Water Quality Management and IWRM

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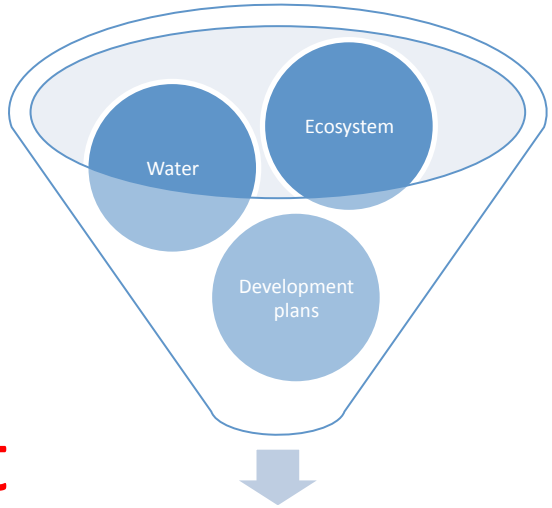
Aim of this Module

- 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
- Setting Water Quality Management Plan
- State of water quality in Kura River basin in Georgia

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%**

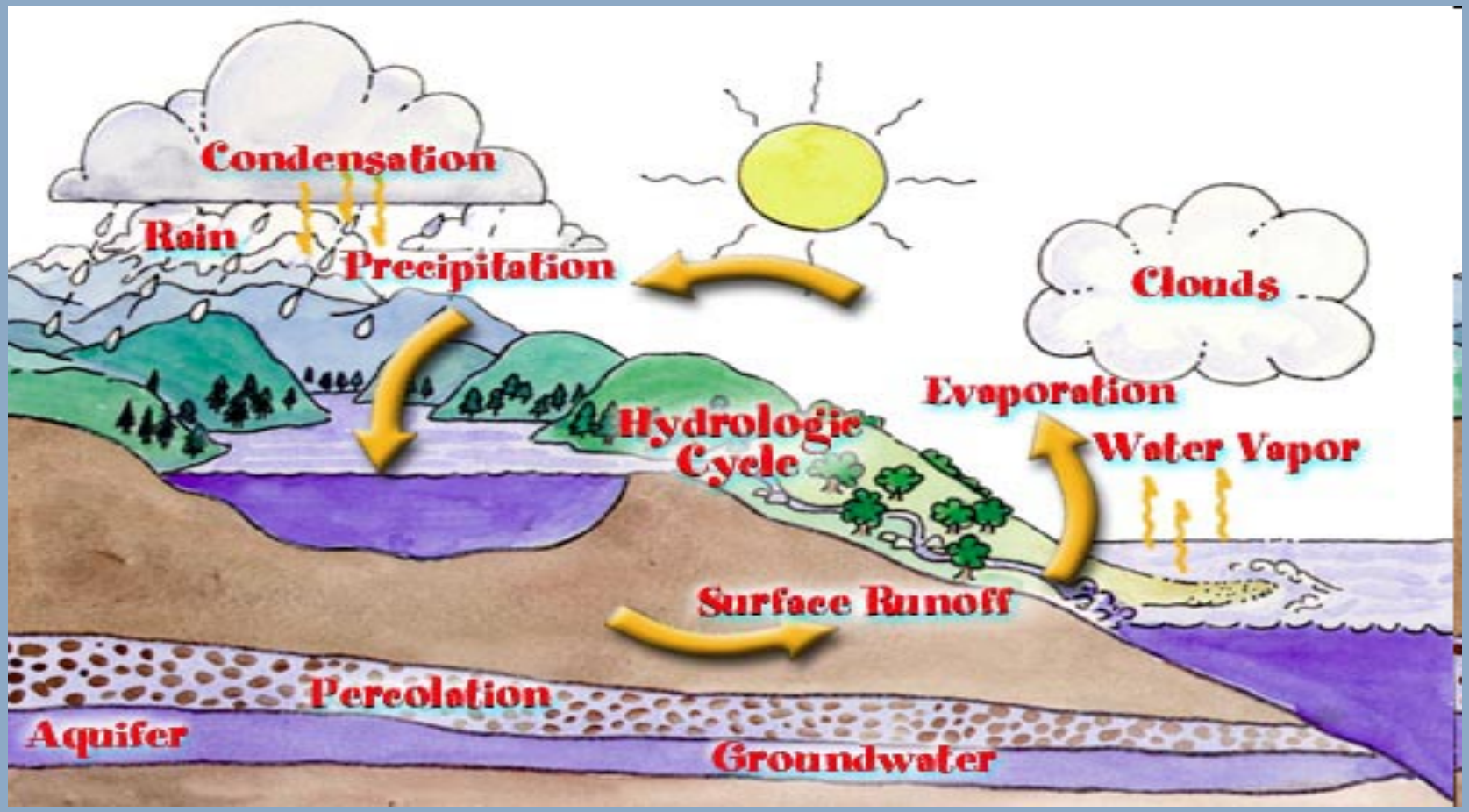
Significance of water

- 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

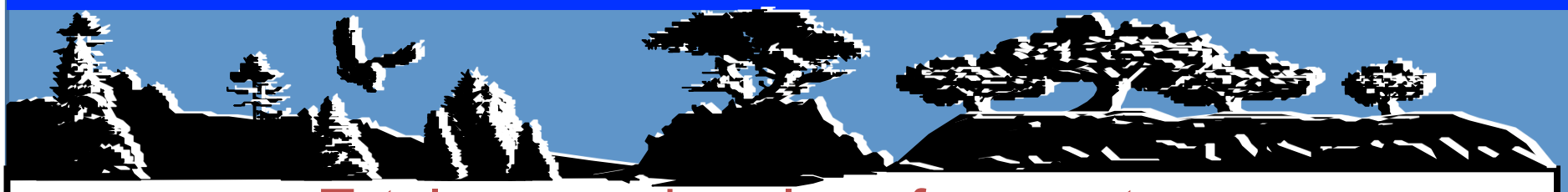
Global hydrologic cycle



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.

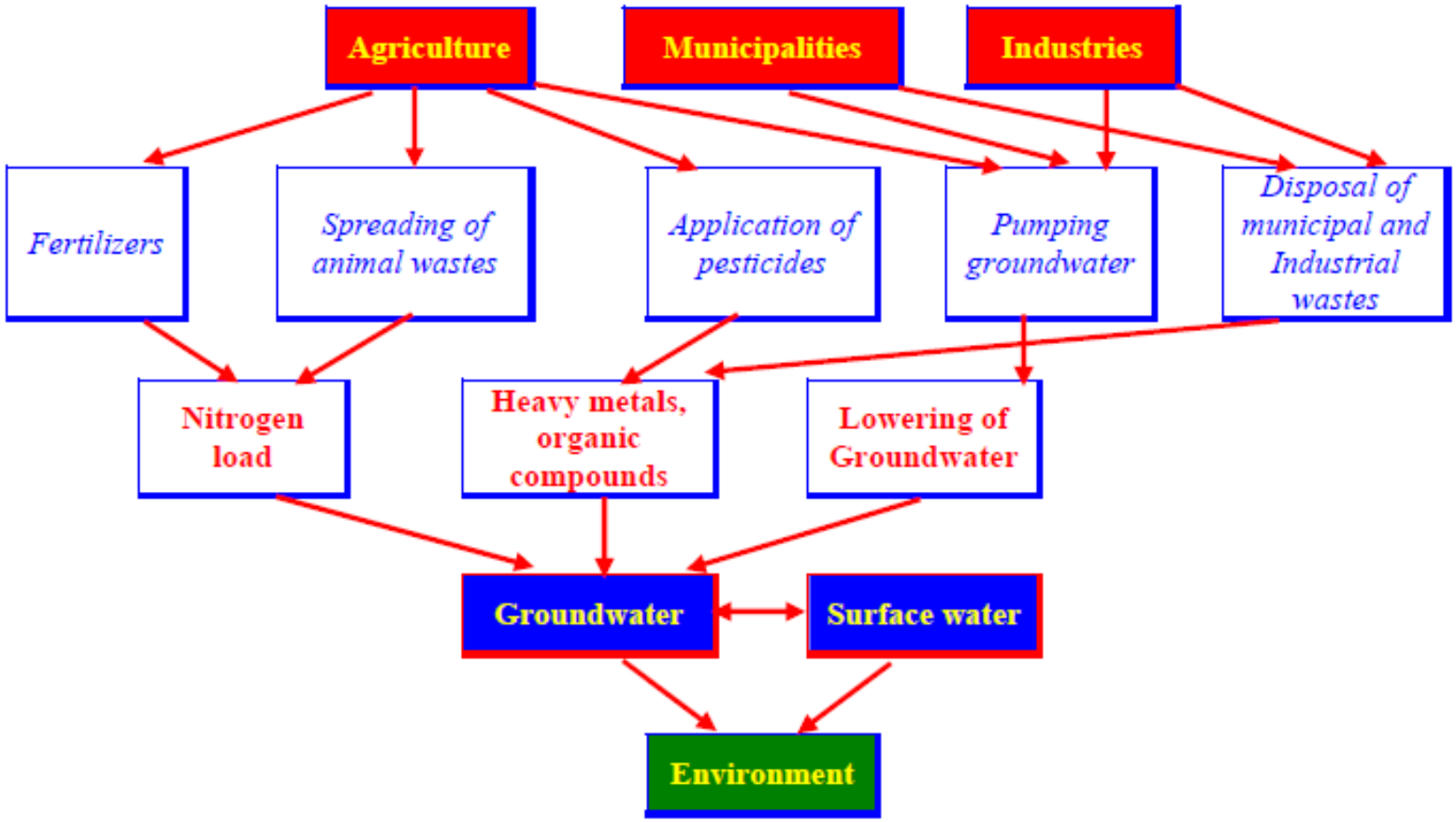
Indirect values
Ecological services, such as catchment protection, flood control, carbon sequestration, climatic control, etc.

