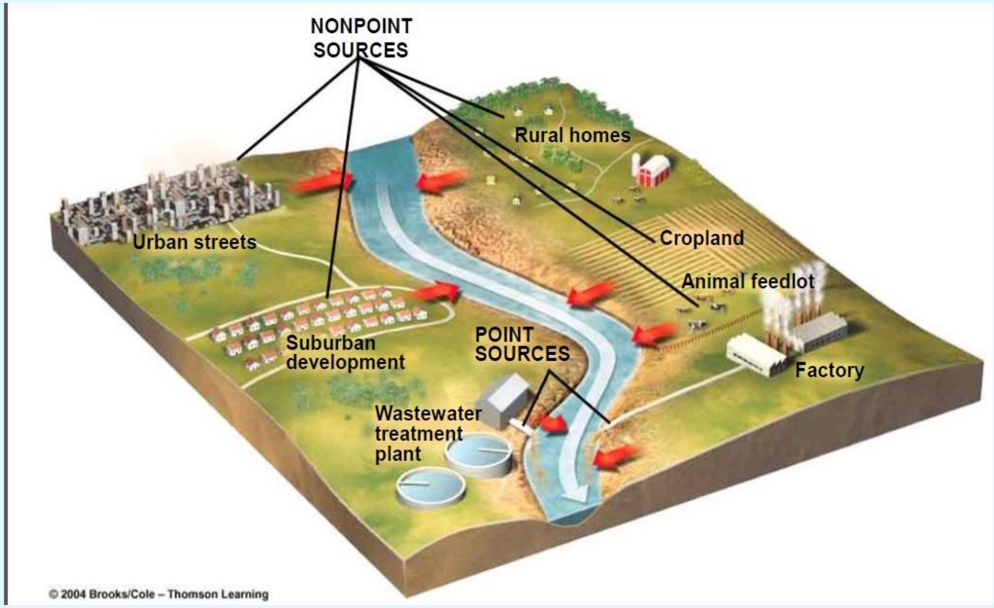
WATER POLLUTION

- **Water Pollution:** Water Pollution occurs when energy and other materials are released into the water, contaminating the quality of it for other users.
- **Types**
  - **Surface water pollution:** found on the exterior of the Earth's crust, oceans, rivers and lakes
  - **Groundwater Pollution:** found in soil or under rock structure or aquifers
  - **Microbiological pollution:** microorganisms that thrives on water and fishes that can cause illness to land animals and humans
  - **Oxygen Depletion pollution:** microorganisms that in water and feeds on biodegradable substances

REASONS

- Dumping
- Industrial Waste
- Sewage, mainly from households
- Nuclear waste
- Oil pollution
- Underground storage leaks



EFFECTS

Effects on Environment

- Toxic water
- Thermal heating
- Our sources of water

Effects on Humans

Diseases caused by:

- Drinking Contaminated water
- Swimming in polluted water
- Contact with chemically polluted water

Effects on Animals

- E.g. 200 turtles in Australian waters die each year
- Birds and mammals become coated with oil

IMPACT

Sr. No.	Pollutants	Impact
1.	Organic pollutants i) Oxygen Demanding wastes: ii) Synthetic organic pollutants iii) Oil	• Adversely affecting aquatic life, if the **DO falls below 4.0 mg/L.** • Most of these compounds are toxic and biorefractory organics. It also make water unfit for different uses. • This pollutant is also responsible for endangering water birds and coastal plants due to **coating of oils and adversely affecting the normal activities** which cause reduction of light transmission and photosynthesis.
2.	Pathogens	• **Number of diseases transmitted by pathogens** available in Wastewater
3.	Nutrients	• When these are disposed in aquatic environment, **it can lead to growth of undesirable aquatic life**. When it discharged on land it causes groundwater pollution.

IMPACT

Sr. No.	Pollutants	Impact
4.	Thermal pollutants	When organic matter is present, the bacterial action increases due to rise in temperature; hence, resulting in rapid decrease of DO. It also results in thermal stratification which alters spectrum of organisms.
5.	Radioactive pollutants	These isotopes are toxic to the life forms; they accumulate in the bones, teeth and can cause serious disorders
6.	Suspended solids and Sediments	Presence of **suspended solids can block the sunlight penetration in the water**, which is required for the photosynthesis by bottom vegetation. Finer suspended solids such as silt and coal dust may injure the gills of fishes and cause asphyxiation.
7.	Inorganic pollutants	These pollutants include mineral acids, inorganic salts, trace elements, metals, metals compounds, complexes of metals with organic compounds, cyanides, sulphates, etc. They have **adverse effect on aquatic flora and fauna** and may constitute a public health problem.

GROUND-WATER POLLUTION

- Groundwater is water present below the ground surface that saturates the pore space in the subsurface.
- At least 50% of the world population depends on groundwater as a source of drinking water.

