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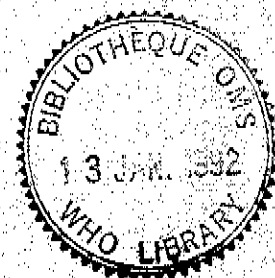
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LAND USE AND WATER QUALITY

A Framework for Discussion

by

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EUR/HFA TARGET 20

This activity was organized by the WHO Regional Office for Europe to promote work aimed at achieving the following target in the health for all strategy.^a

TARGET 20

WATER QUALITY

By the year 2000, all people should have access to adequate supplies of safe drinking-water and the pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health.

Index terms

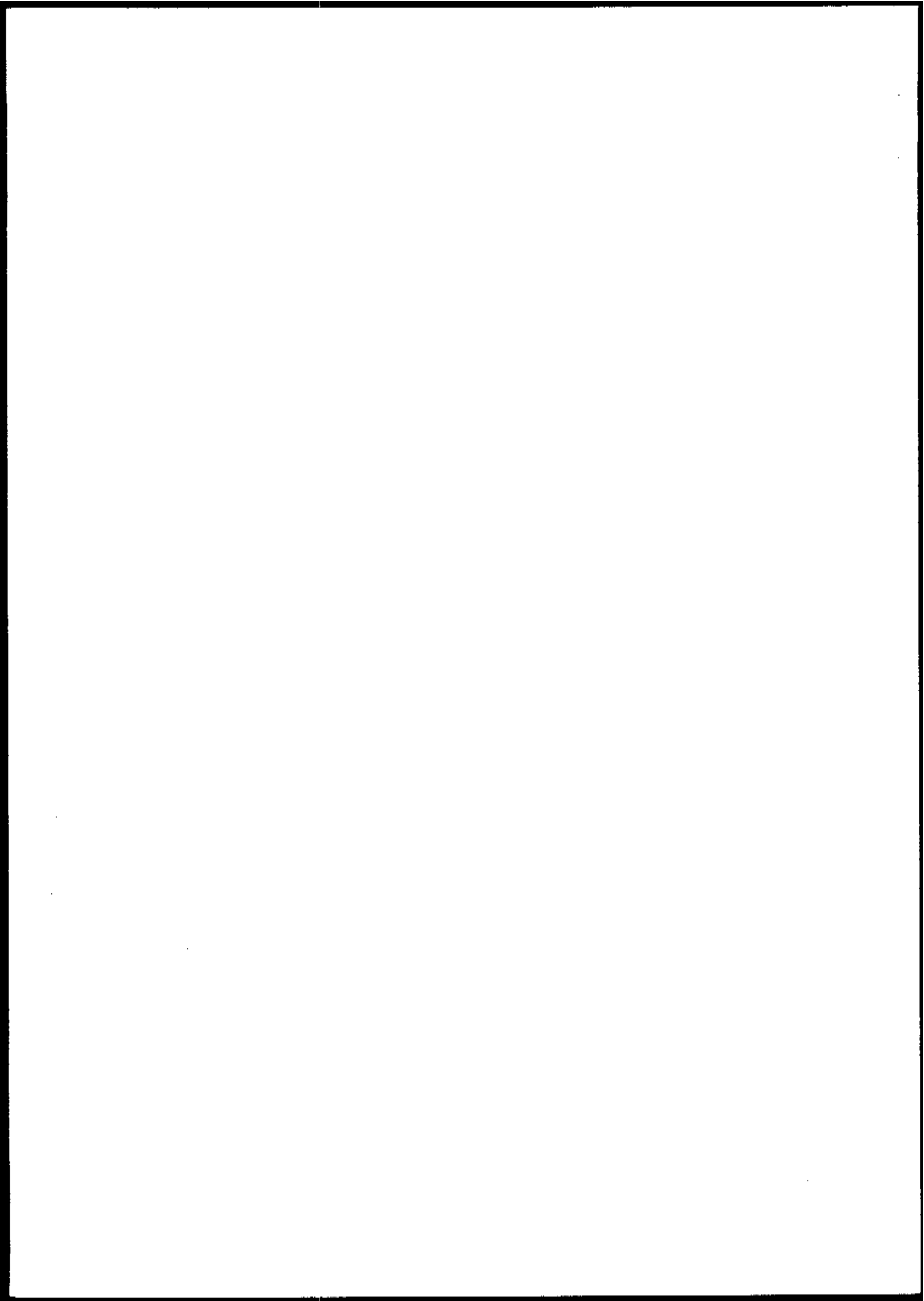
ENVIRONMENTAL HEALTH
WATER SUPPLY
DRINKING WATER
URBANIZATION
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^a *Targets for health for all*. Copenhagen, WHO Regional Office Europe, 1985 (European Health for All Series, No. 1).

