PPLICATION OF ENVIRONMENTAL BIOTECHNOLOG IN WASTE-WATER MONITORING AND TREATMENT

- DR.(MRS.) RITA KUMAR

Institute of Genomics & Integrative Biology

Mall Road,Delhi-110007

WATER - AN ELIXIR OF LIFE

- **WATER IS UNDOUBTEDLY THE MOST PRECIOUS NATURAL RESOURCE COMPRISING OF HYDROGEN AND OXYGEN AND COVERS AROUND 70% OF EARTH SURFACE**

- **WATER IN ITS BIOLOGICAL OCCURRENCE, IS A COMPLEX SYSTEM OF CHEMICAL SPECIES**

- **COMPARED TO OTHER LIQUIDS, WATER HAS A HIGH CAPACITY TO ABSORB AND STORE HEAT AND IS A EXCELLENT LIQUID SOLVENT**
- **HIGH SURFACE TENSION IMPARTS A UNIQUENESS TO WATER FOR PHYSICAL AND BIOLOGICAL PROCESSES**

- **HIGHLY VERSATILE SOLVENT FOR DISSOLVING VARIED COMPOUNDS LIKE SIMPLE SALTS OR EVEN MINERALS**

- **ONLY SOLVENT WHOSE SOLID FORM IS LIGHTER THAN IT'S LIQUID FORM. THIS PROPERTY IS CRUCIAL FOR THE SURVIVAL OF AQUATIC LIVE FORMS**

WATER : THE MOST PRECIOUS NATURAL RESOURCE

- Without the seemingly **invaluable compound** comprised of hydrogen and oxygen, life on earth would have been non-existent
- The need to **maintain clean water** for both humans and animals has become a major, even a **critical concern**
- Till 1972, there were no uniform **national laws** governing water quality
- Two very significant national laws, the

  1972 Clean Water Act and

  1974 Safe Drinking Water Act (SDWA)

  were passed and these laws have been updated over the years.

WATER USE IN DIFFERENT COUNTRIES

COUNTRY	ANNUAL WATER USE PER CAPITA (GALLONS)	PERCENTAGE OF TOTAL WATER USE	
		RESIDENTIAL	INDUSTRY / AGRICULTURE
US	525,000	10	90
CANADA	310,000	13	87
BELGIUM	221,000	6	94
INDIA	132,000	3	97
CHINA	122,000	6	94
POLAND	112,000	14	86
NICARAGUA	72,000	18	82
MALTA	16,000	100	0

HOW MUCH WATER IS USED BY US ?

- **MORE THAN 99 % OF THE EARTH'S WATER IN ITS NATURAL STATE IS UNAVAILABLE OR UNAVITABLE FOR HUMAN USE**

- **THUS, THE AMOUNT OF WATER FOR ALL THE PEOPLE, PLANTS AND ANIMALS COMPETE IS MUCH LESS THAN 1 % OF THE TOTAL**

- **ON AN AVERAGE, OUR SOCIETY USES ALMOST 100 GALLONS OF DRINKING WATER PER PERSON PER DAY**

- **IN INDIA, ABOUT 10 % OF THE TOTAL SURFACE WATER IS POLLUTED LEADING TO A FURTHER REDUCTION IN THE PERCENTAGE OF WATER AVAILABE FOR HUMAN CONSUMPTION**

WHERE DOES WATER COME FROM ?

WATER SOURCES CAN BROADLY BE CLASSSIFIED INTO TWO TYPES :

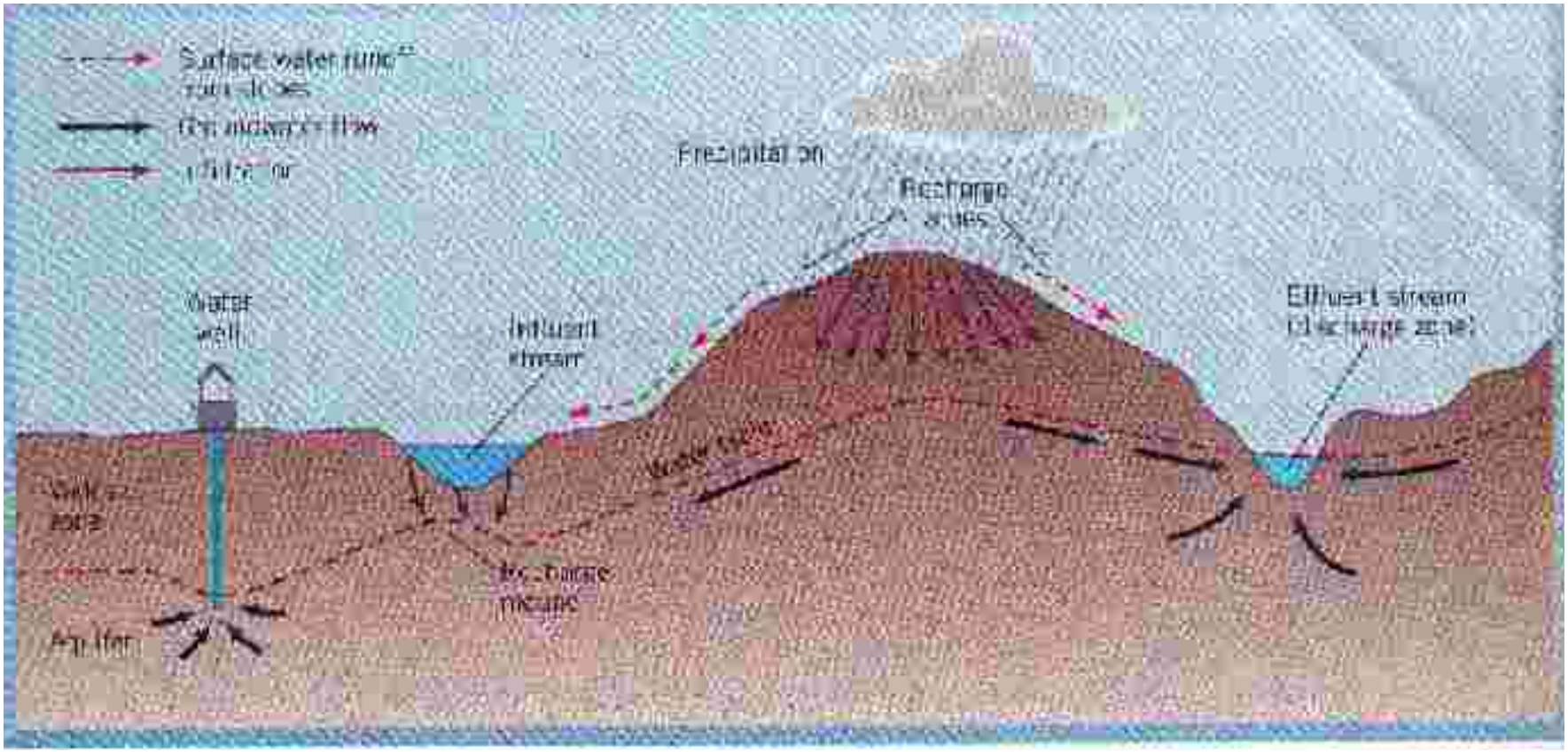
SURFACE WATER

- A GENERAL TERM DESCRIBING ANY WATER BODY WHICH IS FOUND FLOWING OR STANDING ON THE SURFACE, SUCH AS STREAMS, RIVERS, PONDS, LAKES AND RESERVOIRS

GROUND WATER

- IT IS IN THE FORM OF AQUIFERS (NATURAL GEOLOGICAL FORMATIONS - UNDERGROUND WATER BEARING LAYERS OF POROUS ROCKS THROUGH WHICH WATER CAN FLOW AFTER IT HAS PASSED DOWNWARD THROUGH THE UPPER LAYERS OF SOIL)

GROUND WATER AND SURFACE WATER FLOW SYSTEM



WHERE DOES THE WATER GO ?

WATER RESOURCE PROBLEMS FALL INTO THREE CATEGORIES:

- **TOO MUCH WATER**
- **TOO LITTLE WATER**
- **POOR QUALITY / CONTAMINATION**

- **(ALL THE ABOVE CATEGORIES ARE A DIRECT OUTCOME OF HUMAN ACTIVITIES WHICH OFTEN QUOTE DISASTER)**

WATER IS UTILIZED PRIMARILY FOR THREE MAJOR ACTIVITIES

INDUSTRIAL **DOMESTIC** **AGRICULTURAL**

- **WATER INDEPENDENT OF THE SOURCE WHEN UTILIZED FOR THE ABOVE SAID ACTIVITIES, RESULTS IN WATER CONTAMINATION / POLLUTION WHICH IS A MAJOR ISSUE IN TODAY'S CONTEXT**

POLLUTION

- **THERE ARE A NUMBER OF DEFINITIONS OF POLLUTION BY DIFFERENT AGENCIES**

- **THE UK SUSTAINABLE DEVELOPMENT STRATEGY (DOE, 1995) DEFINES IT AS A SUBSTANCE WHICH IS PRESENT AT CONCENTRATIONS WHICH CAUSE HARM OR EXCEED AN ENVIRONMENTAL STANDARD**

- **POLLUTION MAY ALSO BE REFERRED AS ANY CHANGE IN THE ENVIRONMENT DUE TO HUMAN ACTIVITIES**

- **ACCORDING TO THE 1996 EU DIRECTIVE ON INTEGRATED POLLUTION PREVENTION & CONTROL, POLLUTION CAN BE DEFINED AS "ANY DIRECT OR INDIRECT INTRODUCTION AS A RESULT OF HUMAN ACTIVITY, OF SUBSTANCES, VIBRATION, ETC. WHICH MAY BE HARMFUL TO THE QUALITY OF ENVIRONMENT"**

WHERE DOES POLLUTION COMES FROM ?

ALTHOUGH NATURAL SOURCES OF POLLUTION ARE SOMETIMES OF LOCAL CONCERN, POLLUTION CAUSED BY HUMAN ACTIVITIES IS MORE WIDESPREAD

SOURCES OF WATER POLLUTION CAN BE CATEGORISED INTO TWO MAJOR TYPES:

POINT SOURCE POLLUTION

- POLLUTION THAT ENTERS THROUGH PIPES, SEWERS OR DITCHES FROM SPECIFIC SITES SUCH AS FACTORIES OR SEWAGE TREATMENT PLANTS
- eg. THE EXXON VALDEZ OIL SPILL IN 1989

NON POINT SOURCE POLLUTION

- ALSO CALLED POLLUTED RUN-OFF CAUSED BY LAND POLLUTANTS THAT ENTERS BODIES OF WATER OVER LARGE AREAS RATHER THAN AT SINGLE POINT
- eg. AGRICULTURAL RUNOFF
- MINING WASTES
- MUNICIPAL WASTES
- CONSTRUCTION SEDIMENTS

NON-POINT SOURCES POLLUTION ACCOUNTS FOR MAJORITY OF THE CONTAMINANTS IN STREAMS AND LAKES

WATER CONTAMINANTS - SOURCES AN EXHAUSTIVE SURVEY

RESOURCE BASED

- **NITRATES**
- **PESTICIDES**
- **INDUSTRIAL SOLVENTS**
- **ODOUR AND TASTE**
- **IRON AND MANGANESE**
- **HARDNESS**
- **PATHOGENS**
- **ALGAL TOXINS**
- **RADIOACTIVITY**

WATER TREATMENT BASED

- **ALUMINIUM**
- **DISCOLORATION**
- **CHLORINE**
- **ODOUR AND TASTE**
- **IRON**
- **TRIHALOMETHANES**
- **FLUORIDE**
- **PATHOGENS**
- **NITRITE**

DISTRIBUTION SYSTEM BASED

- **SEDIMENT**
- **DISCOLOURATION**
- **ASBESTOS**
- **ODOUR AND TASTE**
- **IRON**
- **PAH**
- **ANIMAL AND BIOFILMS**
- **PATHOGEN**

HOME PLUMBING SYSTEM

- **LEAD, COPPER, ZINC, ODOUR AND TASTE, FIBRES**
- **CORROSION**
- **PATHOGENS**

WHAT ARE THE CATEGORIES OF WATER POLLUTION ?