- Other uses of groundwater includes Irrigation of crops, Industrial uses etc.
- Groundwater is a part of natural water cycle therefore, it can spread throughout the cycle and if contaminated, can cause damage to other entities (Sea life, lakes, human health etc)

Sources of Groundwater Pollution

Improper use of contaminated water

Leaking Fuel and Chemical Tanks

Industrial Chemical spills

Industrial Emissions

Extensive use of Pesticides, Herbicides and fertilizers

Drainage of house hold chemicals

Badly Managed Landfill

GW: PREVENTION

A. Participation of Industries

- Minimize use of Toxic / Hazardous Raw Materials
- Maintain Integrity of the Storage Tanks, Pipelines, surface impoundments
- Adopt Good Engineering Practices for selecting proper material for tanks and pipes.
- Implement monitoring programs: Leak Detection and repair program, spill detection, spill control, emergency response plan etc.
- Manage Properly: Waste materials, their transport and disposal.
- Install Monitoring Wells
- Monitor Periodically: Groundwater quality

GW: PREVENTION

B. Participation of Community:

- Minimize use of house hold chemicals containing Hazardous substances.
- Avoid draining chemicals, motor oil, insecticides in community areas.
- Reduce pesticide application
- Use proper procedures for handling chemicals (Paints, Pesticides, Insecticides, polishing materials, cleaning chemicals and detergents).
- Immediately clean any spills and report any leakages to concerned department.

DISSOLVED OXYGEN

Dissolved Oxygen (DO)

By far the most important characteristic determining the quality of a river or stream is its dissolved oxygen, DO (measured in mg/L).

While the saturated value DO_s is rarely achieved, a stream can nonetheless be considered healthy as long as its dissolved oxygen DO exceeds 5 mg/L.

Below 5 mg/L, most fish, especially the more desirable species such as trout, do not survive. Actually, trout and salmon need at least 8 mg/L during their embryonic and larval stages and the first 30 days after hatching.

DISSOLVED OXYGEN

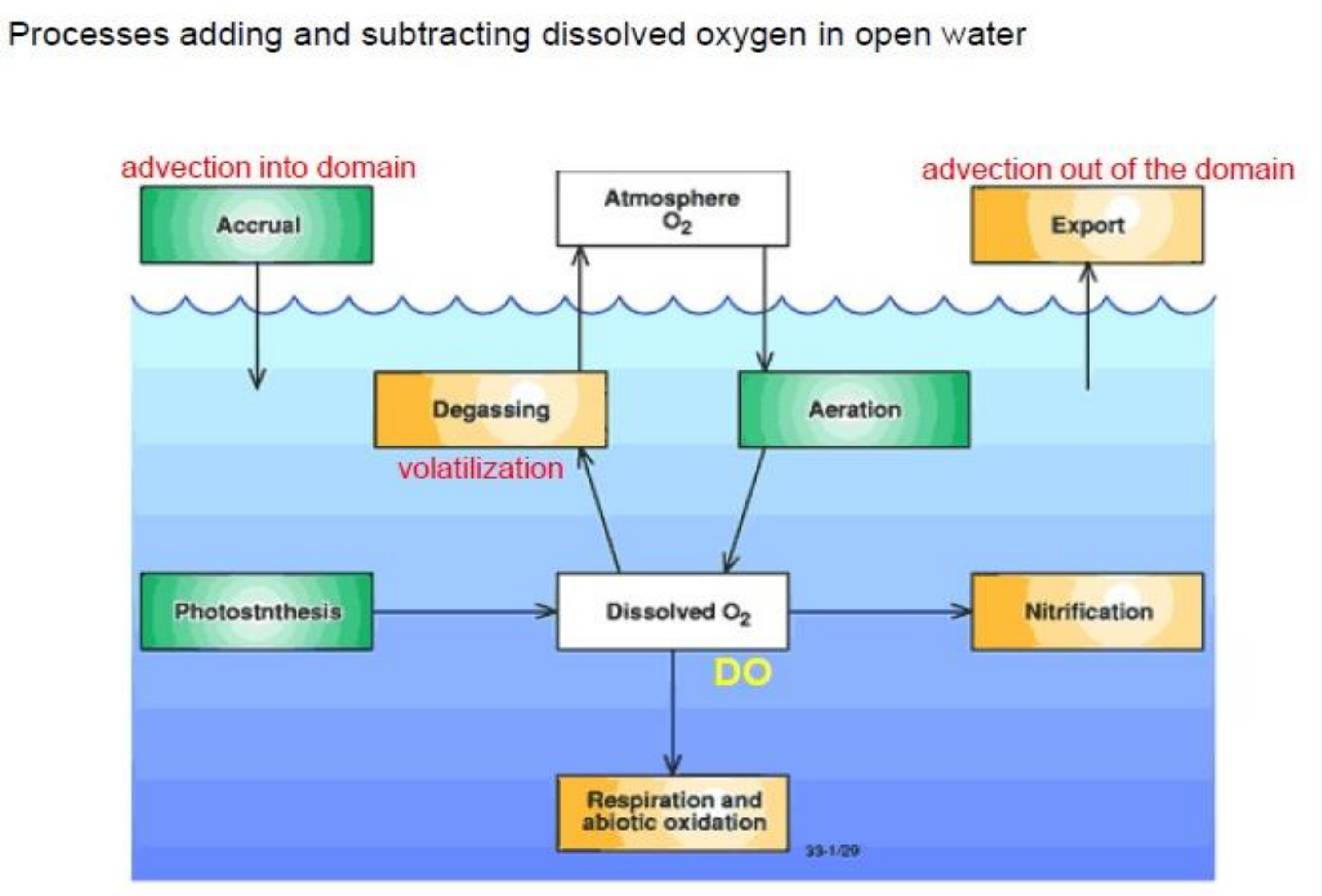
Why is oxygen in water important?