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NOTE ON TERMINOLOGY

The following explanations of selected terms used in this paper are given to aid the reader.

Hard areas: Roofs, courtyards, paved areas, roads and parking areas that have been surfaced and any surface or area where precipitation (rain or snow melt) runs over, not into, it. Absorption is minimal, and nearly all the precipitation is assumed to enter the water course. A run-off value between 60 and 80% of the total precipitation is not unusual, the losses being due to evaporation and leakage from the drainage network.

Soft areas: Grassed areas, farm land and any area where precipitation could penetrate the soil. The amount of run-off from an area is reduced by the amount absorbed by it. Water is absorbed by the ground and used by trees and other plants. A water balance can be reached that permits precipitation, run-off and absorption to compensate for losses in soil moisture and in evaporation and transpiration from the atmosphere and trees (evapotranspiration).

Groundwater: This may be generally classified into zones of saturation and aeration. The saturated zone is where all the voids (gaps) are filled with water under hydrostatic (water) pressure. The aeration zone is where the interstices (e.g. spaces, cracks, splits) are partly filled with air and water. This zone can be further divided into four subzones: soil water, intermediate, capillary and groundwater.

To aid the reader's understanding of the interaction between the natural, environmental and hydraulic processes, the Appendix contains a diagram to illustrate the hydrological cycle.

Other technical terms are explained as they are used.

INTRODUCTION

This paper was written in response to a need to develop an integrated regional code of practice for land use and is submitted as a framework for discussion in Member States of the WHO European Region. As such, it does not dwell on technical and theoretical points. It presents a simple land use classification devised by the author in which specific major usage groups were selected then subdivided according to further criteria of individual land usage.

Without exception, any change in land use will affect groundwater and receiving water quality. The effect of a change - positive or negative - will depend on whether the persons making or undertaking the changes appreciate the effects of their actions and whether the correct criteria are chosen to monitor and control the possible interactive effects of these changes.

1. URBAN DEVELOPMENT

1.1 Housing

High-density housing and the construction materials used convert soft areas to hard. Precipitation is intercepted by roofs and the other hard areas associated with housing. This intercepted precipitation runs to collecting points (e.g. drains, gulleys) and quickly enters a ditch, stream or river. As

it runs, or is directed along pipe networks, culverts and street gutters, little is lost and almost all the intercepted precipitation enters a water course. These factors increase the maximum flow in the water course and reduce the time taken for it to reach the maximum flow rate, called the time of concentration (T_c).

Larger flow rates increase the risk of downstream flooding, bank erosion and the problems associated with the transport of debris and other suspended materials. A period of heavy rain may cause the river to rise above the level of the bank, and subsequently flood into and flush out the contents of septic systems and wastewater treatment works. This carries a risk that untreated or partially treated wastewater could contaminate bankside water storage and water supply abstraction areas; a pollutant may also migrate into the groundwater zones. In areas of older housing, drainage pipes are likely to be cracked or broken from earthquakes, traffic movement or, in some cases, by a combination of both. The result could be system losses and pollution of the aquifer. The use of a soakaway at a safe distance from a drinking-water abstraction point, sacrificial land (i.e. land that by design is allowed to be flooded) and other methods to increase the time taken for water to reach the water course or river can and do alleviate the situation.

