Water Quality Management and IWRM

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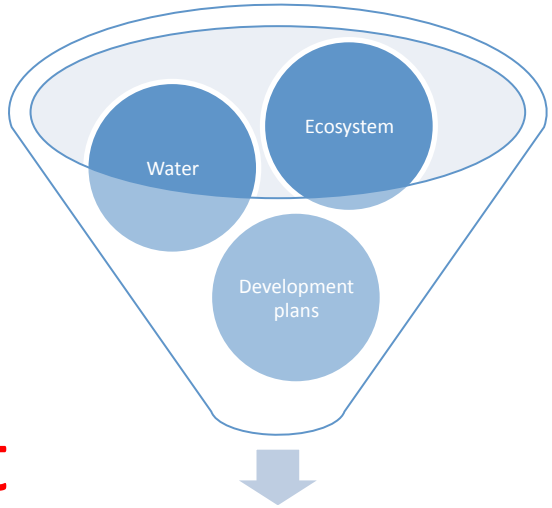
Aim of this Module

- The aim of the module is to introduce the concepts of ecosystem and its services so that it can be incorporated in water resources management



Topics for the Day

- Water quality and Environment – an IWRM Approach
- Source/ types of pollution
- Health and Economical Impacts of Water Pollution
- Monitoring systems
- Examples of Pollution Control systems
- Setting Water Quality Management Plan

Why am I taking this course?

Water : A precious Natural Resource

- We use water for drinking, irrigation, industrial purposes and energy production. ♪
- **Water use:**
  - **agriculture and energy production - 80%**
  - **industry and public use - 20%**

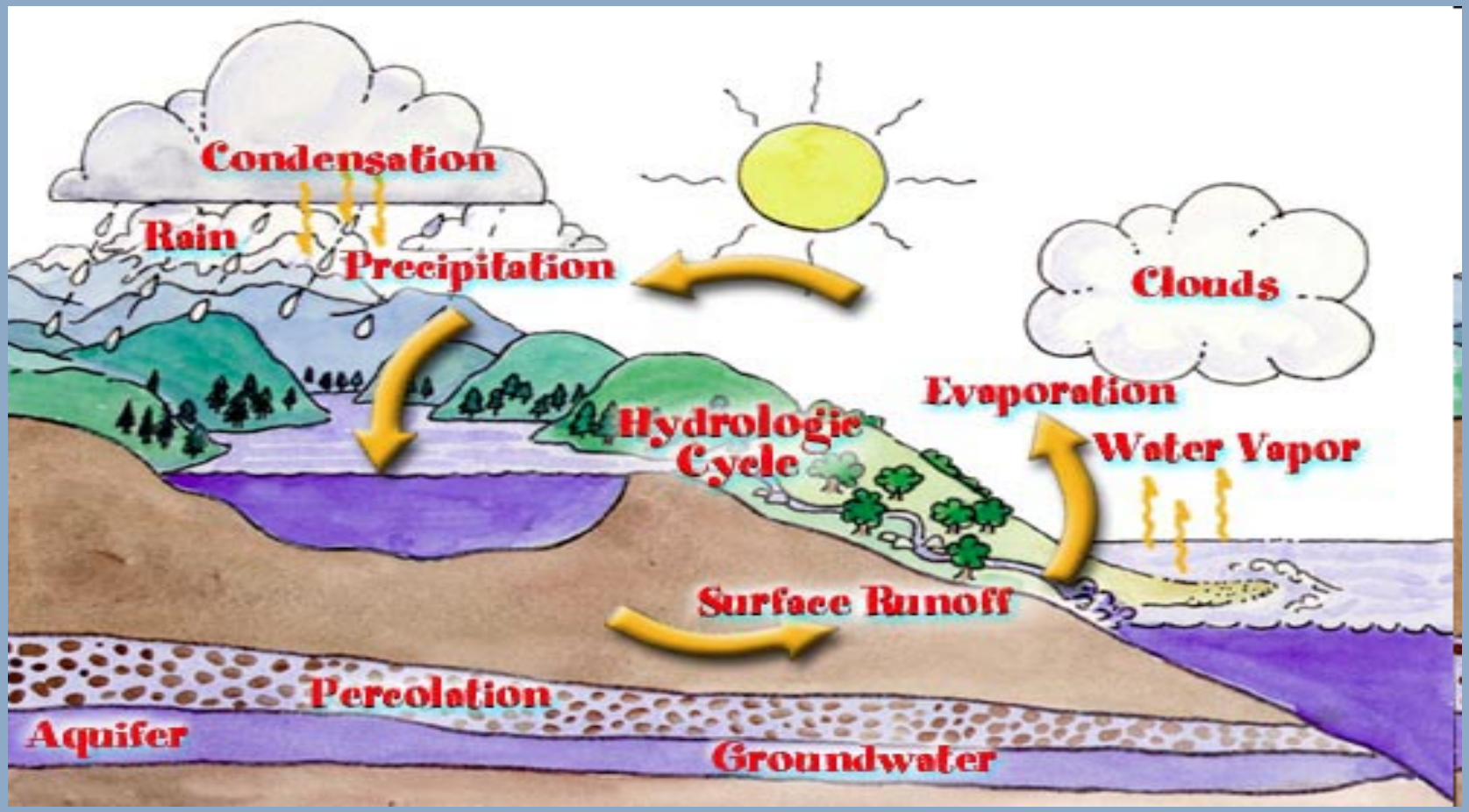
Significance of water

- Water covers more than three-fourths of the Earth's surface.
- Most of the water on Earth, 97% to be exact, is salt water found in the oceans.
- Most of the fresh water, 87%, is in the form of snow in the two poles.

Water as Basic Needs

- More than 90% of all the sewage produced in the developing countries returns to the land and water untreated
- For many millions of people, fresh water scarcity is defined as much by poor quality as by insufficient quantity

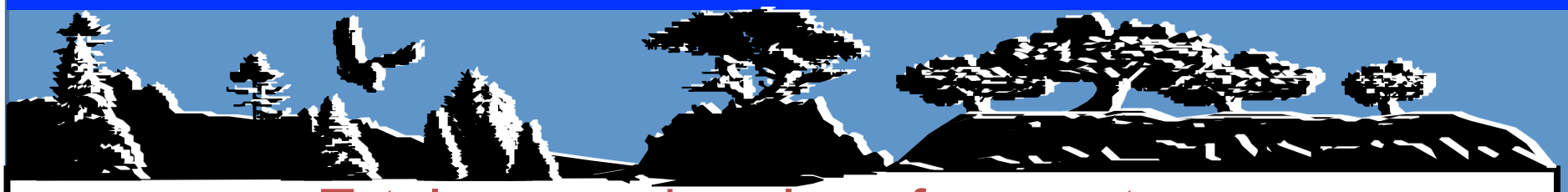
Global hydrologic cycle



Linkage between water and the Millennium Development Goals

- It Expressed the Importance of Ensuring "Environmental Sustainability"
- Integrate the principles of Sustainable Development into country policies, programs and projects
- Environment is a Public Good with Social and Economic Costs

What is the economic value of ecosystems?



Total economic value of ecosystems

Use

Direct values
Outputs that can be consumed directly, such as fish, medicines, wild foods, recreation, etc.