Dissolved oxygen (**DO**) analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a product of photosynthesis.

DO is measured in standard solution units such as milligrams O_2 per liter (mg/L), millilitres O_2 per liter (ml/L), millimoles O_2 per liter (mmol/L), and moles O_2 per cubic meter (mol/m^3).

DO is measured by way of its oxidation potential with a probe that allows diffusion of oxygen into it.

DISSOLVED OXYGEN



DISSOLVED OXYGEN IN RIVERS

- Oxygen demanding wastes affect available DO
- Tributaries bring their own oxygen supply
- Photosynthesis adds DO during the day but the same plants remove oxygen at night
- Respiration of organisms living in water as well as in sediments remove oxygen
- In the summer rising temperatures reduce solubility of oxygen
- In the winter oxygen solubility increases, but ice may form blocking access to new atmospheric oxygen

BIOCHEM OXYGEN DEMAND

Biochemical oxygen demand or **BOD** is a procedure for determining the rate of uptake of DO by the organisms in a body of water

BOD measures the oxygen uptake by bacteria in a water sample at a temperature of 20°C over a period of 5d in the dark.

Significance: BOD is a measure of organic content and gives an indication on how much oxygen would be required for microbial degradation.

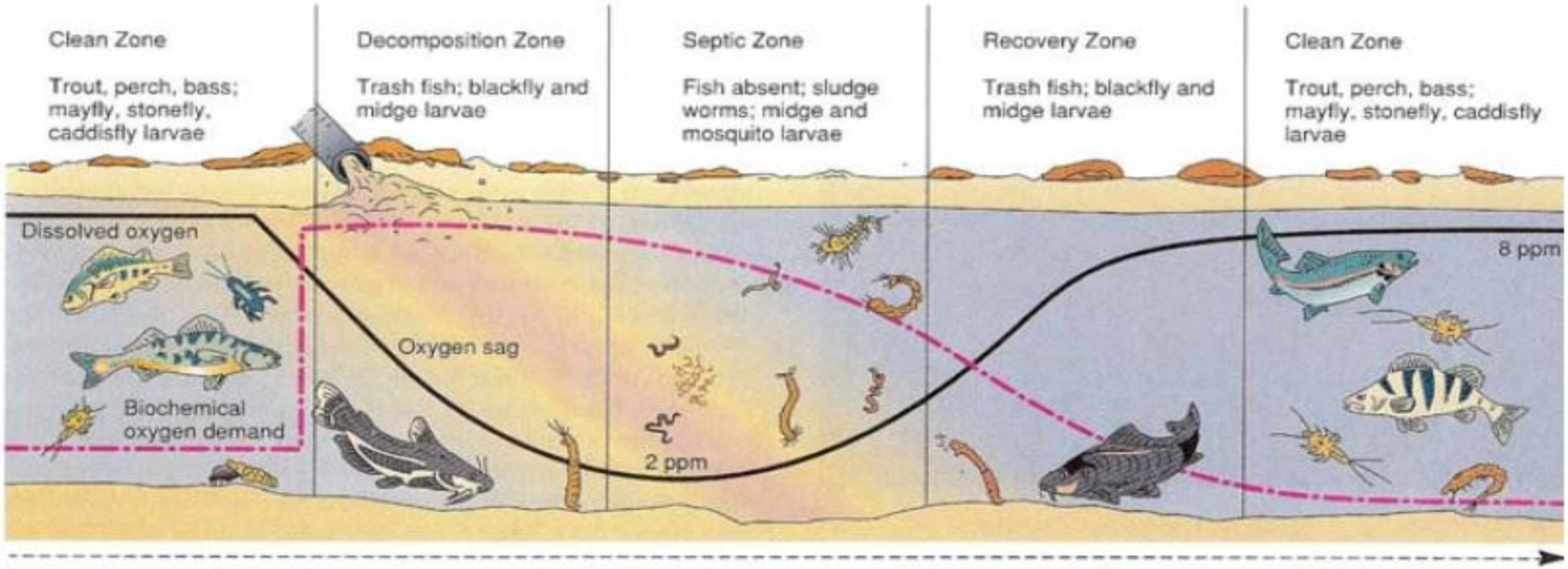
OXYGEN DEPLETION IN STREAMS

- Bio**chemical** oxygen demand measures the molecular oxygen utilized for the biochemical degradation of organic material (carbonaceous demand) and…..

