Industrial Waste Water Treatment

Unit 5

Outline

- Water
- Water availability in the earth
- Distribution of available water in the earth
- Importance of industrial wastewater treatment
- Characteristics of waste water
- Constituents of concern in Industrial wastewater
- Various tests for wastewater
- Waste water treatment levels
- Advance waste water treatment methods

Water

- Water is a transparent and nearly colourless liquid
- Most essential constituent for living organisms in the earth
- The molecular formula for water is H_2O – One oxygen and two Hydrogen atoms
- It also occurs in nature as *snow, glaciers, icepacks and icebergs, clouds, fog, dew, aquifers, and atmospheric humidity*.

"*Life will not exist without water in our Mother Earth*" – Anonymous

Distribution of available water in the earth

Distribution of Water

Salt water dominates

97.5%

Salt Water

About 97.5% of all water on earth is salt water

Most fresh water is unattainable

2.5%

Fresh water

Only 2.5% of all the water on Earth is Fresh water

Source: FAO, 2009

Distribution of Water

Most fresh water is unattainable

2.5%

Fresh water

Only 2.5% of all the water on Earth is Fresh water

Frozen icecaps

70%

Polar Ice caps

Around 70% of fresh water is frozen in Antarctica and green land icecaps

Underground

30%

Underground

Most of the remaining fresh water lies too deep underground

Source: FAO, 2009

?%

is available for

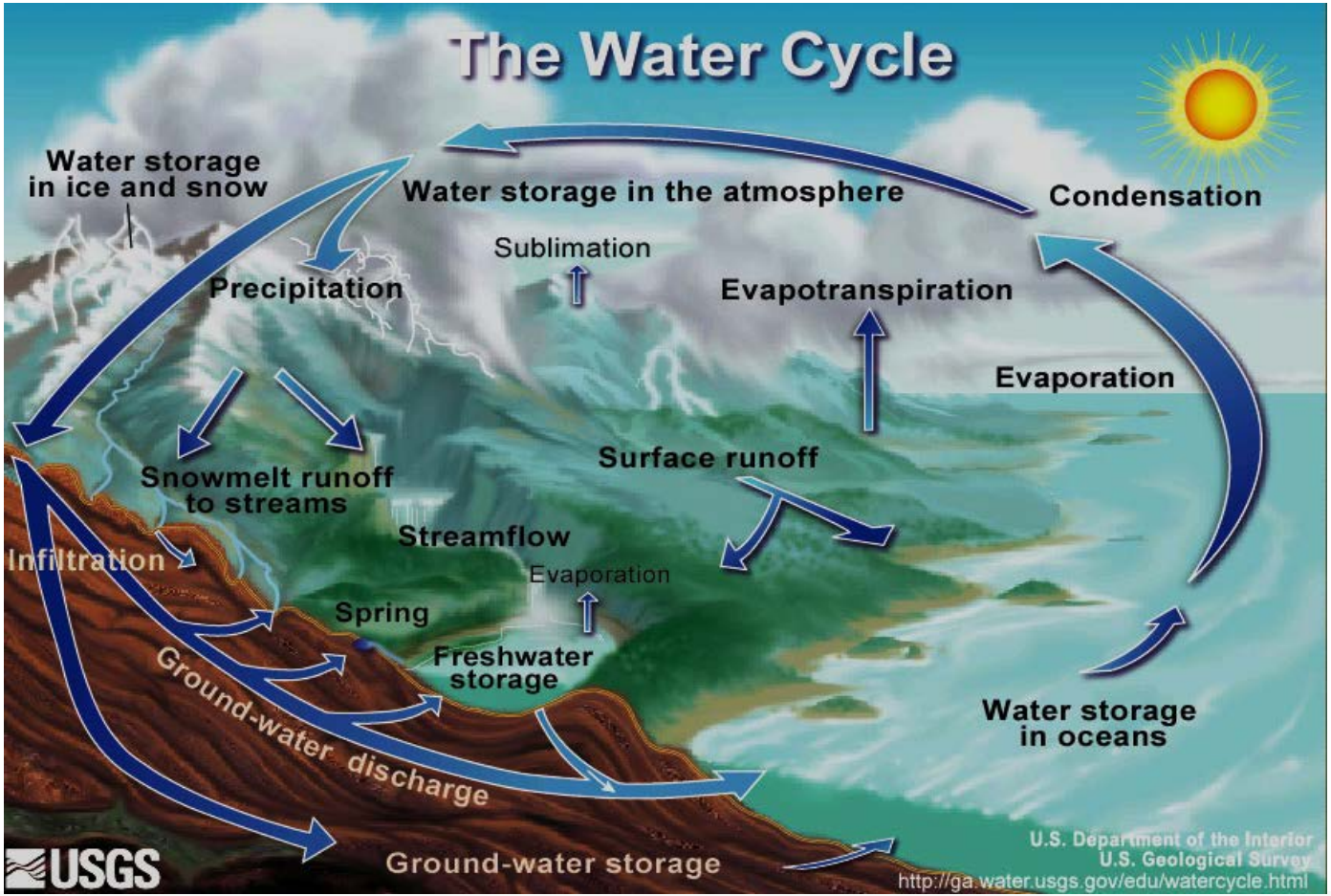
Human Consumption

<1%

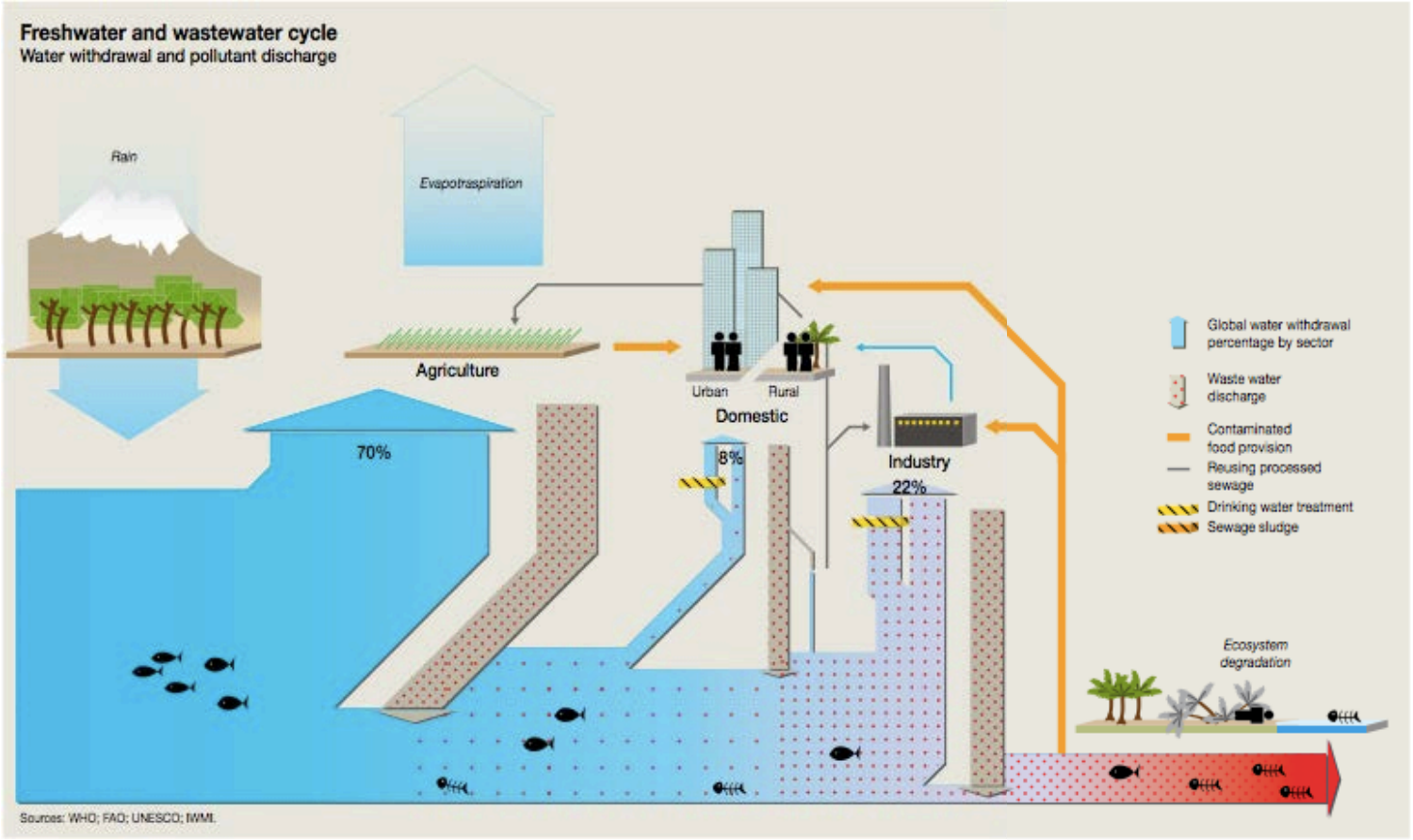
is available for

Human Consumption

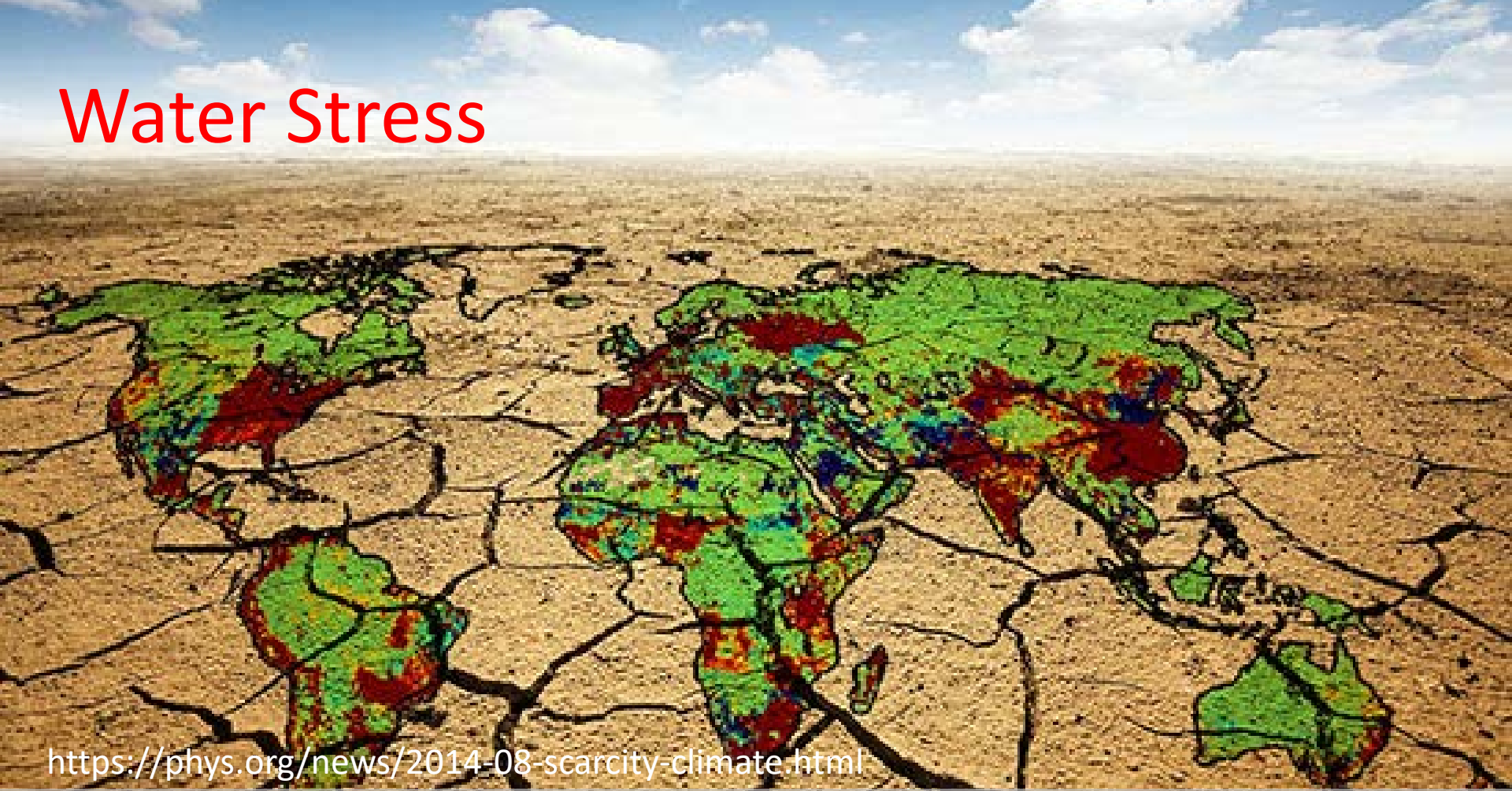
Water cycle


The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey
http://ga.water.usgs.gov/edu/watercycle.html

Water cycle


Freshwater and wastewater cycle
Water withdrawal and pollutant discharge
Rain
Evapotraspiration
Agriculture
Urban
Rural
Domestic
Industry
70%
8%
22%
Global water withdrawal percentage by sector
Waste water discharge
Contaminated food provision
Reusing processed sewage
Drinking water treatment
Sewage sludge
Ecosystem degradation
Sources: WHO; FAO; UNESCO; IWMI.

Water Stress



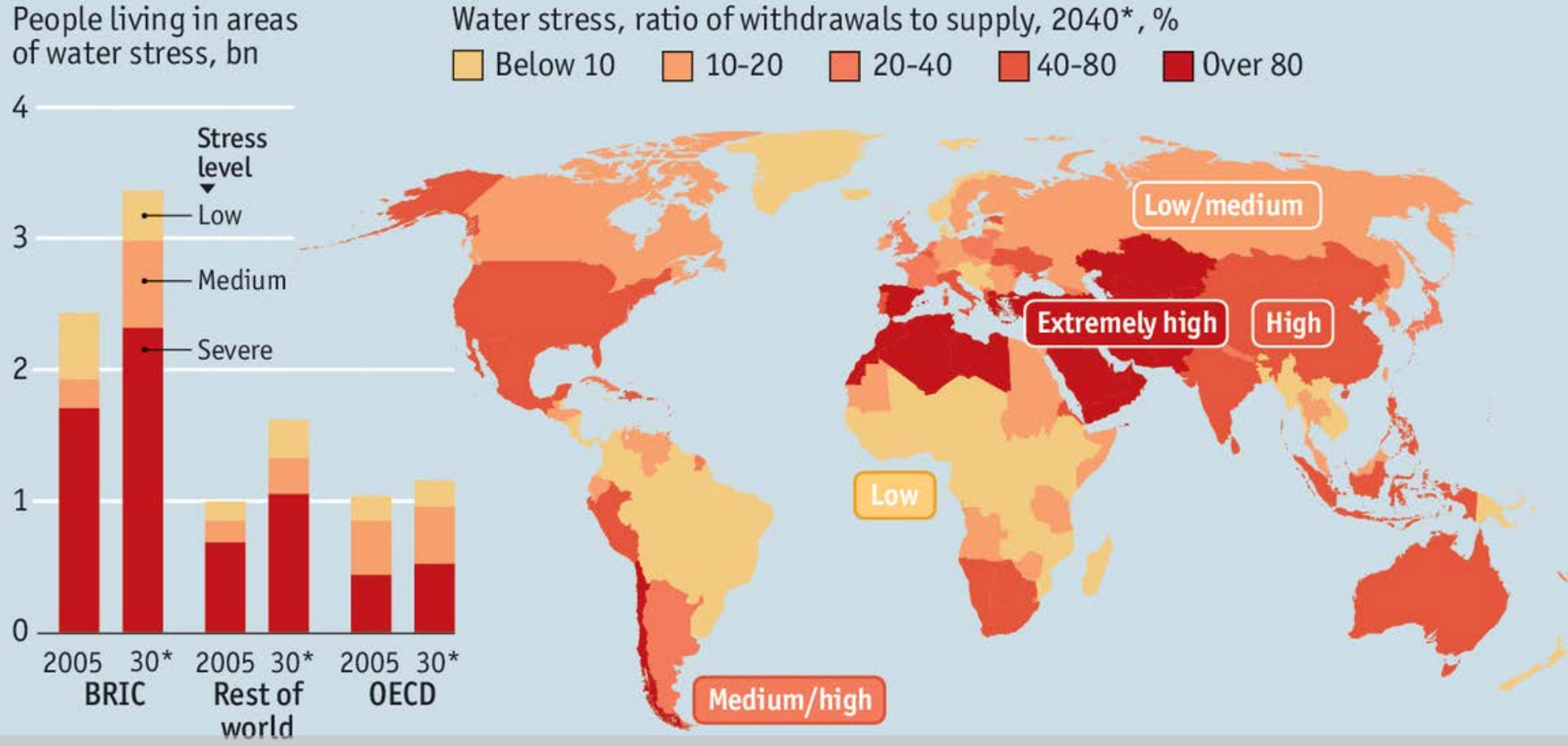
https://phys.org/news/2014-08-scarcity-climate.html