- **THERMAL POLLUTION**
- **SEDIMENT POLLUTION**
- **INORGANIC CHEMICAL POLLUTION**
- **DEAD ORGANIC MATTER**
- **RADIOACTIVE SUBSTANCE**
- **INORGANIC PLANT OR ALGAL NUTRIENTS**
- **ORGANIC CHEMICALS / COMPOUNDS**
- **SEWAGE POLLUTION**

INORGANIC CHEMICAL POLLUTION :

- SULFURIC ACID (H_2SO_4) FROM COAL AND SOME METAL MINES; INDUSTRIAL PROCESSES THAT DISPOSE OF ACIDS IMPROPERLY
- RESULTS IN ACID MINE DRAINAGE, DAMAGING ECOSYSTEMS AND SPOILING WATER RESOURCES
- LEAD AND MERCURY CAN CAUSE VARIOUS HUMAN DISEASES AND RENDER WATER UNSUITABLE FOR USE

DEAD ORGANIC MATTER :

- RAW SEWAGE, AGRICULTURAL WASTES, URBAN GARBAGE CAUSE BIOCHEMICAL OXYGEN DEMAND AND VARIOUS DISEASES

RADIOACTIVITY :

- CONTAMINATION BY NUCLEAR POWER PLANT, MILITARY AND NATURAL SOURCES
- OFTEN RELATED TO STORAGE OF RADIOACTIVITY WASTES

INORGANIC PLANT OR ALGAL NUTRIENTS :

MAJOR CAUSE OF ARTIFICIAL EUTROPHICATION

PHOSPHORUS AND NITROGEN FROM AGRICULTURAL AND URBAN LAND USE (FERTILIZERS) AND WASTE WATERS FROM SEWAGE TREATMENT

NITRATES CAN CAUSE POLLUTION AND DAMAGE TO ECOSYSTEM AND PEOPLE

ORGANIC CHEMICALS/COUMPOUNDS :

- SYNTHETIC CHEMICALS THAT ARE PRODUCED BY HUMAN ACTIVITIES INCLUDE PESTICIDES, SOLVENTS, INDUSTRIAL CHEMICALS AND PLASTICS

SOME EXAMPLES :

NAME OF COMPOUND	SOME REPORTED HEALTH EFFECTS
ALDICARB (PESTICIDE)	ATTACKS NERVOUS SYSTEM
CARBON TETRA CHLORIDE (SOLVENT)	CANCER, LIVER DAMAGE, MAY ALSO ATTACK KIDNEYS AND VISION
POLYCHLORINATED BIPHYNYLS (PCBS)(INDUSTRIAL CHEMICALS)	ATTACK LIVER AND KIDNEYS, MAY CAUSE CANCER
VINYL CHLORIDE (PLASTIC INDUSTRY)	CANCER

INDUSTRIAL GROWTH AND ENVIRONMENT

In pursuit of a better life, industrialization is growing day by day leaving behind the pollutants in our environment.

Environmental pollution is an inevitable consequence of economic development and people's desire to improve their quality of life.

These pollutants can undermine our health in various ways

- *contributing to cancer*
- *birth defects or by damaging the immune system*
- *other health risks*

17 RED CATEGORY INDUSTRIES

- Distillery including Fermentation industry
- Fertiliser
- Dyes and Dye Intermediates
- Petrochemicals
- Sugar
- Pulp & Paper
- Pharmaceuticals
- Fertilisers and Pesticides
- Tanneries
- Thermal Power Plants
- Organic solvent, chlorinated minerals
- Heavy and large industries
- Inorganic chemical industries
- Oil Refinery
- Phenols and related industries based on coalta distillation
- Iron & Steel
- Copper Smelter

CHEMICAL NAME	PUBCHEM CHEMICAL ID	MW
ACIFLUORFEN	44072	383.639
ACRYLONITRILE	6342	71.0779
AMETRYN	3263	227.331
ANTHRACENE	8418	8418
ATRAZINE	2256	215.683
BENZOPERYLENE	9117	276.331
BIPHENYL	7095	154.208
DIBENZOFURAN	568	168.191
DIBUTYLTHALAMATE	3026	278.343
DICHLORVOS	3039	3039
FOMESAFEN	51556	438.764
LINURON	9502	249.093
MALATHION	4004	330.36
MECOPROP	85445	214
METHXONE	7153	214.645
BUTYLPHOSPHOROTRITHIOATE	9011	298.515
CAPTAN	8606	300.589
CARBARYL	6129	201.221
CARBOFURAN	2566	221.252
CUPFERRON	8665	138.124

POLLUTANT	RELATED DISEASES
Pesticides	Damage the nervous system and can cause cancer
Excess Fluoride	Can cause yellowing of the teeth and damage to the spinal cord and other crippling diseases
Nitrates	Blue baby' syndrome
Dioxins (2,3,7,8-tetrachlorodibenzo-p-dioxin)	Ability to cause birth defects (teratogenicity)
Petrochemicals	Can cause cancer even at low exposure levels.
Arsenic	Can cause liver and nervous system damage, vascular diseases and also skin cancer.
Some chemicals found in paints, dyes, cosmetics and detergents	Dermatitis(rashes and blisters)
1-methyl-4-phenyl-1,2,5,6-tetrahydropyridine (MPTP), a compound with structural similarities to some herbicides and pesticides.	Parkinsonism
Isoquinolines (IsoQ) and two classes of pesticides, an organochlorine and a dithiocarbamate	Mitochondrial dysfunction in the dopaminergic neurons of the substantia nigra

TASTE AND ODOUR

- CATEGORIZED ACCORDING TO THE ORIGIN OF THE SUBSTANCE CAUSING THE PROBLEM
- SUCH SUBSTANCES CAN BE PRESENT EITHER IN RAW WATER, BE ADDED / CREATED DURING WATER TREATMENT; ARISE WITHIN THE DISTRIBUTION SYSTEM OR ARISE WITHIN THE PLUMBING SYSTEM
- FOUL TASTE AND ODOUR IN WATER RENDER IT AESTHETICALLY UNPALATABLE

IRON AND MANGANESE

- FOUND IN LARGE AMOUNTS IN SOIL AND ROCKS IN INSOLUBLE FORM
- DUE TO COMPLEX REACTIONS OCCURING NATURALLY, THEY ARE SOLUBILIZED AND ENTER THE WATER RESOURCES, LEADING TO THEIR CONTAMINATION
- HIGH CONCENTRATION OF IRON CAUSES DOMESTIC PROBLEMS LIKE STAINING OF LAUNDRY AND DISCOLORATION OF VEGETABLES
- HIGH CONCENTRATION OF MANGANESE INDUCES NEUROLOGICAL DISORDERS

NITRATES

- FINDS ITS WAY INTO WATER RESOURCES EITHER BY LEACHING INTO AQUIFERS OR AS RUN-OFF INTO SURFACE WATERS FROM AGRICULTURAL LAND
- THE MAIN CONCERN IN POTABLE SUPPLIES IS METHAEMOGLOBINEMIA OR BLUE-BABY SYNDROME IN INFANTS

ORGANIC COMPOUNDS

- CAN BE NATURALLY OCCURRING OR SYNTHETIC, SUCH AS PESTICIDES AND INDUSTRIAL SOLVENTS
- NEARLY ALL ORGANIC COUMPOUNDS FOUND IN DRINKING WATER ARE TOXIC AND CARCINOGENIC, EVEN AT VERY LOW CONCENTRATIONS

CHLORINE AND CHLORINATED ORGANIC COUMPOUNDS:

- CHLORINE AND CHLORAMINES HAVE DISTINCTIVE ODOUR WHICH IS RESPONSIBLE FOR MOST REPORTED ODOUR AND TASTE PROBLEM IN DRINKING WATER
- MONO OR DI-CHLOROPHENOLS WHICH ARE FORMED WHEN PHENOLIC COUMPOUNDS REACT WITH CHLORINE, IMPART A STRONG MEDICINAL ODOUR TO DRINKING WATER
- TRIHALOMETHANES ARE KNOWN TO BE CARCINOGENIC

FLUORIDE

- PRESENT NATURALLY IN WATER
- EXCESS FLUORIDE CAUSES TEETH TO BECOME DISCOLORED (FLUOROSIS) AND LONG - TERM EXPOSURE RESULTS IN PERMANENT GREY TO BLACK DISCOLORATION OF THE ENAMEL. OTHER EFFECTS INCLUDE MILD GASTROENTERITIS AND POSSIBLE SKIN IRRITATION

POLYCYCLIC AROMATIC HYDRO CARBONS (PAH)

- GENERALLY NOT VERY SOLUBLE BUT ARE READILY ADSORBED INTO PARTICULATE MATTER RESULTING IN HIGH CONCENTRATIONS WHERE SUSPENDED SOLIDS ARE PRESENT IN WATER
- THEY ARE CARCINOGENIC, CAN CAUSE GASTROINTESTINAL AND OESOPHAGEAL TUMOURS

ANIMALS AND BIOFILM

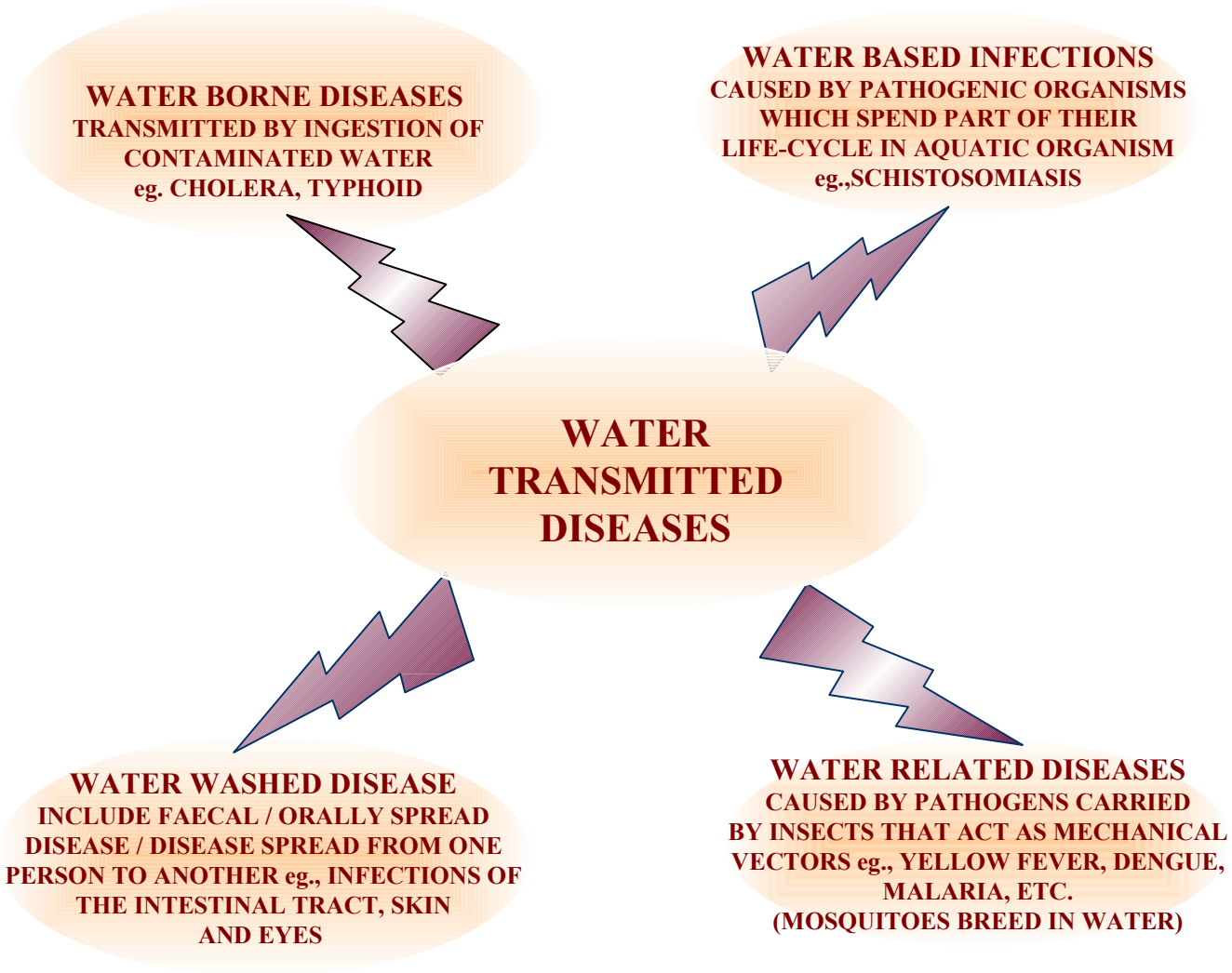
- BACTERIA AND FUNGI ARE COMMON IN WATER AND FOUND AS BIOFILMS AND SLIME GROWTHS
- THEIR PRESENCE CAUSES CORROSION OF PIPES, ALTERS CHEMICAL NATURE OF WATER, REDUCES DISSOLVED OXYGEN LEVELS AND ALSO ODOUR AND TASTE PROBLEMS