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.

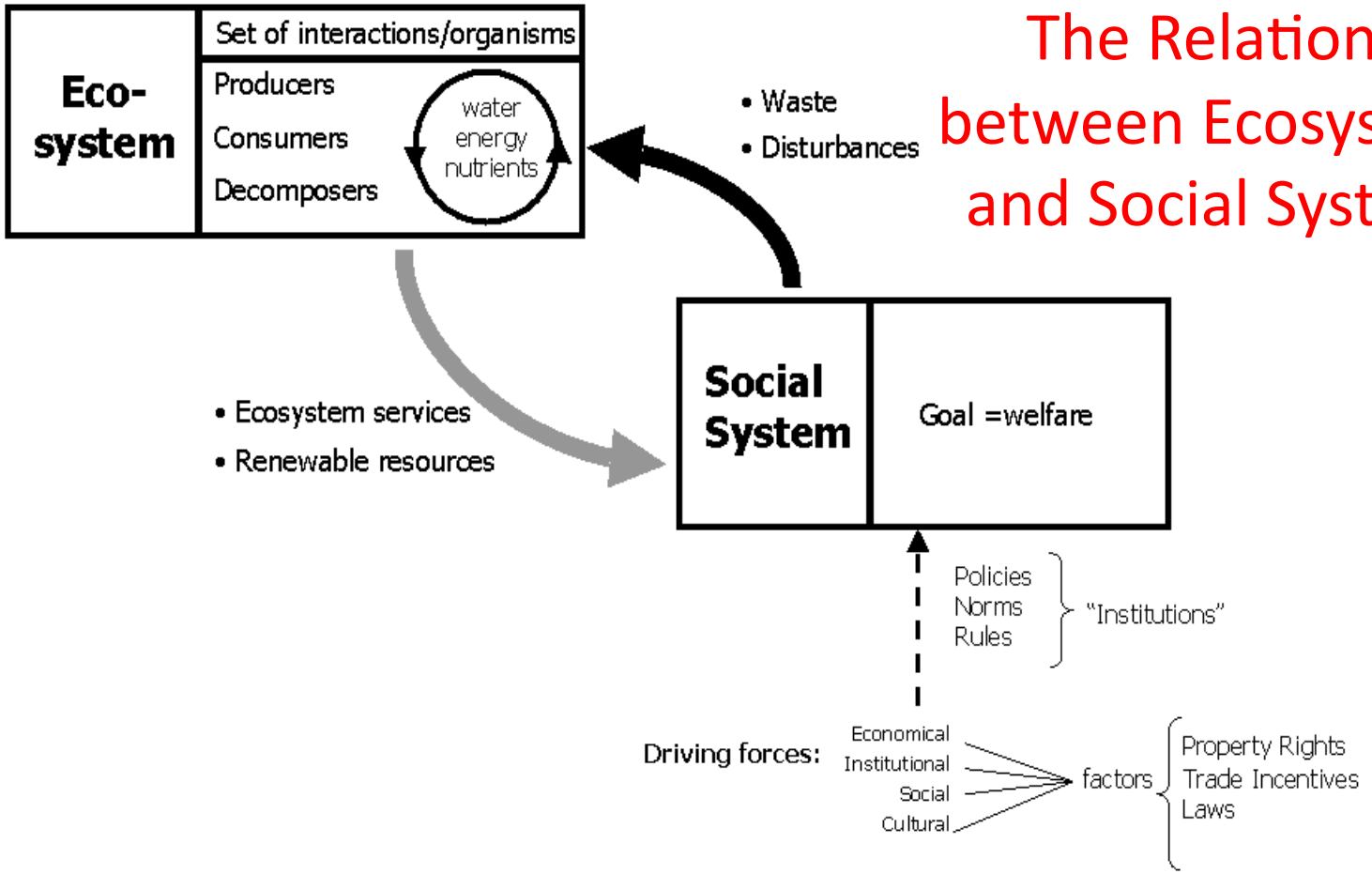
Non use

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,

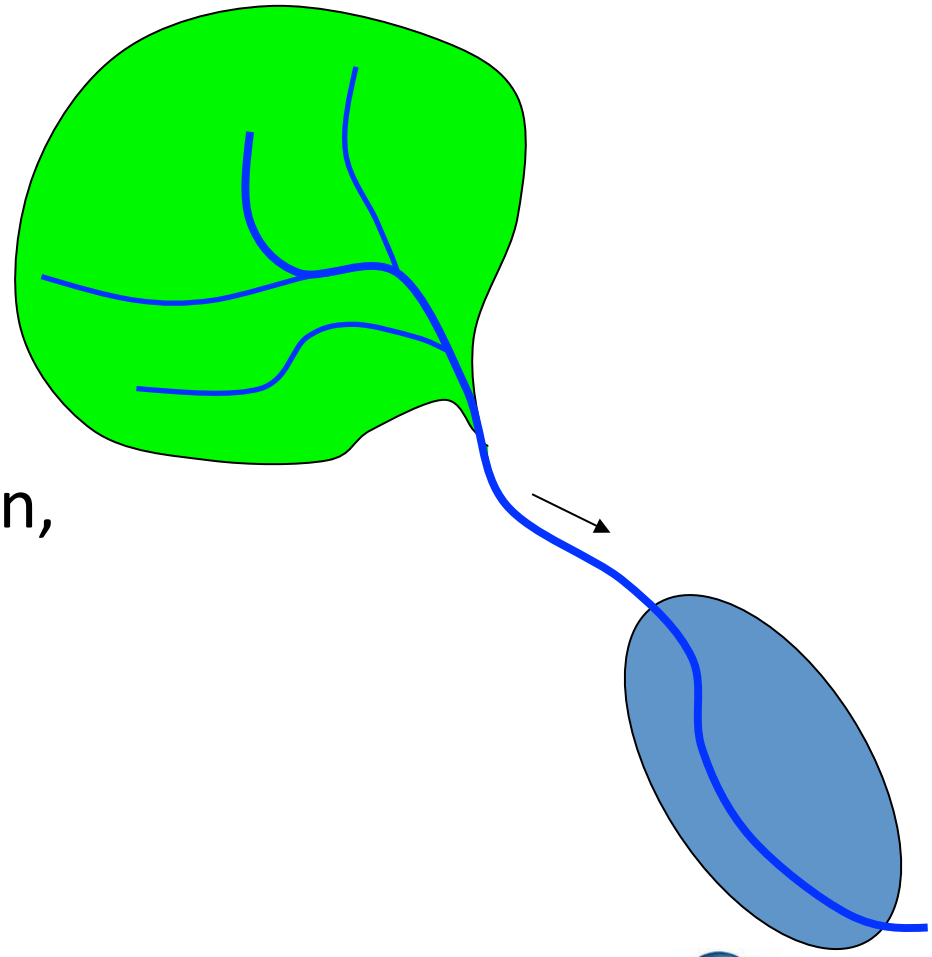
- but involve the production of waste and other disturbances that influence the functioning of the ecosystems.