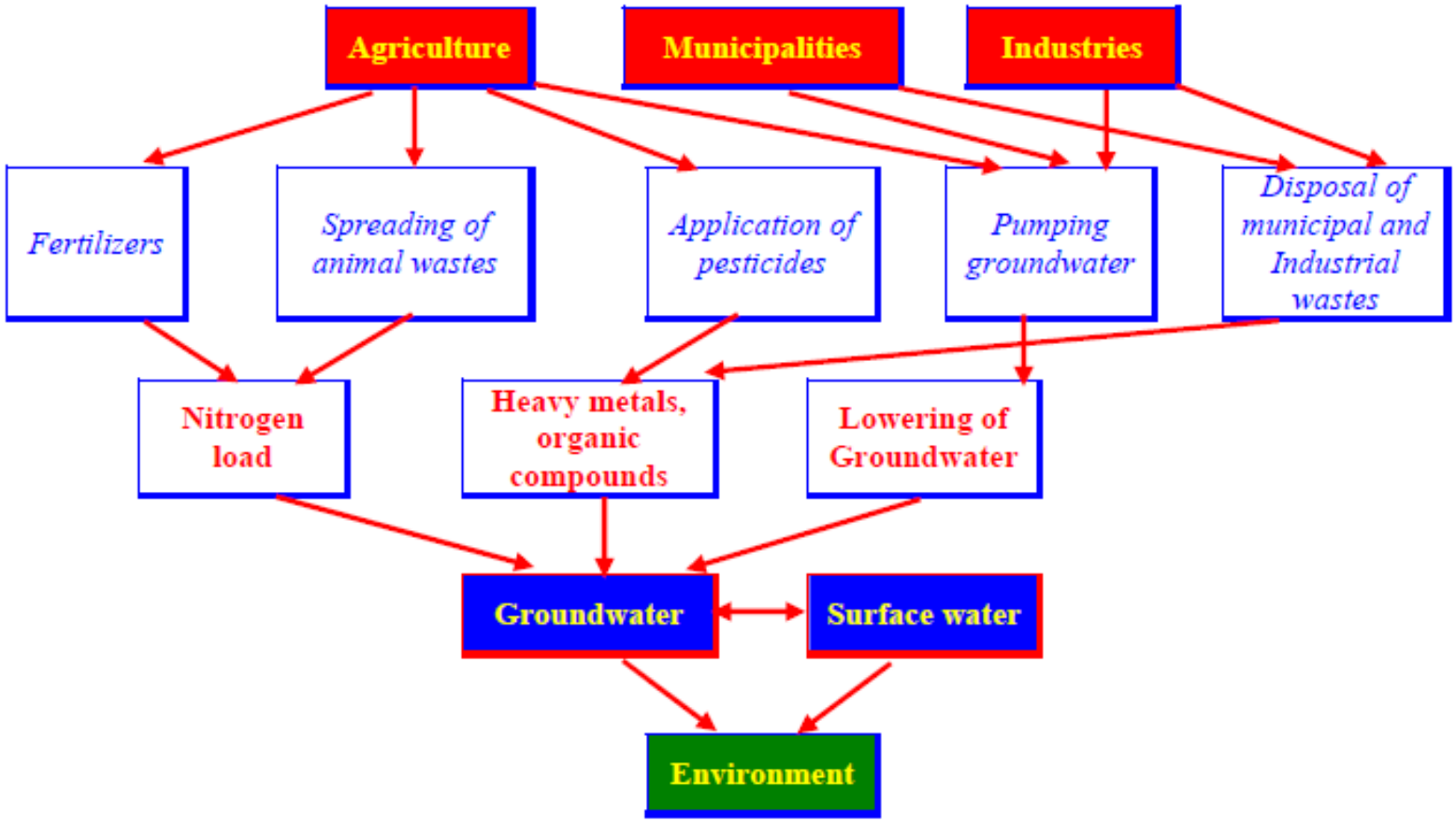
Indirect values
Ecological services, such as catchment protection, flood control, carbon sequestration, climatic control, etc.

Option values
The premium placed on maintaining resources and landscapes for future possible direct and indirect uses, some of which may not be known now.

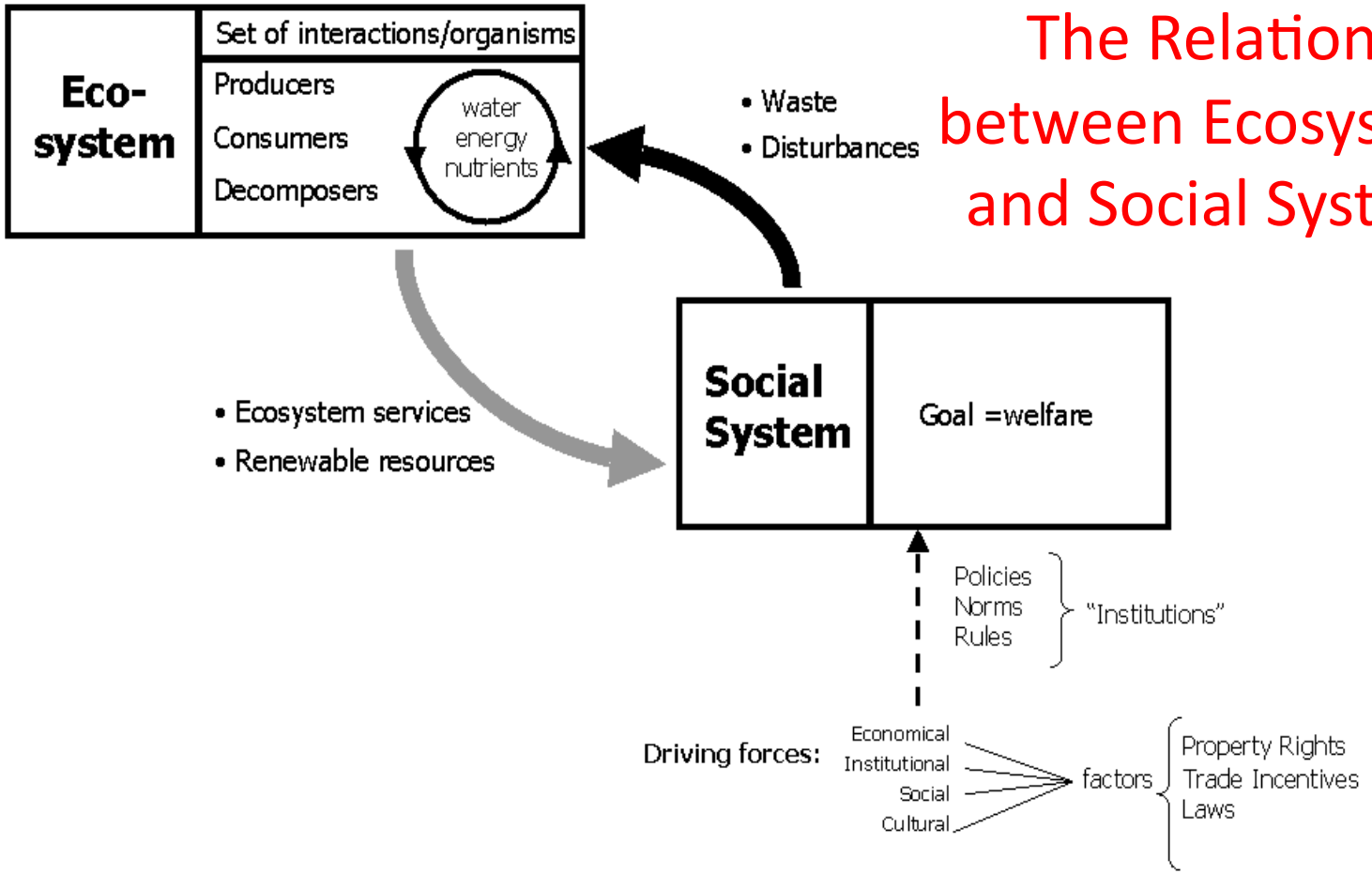
Non use

Existence values
The intrinsic value of resources and landscapes, irrespective of its use such as cultural, aesthetic, bequest significance, etc.

Interaction of Land-use and Water Resources



The Relations between Ecosystem and Social System



Humanity critically depends on the ecosystem offering renewable resources and producing ecological services.