Water stress occurs when the demand for **water** exceeds the available amount during a certain period or when poor quality restricts its use.

Water stress causes deterioration of fresh **water** resources in terms of quantity

Water stress — European Environment Agency
https://www.eea.europa.eu/themes/water/wise-help-centre/glossary-definitions/water-stress

Water pressure - World wide



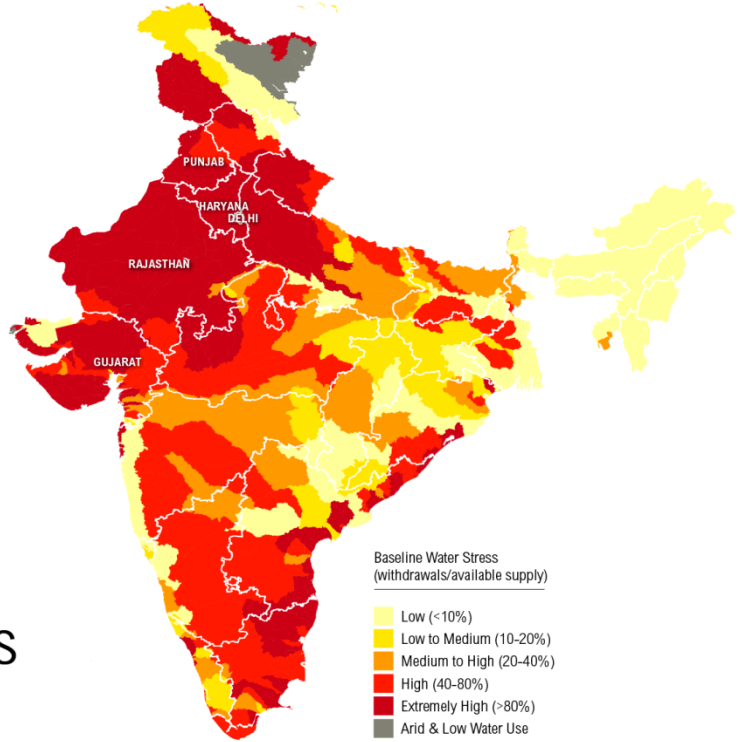
Sources: OECD; World Resources Institute

*Forecast


1.1 billion
The number of people worldwide — 1 in every 6 — without access to clean water
Really we need to
think?

