MAN'S INFLUENCE ON HYDROLOGIC CYCLE

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INTRODUCTION

Water is the lifeblood of the environment. Some very simple life organisms can survive without air but none can grow without water. Water means different things to different people. It has unique physical and chemical properties. You can freeze it, melt it, evaporate it, heat it and combine it. All life depends on water. It makes up two thirds of the human body. A person can live without food for more than a month but can live for only a few days without water. All living things from the tiniest insect to the tallest tree need water to survive.

> Water is the solvent, the medium, the participant, and the catalyst in most of the chemical reactions occurring in our environment.

Once we have understood the importance of water for the survival of mankind , the next issue which comes before us is that if it is so vital how much of it we have ? Scientists estimate over one billion cubic kilometer. To break it up we can say that world's total water supply is 1386 million cubic km i.e. 97.5% is salt water. 2.5% of the remaining water is fresh water but this is almost locked up in ice or underground. Out of this 2.5% only 0.)1% is not in ice or underground.

In nature all organisms as a rule live within environments which provide them with adequate conditions of existence. The space where the exchange of matter between the living and non-living part of the nature takes place, dependent on organic and inorganic substances, is called the ecosystem. This ecosystem is defined by ecologic factors which may be divided into abiotic (physico-geographic), biotic (plant and animal life) and anthropogeneous (effect of man's action on these factors). Provided the factors aggregate and change only to a sufficient extent to permit the continuous adaption of living organisms, there is an ecological balance.

It is man who interferes with the ecological balance to the most marked degree especially through economic activity and by growth of population entailing excessive exploitation of natural resources.

Within the complex of all the resources exploited by man
WATER is of particular importance.

From the beginning of time when water first appeared, it has been constant in quantity and continuously in motion. Little has been added or lost over the years. The same water molecules have been transferred time and time again from the oceans into the atmosphere by evaporation, dropped upon the land as precipitation and transferred back to sea by rivers and groundwater. This endless circulation is known as the **HYDROLOGIC CYCLE**. At any instant about 5 litres out of 100000 litres is in motion.

COMPONENTS OF HYDROLOGICAL CYCLE

Evaporation

As water is heated by the sun, its surface molecules become sufficiently energized to break free of the attractive forces binding them together, evaporate and rise as invisible vapour in the atmosphere.

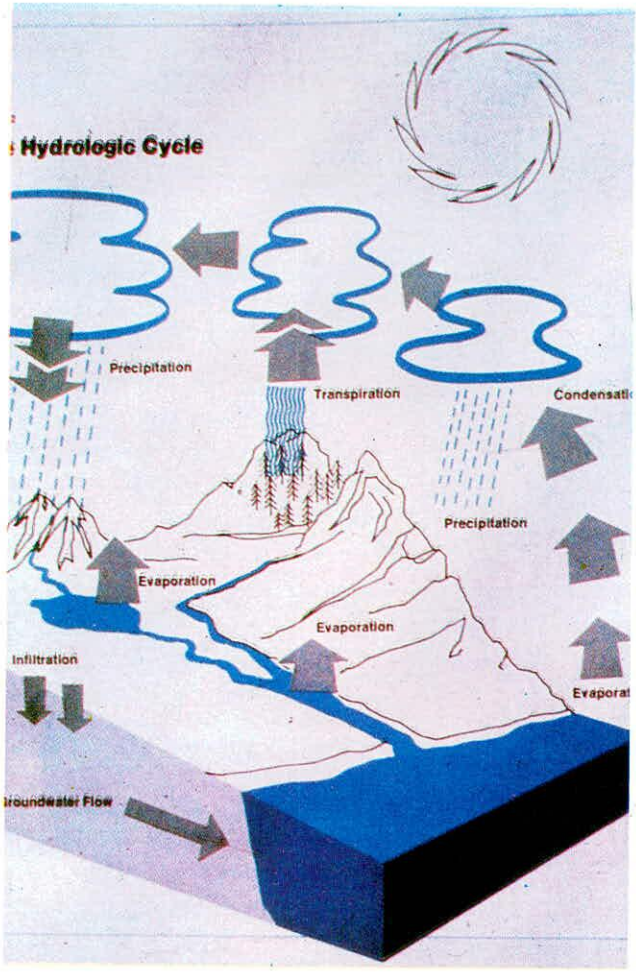
Transpiration

Water vapour is also emitted from plant leaves by a process called transpiration. Every day an actively growing plant transpires 5 to 10 times as much water as it can hold.

