, 1996)**

India's Drinking Water Trail

Dr Arunangshu Mukherjee

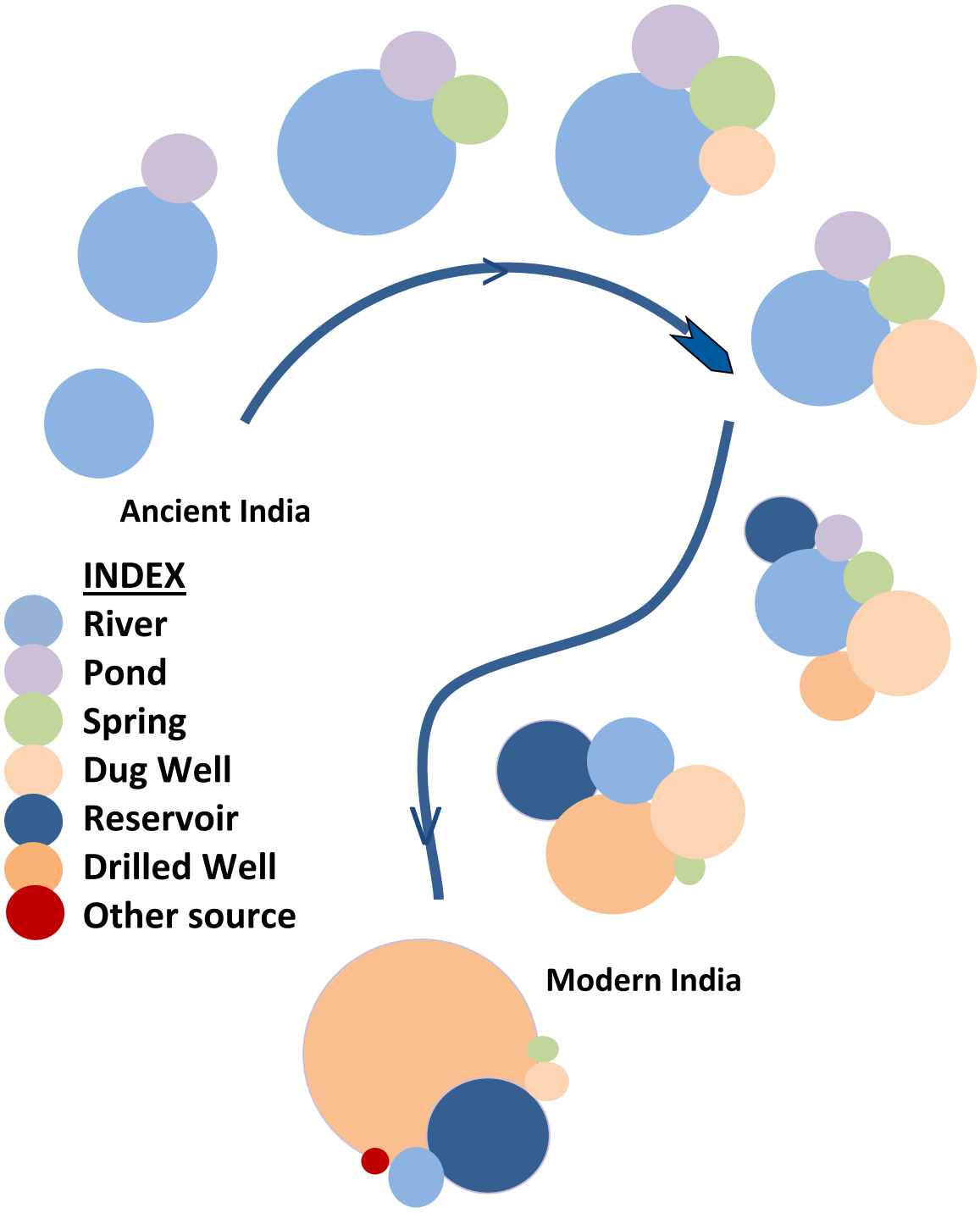
Indian traditionally started drinking water from open source like rivers, streams and gullies. The earliest civilization, therefore flourish in the bank of rivers. Gradually the population migrated towards the higher land away from river banks and then felt the need of alternative source of drinking water. Natural depressions act as ponds and became the source of drinking water away from the river banks. In want of livelihood habitations grew even in the hilly areas. The population living in the hills started using spring water as drinking water. Slowly people understood the existence of groundwater and started using sanitary dug wells. These dug wells could be constructed easily at various locations thus became a popular source of drinking water.