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

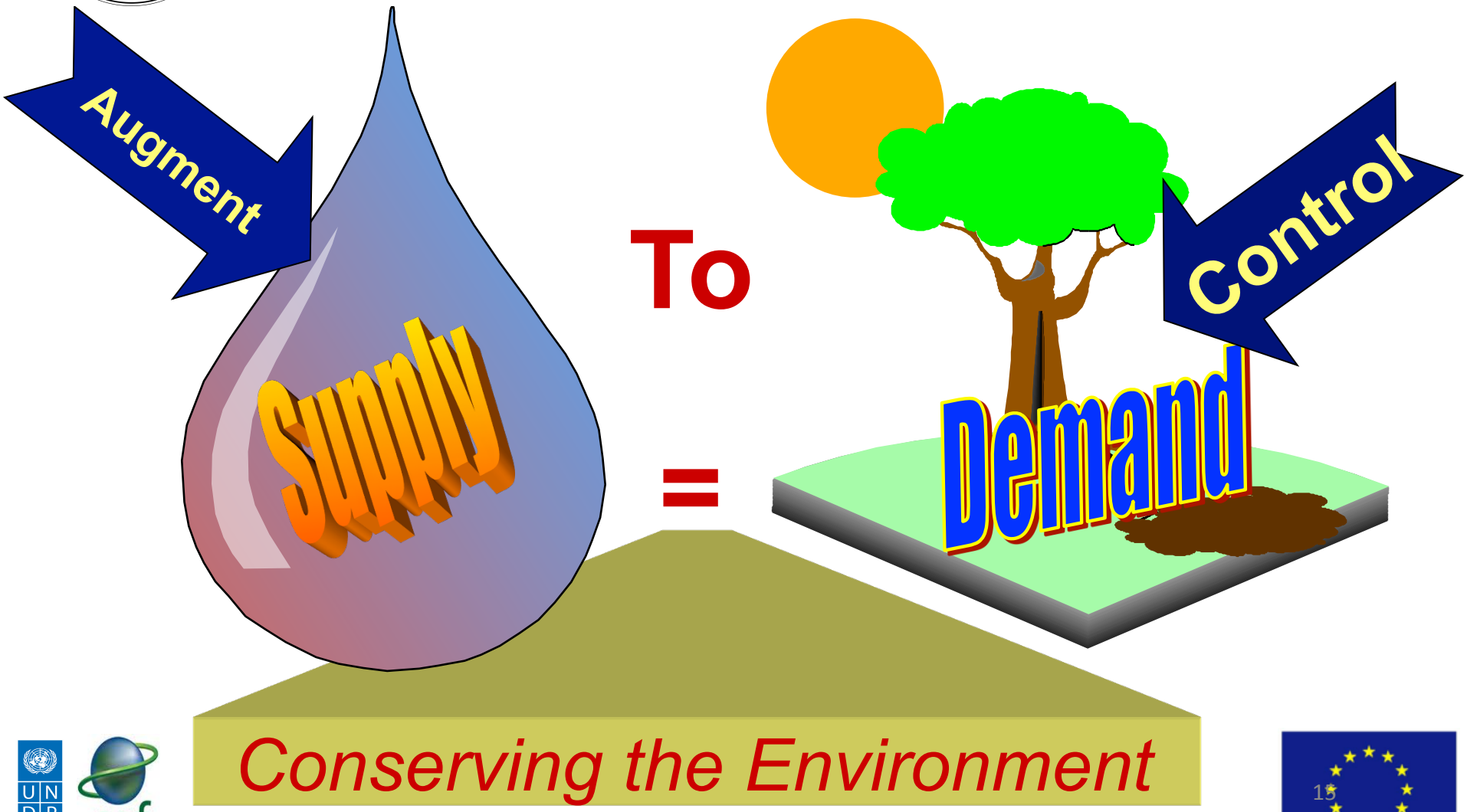


Environment and IWRM

- Third, integrated water resources planning and management are facilitated by policies, laws, strategies, and plans based on the following principals:
  - 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

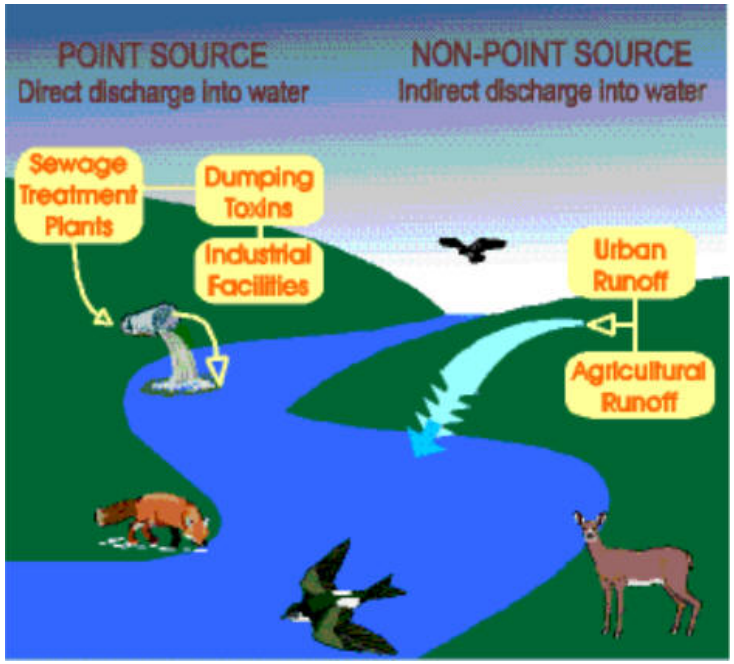
Sources and Types of Water Pollution

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.

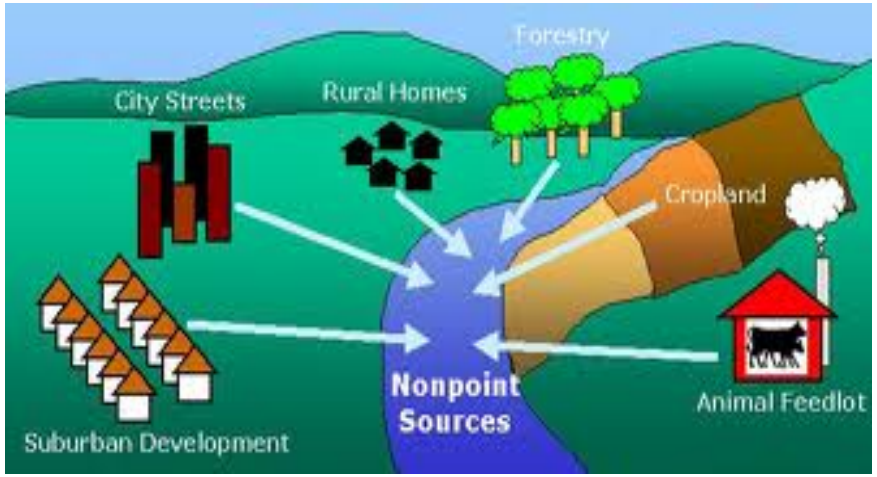
Where do Water pollutants come from?

- **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.**

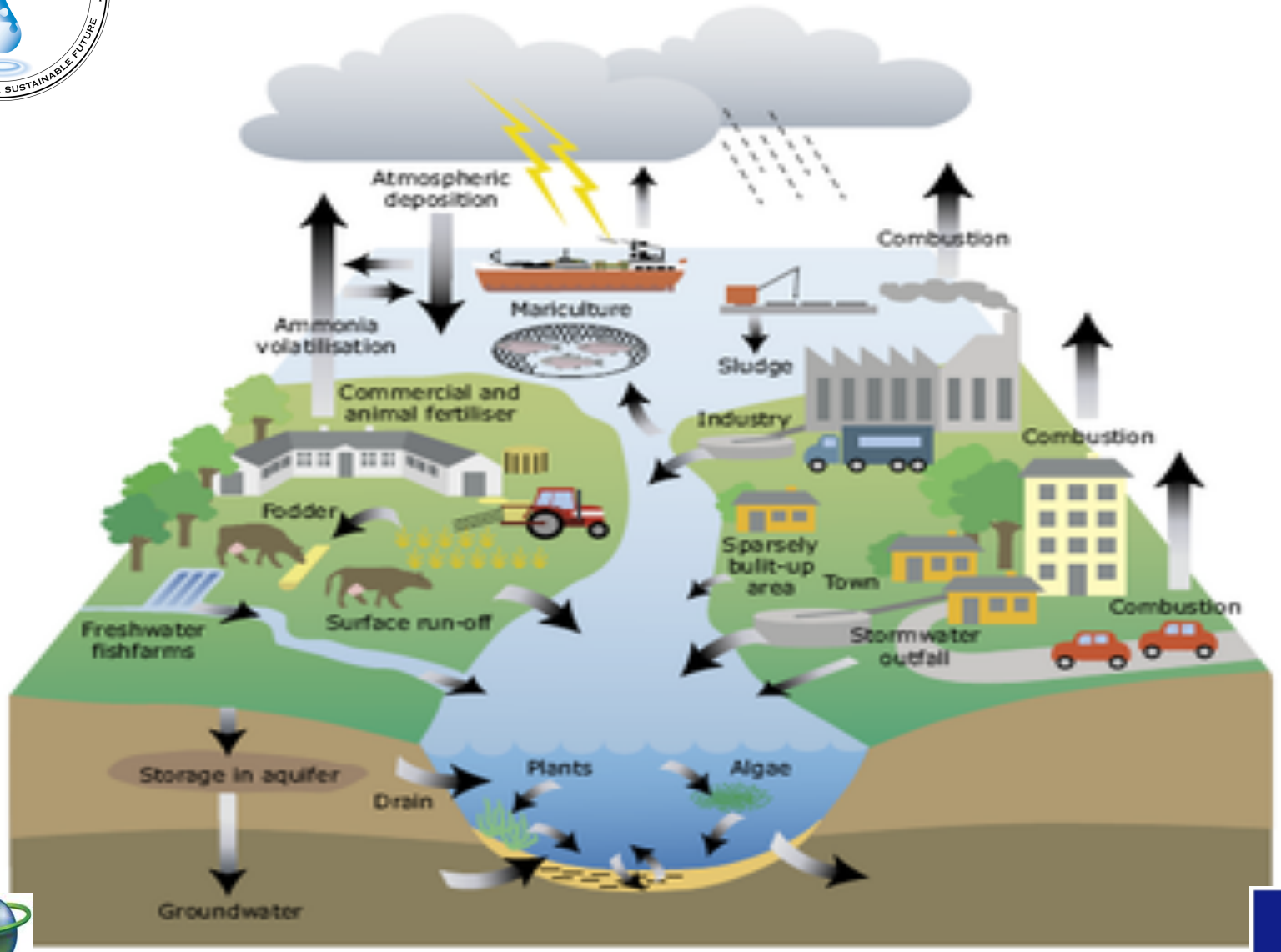


Where do Water pollutants come from?

- **Non-point sources – No one single source, but a wide range of sources.**
- **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.