Condensation

As water vapour rises, it cools and eventually condenses, usually on tiny particles of dust in the air. When it condenses it becomes

liquid again or turns directly into a solid(ice, hail or snow). These particles then collect and form clouds.



HYDRLOGIC CYCLE

Precipitation

Rain, snow and hail are all forms of precipitation that comes from clouds. Clouds move around the world propelled by air currents. When they rise over mountain ranges they cool, becoming so

saturated with water that water begins to fall as rain, snow or hail, depending on the temperature of surrounding air.

Surface runoff

Some of the water after reaching the land surface drains by running across the land surface into creeks, ponds, lakes and rivers that eventually takes the water back to the ocean.

Percolation

Surface water moves downwards, or percolates through cracks, joints and pores in soils and rocks.

Ground water

Much water is stored in the earth, occupying pores, cavities, cracks and other spaces in the crystal rocks and soils.

Water table

The water table marks the change in the ground water zone between the zone of aeration, where some pores are open, and the underlying zone of saturation, in which water fills all the spaces in the soil and rocks.

USES OF WATER

As mentioned earlier, man is a part of a large complex bio-eco-system evolved around water, and is fully dependent on water for survival and growth as the infant is on mother. The presence or absence of water has a pronounced influence on his development and prosperity. Water is required by the human society for a wide range of diverse purposes. Some of these are:

i. Domestic uses

ii. Agricultural production

iii. Industrial consumption

iv. Fisheries survival and growth

v. Recreational purposes

vi. Power generation

vii. Navigational purposes

viii. Other uses.

Do You Know ?

- About 70% of our body is water.
- Life on earth originated in water.
- More than half of the world's animals and plant species live in water.
- Almost 75% of the earth is covered with water.
- The human body needs a minimum of two litres of water everyday, however we can last only a few days without water.
- Most of our food is water; tomato (95%), milk (90%), apples (85%), spinach (91%), potato (80%).
- Raindrops are not tear shaped as is the belief. Scientists using high powered cameras have discovered that these resemble more to bread buns.

Body needs are small. Only 5 litre are required per day for human consumption. But domestic services need a minimum of 60 litres per day. For social and industrial services another 50 litres per capita per day are required. In addition each cattle requires about 30 litres and other live stock animals require 10 litres per day per head. But of all the withdrawal uses agriculture requires

the maximum amount of water. It is as high as 100 litres per capita per day i.e. about 400 cubic meter per capita per year. The predominant factor influencing the per capita demand is the availability. To have an idea of the comparative figures of water availability in different countries we can see the figure below:

PER CAPITA WATER AVAILABILITY IN DIFFERENT COUNTRIES	
United States of America	6200 cubic meter per year
Japan	6500 cubic meter per year
Undivided U.S.S.R.	17536 cubic meter per year
India	3200 cubic meter per year

The surface of the earth forms a geographical space in which man creates an anthropologeneous living environment. He influences the land directly and indirectly, deliberately and unintentially. Man transforms the situation mainly by his building activities. This is particularly true of continuous built up areas of housing and industries, linear civil engineering structures (railways, roads, bridges, tunnels), public utility networks, water structures, etc. These activities are complemented by those of agriculture. The effect of such influences becomes evident in terrace cultivation in slopes, strip tillage, felling of forests, etc. Exploitation of minerals and other substances by mining causes substantial and often very adverse changes.