  ……the oxygen used to oxidize inorganic material such as **sulfides** and **ferrous ion**.

- It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand).

- Biological oxygen demand only addresses the oxygen used up by the bacteria to degrade organic substances.



Oxygen sag downstream of an organic source. A great deal of time and distance may be required for the stream and its inhabitants to recover.

BOD LIMITS

Items	BOD standards(mg/L)
Most pristine rivers	<1
Moderately polluted rivers	2-8
Ordinary domestic sewage	150- 200
Municipal sewage efficiently treated	<20

- Any effluent to be discharged into natural bodies of water should have BOD less than 30 mg/L.
- Drinking water usually has a BOD of less than 1 mg/L.
- But, when BOD value reaches 5 mg/L, the water is doubtful in purity.

BOD LIMITS

BOD Level *(in ppm)*	Water Quality
1 - 2	**Very Good** There will not be much organic waste present in the water supply.
3 - 5	**Fair: Moderately Clean**
6 - 9	**Poor: Somewhat Polluted** Usually indicates organic matter is present and bacteria are decomposing this waste.
100 or greater	**Very Poor: Very Polluted** Contains organic waste.

GWP: REMEDIATION

- Groundwater remediation is the process that is used to remove pollution from groundwater.

- Groundwater remediation techniques are mainly divided into two technologies:

A. Ex-Situ Technology: involves treatment of groundwater by de-watering the polluted aquifer (pumping out), then treating the water on surface by Physical, chemical or biological technology and finally re-injecting the treated water to the aquifer.

B. In-Situ Technology: involves treatment of groundwater within the aquifer (in the sub-surface) by using thermal, chemical and biological treatment technology.

Ex-Situ Technology:

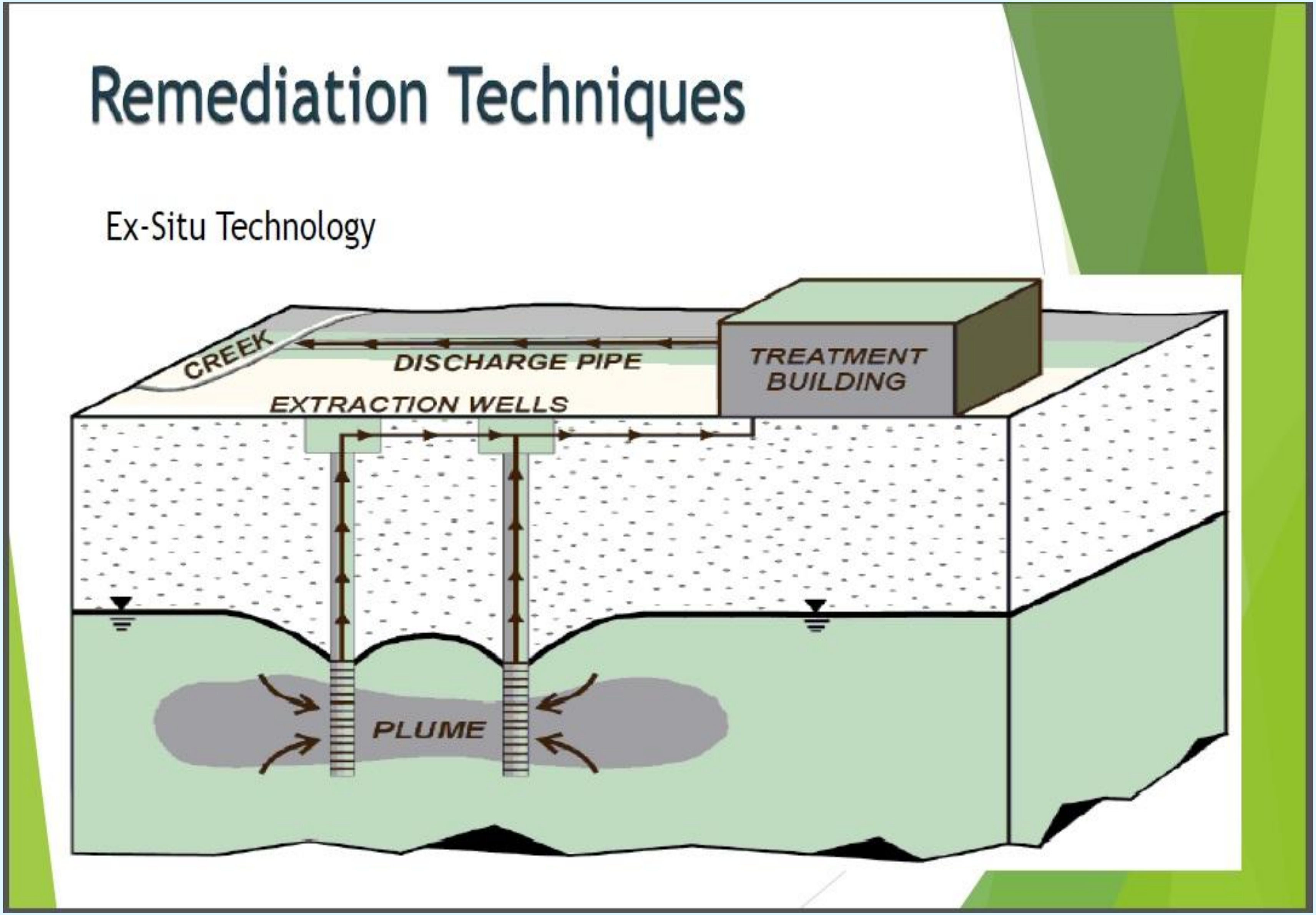
Stream stripping:- Involves treatment by introducing steam which extract the contaminants from the pumped out groundwater. The extracted steam along with contaminants can be recovered from the condensate or treated further by incineration.