CORROSION

- INVOLVES ELECTRO CHEMISTRY ie., ANODE AND CATHODE (THE PIPE) AND THE CONDUCTING SOLUTION (THE WATER)
- CORROSION OF PIPES LEADS TO CHANGES IN THE ORGANOLEPTIC QUALITY OF WATER RENDERING IT UNPALATABLE
- THE PROBLEM CAN BE CIRCUMVENTED BY USING PLASTIC / PVC PIPES

PATHOGEN AND THE MICROBIAL QUALITY OF DRINKING WATER

MICROBIAL CONTAMINATION IS THE MOST CRITICAL RISK FACTOR IN DRINKING WATER QUALITY



MAJOR WATER BORNE DISEASES

GROUP	PATHOGEN	DISEASE
VIRUSES	*ENTEROVIRUS (POLIO, ECHO, COXSACKIE)*	MENINGITIS, PARALYSIS, RASH, FEVER, RESPIRATORY DISEASES
	HEPATITIS A & E	HEPATITIS
	ADENOVIRUS	DIARRHEA, EYE INFECTIONS, RESPIRATORY DISEASES
BACTERIA	*VIBRIO CHOLERAE*	CHOLERA
	SHIGELLA	SHIGELLOSIS
	YERSINIA ENTEROCOLITICA	DIARRHEA
PROTOZOA	*ENTAMOEBA HISTOLITICA*	AMOEBIC DYSENTARY
	NAEGLERIA	MENINGO-ENCEPHALITIS
	CRYPTOSPORIDIUM	
BLUE GREEN ALGAE	*MICROCYSTIS*	DIARRHEA,
	ANABENA	POSSIBLE PRODUCTION OF CARCINOGENS
	APHANITOMENOM	
HELMINTHS	*ASCARIS LUMBRICOIDS*	DIARRHEA, POSSIBLE PRODUCTION CARCINOGEN
	TAENIA SOLIUM	
	SCHISTOSOMA MANSONI	

- Increasing demands on water resources for domestic, commercial, industrial, and agricultural purposes have made water **reclamation and reuse** an attractive option for conserving and extending available water supplies.

WATER REUSE DRIVERS

- **Increasing water demands** to sustain industrial and population growth.
- **Water scarcity and droughts,** particularly in arid and semi-arid regions.
- **Environmental protection and enhancement** in combination with **wastewater management needs** represent an emerging driver, in a number of industrialized countries, coastal areas, and tourist regions.
- **Socio-economic factors** such as new regulations, health concerns, public policies, and economic incentives are becoming increasingly important to the implementation of water reuse projects.
- **Public health protection** is the major driver in developing countries where lack of access to fresh water supplies coupled with high market access in urban and peri-urban areas, drives untreated reuse in agriculture. Public health protection and environmental risk mitigation are key components of any reuse program under these conditions.

Population growth, urbanization, and industrial development, contribute to water shortages by perpetually pushing up demand. In addition, these same factors increase water pollution, add to potable water treatment costs, and most likely, have adverse health effects

Water recycling is a critical element for managing our water resources. Through water conservation and water recycling, environmental needs can be met and we can still have sustainable development as well as a viable economy

SOURCE OF WATER THAT CAN BE REUSED

- Grey water Systems
- Agricultural Industrial Process Water
- Industrial Reuse Water

"Greywater" is wastewater having the consistency and strength of residential domestic wastewater. Greywater includes wastewater from sinks, showers and laundry fixtures but does not include toilet or urinal waters. Greywater use is administered by the Department of Health.

WHAT IS RECLAIMED WATER?

"Reclaimed water" is defined as effluent derived in any part from sewage that has been adequately and reliably treated to a high quality so that it is suitable for beneficial uses. Reclaimed water is no longer considered a wastewater. All reclaimed water must meet the Water Reclamation and Reuse Standards established by the state Departments of Health and Ecology. The standards have stringent requirements to assure adequate treatment and pathogen removal.

CLASSES OF RECLAIMED WATER

Four basic classes of reclaimed water A, B, C and D

All classes use an oxidized wastewater – a minimum of secondary treatment All require a high level of disinfection

Class A requires advanced treatment and allows the most uses.

Classes B, C and D are of a lesser quality and have more restrictions on use depending on the potential for human contact.

GOALS:

Encourage and facilitate reclaimed water use

Provide new basic water supplies to meet future water needs

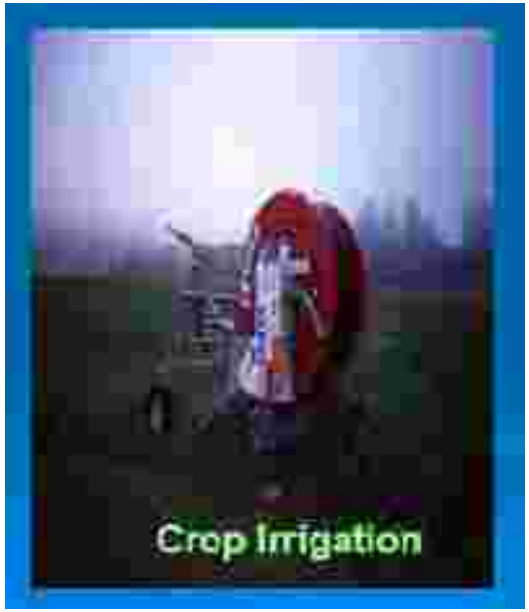
Protect public health and safety

Protect and enhance our environment

Gain public confidence and support in reclaimed water

Find cost-effective solutions

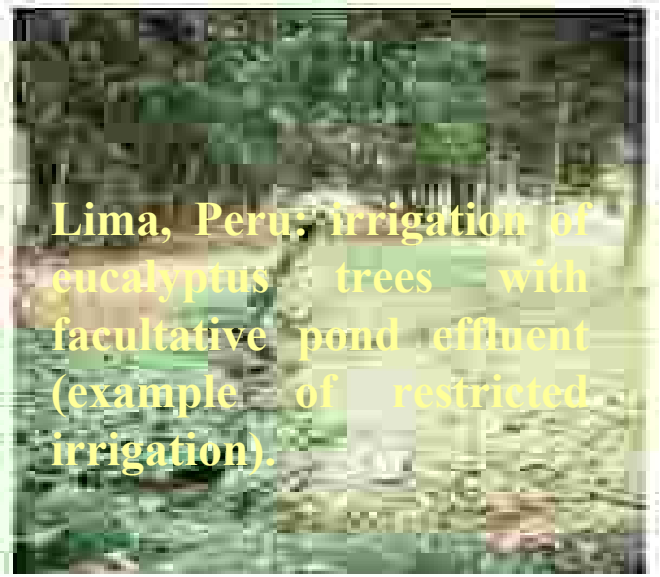
TYPICAL USES -



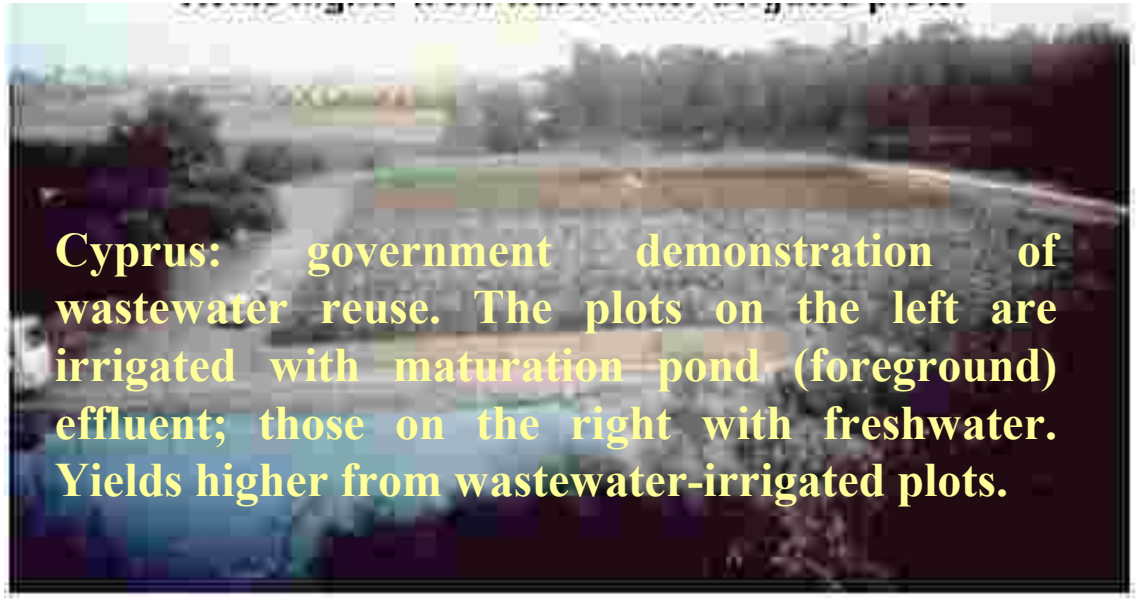
AGRICULTURAL REUSE

Greening of the Saudi Arabian desert as a result of crop irrigation with treated wastewater.