MAN'S ACTIVITY

- Forestry
- Agriculture
- Urbanization
- Industrialisation
- Water Resources Management

CLIMATE

- Precipitation
- Radiation
- Temperature
- Humidity
- wind

CATCHMENT CHARACTERISTICS

- Geology, soils, and topography
- Lakes and swamps
- Drainage system
- Vegetation, land use
- Hydraulic structures

HYDROLOGIC CYCLE

- Precipitation
- Soil moisture
- Evapotranspiration
- Groundwater
- Streamflow

Many human activities have an impact on water quantity and water quality, and it is useful to look at the interactions between man's activity, the climate, the catchment characteristics and the hydrologic cycle.

Man's activity can have a considerable impact on the catchment characteristics and hence on the hydrologic regime. Depending on the nature of this impact, man's activity can be classified into the following categories:

- Activities leading to changes in the vegetation and land use (deforestation and afforestation, agriculture, drainage of swamps and marsh ridden areas, urbanization etc.)

- Activities leading to changes in topography and drainage system (construction of various hydraulic structures such as dams, barrages, embankments, polders, terraces and contour plowing)

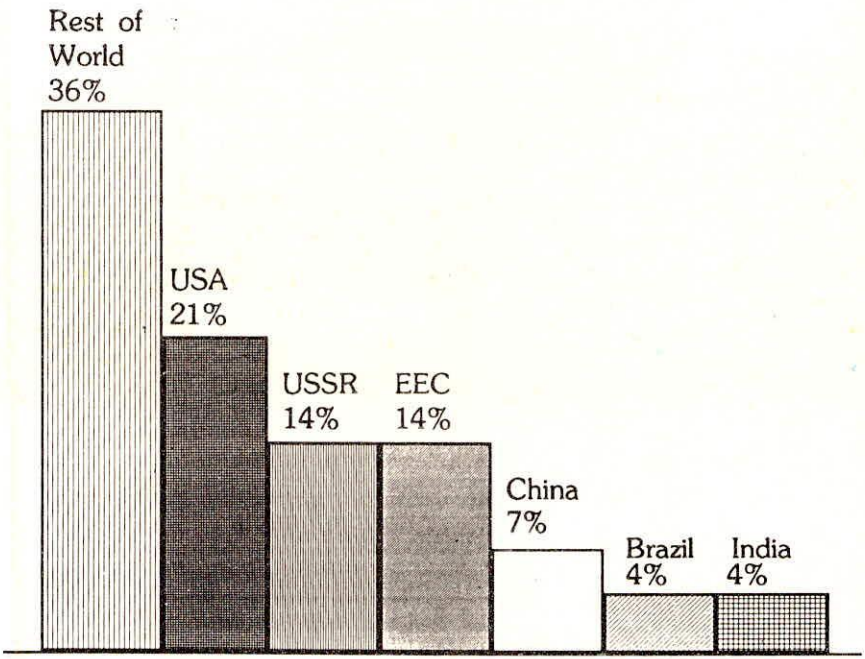
- Activities leading to direct and indirect eater diversions from or to the rivers the groundwater system (surface and groundwater abstraction for use outside the area, affluent discharge, artificial groundwater recharge, drainage, irrigation etc.)

WAYS TO AFFECT THE WEATHER

- Remove and burn the forest
- Drain the wetlands and lakes
- Pollute the oceans
- Cover the ground with paving and buildings
- Operate combustion engine
- Exhaust industrial and domestic gases into the atmosphere

A climatic change induced by increased concentration of greenhouse gases is possibly the greatest potential human impact on the inputs of energy and precipitation into the catchment system. Cloud seeding is deliberate attempt to alter inputs- although within certain effects- and emission of sulfur dioxide and other industrially produced gases leads to changes in chemical deposition in a catchment. Many activities influence hydrological regimes by their effects on evaporation and transpiration, of which deforestation is the longest established and well documented. A large number of these activities also influence both the way water enters the surface and sub-surface soil water storage and movement process. Field drainage, for example, is a deliberate attempt to alter the soil moisture characteristics of a field.