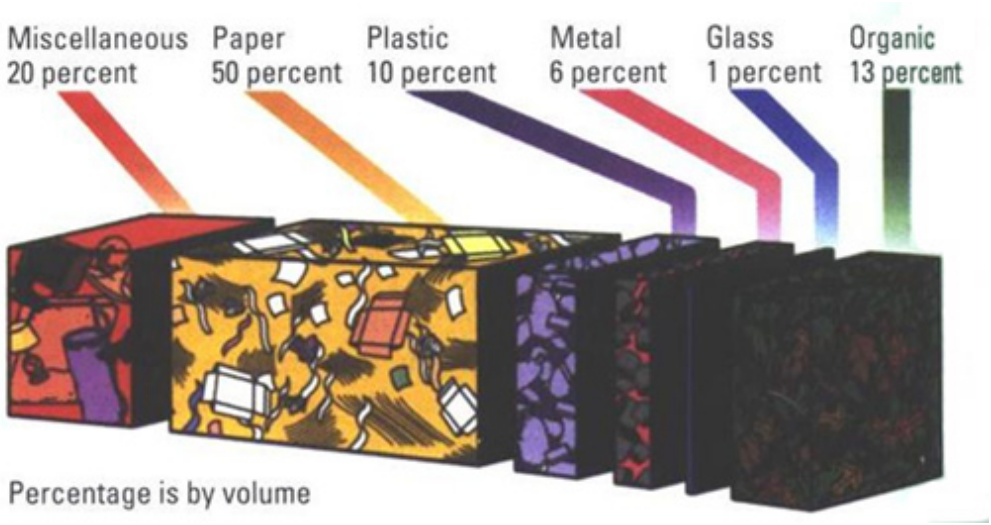
- **Sewage Disposal and Domestic Wastes**
  Sewage as well as domestic and farm wastes were often allowed to pollute rivers and dams.

Other water quality pollutants

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

Types of Water pollutants

- Degradable
- Non-Degradable



Non-persistent (degradable) Water pollutants

- Domestic sewage
- Fertilizers
- Some industrial wastes

The Environmental 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

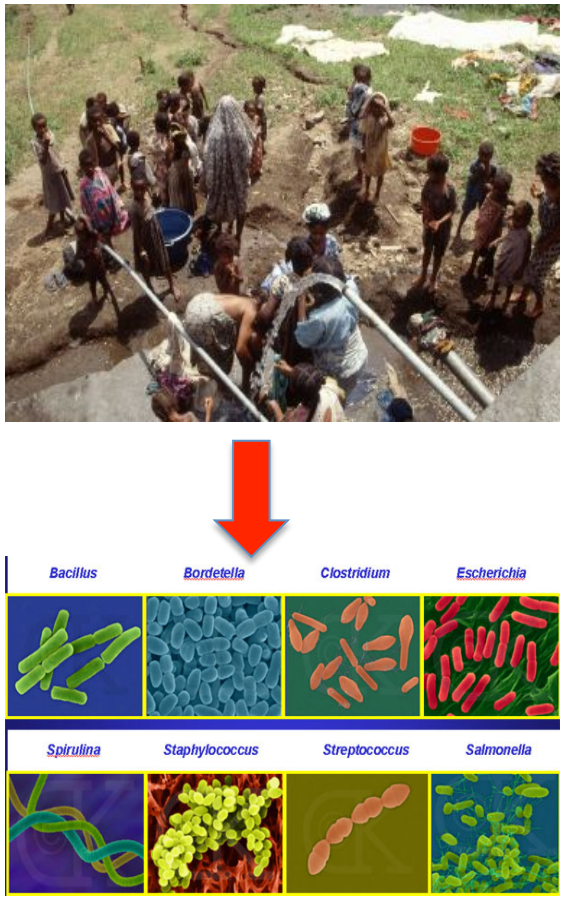
Plastic waste in water

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

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

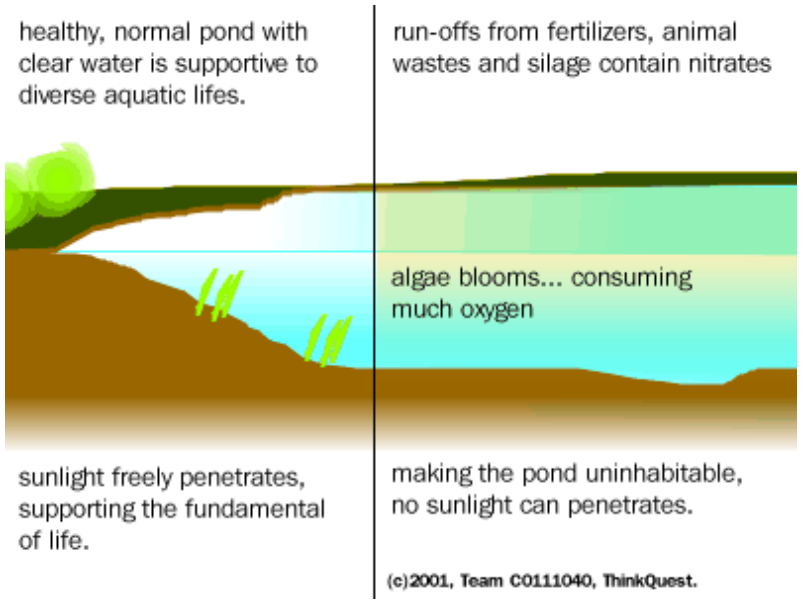
Microbial contamination of water

- 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.



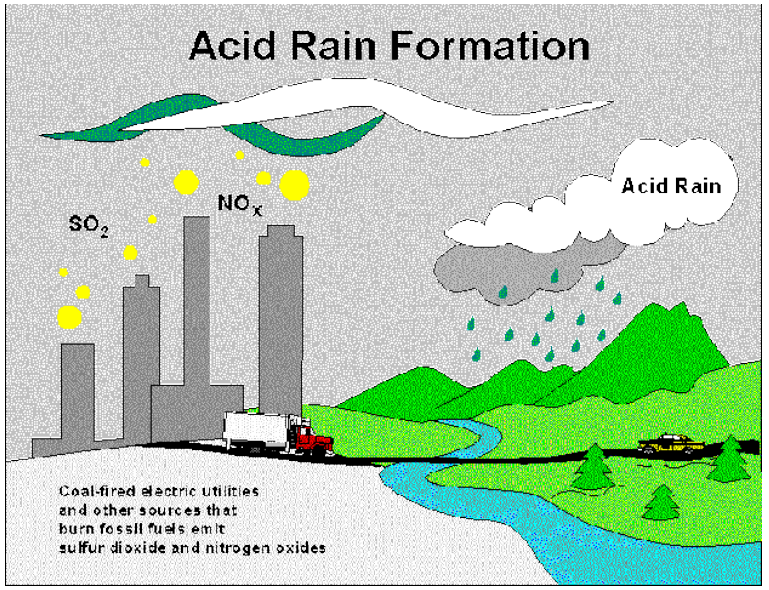
♪♪Eutrophication ♪

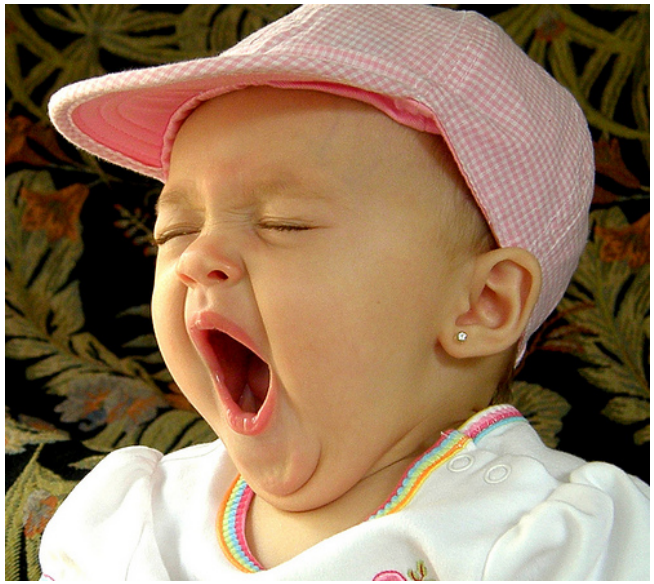
- **Increases in nutrient loading may lead to eutrophication .**
- **Organic wastes such as sewage impose high oxygen demands on the receiving water leading to oxygen depletion.**



Acid rain

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





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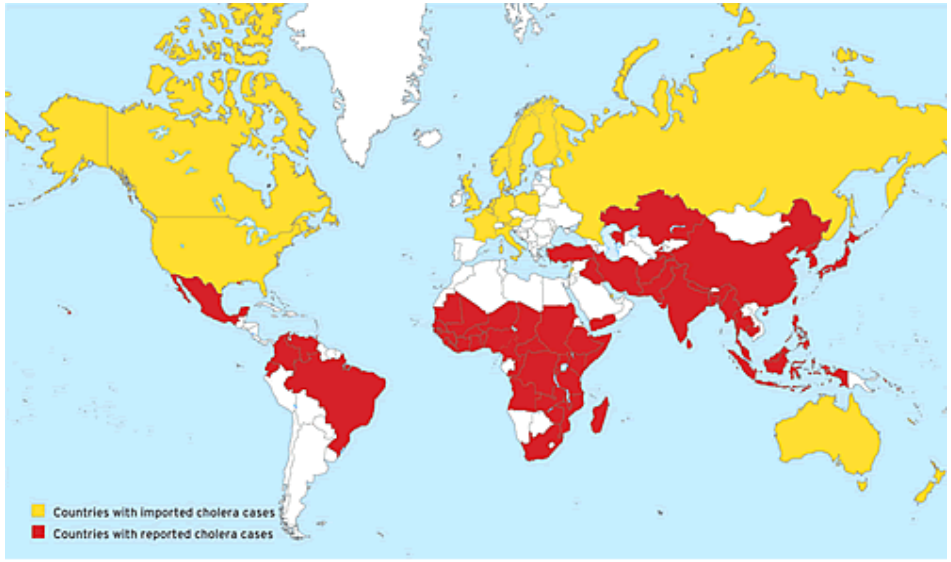
Health Impact of Water pollution