For the safe disposal of human and household sink waste, two approaches are possible. One system separates collected precipitation and wash basin water from organic human waste. If adopted, water from wash basins together with water from yards and streets can be collected and discharged into a water course. However, the final decision may depend on the future use of the water in the water course, as discharging into it would increase doubts about its biological quality. In addition, organic human waste has to be collected and disposed of safely, either by hydraulic collection and delivery to local or central treatment points, or by the use of septic tanks. The second is to have a combined system where all internally and externally collected water is used to flush the foul waste to a place of treatment. If adopted, the system needs to be designed to take the higher flows (compared to the separate system method).

1.2 Streets

Streets are usually hard areas with little precipitation loss to the ground. However, if the surface finish is poor and the method of construction faulty, precipitation will pass through the road surface into the substructure. To be efficient a road surface should be watertight and all precipitation that falls onto the surface should enter the collection system and perhaps ultimately a water course. There is a risk that the water that enters the street substructure will, during periods of cold weather, freeze and expand, thus increasing the damage to it (i.e. frost heave).

Dirt, debris and other loose surface deposits can be carried into the drainage system and then into the water course. The biological effects of animal pollution are reduced through dilution, and the self-cleansing properties of the water course itself, but doubts may still arise as to its biological integrity.

Water from any water course that enters a drinking-water supply should be carefully scrutinized and, if need be, made safe prior to distribution. Problems have been associated with rubber deposits and oil products entering the drainage systems and water courses. Many problems can be overcome by using oil interceptors and by the settling out and screening of road grit.

The sedimentation of heavy organic deposits and improved quality of sewage effluent can reduce the effects that discharges have on water courses and increase their self-cleansing capabilities.

If a combined system is to be adopted, the street drainage system can be combined with the sewage network; this will increase dilution and assist in flushing/cleansing the network.

When a water course is to be used as a source of community water supply, the locations of the waste and rainstorm discharge and water abstraction points should be carefully considered. The sewage discharge point should preferably be downstream from the abstraction point. However, in some countries and under drought conditions, the only water in a water course will be the discharge from the wastewater treatment works. Under these conditions the abstraction point may have to be downstream from the discharge point. Treatment processes and stringent controls must be adopted to safeguard and maintain public health, and to remove the increased levels of inorganic salts in the recycled influent.

1.3 Leisure Areas

Leisure areas are a mixture of hard and soft areas that can affect the run-off characteristics. The areas tend to be self regulatory and any deposited organic material, although a nuisance and a possible hazard to small children, is broken down by natural processes.

The overuse of fertilizers and herbicides can create problems by promoting a build-up of their constituent inorganic salts (e.g. phosphates and nitrates) and their residuals in the upper and lower soil zones. The use of fully or partially treated wastewater for irrigation, particularly in times of drought, and the use of wastewater sludge as an organic fertilizer can be potential health hazards (e.g. on play areas where there is a risk of cuts, bruising and possible infection).

As a matter of good practice, hard play areas should be cleaned of animal waste, or even better, be off limits to animals.

1.4 Green Areas

These areas are usually a mixture of grass land and forestry with some small hard areas (e.g. parking lots, summer cottages). As such, the considerations covered in the sections on housing, streets and leisure areas also apply here.

1.5 Commercial Zones

Light industrial units and shopping areas are hard areas that in some cases are set in landscaped surroundings to help them blend into the environment. As such, the same comments apply that were raised for housing. However, as the roof and parking area are much larger, greater quantities of collected (intercepted) precipitation will need to be considered and managed.

1.6 Waste Sites

Domestic refuse can be disposed off in landfill, in quarry fill operations or by incineration with wastewater sludge.