ESTIMATED REGIONAL CONTRIBUTIONS TO THE GREENHOUSE EFFECTS



Survey by US Environmental Protection Agency(Quoted from Water Related Issues and Problems of the Humid Tropics and other Warm Humid Regions, UNESCO)

EFFECTS OF SOME OF HUMAN ACTIVITIES

Though all the human activities affect one or more than one components of the hydrologic cycle in small or big way however influence of four activities of man has got great concern on the hydrologic cycle. These are deforestation, urbanisation, use of agricultural fertilisers and reservoir impoundments. The description below does not claim to be exhaustive but aims to highlight the impacts.

COAL FIRED GENERATING STATION

i) Deforestation and Afforestation

Removal of forest has been the most widespread human impact in catchments - both intentional and unintentional. This impact has been studied extensively but still lot of gray areas exist in our understanding of influence of deforestation on various components of hydrologic cycle.

Several conclusions concerning the effects of deforestation on run-off are qualitatively consistent across virtually all studies. Annual run-off totals are generally increased because evapotranspiration from forests is generally higher than from other land types. This is primarily due to increased evaporation of intercepted water. The removal of trees can also increase the amount of snow stored on a catchment. Flood magnitude tend to increase once forest cover is reduced, and reduced losses often mean that ground water tables rise and minimum flows increase. The increase in flows is frequently during the growing season when the difference in evaporated losses is greatest. However there are some important exceptions to these conclusions like the studies conducted in Japan wherein it has been inferred that evaporative losses from a pasture covered catchment were higher than losses from forest, and losses from a lowland forest in Eastern England were similar with those from grass.

There have been a great many studies of the impact of deforestation on many hydrological characteristics. The need now is for the results of these studies to be compared and placed in context : why do low flows reduce when forests are cleared in some areas, and why do they increase in others? There is also a great popular concern over the effect of deforestation in mountain headwaters on flow characteristics in some of the world's largest rivers. At present it is not possible to extrapolate the results from the few basin studies that have been made in such headwaters, and a priority task is clearly to examine deforestation impact at different spatial scales. Also, relatively little is known of the effects of deforestation on the semi-arid environments.

A summary of studies conducted in India and elsewhere is being given below, as this is regarded as the most dominating influence the man has got in the hydrologic cycle:

a **Rainfall**

Based on the limited studies done in India and abroad, it may be concluded that the effects of ot deforestation and afforestation on rainfall are generally inconclusive in

nature., indicating that forests do not affect rainfall on a regional scale. However in coastal forests the precipitation may be more because of interception and the condensation of fog by forests.

b. Interception

From the available studies it can be concluded that the interception is a function of forest type, forest density, composition, structure and rainfall amount and intensity. It has been observed that the interception is higher from needle leaved trees as compared to broad leaved trees. The interception in forested catchments does not have significant effect during heavy storms. However this is important from soil conservation point of view.

c. Infiltration

In general, it can be concluded that the infiltration rates are relatively more in forested soils as compared to agricultural areas and grasslands. Based on the results of some of the infiltration studies carried out it could be inferred that the infiltration rates from arable crops and grasslands are generally 30-35% and 40-45% respectively that from forest lands. However it is drastically affected due to biotic interference like forest fires, tramping by cattle, removal of leaf litter etc.

d. Soil moisture

In general, it can be concluded that much efforts have not been made to quantify soil moisture storages under forested lands. However, forested soils have a better soil moisture retention capacity due to improved soil structure because of more humus and organic content.

e. Evapotranspiration

The studies conducted in India and abroad indicate that forest have higher evapotranspiration requirements as compared to other land uses. However, more studies are required to be done for systematic computation of evapotranspiration by forests.

f. Groundwater

The effects of forests on groundwater have not been studied on large scale. A limited number of studies done abroad in this regard have indicated non coherent results. The studies from U.S.A. claim that water table collapsed as a result of deforestation or forest fire while studies from Switzerland seem to indicate no effects on water table by forest cover changing to grass.