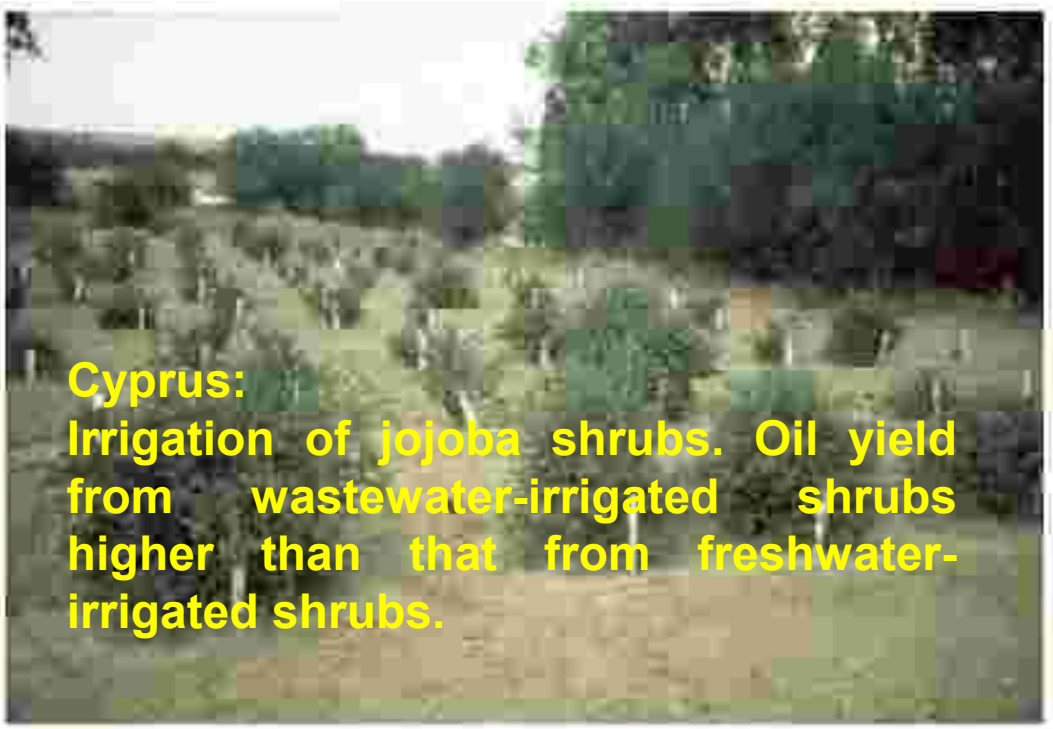
Lima, Peru: crop irrigation with maturation pond effluent (see channel bottom right) – actually effluent from 4thmaturation pond: so an example of unrestricted irrigation.



Lima, Peru: irrigation of eucalyptus trees with facultative pond effluent (example of restricted irrigation).

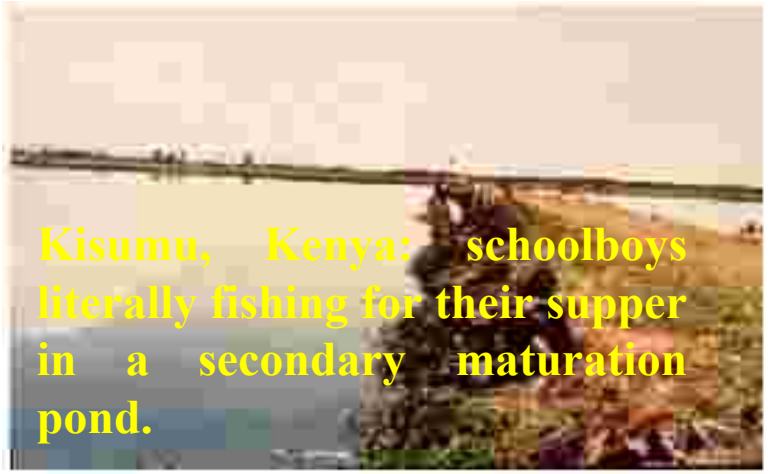


Cyprus: government demonstration of wastewater reuse. The plots on the left are irrigated with maturation pond (foreground) effluent; those on the right with freshwater. Yields higher from wastewater-irrigated plots.

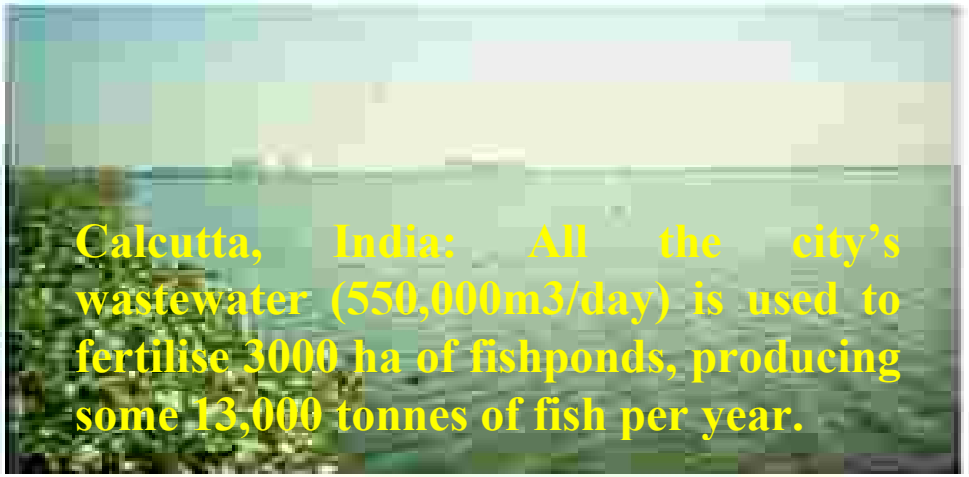

Cyprus:
Irrigation of jojoba shrubs. Oil yield from wastewater-irrigated shrubs higher than that from freshwater-irrigated shrubs.


Yorkshire, England. A farmer is pumping maturation pond effluent…

AQUACULTURAL REUSE

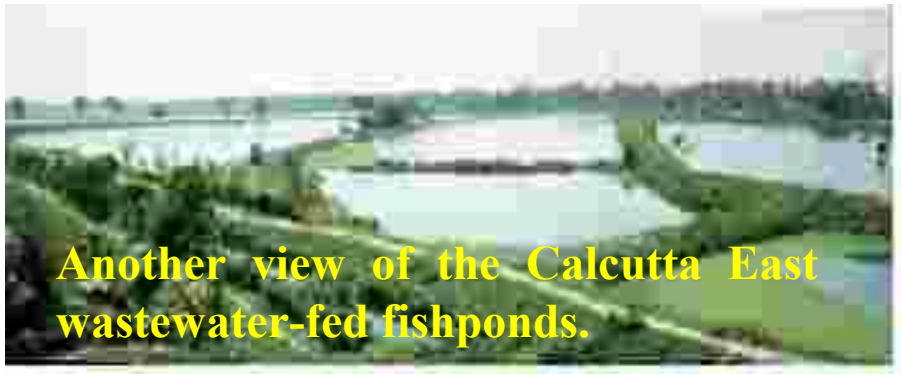


Kisumu, Kenya: schoolboys literally fishing for their supper in a secondary maturation pond.



Calcutta, India: All the city's wastewater (550,000m3/day) is used to fertilise 3000 ha of fishponds, producing some 13,000 tonnes of fish per year.

Fishing at the Calcutta East fishponds.



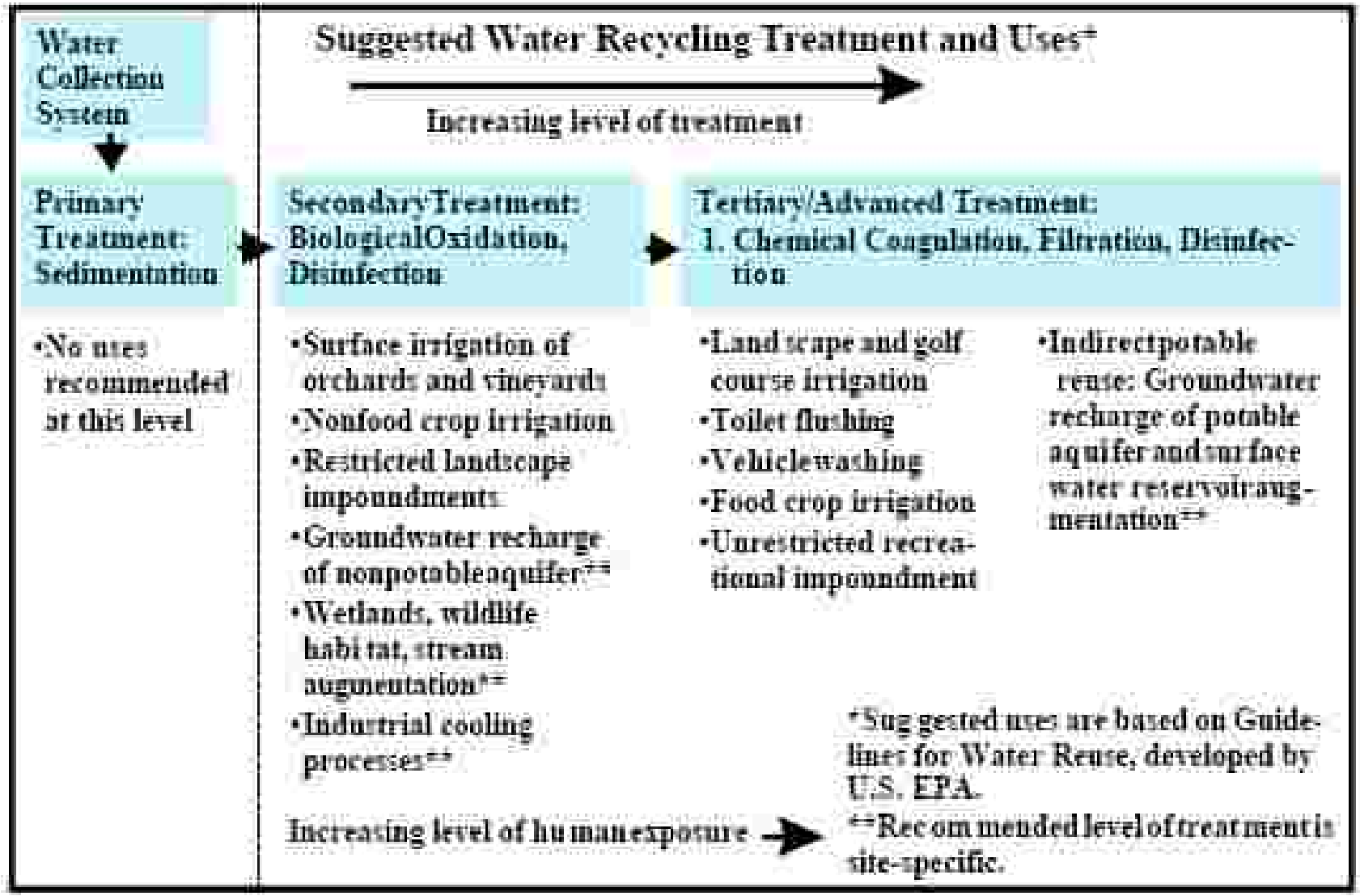
Another view of the Calcutta East wastewater-fed fishponds.

Ditto: local women taking fish to market. They also irrigate some crops with water taken from the fishponds.

Ditto: the fish are mainly Indian major carp, with some tilapia. The carp arecatla(Catla catla),mrigal(Cirrhina mrigala) androhu(Labeo rohita).

Ditto: sludge removal from a fishpond.

HOW CAN RECYCLED WATER BENEFIT US?



WATER RECYCLING AND REUSE: THE ENVIRONMENTAL BENEFITS

WHAT ARE THE ENVIRONMENTAL BENEFITS OF WATER RECYCLING?

Water recycling can decrease diversion of freshwater from sensitive ecosystems.

Water recycling decreases discharge to sensitive water bodies.