For a long period thus the river and dug wells remained the main source of drinking water. Due to increasing population density constructed drain were made to discharge the used water away from the houses. Due to unscientific discharge of drain water the sources of surface water started getting polluted. Due to pollution of surface water dependency on groundwater increased. Sanitary system introduced septic tanks. Faulty construction of sanitary system started polluting the dug well zone. The pollution of dug well zone and surface water became the source of waterborne diseases. These water borne diseases are largely seasonal and spared rapidly to become epidemic. It introduced the drilled well concept. The drilled wells are largely drilled beyond the penetration of surface percolation of contaminated water therefore considered as safe source of drinking water. However it was later recognized that deeper water drawn from drilled wells, many a times naturally contained toxic element which are responsible for chronic diseases. The dug wells water on the other hand if not contaminated with biological pollution is better option for getting long term safe drinking water. The dug wells largely free from geogenic contamination like toxic elements. The toxic elements that are present in the groundwater in the shallow zone get precipitated due to oxidation and make the water free from toxic element. Therefore the common pollutants like high iron, higher fluoride and arsenic etc are not commonly found in the dug well water. Dug well zone being phreatic zone gets recharge with every monsoon and are more sustainable then the deeper drilled well zone. It is therefore, more environmental friendly zone. Getting water from this zone consumes no or less electric energy thus is a green technology.

The dug wells are time tested source and sustained for a long period in Indian environment where national average rainfall is more than eleven hundred millimeters. It is the faulty sanitation system which spoiled the sustainable dug well system and introduced more risky and environmentally less sustainable drilled well culture. India dominantly being a hard rock area, secondary porosity is largely responsible for yield from hard rocks. The shallow secondary porosity are easily being recharged from monsoon rainfall, keep the zone environmentally sustainable.

With increasing toxic contamination and salinity in the groundwater obtained from the deeper zones water purifier like RO system has been introduced by the marketing people. Though RO technology is boon for many areas but is not required in large part of the country where no toxic elements present or salinity exists in the groundwater. RO system works with membrane technology having nano-pores and filters all the ions whose ionic size is larger than the nano pores. In this process it filters all the useful ions from the natural groundwater that a healthy human needs. Research shows prolong use of this "de-ionized" water can cause many chronic diseases. Magnesium is required for strong cardiovascular muscles. RO water with very low TDS is devoid of calcium and magnesium ions. Many RO manufacturers have introduced ion dosing to maintain the TDS of the drinking water. Removing the natural ion and dosing with chemicals is always a questionable proposition.

The RO culture works against the very concept of mineral water. Market forces have introduced the RO culture in India for their own profit and it has been propagated by the scientific community without knowing the grids behind. In India, water literacy is grossly poor. Even well educated people do not have adequate water literacy; it is therefore easy to propagate such ideas of vested interest in India. So RO has now bwcome a status symbol in Indian house hold. About 60% water is rejected during domestic RO process. This has introduced lager scale wastage while obtaining drinking water at domestic level.



Schematic representation of changing source of drinking water in India

"Communicating Science through Model Water & Eco Health Clinic for Quality of Life" Catalyzed and Supported by National Council for Science & Technology Communication, DST, New Delhi

Project in Brief

The project titled "Communicating Science through Model Water & Eco Health Clinic for Quality of Life" Catalyzed and Supported by National Council for Science & Technology Communication, DST, New Delhi was sanctioned to Centre for Advance Water Technology and Management, MRIIRS, Faridabad in March 2019. The project is formulated to achieve the target of mission Eco next taking water and water related health aspects. The project envisages instituting replicable Model Water & Eco Health Clinics so that science communication can be established with targeted groups of community i.e. students, for improving their overall quality of life by reducing the water related health risk through scientific interventions and IEC. The targeted group are largely school going children and associated persons as teachers and staff apart from small peri-urban/ rural population. The project wants to educate the students about the water literacy, water quality improvement, sanitation, hygiene conditions through intervention of technology the eco health improvement by demand side and supply side water management. The project also contemplates developing sustainable local leadership through talent hunt to take forward the science communication within the society. Various activities are to be taken up under the project like Establishing Model Water & Eco Health Clinics, conduction of Capacity and competence building and TOTs (Training of Trainers), Eco-Next Consult for sustainable water use etc. The activities proposed under the project will provide hands on training to about 2200 students and a better understanding of S&T for quality of life by reducing the water related health risk. A 5 day Eco Consult Meet on "Water Quality and Water Budgeting" was organized in May 2019 under the DST project. The participant group was though heterogeneous but over all constituted the part of society that has been identified important for spreading the message of communicating science for WATER & ECO HEALTH. It includes representatives of project partners, mentors, parents, academia, media, RWA, NGO and representatives from local, state and central government institutions & Panchayti raj institution. Selected participants would be the future representatives and trainees in the opted schools for educating the students.

The outcome indicator will be number of person (students and others) sensitized through actual working in the clinic. The reduction in health risk will be assessed due to IEC and operational involvement of target group, will be the second indicator.

CENTRE FOR ADVANCE WATER TECHNOLOGY & MANAGEMENT

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