Landfill and quarry fill disposal methods can be used if the refuse is sandwiched between zones of top soil or other inert material. To prevent explosions, the gas produced by the decomposition of the organic matter in the refuse must be vented. The gas produced can be collected and sold to offset

operational costs. Refuse liquor, which has a high biochemical oxygen demand (BOD, or the oxygen absorbed by a sewage sample in 5 days at 20 °C)), is produced when precipitation passes through the material. Refuse liquor should be collected and either treated on-site or transferred to the wastewater treatment works where it should be diluted with other effluent and then treated.

Raw or digested wastewater sludge and chemical residues from water treatment can be buried, provided the same precautions as described for the disposal of domestic refuse are followed.

In all cases the possibility of sludge liquor leaching into water courses, karstic waters and bankside storage from wastewater sludge storage sites and drying beds must be removed either by selecting areas with an impervious clay layer or by laying an impervious membrane under the fill.

Refuse and wastewater sludge can be mixed and incinerated. There is, however, a problem with the phasing of the two operations. Wastewater sludge is produced continuously, a 7-day process, whereas domestic refuse is collected over a 5-day period. Domestic refuse can be sorted and separated at the incinerator, and many useful materials can be recovered for recycling. Nonrecoverable materials are incinerated with the organic wastewater sludge, and heat energy is the saleable byproduct.

Any pollutants entering the chimney should be removed by filtering and scrubbing.

Domestic wastewater sludge can be used as a fertilizer. However, this practice is not widely accepted as it carries a risk of heavy metal pollution. In addition, to reduce the risk of infection, the land should remain fallow for up to 6 months after the sludge has been spread (Note: codes vary from country to country). Studies have found that in some cases crop yields have been reduced.

Site selection should consider soil conditions, and groundwater levels and location relative to populated areas and the future use of the land. Conditions must be such that gas leachate, water seepage and run-off do not cause a nuisance or become a health hazard. A monitoring program should be established to ensure that an adequate environment is maintained at and around the site.

2. INDUSTRIAL ACTIVITIES

2.1 In an Urban Environment

Industrial activities are assumed to create hard areas, bringing an associated risk of ground and water course pollution. Examples are gas contamination from coke-making plants and town gas works; oil spillage at storage depots and refineries; and escapes from tanneries, breweries, abattoirs and dairies. Discharges of untreated or partially treated industrial and domestic effluents from soakaways can change the biological regimes of the water course receiving them.

Old industrial land is likely to be contaminated. Therefore, care must be taken during reclamation, especially if the land is to be developed or adopted as a recreation area.

Water passing through contaminated land will transport pollutants to the aquifer. As a result it is often cheaper to remove and safely dispose of

contaminated top soil and other materials than to spend time on decontamination and risk the chance of polluting the aquifer. Necessary precautions must be taken and directives observed if hazardous materials are found during the refurbishment of industrial and office premises (e.g. asbestos).

Care must be taken when working near an old soakaway or well as they will allow contaminated water to enter an aquifer rapidly.

Discharges to water courses are controlled in most countries by agreements that govern the amount, type and time of discharge. The problem is how to police the agreements and dischargers, and often it is left to the honesty of the consent holder.

2.2 In a Rural Environment

These activities are usually associated with agriculture and involve the development of new sites in a rural environment. As a result, the land changes from a soft to a hard area. Consideration must be given to the effect that any change will have on existing water courses, ecology, local environment and infrastructure.

As with housing, a change in land use may generate higher peak flow rates and faster times to reach them, thereby altering the local river regime. One solution is to use a soakaway and, where necessary, an oil interceptor to collect and slow down the effect of precipitation on a water course.

3. MINERAL EXPLOITATION

The main sources of water pollution associated with mining and quarrying activities relate to washing operations, mine waste storage lagoons and discharges from flooded mines.

Wash water contains fine material that has to settle before discharge to a water course. The acid/alkali level (pH) of wash water is often altered and, therefore, must be monitored and sometimes modified before discharge. Fine materials in solution may discolour the wash water, and flocculation, at a controlled pH, may have to be used to remove them.