Water Stress – India

54%
of India
Faces
High to
Extremely
High
Water Stress

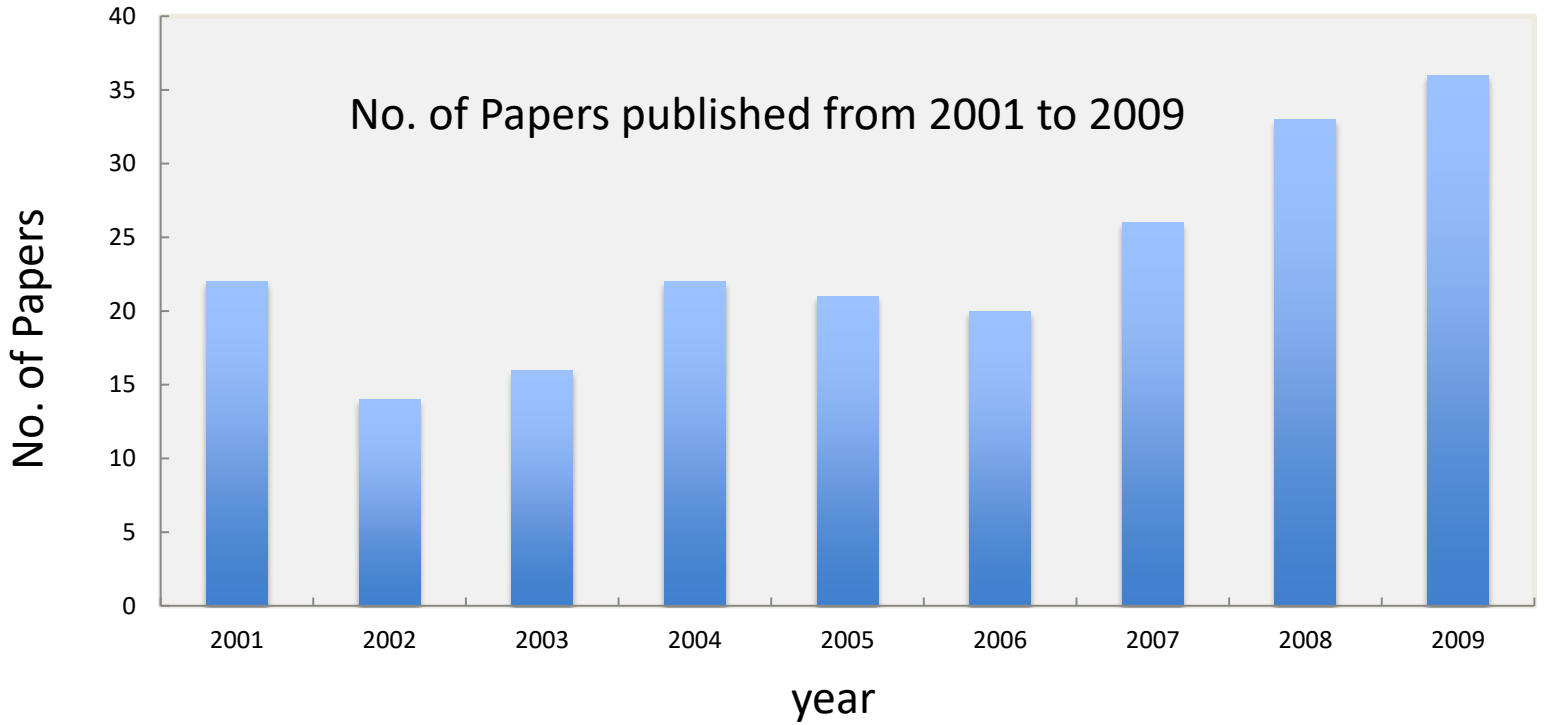


WORLD RESOURCES INSTITUTE


BLUE PLANET
RUN
THE RACE TO PROVIDE SAFE
DRINKING WATER TO THE WORLD
INTRODUCTION BY ROBERT REDFORD
CREATED BY RICK SMOLAN
AND JENNIFER ERWITT