Human activities to improve welfare:

- are driven by societal driving forces and influenced by the institutional system,

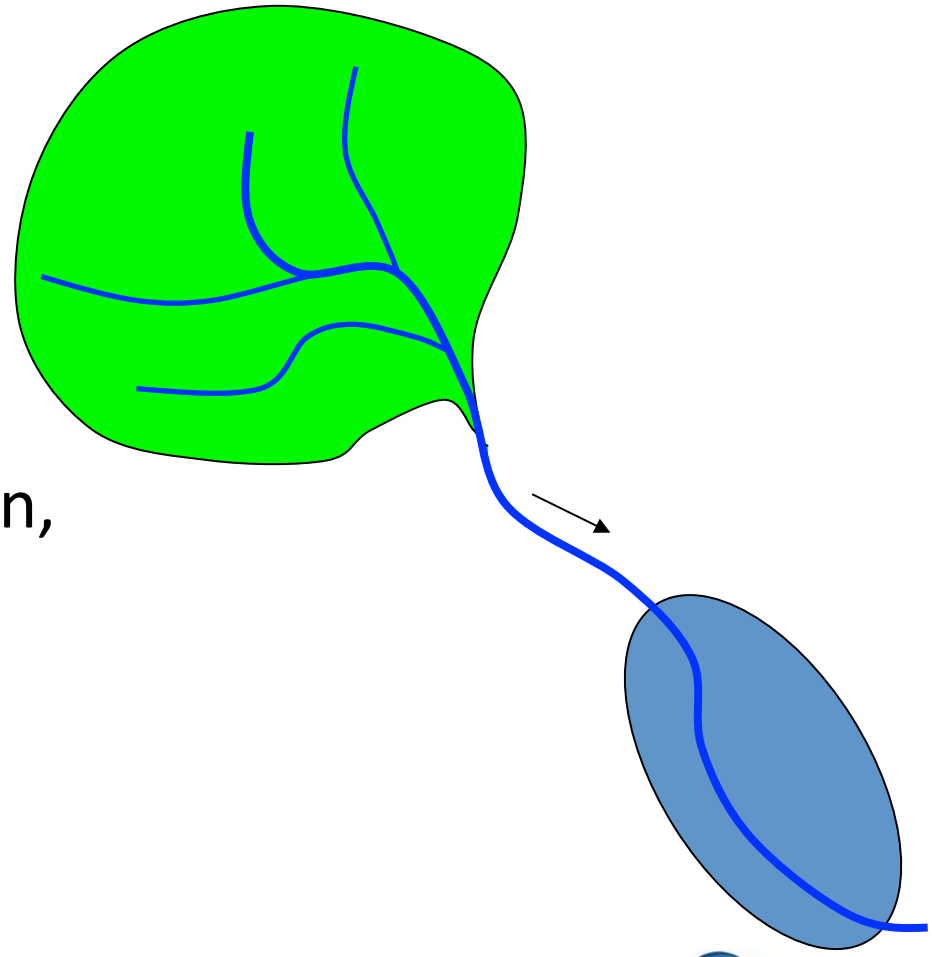
- but involve the production of waste and other disturbances that influence the functioning of the ecosystems.

Environment and IWRM

- The environment is linked to IWRM in three fundamental ways:
  - First, the aquatic ecosystem provides habitat for fish, invertebrates, and other fauna and flora.

Environment and IWRM

– Second, the design and operation of hydraulic infrastructure for water supply, sewerage, irrigation, hydropower, and flood control often affect ecosystems

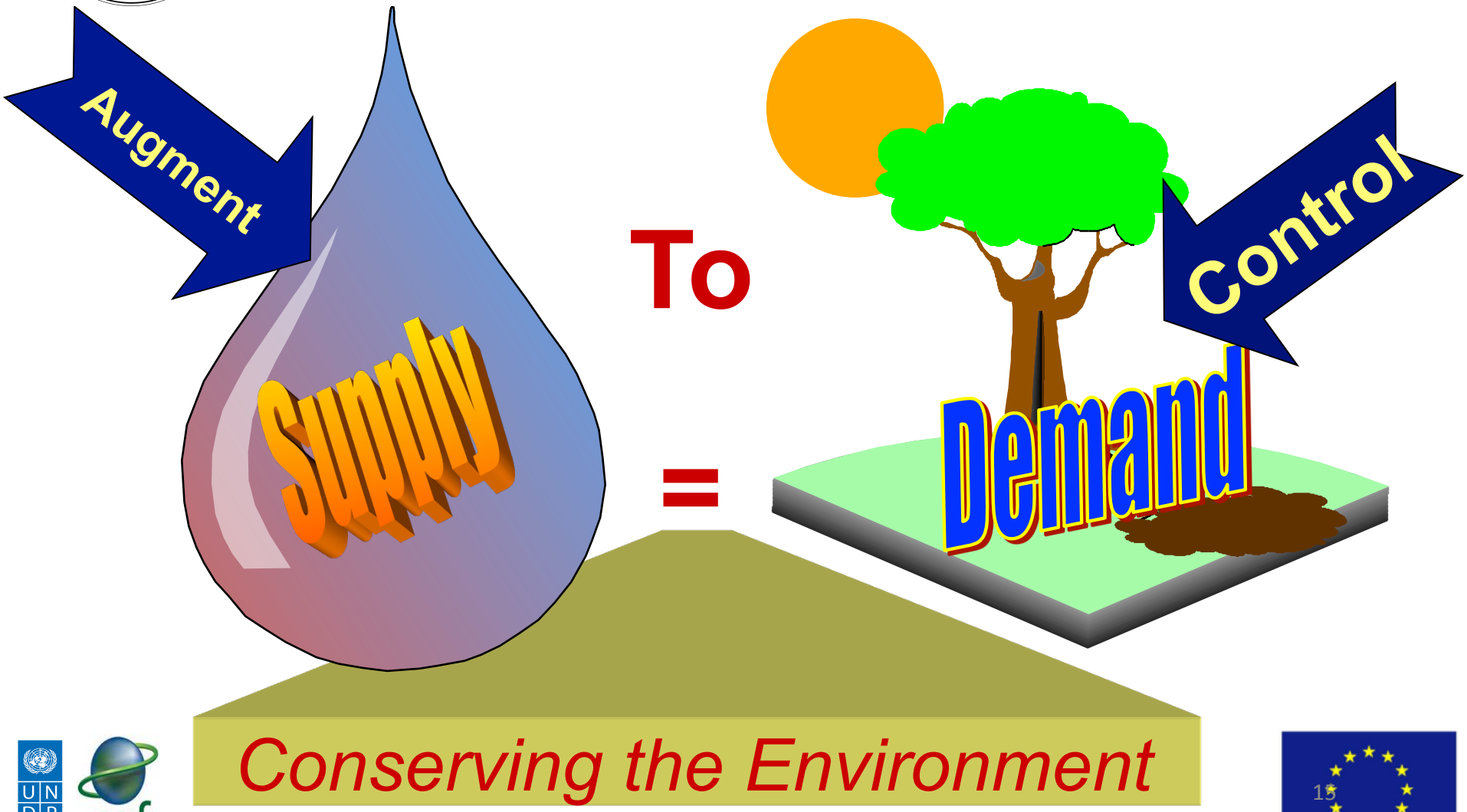


Environment and IWRM

- Third, integrated water resources planning and management are facilitated by policies, laws, strategies, and plans that are multi sectoral, based on :
  - The allocation of water for all uses;
  - The protection of water quality and control of pollution;
  - The protection and restoration of lake basins, watersheds, groundwater aquifers, and wetlands;
  - Control and management of invasive species

- An important part of IWRM is about balancing water between different users including the ecosystem