Oxygen Sparging:- Involves introduction of oxidizing/reducing agents (O3, H2O2, Hypochlorite) to chemically convert the toxic contaminants to less toxic compounds.

Bioremediation:- Involves treatment of pumped up groundwater by air (biodegradation) with careful control of moisture, heat nutrients, oxygen and pH.

Carbon Adsorption:- Involves passing the contaminated pumped up groundwater through activated carbon column in which contaminants gets adsorbed.

GWP: REMEDIATION



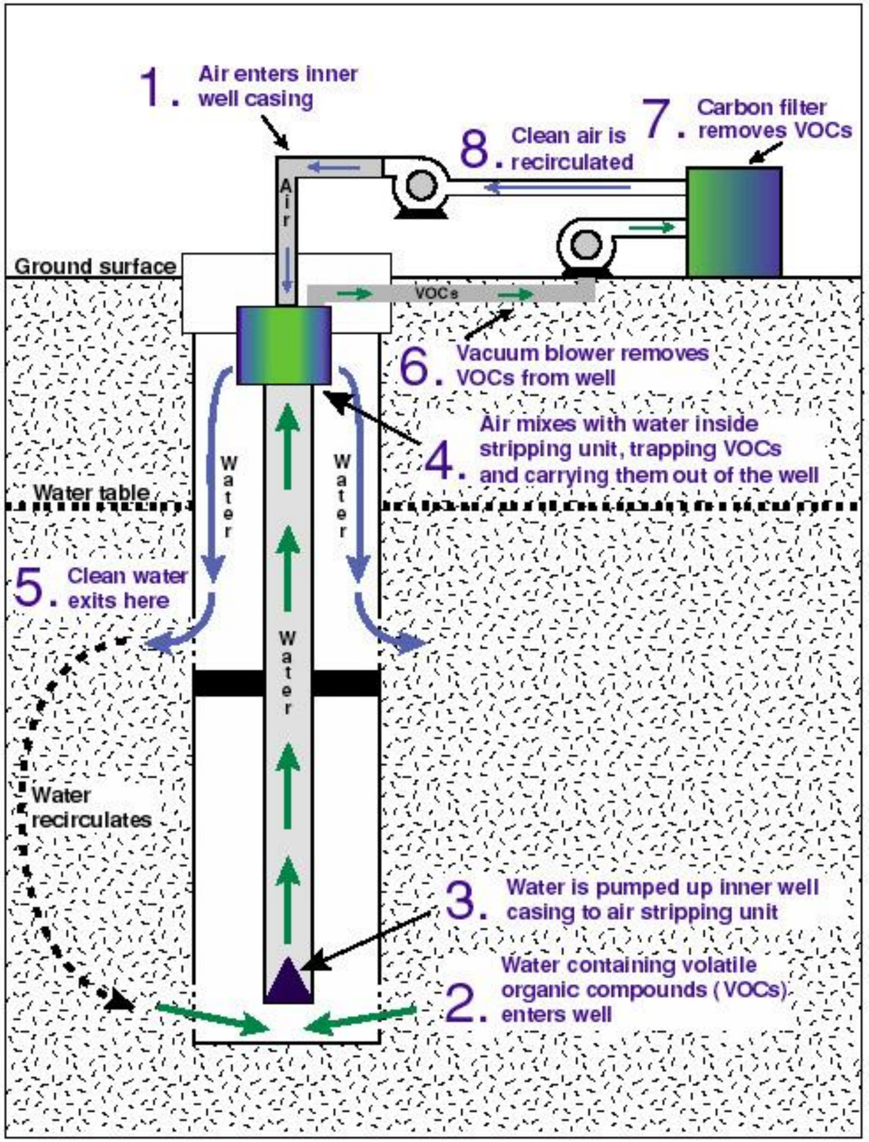
GWP: REMEDIATION

In-Situ Remediation Technology:

Air Sparging: Involves the injection of contaminant-free air into the subsurface saturated zone, **enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase.**

Bioremediation: Involves injection of oxygen to **enhance the biodegradation**. This treatment also combines injection of degrading bacteria and nutrients into aquifer to stimulate biodegradation.