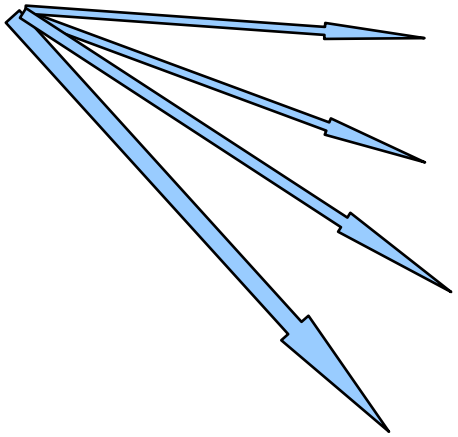
Recycled water may be used to create or enhance wet lands and riparian (stream) habitats.

Water recycling can reduce and prevent pollution.

Although a number of technologies are available to prevent pollution

These are conventional technologies based on chemical or thermal processes which often employ the use of high temperatures, extreme pH and organic solvents.

Other disadvantages are :



uneconomical

further pollute the environment

technologically retarded

increase in mass of waste generated

ENVIRONMENTAL BIOTECHNOLOGY

Biotechnology is a useful tool that is delivering improved products and processes for the environmental sustainability. Biotechnology promises a range of benefits to manage the industrial waste water economically and effectively around the world.

Environmental Biotechnology is the multidisciplinary integration of sciences and engineering in order to utilize the huge biochemical potential of microorganisms, plants and parts thereof for the restoration and preservation of the environment and for the sustainable use of resources.

Cleaning of environment through nature's scavengers

- **Environmental Biotechnology** employs a diverse set of methodological approaches to explore and exploit the natural bio diversity of microorganisms and their enormous metabolic capacities

- The **field includes the application of microorganisms** for
  - improvement of environmental quality
  - discovery of microorganisms with metabolic potentials that can be employed for industrial applications
  - use of molecular methods for assessing the natural distribution of microbes in the environment and the ecological function they perform

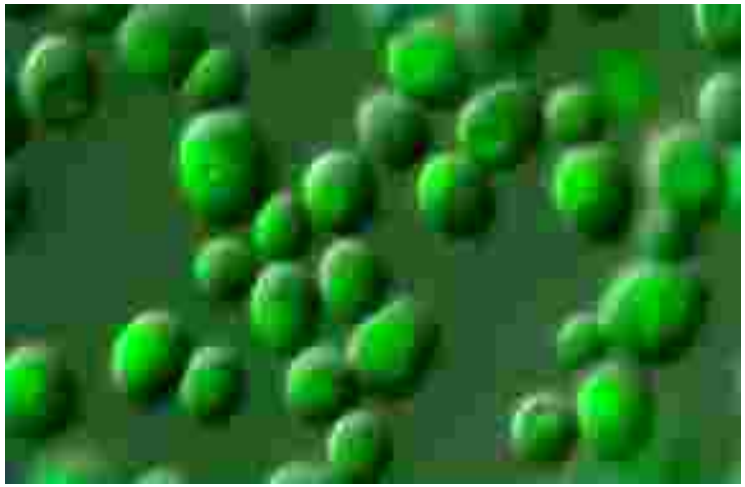
NECESSITY OF THE DIFFERENCE :

- Concern about the environmental impact of genetically engineered microorganisms has greatly constrained the possibility of deliberately releasing recombinant microbes for environmental remediation
- Using such recombinant microorganisms may be possible within contained bioreactors but, their broader environmental applications will depend upon new understanding of ecological functions and risk assessments related to population of introduced organisms

- Technological advancements in the environmental biotechnology sector are concerned with the **industrial processing of materials by microorganisms to provide desirable products or serve other useful purposes.**

- It forms part of biotechnology, which emphasizes the application of biological systems to the manufacturing and service industries or the **use of biological processes within the framework of technical operations and industrial production.**

…Environmental Biotechnology



The use of living microbes to transform undesirable and harmful substances into non-toxic compounds.

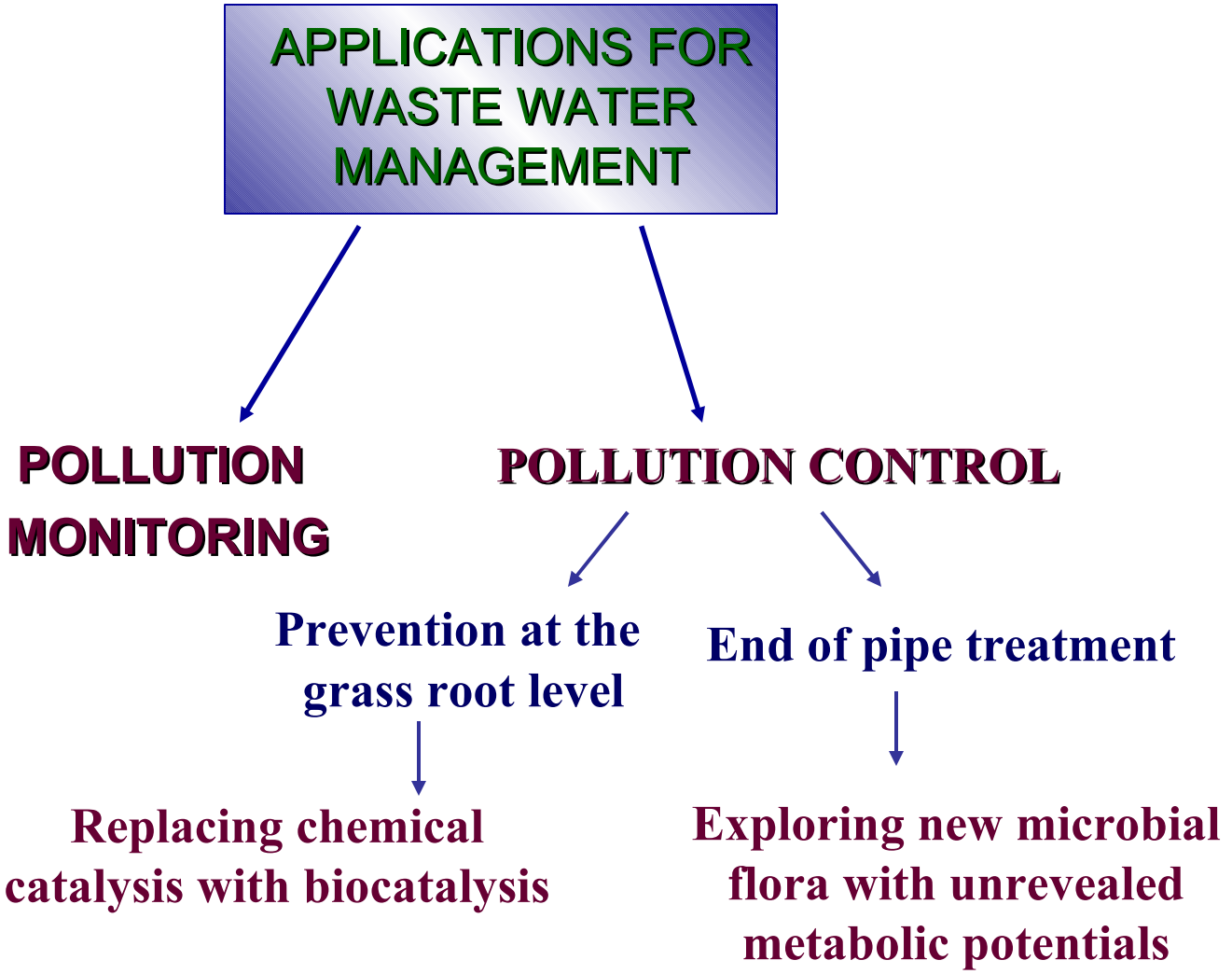
The husbandry and management of naturally-occurring microbes to degrade target pollutants for the purpose of restoring contaminated environment.

Environmental biotechnology offers the private sector remarkable new tools for pollution prevention that have not been widely available before now.

These new tools not only prevent pollution but can also significantly cut energy demand, natural resource consumption, and production costs while creating high-quality intermediates or consumer products.

Accelerated uptake of new industrial biotechnology processes could lead to further pollution prevention, waste reduction, and energy cost savings in related services such as waste disposal or energy production.

ENVIRONMENTAL BIOTECHNOLOGY



HOW CAN WE MONITOR THE WATER QUALITY ?

WATER CAN BE MONITORED BY

BIOLOGICAL MEANS

- BIOLOGICAL OXYGEN DEMAND (BOD)
- PATHOGENS

CHEMICAL MEANS

- CHEMICAL OXYGEN DEMAND (COD)
- pH
- ALKALINITY
- TOTAL SUSPENDED SOLIDS (TSS)
- TOTAL ORGANIC CARBON (TOC)
- OIL AND GREASE

MONITORING PATHOGENS

HETEROTROPHIC PLATE COUNT

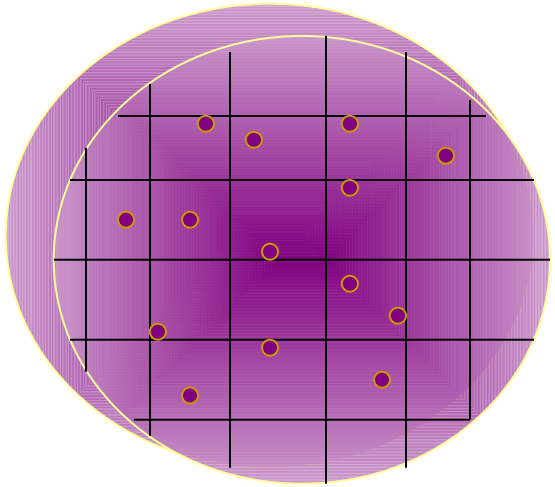
- REPRESENTS THE AEROBIC AND FACULTATIVELY ANAEROBIC BACTERIA PRESENT IN WATER
- NOT A DIRECT INDICATOR OF FAECAL CONTAMINATION BUT DO INDICATE VARIATION IN WATER QUALITY
- THIS VALUE MAINLY INDICATES THE EFFICIENCY OF VARIOUS WATER TREATMENT PROCESSES

MULTIPLE TUBE METHOD

- REPRESENTS THE MOST PROBABLE NUMBER (MPN) OF COLIFORMS PRESENT IN A WATER SAMPLE
- IT IS CALCULATED WITH REFERENCE TO PROBABILITY TABLES

MEMBRANE FILTRATION

- WIDELY USED METHOD FOR ALL COLIFORM TESTING
- TAKES SHORTER TIME, IS SIMPLER, ECONOMIC
- LARGE SAMPLE VOLUMES CAN BE PROCESSED IN SITU



MEMBRANE FILTRATION METHOD

MONITORING PATHOGENS

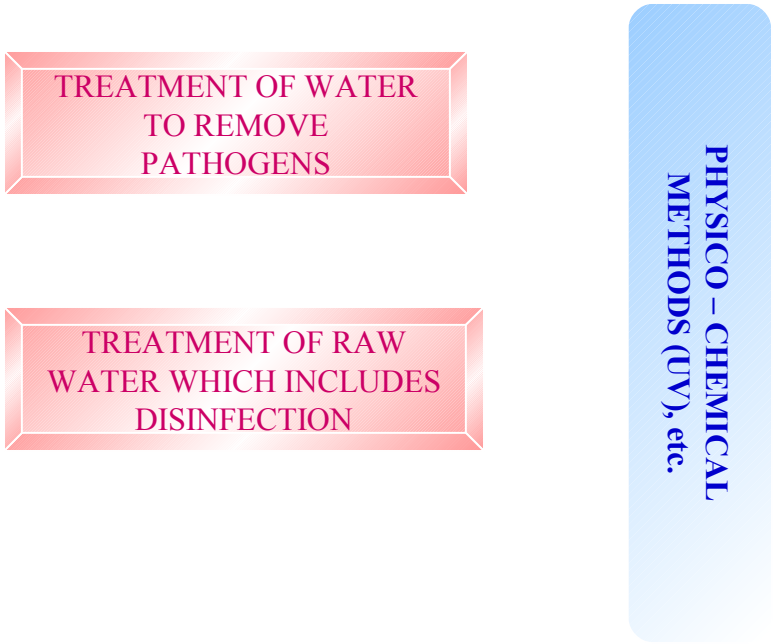
EMERGING TECHNIQUES

- **THESE TECHNIQUES ARE BASED ON COMPLEX BIOCHEMICAL TECHNIQUES SUCH AS ENZYME DETECTION, HYBRIDIZATION, POLYMERASE CHAIN REACTION, GENE PROBE TECHNOLOGY AND MONOCLONAL ANTIBODY METHOD**

- **ALLOW EVEN SINGLE BACTERIAL CELLS PRESENT IN THE WATER SAMPLES TO BE DETECTED**

WHAT ARE THE STRATEGIES FOR CONTROLLING PATHOGEN TRANSFER ?