Integrated Watources Management



Conserving the Environment

Sources and Types of Water Pollution

Water Pollution

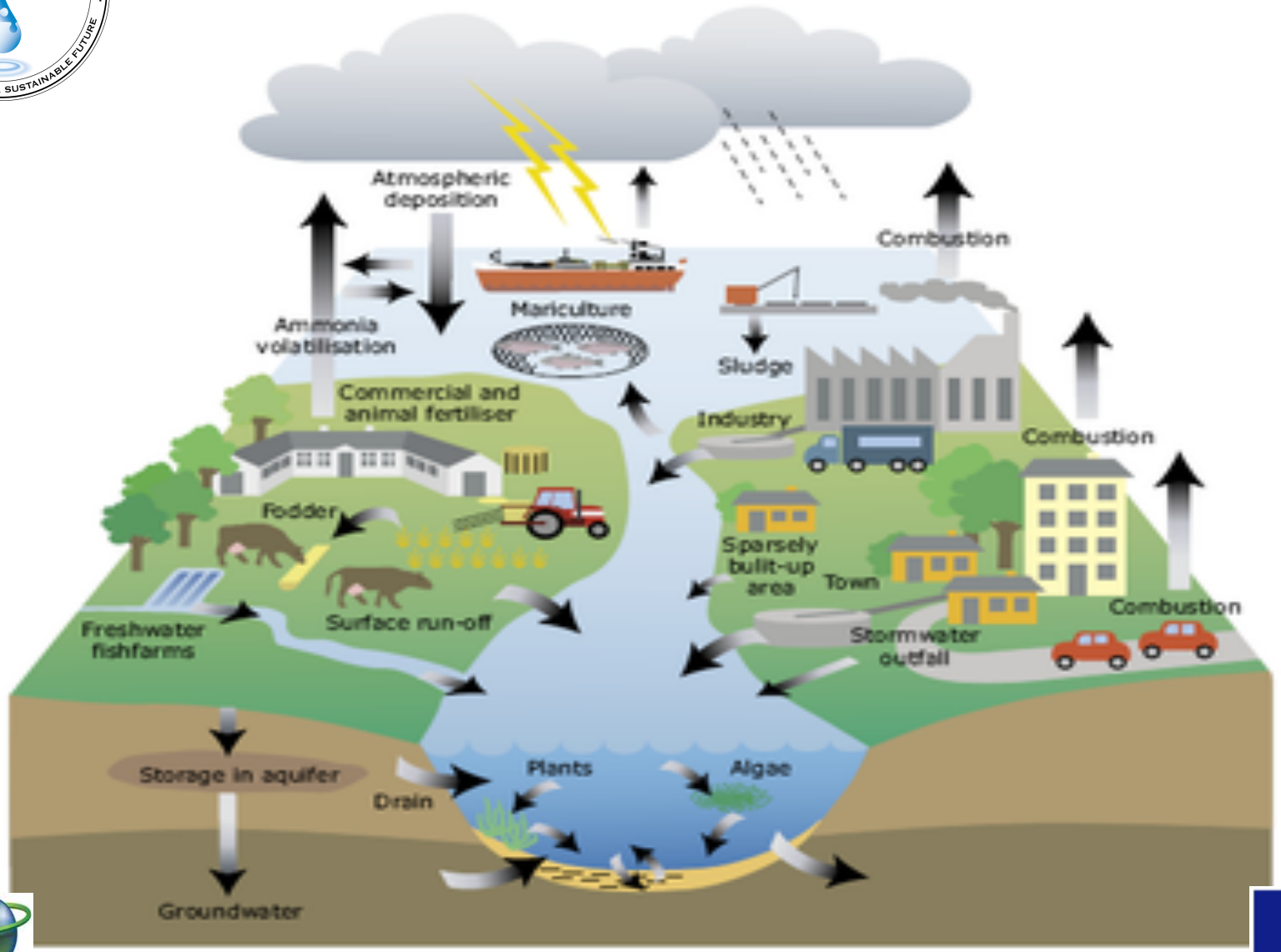
- Water pollution is any chemical, biological, or physical change in water quality that has a harmful effect on living organism or makes water unsuitable for desired uses.
- It is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily.

Where do Water pollutants come from?

- **Point Sources – A single definable source of the pollution, e.g. a factory, a sewage plant, etc. Point-source pollution is usually monitored and regulated.**

- **Non-point sources – No one single source, but a wide range of sources, e.g. runoff from urban areas, or farmland. Non-point sources are much more difficult to monitor and control.**

Sources of Water pollution



Sources of Water Pollution

1. Industrial Sector
2. Agriculture
3. Sewage Pollution
4. Garbage and Floating Debris
5. Oil Spell and Navigation Pollution
6. Fish Cages
7. Thermal pollution

Water pollutants

- **Industrial Effluents**
  This waste water may contain acids, alkalis, salts, poisons, oils and in some cases harmful bacteria.

- **Mining and Agricultural Wastes**
  Mines, especially gold and coal mines, are responsible for large quantities of acid water.

- **Agricultural pesticides, fertilizers and herbicides**
  May wash into rivers and stagnant water bodies.

- **Sewage Disposal and Domestic Wastes**
  Sewage as well as domestic and farm wastes were often allowed to pollute rivers and dams.

Other water quality pollutants

- thermal pollution
- floating debris
- Garbage
- Natural phenomena like volcanos or earthquakes also cause major changes in water quality

Non-persistent (degradable) Water pollutants

- Domestic sewage
- Fertilizers
- Some industrial wastes

Non-persistent (degradable) water pollutants

- These compounds can be broken down into simple, non-polluting substances such as carbon dioxide and nitrogen.
- if the pollution load is high, this process can lead to low oxygen levels and eutrophication.
- This damage is reversible.

Persistent Water pollutants

- some pesticides (e.g., DDT, dieldrin)
- some leachate components from landfill sites (municipal, industrial)
- petroleum and petroleum products
- PCBs, dioxins, polyaromatic hydrocarbons (PAHs)
- radioactive materials
- metals such as lead, mercury, cadmium

Persistent Water pollutants

- This is the most rapidly growing type of pollution
- it includes substances that degrade very slowly or cannot be broken down at all
- The damage they cause is either irreversible or repairable only over decades or centuries

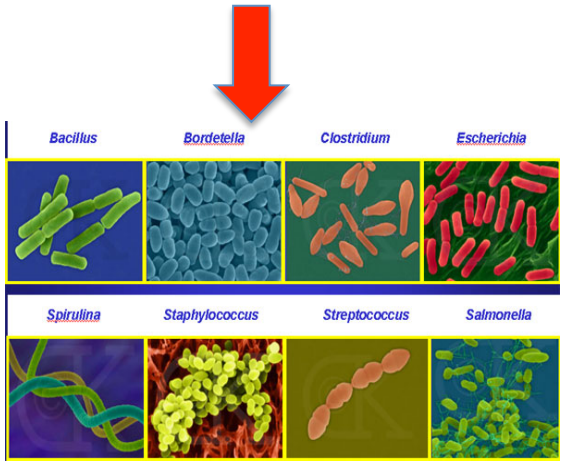
Plastic waste in water

Each year, plastic waste in water and coastal areas kills up to:

- 100,000 marine mammals,
- 1 million sea birds, and
- countless fish.

Microbial contamination of water

- Over 1 billion people lack access to safe water supplies,
- while 2.6 billion people lack adequate sanitation.
- This has led to widespread microbial contamination of drinking water.
- Water-associated infectious diseases claim up to 3.2 million lives each year, approximately 6% of all deaths globally.



♪♪Eutrophication ♪

- Increases in nutrient loading may lead to eutrophication . ♪
- Organic wastes such as sewage impose high oxygen demands on the receiving water leading to oxygen depletion.♪