g. Water yield

Base on studies conducted in India, it can be inferred that substantial reduction of densities of forest overstories and thinning increase water yield and establishment of forest overstories on sparsely vegetated land and / or changing the fast growing species like eucalyptus decrease water yield. This decrease is more significant in first few years of growth. Besides, the type of land cover, the size of watershed has also important bearing on water yield. Based on various studies, it appears that in small watersheds forests tend to decrease the water yield while in large watersheds, the sub-surface component of total water yield gets increased.

h. Soil loss

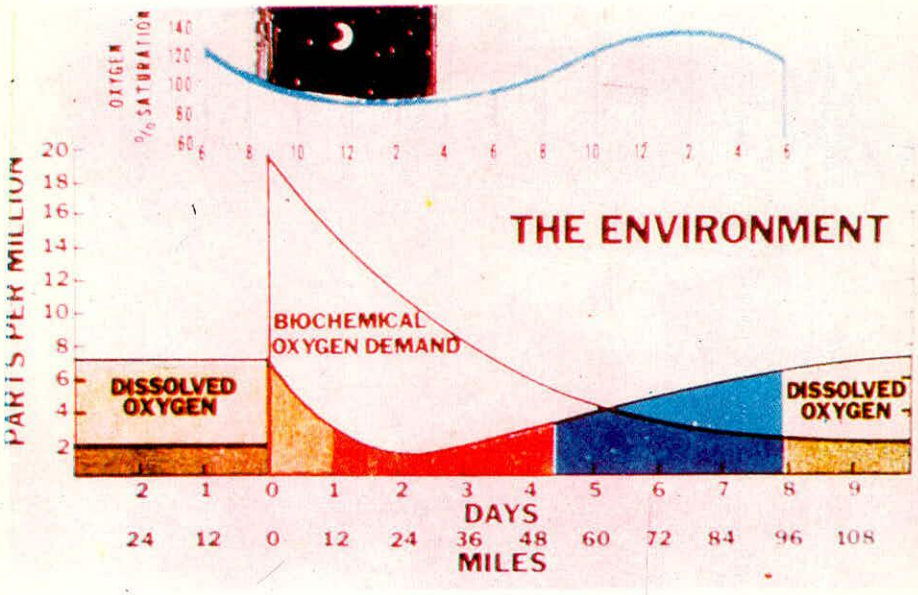
From the limited studies, it can be concluded that the soil loss is less from dense, well managed forests in comparison to ill managed forests. However, soil loss is very less from well managed grass lands. Soil conservation is an effective answer to soil loss problems.

i. Floods

It is important to note that afforestation measures basically minimize soil loss and reduce sediments load in streams and rivers thus moderating flash floods. The effect of afforestation may be insignificant for large floods

Urbanisation

Of all indirect human influences on hydrological characteristics, urbanisation is perhaps the most dramatic and rapid impact. The general impact of urbanisation are well known, and are basically due to the replacement of the natural drainage network with a denser, more efficient and permanent network and the covering of the large areas of the catchments with impermeable surfaces.



DISSOLVED OXYGEN VARIATION BELOW WASTE DISCHARGE

Most studies have been made of the impact of urbanisation on flood plains and all show that urbanisation increases flood peaks and reduces lag time. Such inferences are very important because the designed techniques for small structures depend on these results. Urbanisation may also increase the relative frequency of summer floods: previously summer rainfall would have to fill soil storages before producing floods.

Urbanisation tend to reduce minimum flows and groundwater levels because the rainfall is quickly removed from the surface. THe dramatic effects of construction works associated with urbanisation on sediment load indicate a very significant increase in sediment yield during urbanisation. Once construction is completed sediment yields reduce considerably due to the protective effects of the impermeable surfaces.

How Does Water Cleans Itself?