- **A BARRIER APPROACH IS THE KEY STRATEGY FOR CONTROLLING THE HEALTH RISKS POSED BY MICROBES IN DRINKING WATER**



STRATEGIES FOR CONTROLLING PATHOGEN TRANSFER

SOURCE	FAECAL COLIFORMS (FC)
HUMAN FEACAL COLIFORM DISCHARGES	1,950,000,000 FC/PERSON/DAY
	FAECAL COLIFORMS / 100 ML
	8,260,000 FC CELLS/100 ML
MUNICIPAL RAW SEWAGE	
SEWAGE TREATMENT REDUCTIONS	

	CUMULATIVE REDUCTION (%)	FC SURVIVING
PRIMAR	50	4 130 000
SECONDARY	80	1 652 000
TERTIARY	98	165 200
DISINFECTION	99.99	800

SELF -PURIFICATION AND EFFLUENT DILUTION 10 -15 %

WATER SUPPLY TREATMENT

	CUMULATIVE REDUCTION (%)	FC SURVIVING
RAW WATER STORAGE	50	200 -350
COAGULATION - SEDIMENTATION	60	80 -140
FILTRATION	99.99	0.8 -1.4
DISINFECTION	99.9999	0.000 08 - 0.00014

- **TWO TYPES OF WATER TREATMENT DEVICES CAN BE INSTALLED**

  POINT-OF-USE (POU) → TREATING WATER AT A SINGLE TAP

  POINT OF ENTRY (POE) → TREATING WATER USED THROUGHOUT A HOUSE

- **SUCH DEVICES ARE BASED ON VARIOUS CONTAMINANT REMOVAL TECHNOLOGIES LIKE FILTRATION, ION-EXCHANGE, REVERSE OSMOSIS AND BOILING**

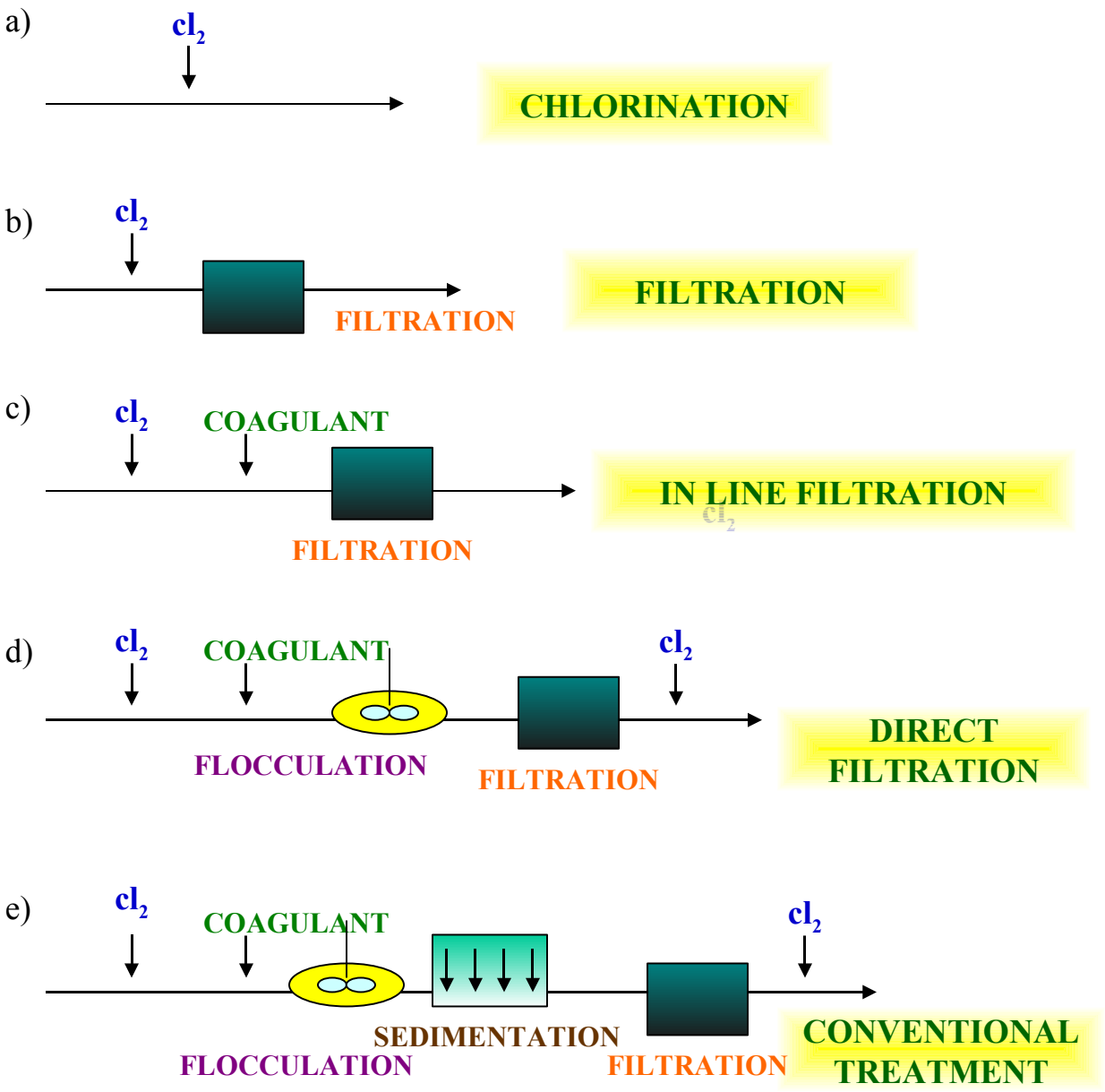
- **HOME FILTRATION UNITS USE ACTIVATED CARBON FILTERS, WHICH ADSORB ORGANIC CONTAMINANTS AND CONSTITUENTS**

- **ION-EXCHANGE UNITS CAN BE USED TO REMOVE MINERALS LIKE Ca^{2+} AND Mg^{2+} AS WELL AS ARSENATE AND FLUORIDE**

- **REVERSE OSMOSIS TREATMENT UNITS CAN REMOVE NITRATES, SODIUM, OTHER DISSOLVED INORGANICS AND ORGANIC COUMPOUNDS**

- **WE MAY ALSO CHOOSE TO BOIL OUR WATER TO REMOVE MICROBIAL CONTAMINATIONS, ALTHOUGH KEEPING IN MIND THAT BOILING MAY CONCENTRATE OTHER CONTAMINANTS**

TREATMENT PROCESS TRAIN



- **The discharge of oxygen consuming materials deplete the Dissolved Oxygen(DO) of receiving waters making it HYPOXIC**

- **Hypoxic aquatic environments pose a threat to aquatic flora/fauna and can even cause a shift in their populations**

- **On top of all, sufficient 'DO' is essential for the proper aeration of many waste-water treatment processes**

Therefore, 'DO' measurement is essential.

WHAT IS THE IMPORTANCE OF 'DO' MEASUREMENT ?

- The rate at which oxygen is used, is perhaps even more important than the determination of 'DO'
- A high rate of oxygen uptake implies a high oxygen demanding waste
- Whereas, a low rate of oxygen use would indicate:
  - either clean water
  - lack of interest of available microorganisms to consume the organic material
  - death/ decay of microorganisms

BIOCHEMICAL OXYGEN DEMAND(BOD):
THE RATE OF OXYGEN USE

- BOD represents the amount of O_2 consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions at a specified temperature (APHA, 1998)

- BOD is not a specific pollutant but rather a measure of the amount of O_2 required by bacteria and other microbes engaged in stabilizing decomposable organic matter

WHY ASSESS BOD ?

- **BOD IS ONE OF THE MOST IMPORTANT AND WIDELY USED PARAMETER FOR ASSESSING THE POLLUTIONAL STRENGTH OF WATER**

- **WHEN BOD IS TOO HIGH , THE DISSOLVED OXYGEN CONTENT OF THE WATER BECOMES TOO LOW TO SUPPORT ALL THE LIFE FORM IN THE WATER**

- **THE COUNCIL OF ENVIRONMENTAL QUALITY DEFINES THE THRESHOLD FOR WATER POLLUTION ALERT AS A D.O. CONTENT OF LESS THAN 5 mg / l OF WATER**

THE CONVENTIONAL BOD TEST : SOME INHERENT PROBLEMS

- It is a complex reaction requiring skilled technicians
- Use of non-standard/uniform seeding material
- Needs 3-5 days to arrive at a plausible conclusion
- Unsuitable for *in situ* and real time monitoring

Environmental bio-technologies developed at IGIB

Technologies

- BODSEED
- BODBEADS
- BIOSENSOR
- ALKANEUTRI
- BIOBLEACHING
- DECOLOURIZATION
- PHENOTREAT

PHENOTREAT

IMPORTANCE OF *SEEDING* IN BOD ANALYSIS

- ***Seeding is a process in which the microorganisms that oxidize the BOD are added to the BOD bottle***
- **Industrial waste-waters rarely contain a single compound and biodegradation of these compounds may not be affected by single microbe**
- ***Efficient biodegradation* can only be obtained by using a *mixture of microorganisms*, because collectively microbes exhibit unparalleled metabolic diversity and adaptability allowing them to survive in environments incompatible with large life forms**

- **Use of activated sludge/non-uniform microbial mixture as seeding material in BOD analysis leads to erroneous and non-reproducible results**

- **Reproducibility of BOD values can be obtained by formulating a defined microbial consortium containing a uniform microbial population**

BODSEED

- A formulated, synergistic, dehydrated uniform microbial consortium to be used as a reference seeding material in BOD analysis
- The product is ***first of it's kind in the Indian market***
- ***Launched in the market*** through M/s. Indo Bioactive Labs Ltd., Pune.
- *Patented in India*
- Use of synthetic seeding material in BOD analysis has been approved by BIS

BODSEED - Seeding for BOD analysis

A REVOLUTIONARY PRODUCT FOR MONITORING BOD

Developed by CBT, Delhi

Validated by CPCB, Delhi

Manufactured and marketed by

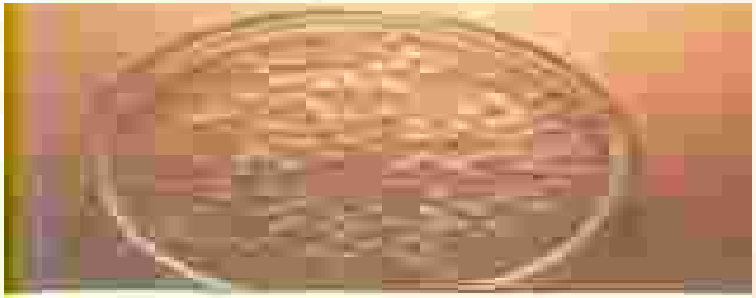
Indo Bioactive Labs (p) Ltd., Pune

E-mail : indobio@vsnl.com

BODBEADS

A CONVENIENT, INSTANT SEEDING MATERIAL FOR REPRODUCIBLE BOD ANALYSIS

- *EXCELLENT AGREEMENT WITH CONVENTIONAL METHOD*
- *SEEDING MATERIAL IN THE FORM OF REUSABLE BEADS*
- *UNIFORM MICROBIAL POPULATION, PROVIDES CONSISTENT RESULTS, THUS REDUCING POTENTIAL FOR ERROR*
- *CAN HANDLE A BROAD RANGE OF SUBSTRATES (SYNTHETIC & INDUSTRIAL EFFLUENTS) IN A CLEAN AND SAFE MANNER*
- *PRODUCT PATENTED IN US AND INDIA*