In-well air stripping: Involves injection of air in double screened well, lifting the water up the well and force it out in upper screen. VOCs in the contaminated water are transferred from dissolved phase to vapor phase in air bubbles and drawn off and treated.



Prepared By: Environmental Restoration Division Brookhaven National Laboratory	**Figure 12** **In-Well Air Stripping System Schematic**	Modified by: P. Genzer, C. Lafon (BNL) Date: 12/23/98

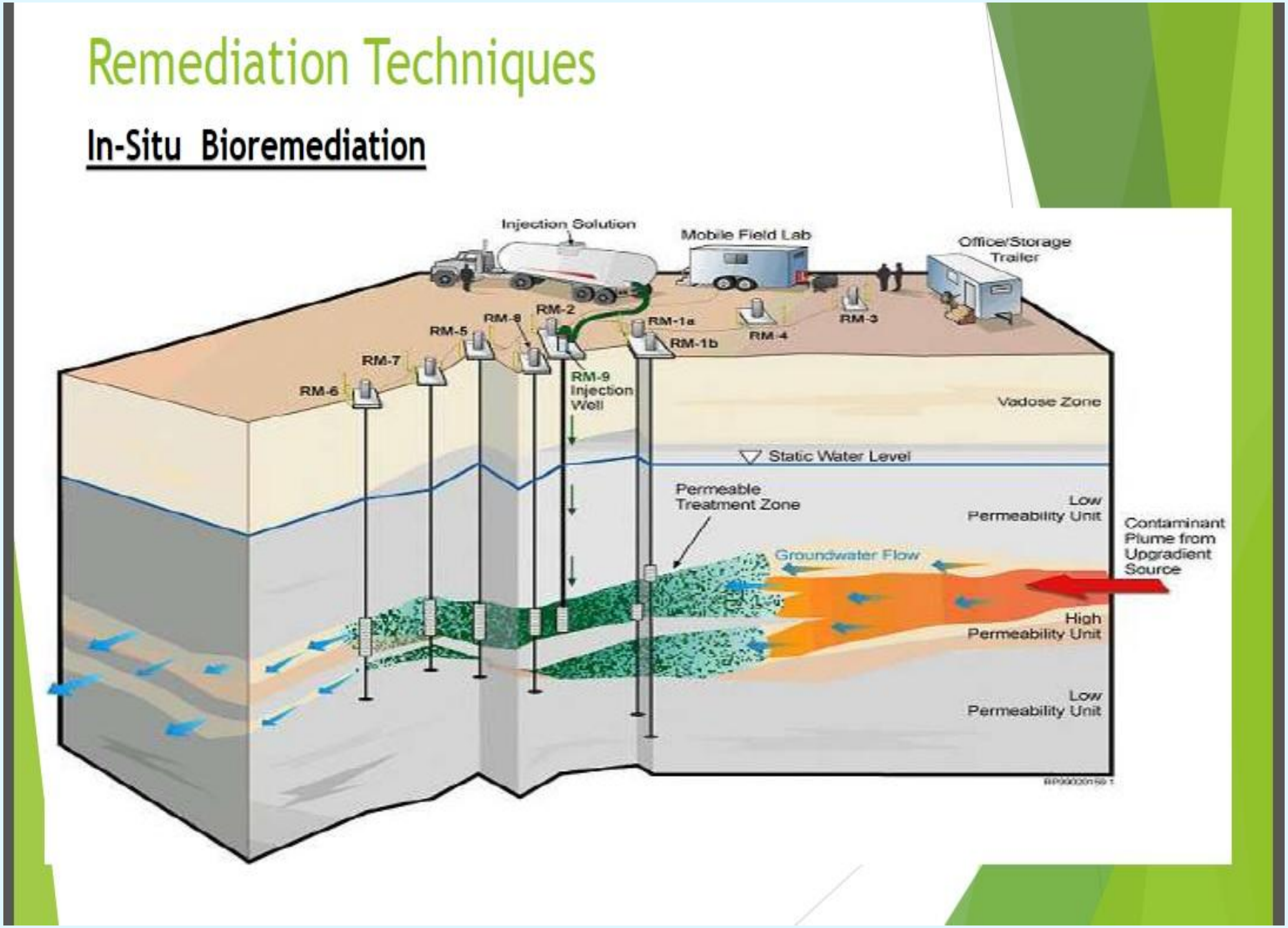
GWP: REMEDIATION

Chemical Oxidation: Involves Reduction-Oxidation reactions that chemically converts hazardous contaminants to less toxic compounds. Cyanide oxidation and de-chlorination are the typical examples of chemical oxidation.