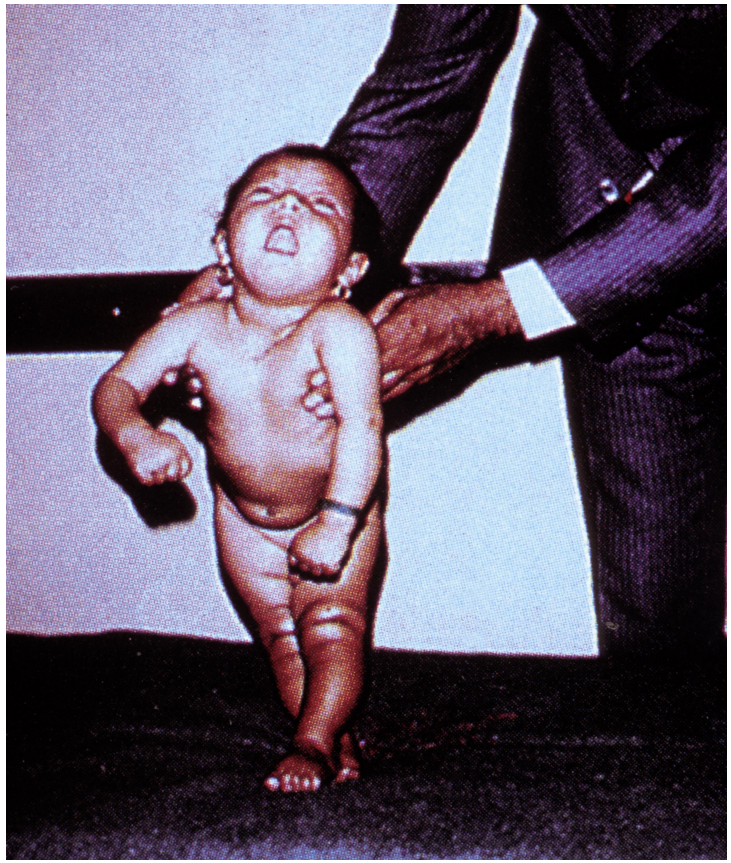
Water borne diseases

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



Most data are from humans

Severe poisoning events occurred in 1960s-70s in Minamata Bay, *Japan*



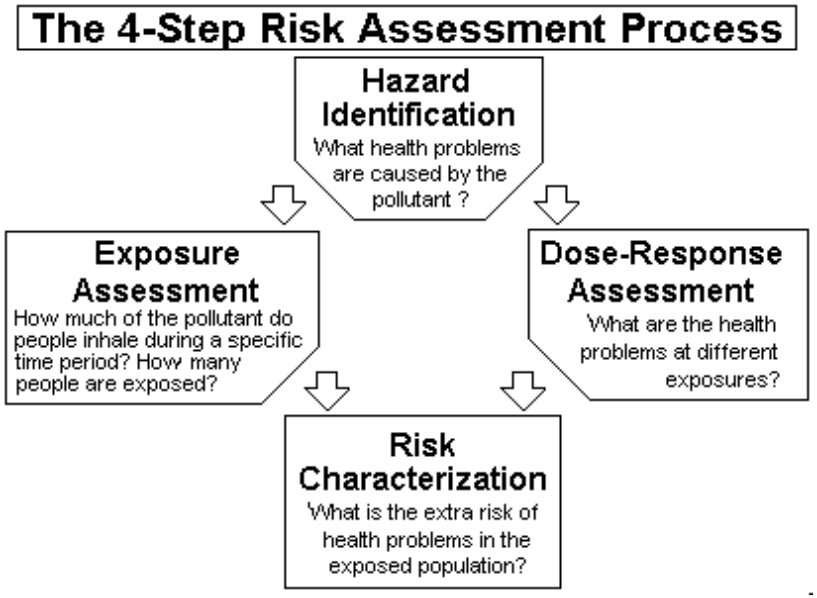
Health Impacts of Water Pollution

- 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/

Health Risk Assessment Studies

- **Hazard identification**: evaluation of all available data for the site and the potential for adverse health effects.
- **Exposure assessment***:* characterization of the chemicals of concern, and the exposed populations and routes and magnitude of exposure.
- **Dose–response**: describing the quantitative relationship between the amount of exposure to a substance and the extent of toxic injury or disease.
- **Risk characterization**: combining exposure estimates and toxicity values for cancer and non-cancer effects. The result is a set of lifetime probabilities of cancer and hazard quotients to assess non-cancer health endpoints



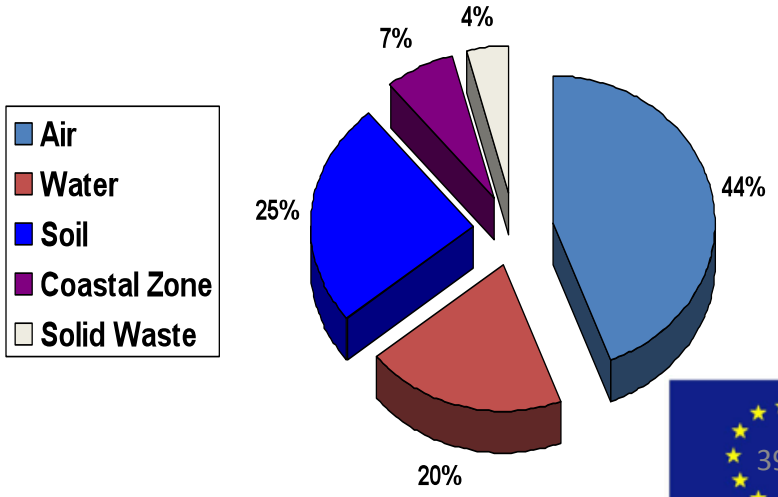
Economic Cost of Water Pollution

- 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

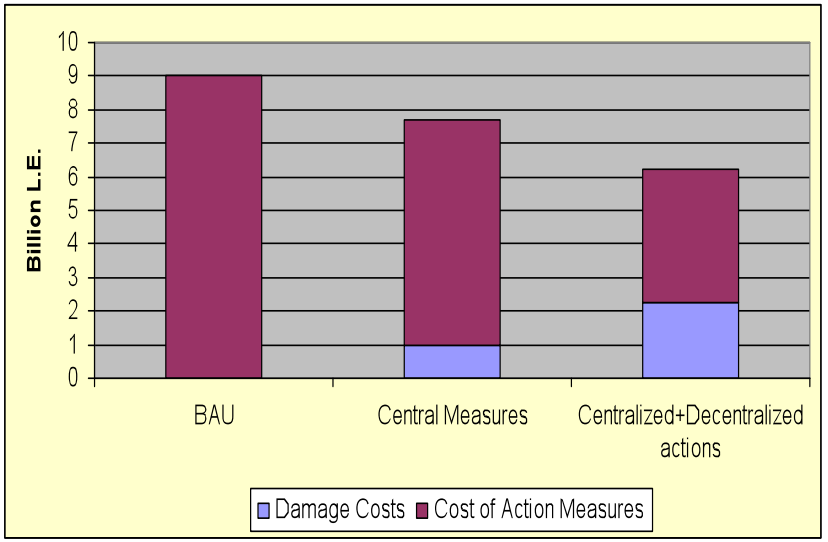
- in 2002, the World Bank carried on a study for Cost Assessment of Environmental Degradation in Egypt
- The cost of environmental degradation was estimated at 4.8% of GDP annually (14.6 Billion L.E./year)

	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



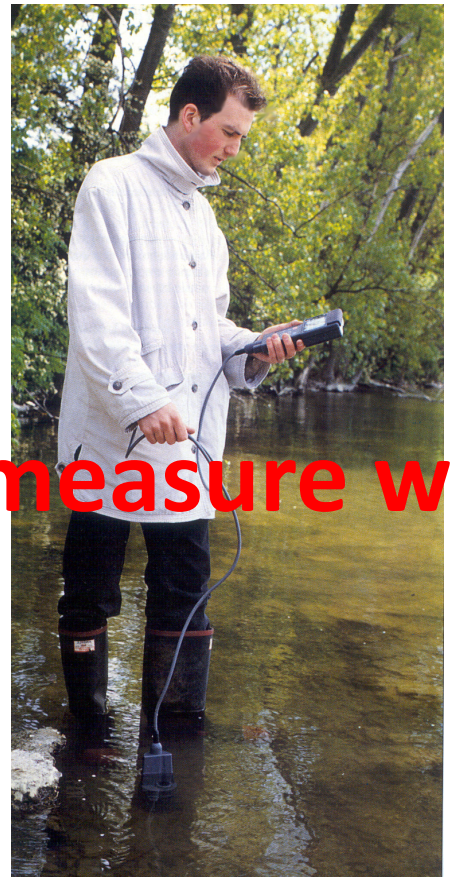
Study Main Results

The damage cost in 2014 will be:

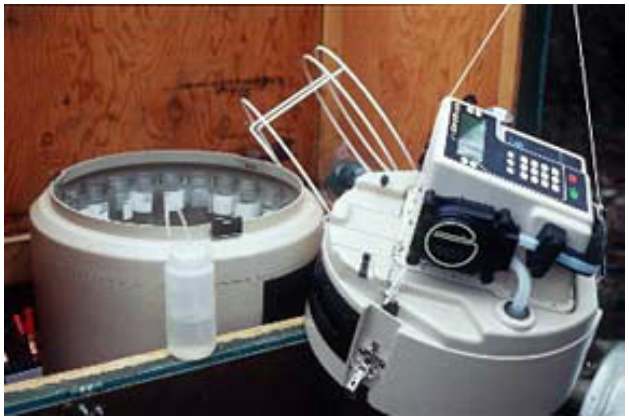
- BAU --→ 9.0 billion L.E./year

- 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)