Developed by Centre For Biochemical Technology, Mall Road,, Delhi-110 007

Validated by Central Pollution Control Board, Parivesh Bhawan, East Arjun Nagar, Delhi -110 032

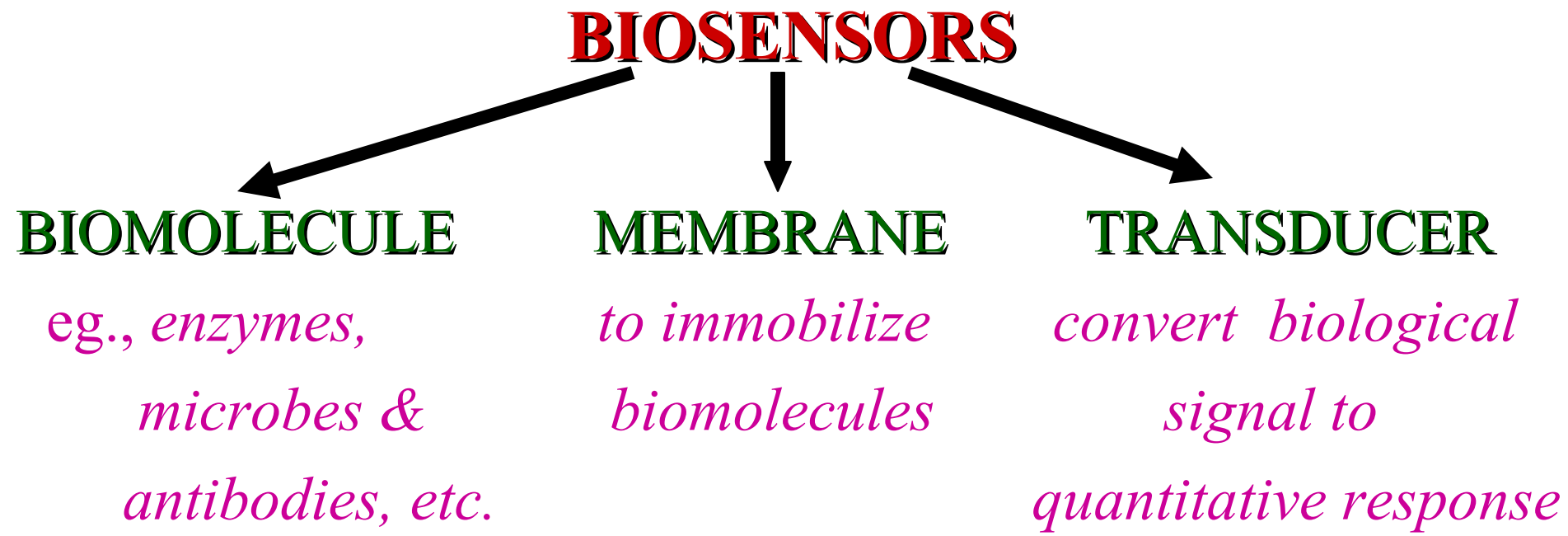
For more information , please contact:

The Director, Centre For Biochemical Technology, Mall Road, Delhi- 110 007

NEED FOR RAPID BOD MEASUREMENT

- The ***conventional BOD test*** requires 3-5 days thus, ***proving too slow*** to provide timely information to the operator for control purposes
- For better operation of treatment plants, we need to have ***rapid analytical methods such as BIOSENSORS***
- Biosensors have evolved by the concerted efforts of scientists and engineers trained in the traditional environmental disciplines, as well as by the diffusion of ideas from other fields

Biosensors are analytical devices sensitive to biological parameters



BOD BIOSENSOR DEVELOPED AT IGIB

Seeding material for the actual estimation of BOD load of Pulp and Paper industrial waste water

SEEDING MATERIAL IN BOD ANALYSIS

- A consortium of specific bacteria for determining the pollution load in pulp and paper effluents
- Confers complete accounting of pollution load in BOD analysis
- Exhibits BOD:COD ratio of 0.65-0.68 as against 0.36 exhibited using BODSEED / conventional seeding material
- BOD:COD ratio of 0.67 with the developed seed is almost equal to that exhibited by GGA (references solution)using the conventional seed i.e., 0.67

WHAT NEXT AFTER MONITORING ?

- **WATER MUST BE TREATED TO RENDER IT SUITABLE FOR DISCHARGE INTO WATER BODIES AS PER THE LIMITS SET BY POLLUTION CONTROL AUTHORITIES**

- **WATER TREATMENT IS DONE IN THREE MAJOR STEPS**

- **PRIMARY TREATMENT**

  PHYSICAL
  - **SCREENING**
  - **FILTRATION**
  - **SETTLING**

  CHEMICAL
  - **FLOCCULATION**

- **SECONDARY TREATMENT**
  - **BIOLOGICAL**

- **TERTIARY TREATMENT**
  - **PHYSICO-CHEMICAL METHODS INCLUDING COAGULATION, FILTRATION, ACTIVATED CARBON, ADSORPTION OF ORGANIC AND ADDITIONAL DISINFECTANTS**

ENVIRONMENTAL CONTROL

- **Besides the indispensable role of microorganisms in environmental monitoring, their potential for controlling waste-water pollution cannot be ignored**
- **Three basic strategies are adopted in combating industrial water pollution, viz., *Bioremediation*, *bioaugmentation* and *Biostimulation***

BIOREMEDIATION :

Exploits the metabolic capacities of microorganisms to remove pollutants from the environment

BIOSTIMULATION :

Relies on the natural activities of indigenous microorganisms combined with the use of environmental modifications, such as addition of mineral nutrients, to stimulate the rate at which microbes metabolize pollutants

BIOAUGMENTATION :

Involves the addition of cultures of microorganisms with specific pollutant degrading capabilities to a polluted site

- **The need of the day is to adopt Environmental Management Systems (EMS) so as to result in industry moving away from end-of-pie treatment to preventive strategies involving recycling, reuse and product substitution**
- **While the concept of zero discharge is widely embraced, in practice few industries have been successful in eliminating the production of all waste-waters requiring disposal after treatment**

WHAT IS WASTE-WATER TREATMENT ?

- A waste-water treatment process is a combination of separate treatment processes or units designed to produce an effluent of specified quality from a waste-water of known composition and flow rate
- Pre-treatment of industrial waste-waters is often necessary to prevent damage to sewers or the treatment processes employed. It can be done at source and is achieved mainly by flow balancing, neutralization and fat/oil suspension

METHODS FOR REMOVAL OF DISSOLVED INORGANICS & ORGANICS

- INORGANICS
  - Distillation
  - Membrane process
    - Electrodialysis
    - Ion exchange
    - Reverse osmosis
  - Filtration
    - Nanofiltration
    - Ultrafiltration
    - Microfiltration
- ORGANICS
  - Adsorption
    - Activated carbon (AC)
      - PAC (powered)
      - GAC (granulated)
    - Synthetic polymer
      - XAD
  - Oxidation
    - O_3
    - H_2O_2
    - O_2

Biotechnology can play a major role in pollution prevention, waste reduction, bioconversion and energy cost savings.

Examples:

Pulp and Paper Industry

Textile Industry

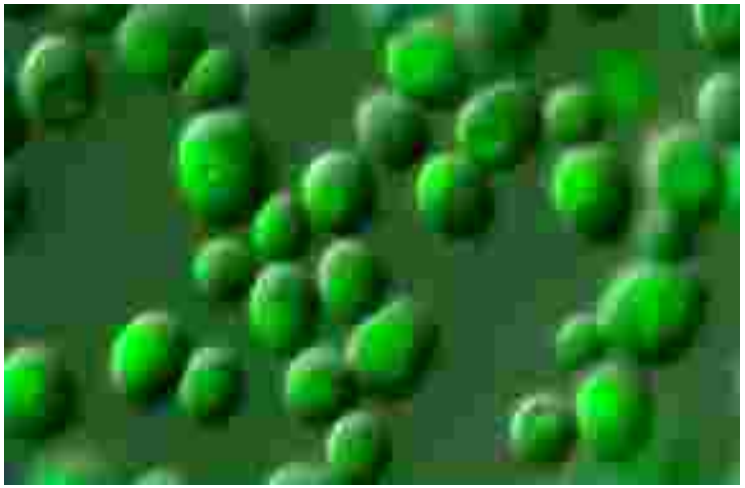
Beverage Industry

Starch Industry

Petrochemicals

REPLACEMENT OF INDUSTRIAL CHEMICAL PROCESSES WITH BIOTECHNOLOGICAL PROCESSES

Elimination of the problem before its generation

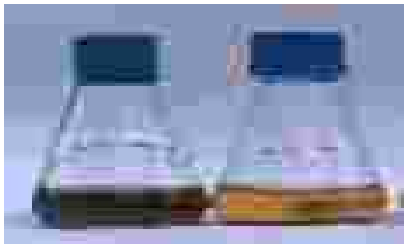


Biotechnology can play a major role in pollution prevention, waste reduction, bioconversion and energy cost savings in various industries.

BIOTECHNOLOGY IN PULP AND PAPER INDUSTRY

Biopulping uses enzymes to selectivity degrade lignin and to break down wood cell walls.

Biobleaching uses enzymes to bleach the pulp.



Biological decolourization uses bacteria or fungi.

BIOTECHNOLOGY IN TEXTILE

- Hydrogen peroxide used for bleaching textiles usually requires several rinsing cycles.
- New enzyme process -- only one high temperature rinse is needed to remove bleach residues.
- Reduced production costs
- Reduced energy consumption
- Reduced water consumption

- Neutralization and decolourization of waste water using bacteria

BIOTECHNOLOGY IN FOOD INDUSTRY

Enzymatic processing- Use of pectinases and amylases in food processing

Effluent treatment of waste water using potential microbes

Biological neutralization of waste water

BIOTECHNOLOGY IN STARCH INDUSTRY

Use of enzymes in starch processing

Biological removal of ammonia from waste water

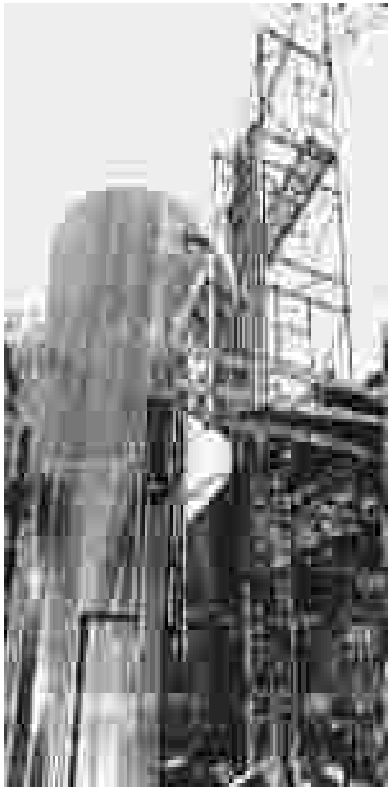
Effective and rapid treatment of waste water using selective microbes

BIOTECHNOLOGY IN PETROCHEMICALS

Cleaning of storage tank using enzymes

oil-spill clean-up using potential microbes

ETHANOL FROM BIOMASS OR ORGANIC WASTE



- Biotechnology allows conversion of biomass or organic waste to ethanol.
- Results in reduced CO_2 emissions by more than 90% (compared to oil).
- Allows for greater domestic energy production and it uses a renewable feedstock.