Thermal Treatment: Involves **increase in temperature of the source zone to increase the mobility of the pollutants.** The mobility facilitate removal of pollutants and can also results in In-Situ destruction of contaminants.

Phythoremediation: It involves the use of **macroscopic plants to destroy, remove, immobilize and treat contaminants**. This process does not use microorganisms.

GWP: REMEDIATION



GWP: REMEDIATION

The selection of the remedial technology depends upon several parameters such as:

A. Contaminant Profile:
- Types of compounds (DNAPL, LNAPL, Ammonia, Virus, Bacteria)
- Quantity and Solubility (Solubility in Water)
- Toxicity and volatility (VOCs , SVOCs, Metals, etc)
- Biodegradability

B. Aquifer Profile:
- Soil Type (permeability, homogeneity, chemistry, confined or open, etc)
- Groundwater Flow direction
- Water Table location
- Recharge location (seasonal Rainfall)

C. Feasibility Profile:
- Cost of technology
- Time of completion

GWP: REMEDIATION

Several man made chemicals are referred to as Groundwater contaminants because of their extensive use, accidental spills and leaks, mismanagement and illegal dumping. Some of the popular contaminants are the following:

- DNAPL (Dense Non Aqueous Phase Liquids)
- LNAPL (Light Non Aqueous Phase Liquids)
- Inorganic Chemicals (Ammonia, Cyanide, Fluoride)
- Metals
- Bacteria and Viruses

GWP: REMEDIATION

LNAPL (Light Non Aqueous Phase Liquids)

Light Non Aqueous Phase Liquids are organic compounds lighter than water and having low solubility. These liquids include Gasoline, fuel oil and other petroleum products.

LNAPL Remediation:

Remediation may require the use of more than one technology. It is likely that several remediation techniques, used in series and/or parallel applications, will be required for maximum contaminant removal. This collaborative effort may be referred to as a treatment train approach.

A conceptual example of a treatment train which might be effective at an LNAPL site includes:

- Pump and Treat for mobile LNAPL removal followed by vapor extraction for removal of residual LNAPL .
- Additional technologies such as bioremediation might be used to further reduce contaminant concentrations.

GWP: REMEDIATION

Contaminant	Main Source	Treatment Technology
Trichloroethylene (TCE)	Degreasing of Metal and Electronic parts, Extract for oil and waxes, fumigant, carries in paints and adhesives	•Pump and Treat •Activated Carbon •Thermal and Biological
MTBE	MTBE can be released to groundwater by leaking underground storage tanks and piping, atmospheric deposition, spills during transportation, and leaks at refineries	•Air Sparging •In-Situ oxidation (H_2O_2 and Fe) •Bioremediation/Bioaugmentation •Pump and Treat.
EDC (DNAPL)	From EDC and VCM Plants, storage tanks, pipelines etc.	•In-situ Bioremediation.
Gasoline (LNAPL)	Gasoline and other petroleum fuels tanks, petrol stations, storage tanks and pipelines.	•In-situ Bioremediation •Vapor extraction
Ammonia	Ammonia Storage Tanks, Landfill leaks, Waste stockpile, etc.	•Pump and Treat •Combination of Air Stripping, Nitrification, Ion Exchange.

WATER QUALITY

- **Water quality:** Water quality is the physical, chemical and biological characteristics of water.
- It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.
- It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

- **Water Quality – Why it is Important ??**

Most disease problems can be avoided with proper management of water quality

WATER Q PARAMETERS

1. Temperature
2. Dissolved oxygen
3. Total ammonia-nitrogen, NH_3, NO^-_2
4. Alkalinity
5. Hardness
6. pH
7. Carbon dioxide

NATIONAL WATER QUALITY MONITORING PROGRAMME

- Water quality monitoring in India started in 1978
- National programme of Monitoring of Indian National Aquatic Resources started in 1984 with a total of 120 stations in 10 River Basins.
- The network comprising of 870 stations extended to 26 states & 5 Union Territories.
- Monitoring done or Quarterly/Monthly/Half Yearly basis.
- Monitoring network covers 189 Rivers, 53 Lakes, 4 Tanks, 2 Ponds, 3 Creeks, 3 Canals, 9 Drains and 218 wells.

NATIONAL WATER QUALITY MONITORING PROGRAMME

- Water samples are analysed for 9 Core Parameters (pH, Temperature, Conductivity, DO, BOD, Nitrite, Nitrate, Total Coliform and Faecal Coliform) for all monitoring. 19 General Parameters, 9 Toxic Metals and 15 Pesticides are also analysed once in a year.
- Frequency of analysis for General Parameters reduced to once in a year in view of resources and to add more stations in non-represented water-bodies.