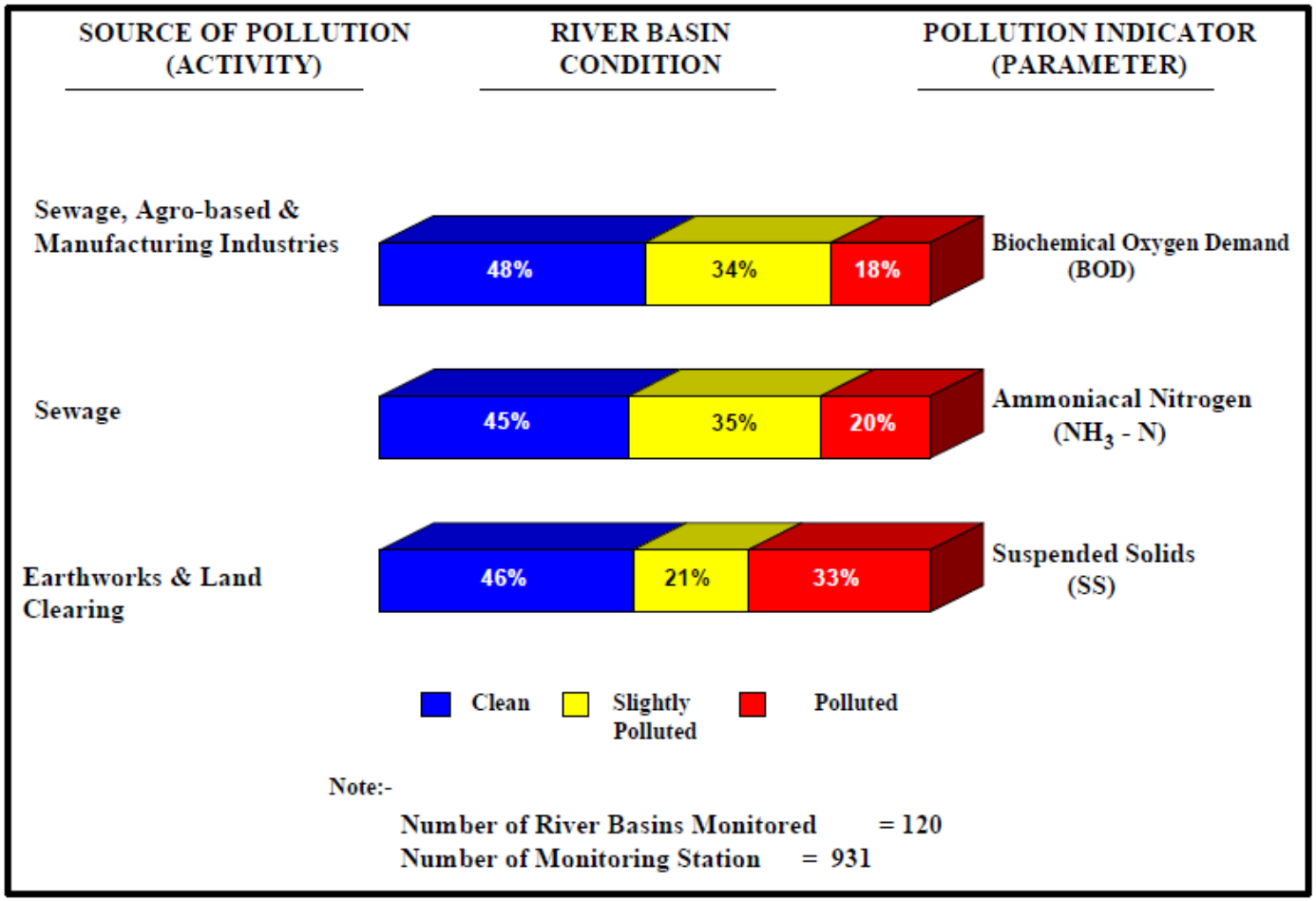
CRITERIA FOR SELECTION OF MONITORING STATIONS

- 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
- Water Quality Index is a unitless Value describing the overall quality of the water

	Excellent	Good	Moderate	Polluted	Highly Polluted
Class	I	II	III	IV	V
Parameter					
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
- Setting WQS based on the EU directives should have the basic 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

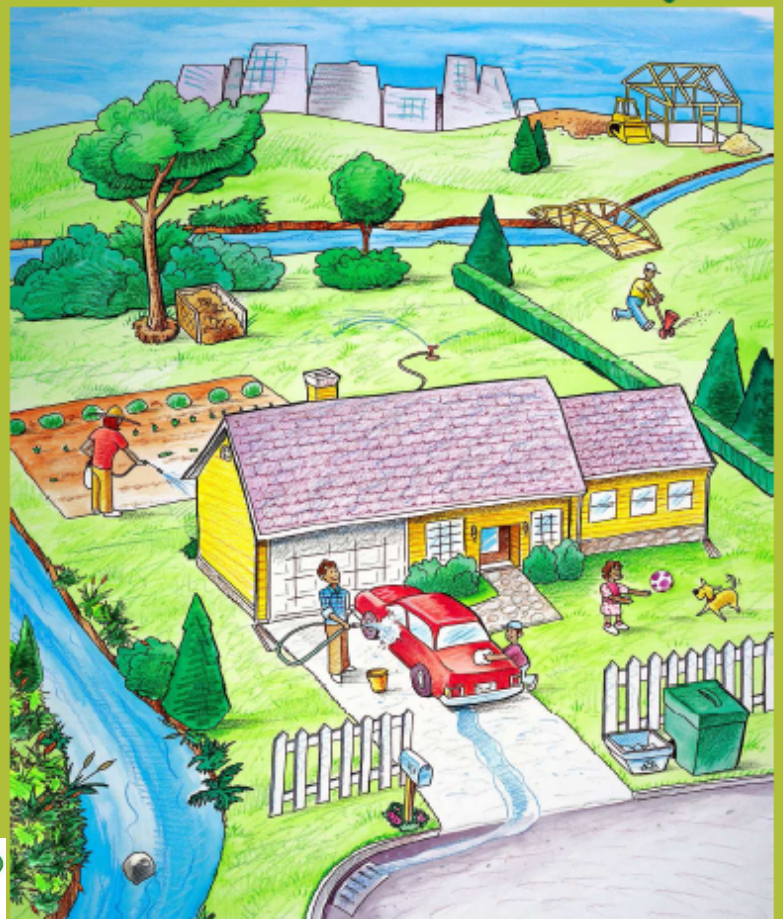
Water Quality Standards

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

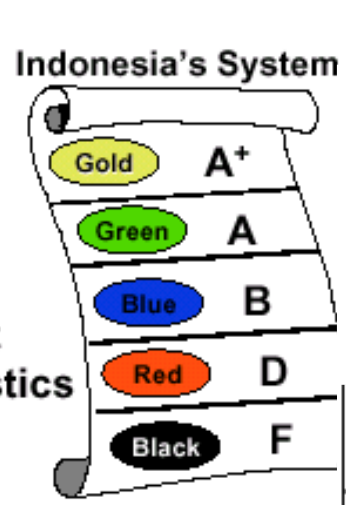


Agriculture Management

- 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!