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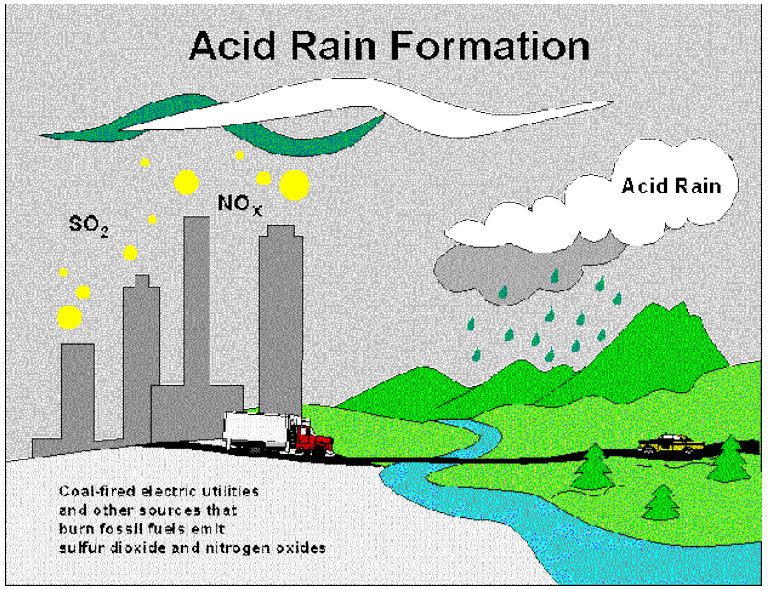
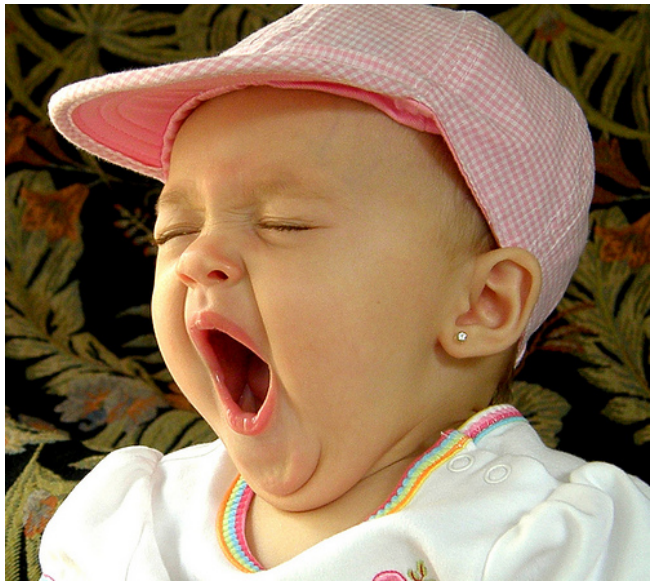
Acid rain

- Acid rain includes rain, sleet or snow with a pH level that falls below 5.6 (normal rainwater).





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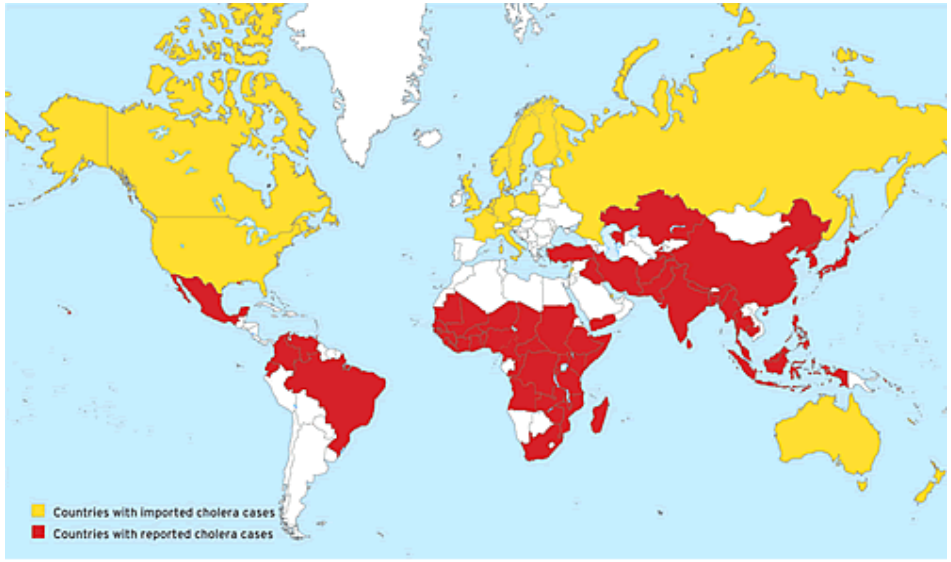
Health Impact of Water pollution

Water borne diseases

- Diseases caused by the ingestion of water contaminated with pathogenic bacteria, viruses, or parasites include:
  - cholera
  - typhoid
  - schistosomiasis
  - dysentery and other diarrheal diseases



Health Impacts of Water Pollution

- Evidence from the WHO:
  - In 2003, an estimated 1.6 million deaths worldwide were caused by unsafe drinking water and sanitation
  - 90% of these deaths were among children under age five
  - 1.1 billion people don't have access to improved water sources
  - 2.4 billion people don't have access to improved sanitation

Source: www.who.int/water_sanitation_health/wsh0404/en/

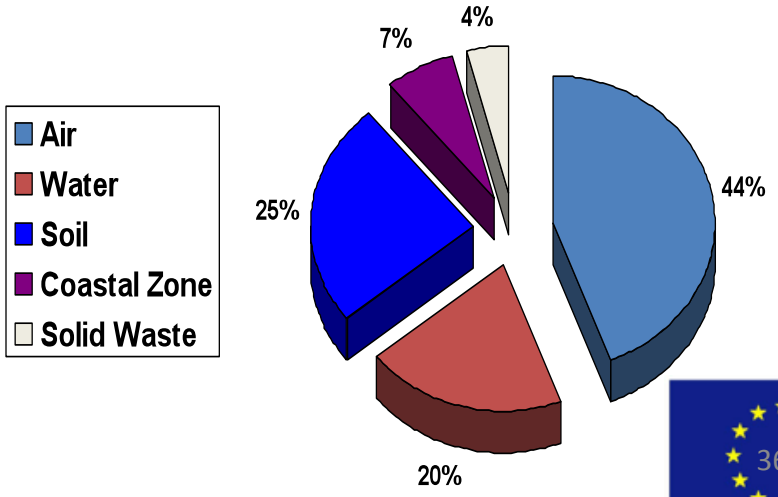
Economic Cost of Water Pollution

- Costs to expand water treatment.
- Loss of commercial fish species.
- Loss in tourism revenue.
- Direct and indirect costs of disease.
- Loss in agricultural production.
- Loss, or increased cost, of industrial production.
- Cost of social unrest and population migration.

Cost of Environmental Degradation

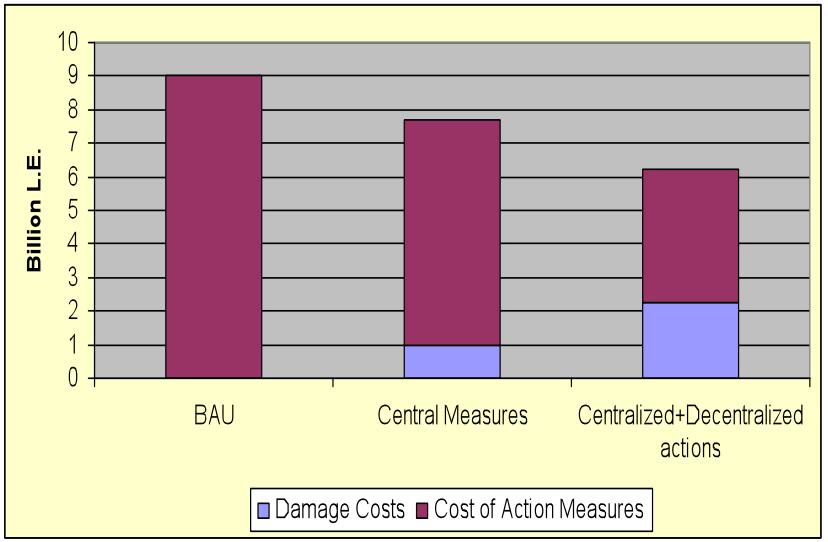
- in 2002, the World Bank carried on a study for Cost Assessment of Environmental Degradation in Egypt
- The cost of environmental degradation was estimated at 4.8% of GDP annually (14.6 Billion L.E./year)

	Damage Cost (Billion L.E./year)	% of GDP
Air	6.4	2.1%
Water	2.9	1.0%
Soil	3.6	1.2%
Coastal Areas	1.0	0.3%
Solid Waste	0.6	0.2%



Scenarios for the Future

- Three scenarios to estimate the future costs of environmental degradation due to water use and disposal:
  - Business as usual
  - Centrally planned actions for protection of the water resources
  - The latter in addition to the measures required to control rural sanitation