Dams and the sedimentation lagoons created to store or treat mine waste must be designed to meet strict safety standards, as overflow or breach could endanger human and other biotic life. The time of retention for maximum sedimentation of solid materials has to be considered. Seepage of untreated wastewater into the groundwater zone must be prevented either by including an impervious membrane under the lagoon or by siting on suitable impervious material. As the settled sludge produced often contains high concentrations of metals, special arrangements must be made for its final disposal, either as landfill or by incineration (dumping at sea, a short-sighted solution, is not to be encouraged).

The quality of water pumped from flooded mines should be monitored and discharged into sedimentation lagoons before being discharged into a water course. The best solution is to prevent water entering the mine, which would in turn reduce the amount of leaching that occurs.

The discharge channel must be routed away from drinking-water abstraction points, groundwater surcharge and recharge zones. This should prevent pollutants, especially enteric organisms and metals, from entering the aquifer and subsequently the water supply network.

4. AGRICULTURAL AND HORTICULTURAL USES

The most important pollutants in run-off from agricultural areas are animal wastes, wastes from the industrial processing of raw agricultural products, plant nutrients, forest and crop residues, inorganic salts, grit, minerals and pesticides.

4.1 Agrochemicals

Nitrogen in the form of nitrate in the leachate from agricultural areas is seasonal and crop related. If it is from recently applied fertilizer, steps to control the rate of application have a beneficial effect. If it is from the soil's organic reserve (e.g. roots), reducing the rate of application has a direct effect on the amount of nitrate in it. A nitrate level would subsequently be reached that could not support productive agriculture.

To summarize, reduction can be achieved by either restricting the agricultural use of the fertilizer and offering compensation to the farmers for the reduction in crop yield, or by removing the nitrate, at a cost, at the water treatment plant.

Problems with herbicides can be separated into three main areas:

- spills: incidents caused by relatively large quantities of material, particularly concentrates, entering a water course, usually by carelessness (e.g. spillage from drums left in the field)
- contamination: acute problems caused by careless use of herbicides such as overspraying water courses, drains or standing water, washing down of equipment and careless disposal of empty containers
- leaching: the slow washing of herbicides from treated areas over a long period of time.

Problems in the first two categories can be prevented, or at least greatly reduced, by adopting sensible precautions when using herbicides. New, more selective methods of application can also reduce the problems. Plant and chemical sciences could help by producing disease-resistant strains and developing root-fed biodegradable herbicides.

4.2 Silage

Problems are usually related to the escape of silage liquor into adjacent water courses. The design and location of the storage facilities should be carefully considered so as to avoid the effects of a liquor spillage due to an embankment failure or seepage, usually after periods of heavy rain. The costs associated with the design and construction of safe and efficient seasonal storage facilities are often the reason for them not being provided.

4.3 Animal Waste Disposal

The animal waste that results from intensive animal husbandry creates a storage and disposal problem. One solution lies in its use as fertilizer, either sprayed on or injected into the land, at the correct time of year. Improved ploughing and fertilizing techniques, coupled with the use of protection zones around boreholes, can reduce the risk of groundwater pollution. However, farmers will have to receive compensation in order to accept lower rates of inorganic fertilizer usage and the consequential reduced rates of crop yield.

Animal carcasses should be removed from fields. However, animals slaughtered in an attempt to contain an outbreak or to reduce transmission of a disease should either be buried in lime or burnt on-site.

Agriculture must be considered a high-risk business in which decisions and required changes take time, perhaps years, to implement for a desired end. Farmers have to be given time to react to the directives and be allowed to plan and manage the required changes.

5. ROAD DEVELOPMENTS

These are hard areas that direct and accelerate the run-off of rain water and collected debris into surrounding soft areas. They can cross both rural and urban areas, divert water courses and overlay groundwater recharge zones.