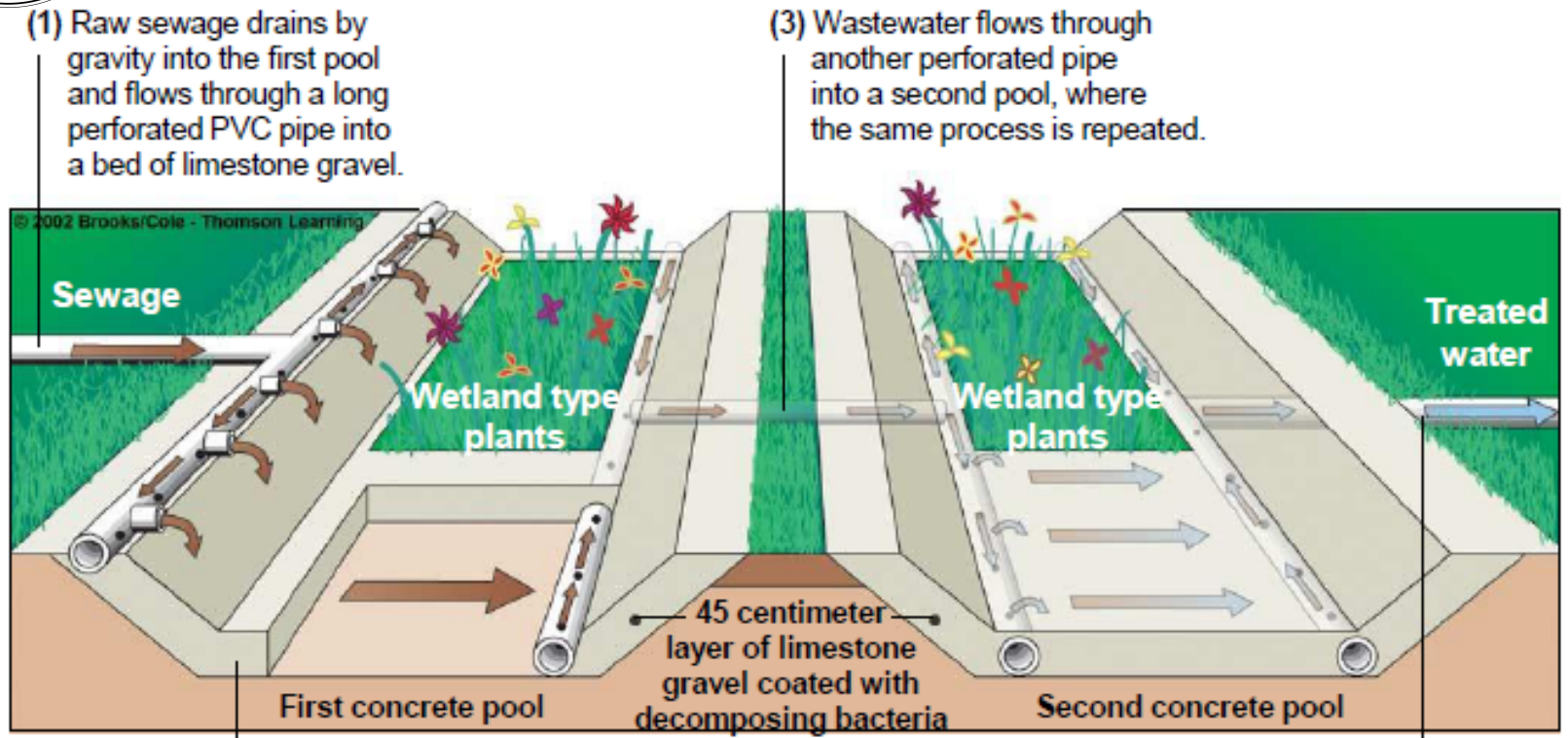
Use Performance grading system

- 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

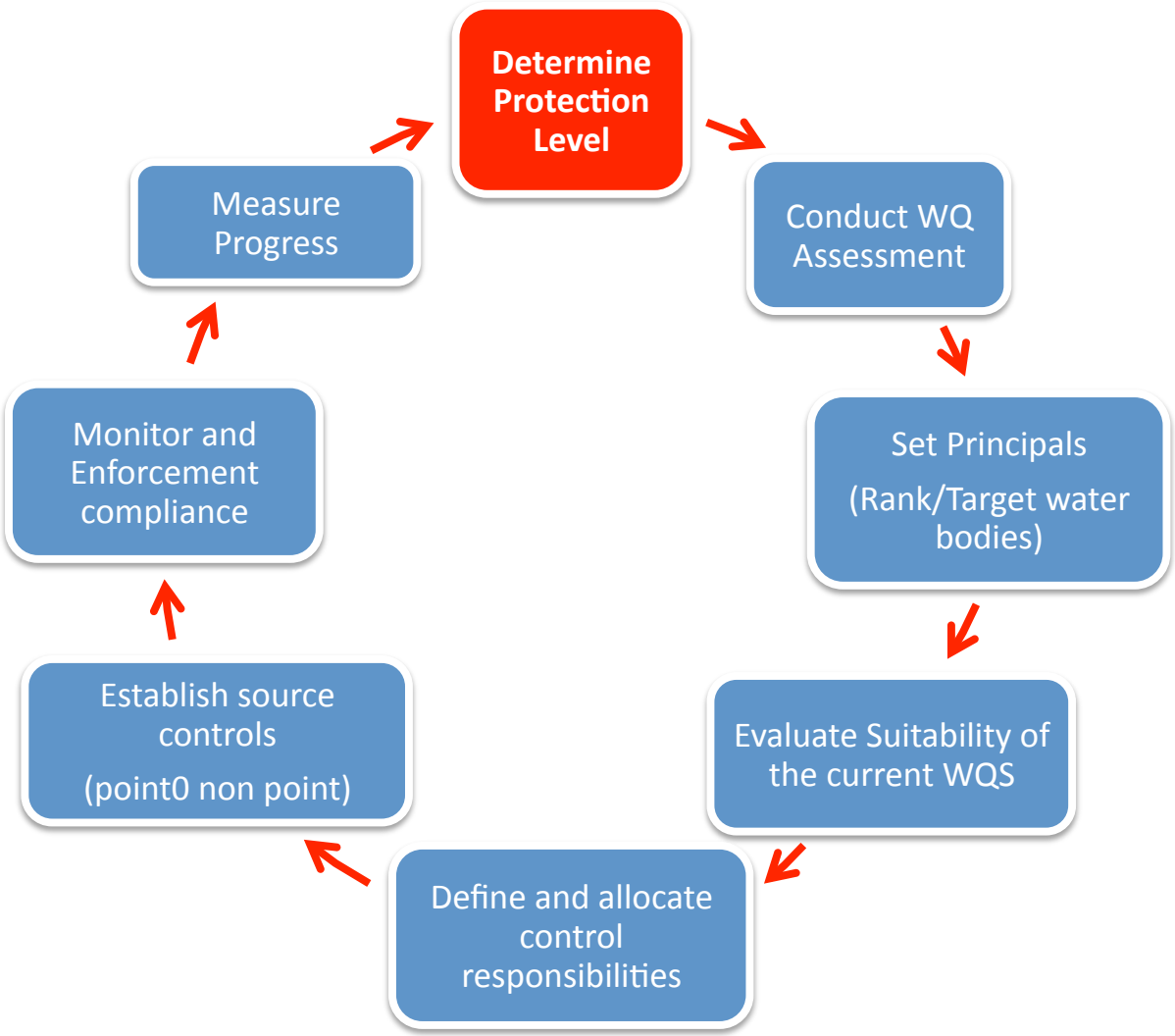
Use Engineered Wetland



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

End of Session (2)

Kura River Water Quality in the Georgian Territory

Kura River Basin in Georgia

- The Kura River is one of the largest watercourses in Georgia
- the length in Georgia is 390 km.
- The area of the Kura River Basin on the territory of Georgia accounts for 36,400 sq. km
- The population of the Kura River Basin accounts for 2, 633, 400 people, which is 60 % of the total Georgian population3
- Approximately 40-44 % of the total drinking water supply in Tbilisi comes from the Aragvi River

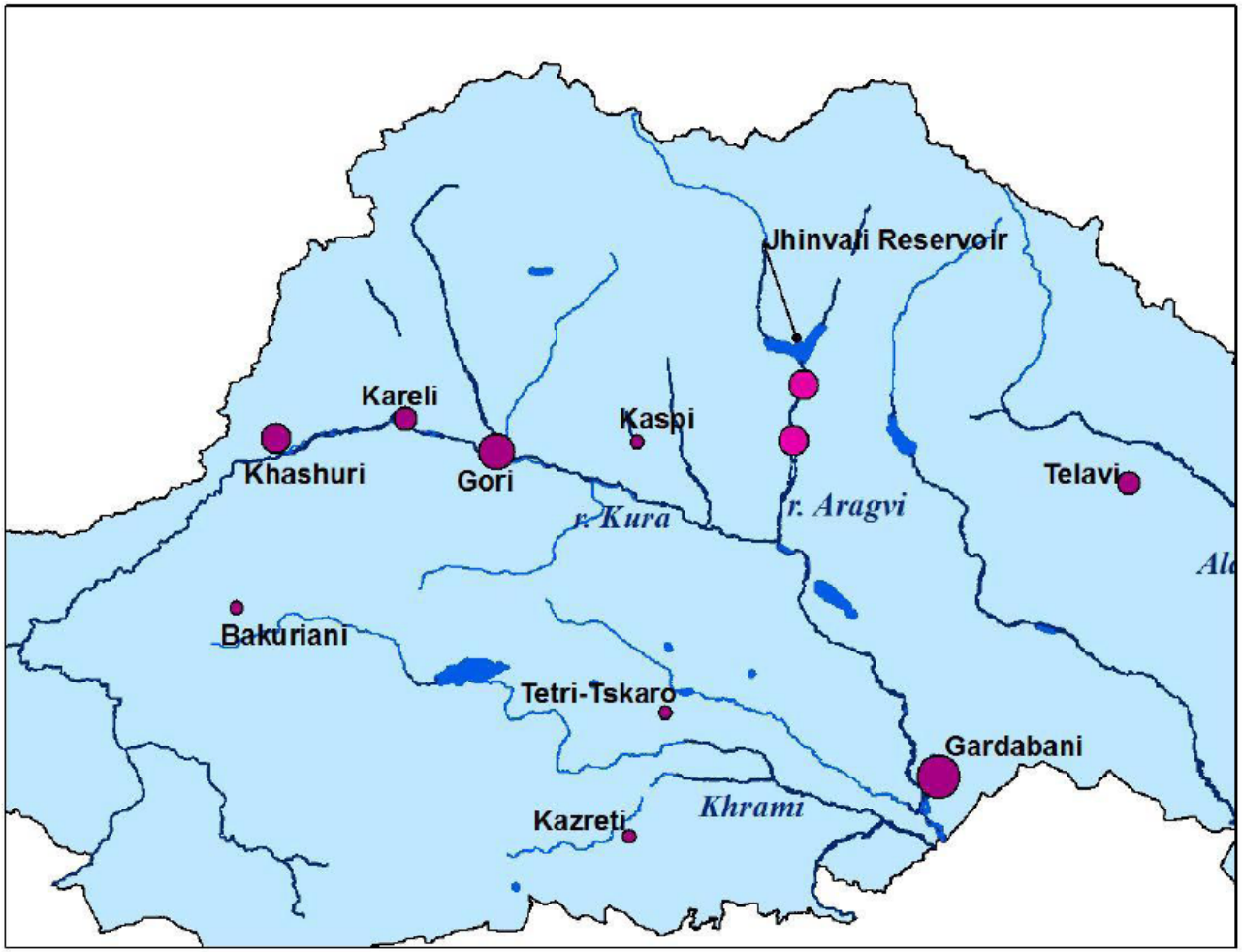
Water Quality in Kura River

- The UNECE (2007) assessment report provides information regarding water pollutants of the Kura River
- The report identifies industry as a primary source of pollution
- According to the report, industrial discharges in 2004 on the territory of Georgia based on production estimations accounted for:
  - 9945 ton surface active synthetic substances,
  - 2 tons sulphate,
  - 72 tons chloride,
  - 46839 tons ammonium-nitrogen,
  - 23 tons nitrate-nitrogen,
  - 159 tons iron,
  - 37.005 tons total inorganic nitrogen,
  - 600 tons Biological Oxygen Demand (BOD)
  - 4,958 tons suspended solids2