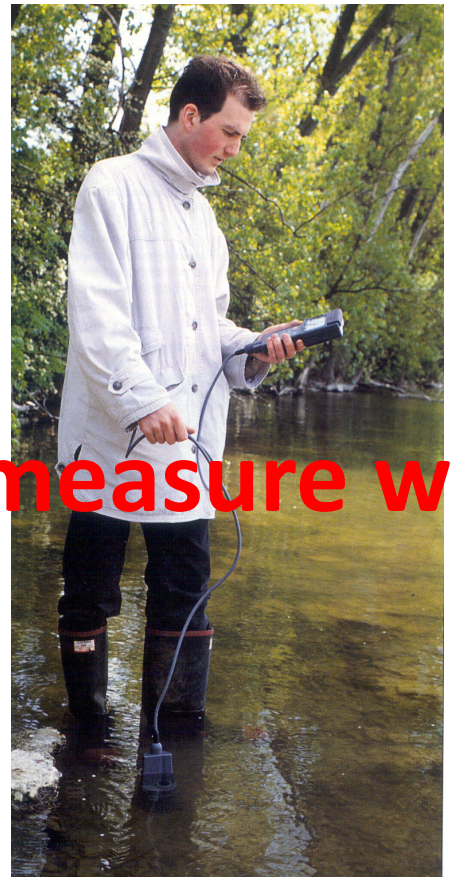
Study Main Results

The damage cost in 2014 will be:

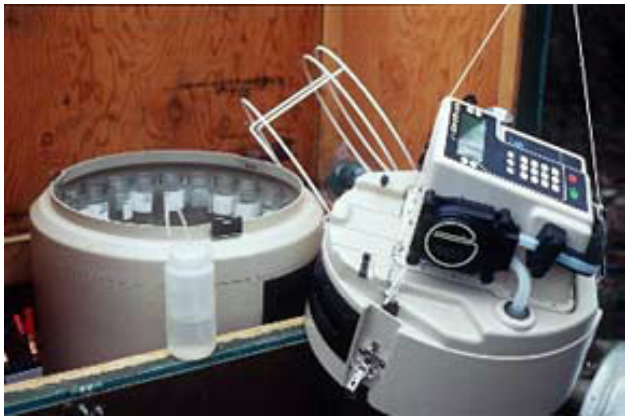
- BAU --→ 9.5 billion L.E./year

- Centralized Measures --→ 6.7 billion L.E/yr +
Cost of Centralized Intervention = 1 billion L.E./yr

- Centralized Measures + Rural Sanitation Improvement --→ 4.2 billion L.E./yr
Cost of Intervention = 2.5 billion L.E./yr



How do we measure water quality?



Objectives of the Water Quality Monitoring Program

- For rational planning of pollution control strategies and their prioritization;
- To assess nature and extent of pollution control needed in different water bodies;
- 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 suitability of water for different uses

What do we measure?

- Fecal Coliform/Coliform
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Temperature
- Turbidity/Total Suspended Solids (TSS)
- Heavy metals, (e.g., lead, mercury, cadmium)
- Carbon dioxide
- Nitrite
- Salinity
- Ammonia
- Chlorine
- Iron
- Selenium
- Hardness
- Sulfate and Sulfite
- Methane
- Conductivity/Total Dissolved Solids (TDS)
- Alkalinity/Acid Neutralizing
- Capacity (ANC) Color Odor
- Synthetic organics (e.g., pesticides, PCBs)

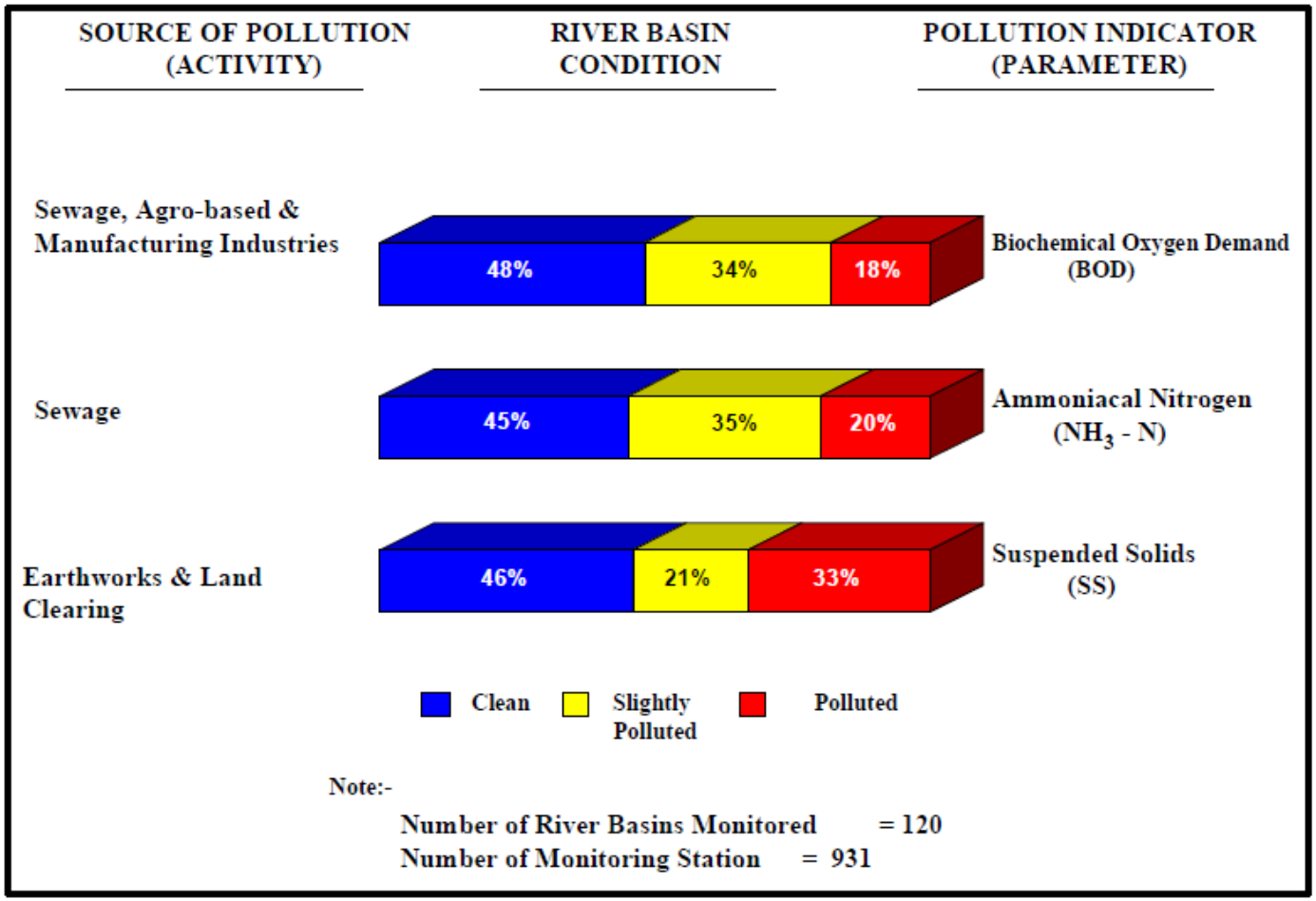
CRITERIA FOR SELECTION OF MONITORING STATIONS

- Water intake point - community water supply.
- Large/medium polluting industries or cluster of SSI.
- Bathing water.
- Source of river – (reference point).
- D/S of large irrigated areas.
- Low flow stretches.
- D/S of big cities.
- D/S of Water abstraction Structures
- U/S and D/S of confluence of rivers.
- Inter-state boundaries.

Outcome of National Monitoring Programme

- periodical reports on the State of the environment for the river basin.
- Identification of Polluted Water Bodies.
- Form the basis for Formulation of River Action Plan and Identification of Pollution Sources.
- Used for Query Response i.e. to reply Parliament Questions, VIP reference, Public Queries, Public Interest Litigation filed in Supreme Court and Various High Courts and to fulfill the requirement of Non Governmental Organisation, Students, and Researchers.
- Is that enough????????????