Good environmental technologies will permit maximum economic activity (*wealth creation*) consistent with minimum public health detriment and environmental degradation (*quality of life*)

ALKANEUTRI

- Development of this technology was an endeavour for the economic, effective and efficient *biological neutralization of alkaline waste-waters*
- Need for this pre-treatment is there, as most of the microbial strains present in the conventional treatment processes work well near neutral pH
- The principle of *BIOSTIMULATION* was utilized for the development of the above said technology
- Model industries chosen for case study : Textile, P&P
- International patent filed for this technology
- Ready for upscaling and commercialization

IGIB gets assignment from Coca-Cola

To develop the biotech-based technology for the neutralization of highly alkaline waste water

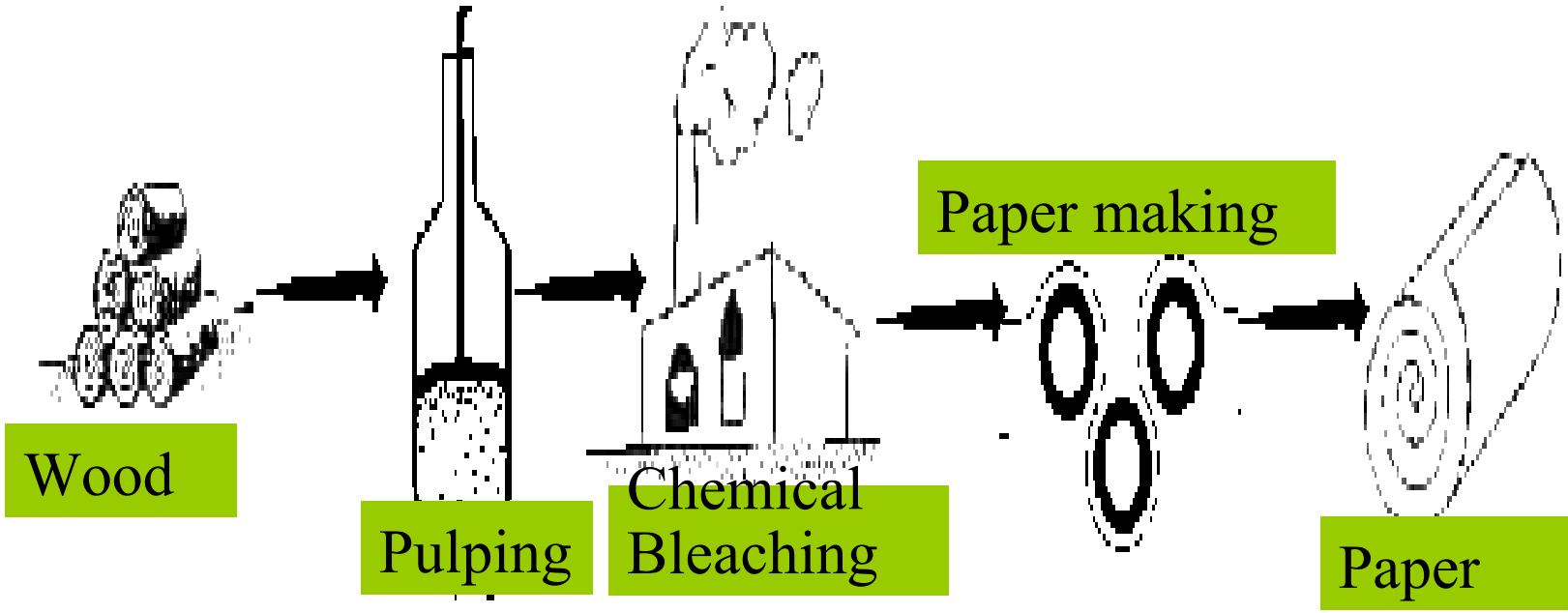
Economical, feasible and environment friendly

Technologically advanced treatment

PHENOTREAT

- Tailor made bacterial package for the effective biodegradation of phenol present in industrial waste-waters
- Relies on the principle of *BIOREMEDIATION* as well as *BIOAUGMENTATION*
- Model industries chosen for case study : Mathura Oil Refinery
- **International patent accepted** for this technology
- Ready for upscaling and commercialization

BLEACHING OF PULP IS A KEY PROCESS IN MILL



Unfortunately, chemical bleaching produces a lot of toxic chlorinated hydrocarbons, which get released into the environment with the wastewater from the mills. These chemicals grab onto other chemicals besides hydrogen, thus creating highly toxic chemicals called "organochlorines", which are basically poisons, such as dioxins etc.

Biobleaching – Elimination of the problem before its generation

- Technologically advanced
- Economical
- Environmentally safe

TREATMENT OF TANNERY INDUSTRIAL WASTEWATER

Microbial package for COD, BOD and TDS reduction from tannery waste water

-Bacterial consortium formulated by strategic selection of specific bacteria.

-Capable to reduce BOD, COD and TDS simultaneously.

-Ready-to-use as lyophilized bacterial powder

-Reduction in TDS upto 10% is a characteristic feature of this consortium

TDS - " TOTAL DISSOLVED SOLIDS"

- "Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water. This includes anything present in water other than the pure water (H_20) molecule and suspended solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp.) cation and anion composition

- In general, the total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water.

- TDS is based on the electrical conductivity (EC) of water. Pure H20 has virtually zero conductivity. Conductivity is usually about 100 times the total cations or anions expressed as equivalents. TDS is calculated by converting the EC by a factor of 0.5 to 1.0 times the EC, depending upon the levels. Typically, the higher the level of EC, the higher the conversion factor to determine the TDS.

IMPORTANCE OF TDS ANALYSIS

2. **TASTE/HEALTH:**

   High TDS results in undesirable taste which could be salty, bitter, or metallic. It could also indicate the presence of toxic minerals. The EPA's rescommended maximum level of TDS in water is 500mg/L (500ppm).

2. **FILTER PERFORMANCE:**

   Test your water to make sure the reverse osmosis or other type of water filter or water purification system has a high rejection rate and know when to change your filter (or membrane) cartridges.

3. **HARDNESS:**

   High TDS indicates Hard water, which causes scale buildup in pipes and valves, inhibiting performance.

4. **AQUARIUMS/AQUACULTURE:**

   A constant level of minerals is necessary for aquatic life. The water in an aquarium or tank should have the same levels of TDS and pH as the fish and reef's original habitat.

5. **COMMERCIAL/INDUSTRIAL:**

   High TDS levels could impede the functions of certain applications.

6. **COLLOIDAL SILVER_WATER:**

   TDS levels must be controlled prior to making colloidal silver.

7. **COFFEE:**

   For a truly great cup of coffee, proper TDS levels must be maintained. A metallic taste present may affect the taste of beverages made from the water.

EFFECTS OF HIGH TDS

Environmental effects

The effects of hardness on aquatic life depend on which cations are making the water "hard."

Irrigation effects

Carbonate deposits may clog pipes and coat the inside of water holding tanks. Extreme hardness may interfere with chemical processes.

Domestic effects

Hard water is objectionable because of the formation of scale in boilers, water heaters, radiators, and pipes with resultant decrease in the rate of flow and heat transfer as well as in increased corrosion. In addition to its effect on soap consumption, excessive hardness can shorten the wearing ability of fabrics and toughen cooked vegetables.

Industry may release dissolved cations into effluent waters

TDS COMPOSITION

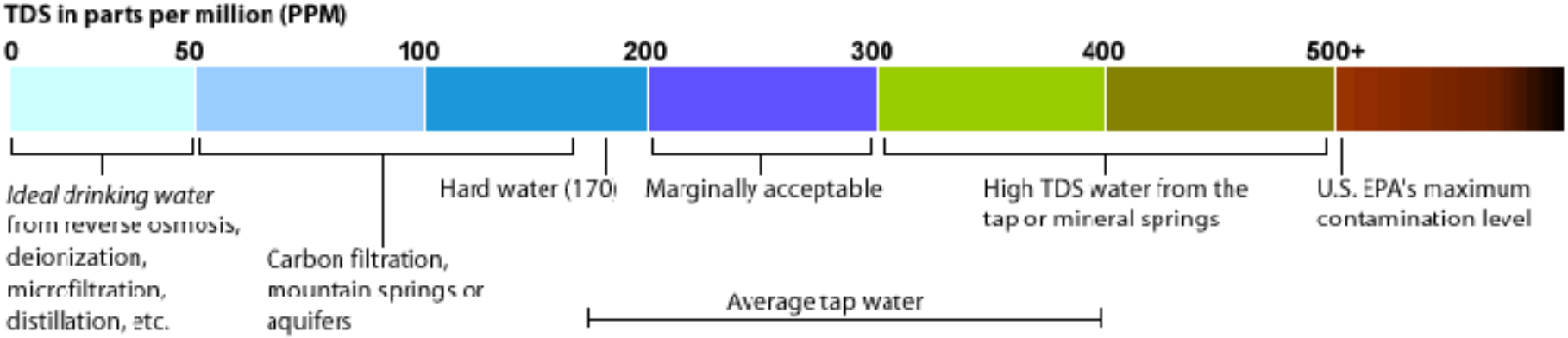
ANIONS

- Cl^-
- NO_2^-
- NO_3^-
- F^-
- HCO_3^-
- CO_3^{2-}
- SO_4^{2-}
- $H_2PO_4^-$

CATIONS

- Na^+
- K^+
- NH_4^+
- Mg^{2+}
- Ca^{2+}
- Fe^{2+}
- Mn^{2+}
- Al^{3+}

TDS STANDARDS



EXISTING TECHNOLOGIES FOR TDS REMOVAL

1. **CARBON FILTRATION**

   Charcoal, a form of carbon with a high surface area, adsorbs (or sticks to) many compounds, including some toxic compounds. Water is passed through activated charcoal to remove such contaminants. (very slight reduction)

2. **REVERSE OSMOSIS (R.O.)**

   Reverse osmosis works by forcing water under great pressure against a semi-permeable membrane that allows water molecules to pass through while excluding most contaminants. RO is the most thorough method of large-scale water purification available. (extremely high reduction and great tasting water)

3. **DISTILLATION**

   Distillation involves boiling the water to produce water vapor. The water vapor then rises to a cooled surface where it can condense back into a liquid and be collected. Because the dissolved solids are not normally vaporized, they remain in the boiling solution. (total reduction - flat taste)

4. **DEIONIZATION (DI)**

   Water is passed between a positive electrode and a negative electrode. Ion selective membranes allow the positive ions to separate from the water toward the negative electrode and the negative ions toward the positive electrode. High purity de-ionized water results. The water is usually passed through a reverse osmosis unit first to remove nonionic organic contaminants. (usually a final polishing filter following a RO Reverse Osmosis filtration system to eliminate TDS)

FOR YOU!

- Why adopt biotechnology? To cut costs and be environmentally friendly.
- Companies -- be aware of change; find yourself an R & D partner.
- Build your own in-house biotech skill base.
- Companies -- work with government and stay close to the regulators.
- Government -- companies still need help – especially incentives and R & D funding.

Thank You !

Visit our web site - WWW.igib.res.in