Industrial Water Pollution

Industrial water treatment - research database



Source: Web of Science

Water is characterized in terms of its

Physical, Chemical and Biological Composition

Test used to asses the

constituents present in water

Characteristics of waste water – Physical

Test[b]	Abbreviation/ definition	Use or significance of test results
Physical characteristics		
Total solids	TS	To assess the reuse potential of a wastewater and to determine the most suitable type of operations and processes for its treatment
Total volatile solids	TVS	
Total fixed solids	TFS	
Total suspended solids	TSS	
Volatile suspended solids	VSS	
Fixed suspended solids	FSS	
Total dissolved solids	TDS (TS – TSS)	
Volatile dissolved solids	VDS	
Total fixed dissolved solids	FDS	
Settleable solids		To determine those solids that will settle by gravity in a specified time period
Particle size distribution	PSD	To assess the performance of treatment processes
Turbidity	NTU[c]	Used to assess the quality of treated wastewater
Color	Light brown, gray, black	To assess the condition of wastewater (fresh or septic)
Transmittance	% T	Used to assess the suitability of treated effluent for UV disinfection

Test[b]	Abbreviation/ definition	Use or significance of test results
Odor	TON[d]	To determine if odors will be a problem
Temperature	°C or °F	Important in the design and operation of biological processes in treatment facilities
Density	ρ	
Conductivity	EC	Used to assess the suitability of treated effluent for agricultural applications

Characteristics of waste water – Chemical (Inorganic)

Test[b]	Abbreviation/ definition	Use or significance of test results
Inorganic chemical characteristics		
Free ammonia	NH_4^+	Used as a measure of the nutrients present and the degree of decomposition in the wastewater; the oxidized forms can be taken as a measure of the degree of oxidation
Organic nitrogen	Org N	
Total Kjeldahl nitrogen	TKN (Org N + NH_4^+)	
Nitrites	NO_2^-	
Nitrates	NO_3^-	
Total nitrogen	TN	
Inorganic phosphorus	Inorg P	
Total phosphorus	TP	
Organic phosphorus	Org P	

Characteristics of waste water – Chemical (Inorganic)

Test[b]	Abbreviation/ definition	Use or significance of test results
Inorganic chemical characteristics (continued)		
pH	$pH = -\log [H+]$	A measure of the acidity or basicity of an aqueous solution
Alkalinity	$\Sigma HCO_3^- + CO_3^{-2} + OH^- - H+$	A measure of the buffering capacity of the wastewater
Chloride	Cl^-	To assess the suitability of wastewater for agricultural reuse
Sulfate	SO_4^{-2}	To assess the potential for the formation of odors and may impact the treatability of the waste sludge
Metals	As, Cd, Co, Cr, Co, Cu, Pb, Mg, Hg, Mo, Ni, Se, Na, Zn	To assess the suitability of the wastewater for reuse and for toxicity effects in treatment. Trace amounts of metals are important in biological treatment
Specific inorganic elements and compounds		To assess presence or absence of a specific constituent
Various gases	O_2, CO_2, NH_3, H_2S, CH_4	The presence or absence of specific gases

Characteristics of waste water – Chemical (Organic)

Test[b]	Abbreviation/ definition	Use or significance of test results
Organic chemical characteristics		
Five-day carbonaceous biochemical oxygen demand	$CBOD_5$	A measure of the amount of oxygen required to stabilize a waste biologically
Ultimate carbonaceous biochemical oxygen demand	UBOD (also BOD_u, BOD_L)	A measure of the amount of oxygen required to stabilize a waste biologically
Nitrogenous oxygen demand	NOD	A measure of the amount of oxygen required to oxidize biologically the nitrogen in the wastewater to nitrate
Chemical oxygen demand	COD	Often used as a substitute for the BOD test
Total organic carbon	TOC	Often used as a substitute for the BOD test
Specific organic compounds and classes of compounds	MBAS*, CTAS[f]	To determine presence of specific organic compounds and to assess whether special design measures will be needed for removal