Water Quality Indicators



The Water Quality Index

- A weighted average of selected ambient concentrations of pollutants usually linked to water quality classes

	Excellent	Good	Moderate	Polluted	Highly Polluted
Class / Parameter	I	II	III	IV	V
BOD	<1	1-3	3-6	6-12	>12
COD	<10	10-25	25-50	50-100	>100
NH3N	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
DO	>7	5-7	3-5	1-3	<1
pH	>7	6-7	5-6	<5	>5
SS	<25	25-50	50-150	150-300	>300
WQI	>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

Constraints in Maintaining the Monitoring Networks

- Sustainability of the operation and maintenance
- Financial as well as Human resources needed.
- The high cost of QA/QC.
- Lack of training for laboratory and field staff.
- Lack of software and modeling capabilities to analyze data and convert them to a decision support tool.

Challenges to incorporate monitoring data in water resources management

- Isolation of the data collecting agency from any users of water quality data.
- Lack of communication protocols and/or facilities for transmitting data/information to users.
- Lack of technical skills to transfer data into meaningful indicators.
- Lack of data standards

Water Quality Standards

Water quality standards (WQS)

- are legally binding norms that describe the desired ambient condition (i.e., level of protection) for a water body
- They consist of the following principle elements:
  - the “designated uses” of water, such as public water supply, recreation, propagation of aquatic life and wildlife, or navigation
  - “criteria” specifying the amounts of various pollutants, in either numeric or narrative form
  - criteria include any one or more of three components: magnitude, duration, and frequency)

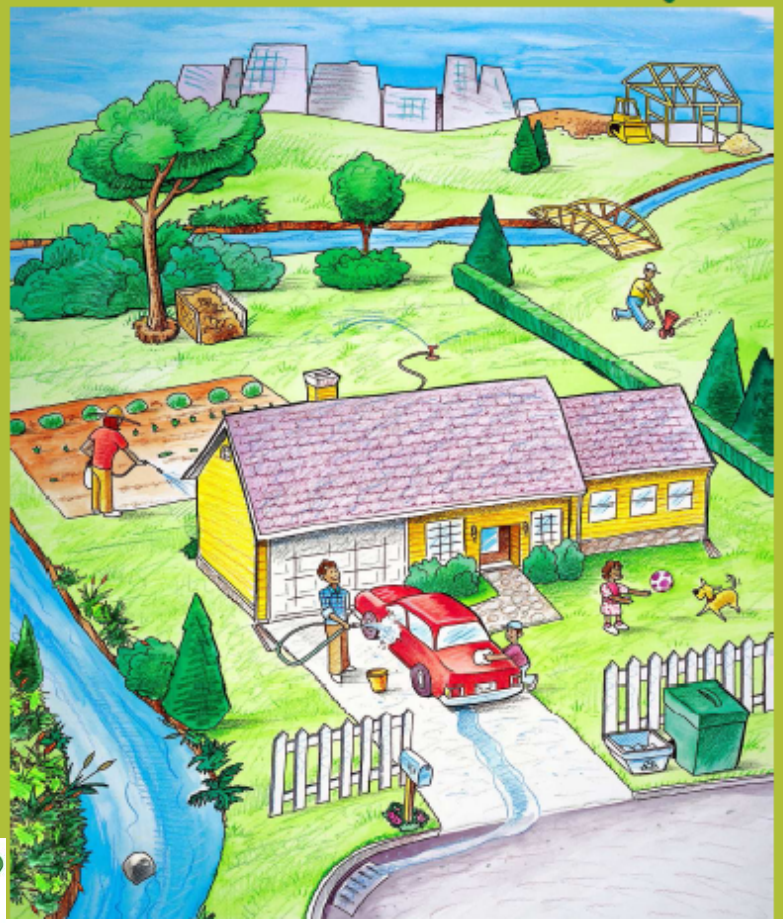
Water Quality Standards

Designated best use	Class	Criteria
Drinking water source without conventional treatment but after disinfections	A	*Total coliform organisms MPN/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 MPN/ 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
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

Institutional and Legal Issues in setting WQS

- Standards should be fixable and updated regularly
- Effluents standards should be based on volume of pollution rather than just concentration of pollutant.
- Leads to proper implementation of the polluter pays principal
- Use both enforcement and compliance as mechanisms to achieve WQS
- EIA must be reviewed and approved prior to the implementation of any development project
- Strengthen the role of the NGOs and the local society in water pollution reduction

Water Pollution?
SOLUTION lies with our attitude in day-to-day workings

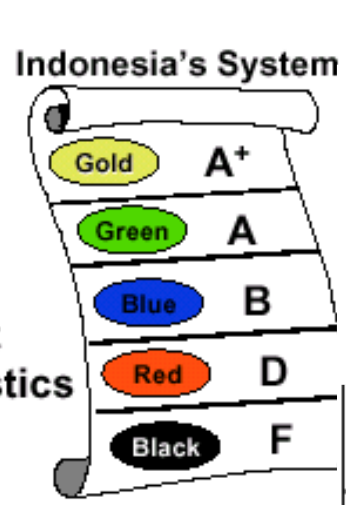


Agriculture Management

- Limiting fertilizer use will avoid nutrient overload in streams
- If a bug is killed in the lawn by pest, it may kill fish in the stream also.
- Physical/ Bio. Controls
- Use Chemicals Sparingly and only when all else fails!