In rural areas, drainage is often by a soakaway that allows run-off to drain directly into the water table, bypassing the unsaturated zone. As a result, pollutants have rapid access to the aquifer.

The salt used for winter de-icing is the most common pollutant in the aquifer, although traces of aromatic hydrocarbons and organic wastes can often be found. The potential pollution from an accidental spillage is of serious concern as worst-case scenarios would have to allow for the rapid transfer of a toxic or hazardous chemical into a major aquifer.

6. ENERGY PRODUCTION

6.1 Lakes and Dams

The flooding of upland pastures and agricultural land to create lakes for water storage and recreation may alter the local climate, increase the amount of water flow and reduce the time taken for the flood flow to reach its peak. A lake is assumed to act as a hard area when the water level is at the level of the spillway. As a result, precipitation over the lake's surface progressively runs over the spillway. Increased and extended flood flows from a catchment can in some cases result from peculiar geographic and geological characteristics or from a particular pattern of rain storms.

Large quantities of agricultural drainage enter lakes by way of ditches, streams and rivers. Debris from forest, agricultural and urban areas can be transported into lakes by the high flood flows associated with periods of heavy rain.

Nutrient enrichment (by phosphates and nitrates) of lakes, rivers and streams can be directly related to population growth, industrial development and intensive agriculture. These washed-in nutrients promote the excessive growth of algae and aquatic plants, resulting in eutrophication of natural waters, which can become a significant water quality problem. They also reduce water quality and cause a deterioration of the aquatic environment. Algal blooms, often the cause of unpleasant taste and odour in water supplies, reduce the transparency of the water and produce malodorous scums. Aquatic plants, often the breeding grounds for insects, choke the shallow water at the edges of lakes and streams, thereby reducing accessibility for recreation.

6.2 Hydroelectric Stations

These facilities require adequate and continuous supplies of water as their prime mover. As a result they are sited in upland regions with an adequate

supply of the energy source, which are usually areas of natural beauty. Electrical power is produced by using the energy stored in the water coming from a higher level to rotate the generating equipment.

The problems associated with storage lakes are covered in section 6.1. However, problems can also occur during the construction period when, through insensitivity, excavation for the materials and the forming of the necessary site roads can adversely affect the hydrological characteristics of the catchment.

6.3 Thermal Stations

These facilities consume fossil fuels to produce steam that is then used to produce electrical energy. Pollution can result from unsafe storage of coal, the spillage of oil or the escape of gas. Water passing through coal heaps can wash out fine materials, forming a slurry. This slurry can flow and enter a water course and possibly an aquifer. Intercepted slurry should be passed into a lagoon to allow settlement before being discharged to a water course.

Air pollution and the resulting associated acid rain clouds, which cause the acidification of lakes and the defoliation of trees, can be reduced by filtering and scrubbing flue gases.

Cooling water artificially increases the temperature of the receiving water and causes local changes in the biological regime that can lead to aquatic pollution.

6.4 Atomic Stations

As a result of the potential health hazard of atomic energy, many generating stations are governed by strict safety procedures and operate within their own self-contained environment.

Escapes of gas liquid and other radioactive materials can and do occur. However, they are usually of a minor nature, and can be managed and controlled locally without significant effects on the surrounding environment. Major disasters have occurred that have had serious longterm affects on ecological and biological regimes. The risk of these events can and should be reduced by good engineering design, and efficient safety and back-up procedures. The possibility of the discharge of radioactively contaminated materials can be reduced by efficient air and water filtration systems and lagoons designed to allow the settlement of the inorganic wastes.

7. WATER PRODUCTION AND STORAGE

7.1 Drinking-water Lakes and Reservoirs

Reservoirs and lakes act as hard areas and can affect natural river flow regimes. They are sited in areas of upland catchments so as to reduce the risk of biological pollution and the related cost of water treatment. Often the only treatment required at works with a high-quality influent is chlorination. Long-retention, slow sand filters remove biological contaminants, and ultraviolet (UV) radiation from sunlight has been shown to reduce and kill viruses.