Parameters for National Water Quality Monitoring

Core Parameters (9)

pH
Temperature
Conductivity
Dissolved Oxygen
Biochemical Oxygen
Nitrate-N
Nitrite-N
Faecal Coliform
Total Coliform

Field Observations (7)

Weather
Approximate depth of main stream/depth of water table
Colour and instensity
Odor
Visible efluent discharge
Human activities around station
Station detail

General Parameters (19)

COD	Chloride
TKN	Sulphate
Ammonia	Total Alkalinity
Total Dissolved Solids	P-Alkalinity
Total Fixed Solids	Phosphate
Total Suspended Solids	Sodium
Turbidity	Potassium
Hardness	Calcium
Fluoride	Magnesium
Boron	

Bio-Monitoring Parameters (3)

Saprobity Index
Diversity Index
P/R Ratio

Trace Metals (9)

Arsenic	Nickel	Copper	Mercury	Chromium Total
Cadmium	Zinc	Lead	Iron Total	

Pesticide (7)

BHC(Total)	Dieldrin	Carbamate	2.4 D
DDT(Total)	Aldrin	Endosulphan	

WATER Q: REASONS

For rational planning of pollution control strategies and their prioritisation;

To assess nature and extent of pollution control needed in different water bodies or their part;

To evaluate effectiveness of pollution control measures already in existence;

To evaluate water quality trend over a period of time;

To assess assimilative capacity of a water body thereby reducing cost on pollution control;

To understand the environmental fate of different pollutants.

To assess the fitness of water for different uses.

WATER Q: CRITERIA

Designated best use	Class	Criteria
Drinking water source without conventional treatment but after disinfections	A	• Total coliform organisms /100ml shall be 50 or less. • pH between 6.5 and 8.5 • Dissolved oxygen 6 mg/l or more • Biochemical oxygen demand 2 mg/l or Less
Outdoor bathing (organised)	B	• Total coliform organisms MPN/100ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved oxygen 5 mg/l or more • Biochemical oxygen demand 3 mg/l or Less
Drinking water source with conventional treatment followed by disinfection	C	• Total coliform organisms / 100ml shall be 5000 or less • pH between 6 and 9 • Dissolved oxygen 4 mg/l or more • Biochemical oxygen demand 3 mg/l or less

WATER Q: CRITERIA

Designated best use	Class	Criteria
Propagation of wild life, fisheries	D	• pH between 6.5 and 8.5 • Dissolved oxygen 4 mg/l or more • Free ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, controlled waste disposal	E	• pH between 6.0 and 8.5 • Electrical conductivity less than 2250 micro mhos/cm • Sodium absorption ratio less than 26 • Boron less than 2mg/l

WATER Q: STANDARDS

Parameter	Concentration (mg/L)
Hardness, Total (as $CaCO_3$)	>100
Iron (Fe)	<0.15
Nitrogen (N_2)	<110% total gas pressure
	<103 % as nitrogen gas
Nitrite (NO_2)	<1, 0.1 in soft water
Nitrate (NO_3)	0-400 or higher

WATER Q: STANDARDS

Parameter	Concentration (mg/L)
Oxygen Dissolved (DO)	>5
	> 90 mm Hg partial pressure
Ozone (O_3)	<0.005
pH	6.5-8.5
Salinity	<0.5 to 1
Total dissolved solids (TDS)	<400
Total suspended solids (TSS)	<80

WATER Q: PARAMETERS

Critical Parameters

- Dissolved Oxygen
- Temperature
- Ammonia/Nitrite/Nitrate
- pH

Important Parameters

- Alkalinity/Hardness
- Salinity
- Carbon Dioxide
- Solids

WATER Q: PARAMETERS

- ✓ pH Seawater: 8-8.5; Freshwater: 6.5–9
- ✓ Alkalinity: 50 -150 mg/l as Ca CO_3
- ✓ Hardness:

soft (0-75 mg/L , moderately hard (75 – 150 mg/L)

hard (150-300 mg/L); very hard (> 300 mg/L)

Recommended range: 20 to 300 mg/L $CaCO_3$

WATER Q: PARAMETERS

- Carbon dioxide is highly soluble in water.
- Concentration in pure water: 0.54 mg/L at 20° C.
- Groundwater concentrations range from 0-100 mg/L.

- Exposure to high carbon dioxide concentrations reduces respiration efficiency and decreases the tolerance to low dissolved oxygen concentrations.

QUESTIONS

1. What are water pollution and ground-water pollution?
2. What are remediation techniques practised for GWP?
3. What are the seven parameters checked for water quality?
4. What is DO, BOD and the significance of DO?
5. What are the water quality standards set in India?