But Municipal Waste Water is also a Major Source of pollution

- bacteriological pollution of the Kura River is the most critical
- The Gardabani treatment plant only ensures mechanical treatment of sewage
- according to the UNECE report the plant treats only 600,000 m3 of wastewater.
- Between 30% - 50% of the total sewage produced in Tbilisi, is treated and the rest is discharged into the Kura River and its tributaries without any treatment
- The load of Biological Oxygen Demand (BOD) into the river is estimated about 10,800 tons per year

Sewage treatment plants in the Kura River Basin



Sewage treatment plants in the Kura River Basin

Town	Treatment	Designed Capacity,m^3	Condition	Site of Discharge
Gardabani	mech.+biol.	1000.0	mechanical only	River Kura
Kareli	mechanical	5.3	low efficiency	River Kura
Kaspi	mechanical	2.5	low efficiency	River Kura
Telavi	mech.+biol.	4.5	out of order	River Alazani
Tetri-Tskaro	mech.+biol.	1.0	out of order	River Khrami
Khashuri	mech.+biol.	10.0	out of order	River Kura
Gori	mech.+biol.	18.0	low efficiency	River Kura
Kazreti (Bolnisi region)	mech.+biol.	0.6	low efficiency	River Kazreti
Bakuriani (Borjomi region)	mech.+biol.	2.1	out of order	River Borjomula

Source: "Water Resources Management", Working Group 3 Report for NEAP, 1997.

Impact of water pollution

- In 1997-1998, 294 cases of water-borne disease were registered in the city of Borjomi
- During 1997-2001, 2423 cases of amebiasis, a condition that causes liver problems, were reported in Tbilisi

Main Findings

- From the current monitoring list, the main pollutants of the Kura River include cadmium, lead and possibly nitrogen compounds
- The possible sources of cadmium in the Kura River Basin are
  - Storm water discharges from waste landfills
  - Cadmium deposits in river beds that may wash out during high flow
- The possible sources of lead in the Kura River basin are
  - Wastewater discharges from industrial sources,
  - Wastewater discharges for corroded plumbing systems that contain lead
  - Lead containing gasoline

Main Findings

- Nitrogen compounds in the Kura river basin can be attributed to
  - Untreated wastewater discharges
  - normal sewage treatment (primary + secondary)
  - Nitrogen runoffs from agricultural land

Recommendations

- Set pilot monitoring stations at the Turkish- Georgian border upstream on the Kura River in order to prove whether elevated lead in the river results from the transboundary sources of lead or whether local sources alter the quality of the Kura River
- Include the measurement of the bacteriological indicators:
  - E. coli, as a good index for testing recent fecal pollution of water
  - intestinal enterococci as a more reliable group of bacteria for verifying the presence of long time fecal pollution in water
- BOD can be used as an indicator for verifying the presence of organic pollution in the surface waters of the Kura River Basin

Recommendations

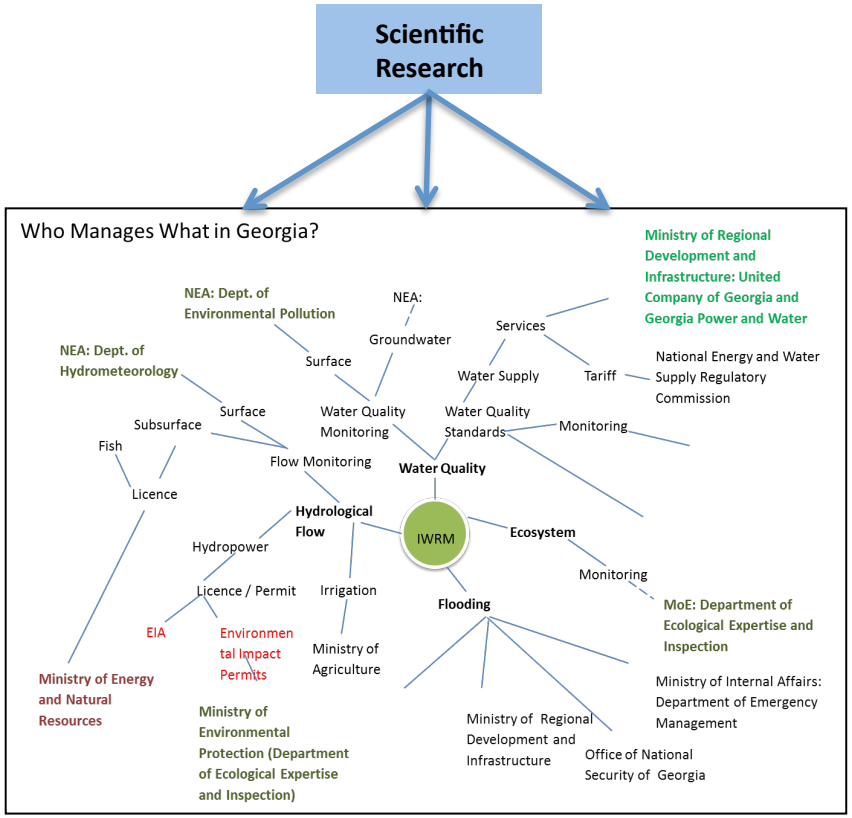
- Establish the On-line Industrial Pollution Monitoring Network and enforce establishments to install these sensors in their factories
- Develop an Environmental Compliance Action Plan for waste water treatment plant with a grace period of 3 years
- Follow up the implementation of the Compliance action plan
- Strengthen the role of environmental inspectors to effectively implement the environmental law on the polluting industry
- Encourage the use of law-cost technologies for waste water treatment at the village level
- Establish Environmental police Department and Environmental specific court
- Train Judges on the health and social impacts of environmental violations

Recommendations

- Review the current environmental fine scheme and replace it with Polluter pays principal
- Shift from the use of max allowable concentrations of pollutant to Total Maximum Daily Load (TMDL)
- Encourage the role of NGOs in developing solid waste management schemes at village level
- Raise public awareness on the health risk of water pollution and start from school children

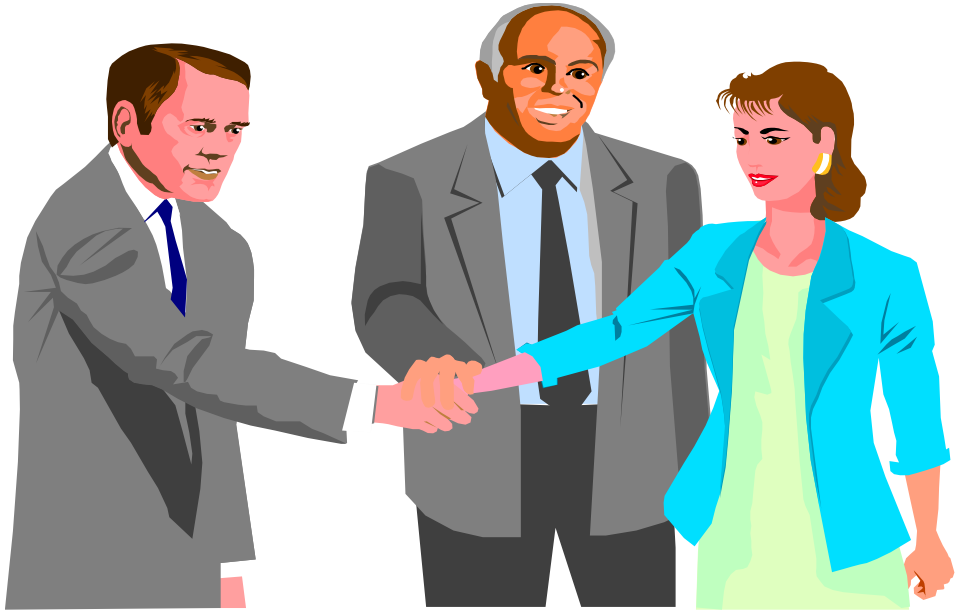
Recommendations

- Strengthen the role of scientific community in water Resources Management:
  - Operate and maintain Monitoring programs
  - Auditing EIA studies
  - Participation in updating the WQS
  - Support industrial facilities in the implementation of the BAT and Cleaner production mechanisms for pollution reduction



We are the solution for water pollution

- www.eeaa.gov.eg Egypt Env Agency
- www.kuraarasbasin.net EU Kura Project
- www.kura-aras.org UNDP GEF Project



THANK YOU