At the origin of the water purification cycle is the energy from sunlight, which drives the oxygen producing process of photosynthesis in aquatic plants. Bacteria use this oxygen to breakdown some of these organic material such as plant and animal waste. This decomposition produces carbon dioxide, nutrients and other substances needed plants and animals living in water. The purification process continues when these plants and animals die and bacteria decomposes them, providing new generation of organisms with nourishment.

Unfortunately this process does not affect a large number of toxic chemicals-specially the persistent ones. This is one reason why these constituents are of such great environmental concern.

It has been indicated by various studies that water quality changes in and downstream of urban and industrial areas are quiet significant. This is due both to the washing of pollutants from the

catchment surfaces,particularly roads,during rain storms and the discharge of polluted waste water. Not only are nitrates and other chemicals higher in urban areas, but pollutants with a more long term impacts, such as heavy metals, are also common.

Effects Arising From Agricultural Uses

The development of agricultural productions has always been of great importance for society and for natural and anthropogeneous ecosystems. Irrigation systems have affected the technical and administrative capabilities of the civilisation they served and have been the instrument of development. The expansion of irrigation has gradually changed the quality of the ecosystem : new plant concentrations have appeared on irrigated soils, the surface of land has been transformed by construction of dams and canals and by the cultivation of top soil.

The role of irrigation differs according to climatic area. In arid and semi-arid areas irrigation is a means of replacing rainfall- either due to the lack of rainfall or its unfavourable distribution. In extremely arid areas irrigation is necessary throughout the year. In humid areas irrigation is used in place of rainfall when it is irregularly distributed. In sub humid areas irrigation is used in place of rainfall to cope with occasional droughts.

The consequences of irrigation can be summarised as below :

a. Salinisation and alkalinisation

b. Production of fertilisers

c. Accelerated erosion

d. Increase in transpiration over large crop areas

e. Irrigation systems can cause substantial loss of fish unless protective measures are provided

Effects From Industrial Uses

Industrial requirements are probably putting severe most strain on water resources. In brief the industrial demands are mainly for the following four purposes :

a. As a raw material

b. As a cooling medium

c. As a recipient for effluents and

d. As a means of mass transportation

Mainly the quality of water required for different industries is the crucial factor. The quantity of water required for various types of industries gives an idea of the water requirement.

Name of Industry	Water requirement cubic meter per ton
Sugar	100
Paper	250
Steel	150
Artificial Silk	1000
Oil	180

Industries operation affect the water in the following ways:

a. Pollute water physically, chemically, physiographically and biologically.

b. Biosphere is heated considerably

c. The water bodies are ecologically effected.

POOR DISPOSAL PRACTICES

The Effects of River Impoundments

Small scale reservoir development has a locally significant impact on hydrological characteristics, but the consequences of large scale developments on major rivers are much more wide ranging. The storage of water in reservoir and its use in generating electric power may result in changes of water temperature in the reservoirs themselves and in small rivers. Of further importance is the way in which reservoir is filled up and emptied. In deep valleys reservoirs stratification is more evident than in shallow reservoirs and the temperature impact on the outflowing water is also stronger. Hydropower dams and diversion have the same general effect as irrigation dams on fisheries. The intensive development of water transport also may have certain negative effects on the bio-physical environment through pollution, specially by oil films.

Navigation on waterways creates artificial waves which cause an intensive scouring of banks. If effective construction measures are not taken the litho-sphere is transformed, the banks suffer abrasion and waterway becomes clogged. It must be cleared by dredgers and costly maintenance works must be carried out. In derived conclusions it can be said:

a. Reservoir impoundments change the flow regime.

b. Reservoir impoundments may lead to reduced annual yields not just in catchments from where water is diverted but also in the reservoir catchments themselves, due to the evaporation from the reservoir.

c. Impoundments may also change the seasonal distribution of flows.

d. The reduction of flood peaks following reservoir impoundment is an established fact.

e. Reservoir impoundments may affect local micro-climate or groundwater levels.

f. The ecological effects of changes in flow regimes down stream of reservoirs have been increasingly studied in recent years, but it is difficult to separate the effects of changes in flow regime from changes in the temperature or the chemical composition of the released water.

g. There are recorded examples of reservoir impoundments causing saline intrusion in deltaic areas, due to reduction- for atleast some part of the year- in discharges of fresh water.