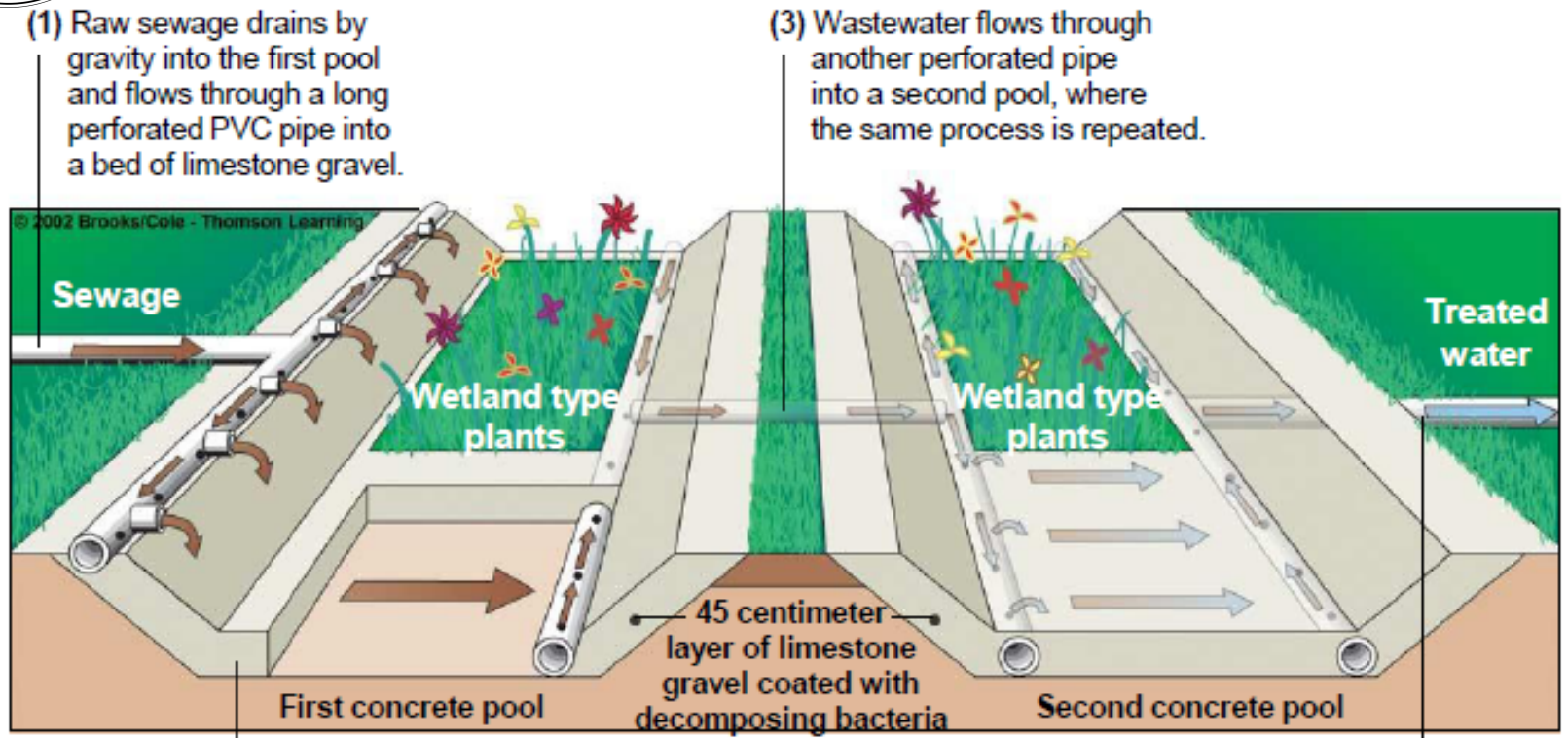
Use Performance grading system

- Easy to Communicate
- Manageable Number of Categories
- Category Symbols Reflect Socio-cultural Characteristics
- Technically Consistent



PERFORMANCE LEVELS	PERFORMANCE CRITERIA
GOLD	•Clean technology, waste minimization, pollution prevention, conservation, etc.
GREEN	•Above standards & good maintenance, housekeeping, sludge management, etc.
BLUE	•Efforts meet minimum standards
RED	•Efforts don't meet standards
BLACK	•No pollution control effort, •Serious environmental damages

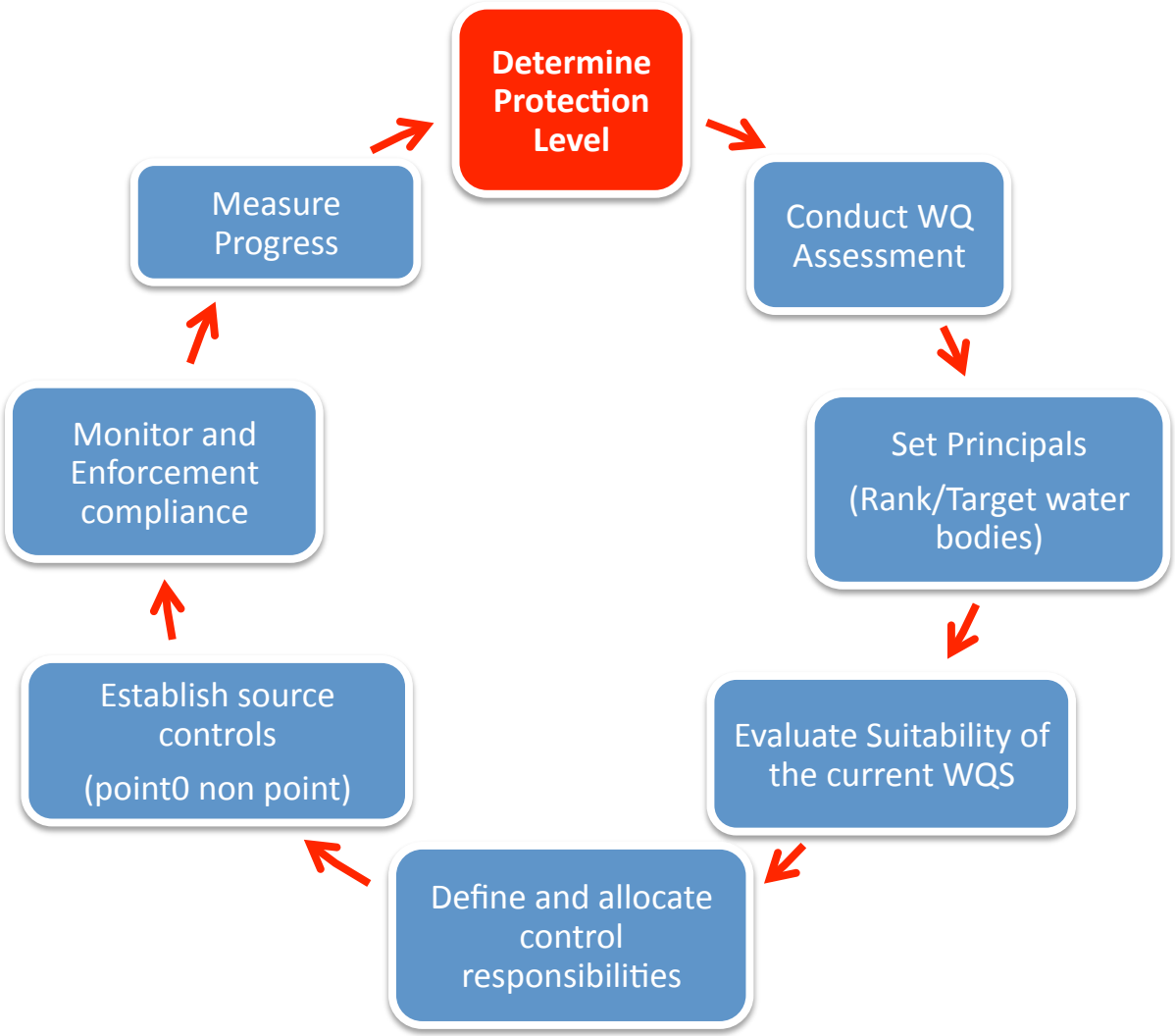
Use Engineered Wetland



What are my water management objectives?

- Measure the extent of the pollution problem and the progress being made.
- Ensure major polluters are known and are managed through a licensing or permit system.

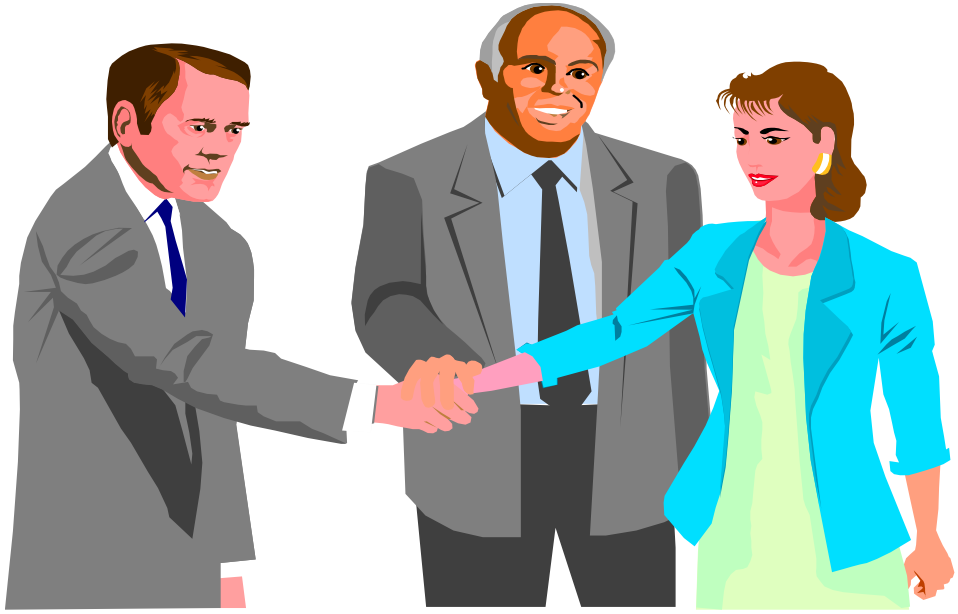
Setting a Water Quality Management Plan



Water Quality Management Tools

- Regulations, management procedures and by-laws
- Water quality standards
- Economic instruments
- Monitoring systems
- Discharge permitting
- Water quality modelling tools
- Environmental impact assessment

We are the solution for water pollution



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