Test[b]	Abbreviation/ definition	Use or significance of test results
Biological characteristics		
Coliform organisms	MPN (most probable number)	To assess presence of pathogenic bacteria and effectiveness of disinfection process
Specific microorganisms	Bacteria, protozoa, helminths, viruses	To assess presence of specific organisms in connection with plant operation and far reuse
Toxicity	TU_a and TU_c	Toxic unit acute, Toxic unit chronic

Principal Constituents of concern in Industrial wastewater treatment

Constituent	Reason for importance
Suspended solids	Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment
Biodegradable organics	Composed principally of proteins, carbohydrates, and fats, biodegradable organics are measured most commonly in terms of BOD (biochemical oxygen demand) and COD (chemical oxygen demand). If discharged untreated to the environment, their biological stabilization can lead to the depletion of natural oxygen resources and to the development of septic conditions
Pathogens	Communicable diseases can be transmitted by the pathogenic organisms that may be present in wastewater
Nutrients	Both *nitrogen and phosphorus*, along with carbon, are essential nutrients for growth. When discharged to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharged *in* excessive amounts on land, they can also lead to the pollution of groundwater

Principal Constituents of concern in Industrial wastewater treatment

Constituent	Reason for importance
Priority pollutants	Organic and inorganic compounds selected on the basis of their known or suspected carcinogenicity, mutagenicity, teratogenicity, or high acute toxicity. Many of these compounds are found in wastewater
Refractory organics	These organics tend to resist conventional methods of wastewater treatment. Typical examples include surfactants, phenols, and agricultural pesticides
Heavy metals	Heavy metals are usually added to wastewater from commercial and industrial activities and may have to be removed if the wastewater is to be reused
Dissolved inorganics	Inorganic constituents such as calcium, sodium, and sulfate are added to the original domestic water supply as a result of water use and may have to be removed if the wastewater is to be reused

Levels of wastewater Treatment

Treatment level	Description
Preliminary	Removal of wastewater constituents such as rags, sticks, floatables, grit, and grease that may cause maintenance or operational problems with the treatment operations, processes, and ancillary systems
Primary	Removal of a portion of the suspended solids and organic matter from the wastewater
Advanced primary	Enhanced removal of suspended solids and organic matter from the wastewater. Typically accomplished by chemical addition or filtration
Secondary	Removal of biodegradable organic matter (in solution or suspension) and suspended solids. Disinfection is also typically included in the definition of conventional secondary treatment
Secondary with nutrient removal	Removal of biodegradable organics, suspended solids, and nutrients (nitrogen, phosphorus, or both nitrogen and phosphorus)
Tertiary	Removal of residual suspended solids (after secondary treatment), usually by granular medium filtration or microscreens. Disinfection is also typically a part of tertiary treatment. Nutrient removal is often included in this definition

Treatment level	Description
Advanced	Removal of dissolved and suspended materials remaining after normal biological treatment when required for various water reuse applications

Treatment Methods employed

- Physical – Screens, Coarse solids reducers, Grit separators, Flow equalizers, Sedimentation, Clarifiers - Mixing, flocculation, Coagulation, Filters – Sand Filtration, Rotary filtration, Adsorption, Membrane separations
- Chemical – Precipitation (oxidation and reduction)
- Biological Methods (Aerobic and Anaerobic)

https://en.wikipedia.org/wiki/Water

RICK SMOLAN and JENNIFER ERWITT, Blue Planet Run: The race to provide safe drinking water to the world, www.bluplanetrun.org

CORCORAN, E. (Editor); NELLEMANN, C. (Editor); BAKER, E. (Editor); BOS, R. (Editor); OSBORN, D. (Editor); SAVELLI, H. (Editor) (2010): *Sick Water? The central role of wastewater management in sustainable development*. A Rapid Response Assessment. United Nations Environment Programme (UNEP), UN-HABITAT, GRID-Arendal

Water Resources Institute

Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGraw, Hill