AQUATIC WEED PROBLEMS

AT A GLANCE

Most Widespread Human Impacts:

* Deforestation
* Irrigation
* Urbanisation
* Use of Agricultural chemicals
* Industrial uses of water
* Regulation of rivers
* Land Use changes.

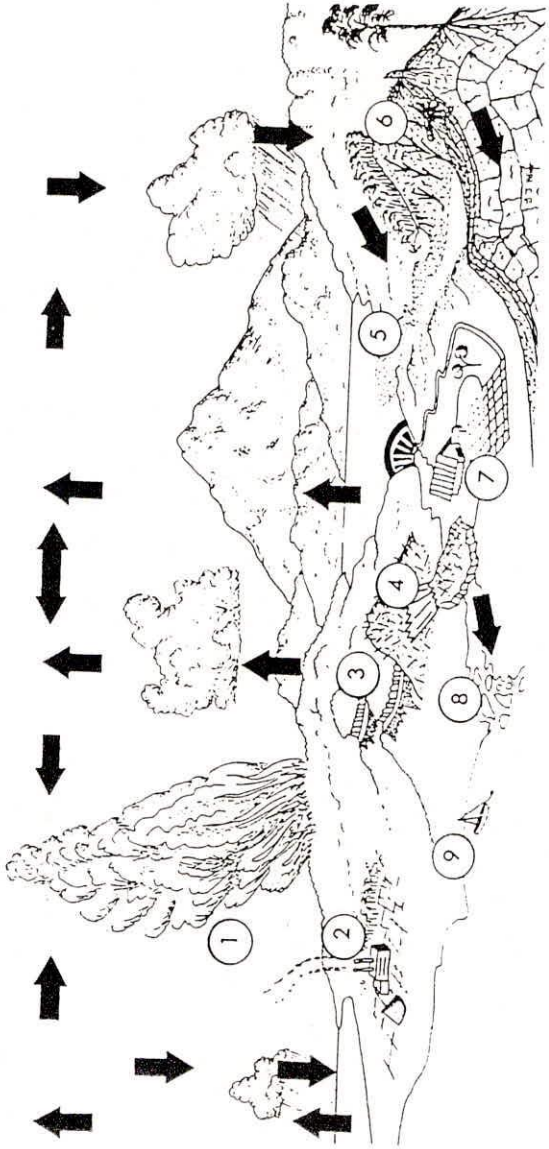
Water Quality Pollutants
Non Persistent (degradable)
* Domestic sewage
* Fertilizers
* Some household cleaners
* Some industrial wastes
Persistent (non-degradable)
* Some pesticides (like DDT etc.)
* Petroleum or petroleum products
* Metals such as lead, mercury, cadmium
* Leachate from land-fill sites
* PCBs, dioxins etc.
* Radioactive material such as radium-226, cesium-137, strontium-90, uranium etc.
Others
* Warm water from cooling towers
* Floating debris
* Garbage
* Foam

IMPACTING THE WATER CYCLE

Precipitation then Percolation then Transpiration then Evaporation then Transportation then again Precipitation thousands of cubic kilometers of water recirculate each year in the earth's marvelous hydrologic cycle. Human activities, however, are impacting the cycle locally and regionally, and possibly, globally. Some of the activities and impacts are :

PLUME OF POLLUTION IN RIVER

1. Forest burning
2. Domestic and industrial gaseous effluents
3. Soil erosion from road construction
4. Landslides from vegetation removal
5. Sedimentation in reservoirs
6. Farm field run-off
7 Flood plain enlargement
8. Estuary, island formation
9. Coastal fisheries depletion
10. Some more which are not shown.



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