Careful consideration has to be given to the siting of storage and balancing reservoirs as these can be a hazard to children and accidental or deliberate contamination could affect the whole community. In large areas of slow-moving or stagnant water, temperature varies with depth (thermal

stratification). Changes in biological regimes are associated with these variations in temperature. The favoured solution is to induce mixing by creating turbulence within the water body. This is achieved by passing the water into and drawing it off at different positions and levels in the lake or storage reservoir.

7.2 Groundwater for Drinking-water Use

Groundwater pollution, although interrelated with the pollution of other environmental media, is specifically associated with the pollution of surface water, land and soil. It can be prevented in the following ways:

- controlling and preventing effluent discharges from wastewater treatment plants, and the use of consents
- controlling and preventing refuse liquor losses from domestic waste disposal sites
- controlling subsurface untreated waste contamination by deep well injection or seepage from contained storage
- monitoring and safe surface storage of hazardous chemical wastes
- implementing and monitoring specific regulations to cover nuclear plants and the handling and processing of radioactive substances
- monitoring and controlling flue gas pollutants so that emitted particles do not fall onto the ground and leach into it.

Land use policies should be sensitive to pollution issues, and a constrained and coordinated approach should be adopted together with the introduction of an aquifer classification system.

Protection zones are another possible answer to reduce the risk of contamination to the aquifer and water supply network.

Much has been written on the use/reuse of town waste water for aquifer recharge. Its use is acknowledged, provided design, water quality and safety standards are met.

7.3 Irrigation

The quality of a water source may in the first instance make it unsuitable for irrigation. In addition, abstracting water from a source may reduce its ability to dilute the contained contaminants to an acceptable level. Waste water can be used for the irrigation of some crops. However, its use on green leaved vegetables (i.e. lettuce) is not recommended. Eating these vegetables unwashed carries a risk of bacterial transmission.

Spray irrigation is nonspecific; the entire field crop is sprayed by using either a rotating spray jets or a travelling boom. Water not used by the crop or lost through evaporation enters the water course and then the aquifer. Pollutants and other materials leached from the soil mass collect and are carried to the aquifer.

Although field channels direct the water to the crop, they are wasteful as some of the water will be lost on-route by direct evaporation and some will be used by the soil to replace losses caused by evaporation. Pollutants will also be taken into solution and carried to the groundwater zone.

Drip irrigation uses a long plastic pipe laid between the plants. At each plant a hole is made in the pipe that allows water to drip directly onto the plants (often the root area is covered with black polythene to reduce local evaporation losses). This method is very precise as only water required for growth is used. The result is that water losses are minimized. As the fertilizer can be added to the feed water, its rate of application can be controlled: the bonus is the reduced loss of fertilizer to the underlying aquifer. The method is more valuable in arid countries where water treatment costs are high, a result of the high natural salt content and expensive fertilizers.

(Note: The drip method was used in Jordan to irrigate citrus and other trees, but there was build-up of salts between the trees which, when washed down to the root zone by spring rains, killed some of them.)

Although not discussed in the above section, the infiltration capacity of a soil is affected by several factors: thickness of the saturated soil layer; initial soil moisture state, compaction of the soil and inwash of fine particles into the pores of its mass; and mechanical action of plant root systems.

8. FORESTRY

Forestry can effect both water quality and water quantity.

8.1 Water Quality

Rain falling on forested areas will wash and absorb air pollutants from the branches of the trees, flush surface deposits from the forest floor and leach unused nutrients from the soil mass to the water course and then to the aquifer.

Ploughing and planting techniques will also affect the water quality. Furrows dug down the slope will provide routes for water to leave the forested areas. As a result, the catchment becomes more "flashy" (very responsive to the effects of precipitation/a storm) and the risk increases of soil erosion and the possible exposure and wash out of polluting minerals.

On-route the water collects minerals and other loose materials exposed in the furrows or washed from the forest floor. The consequence is a more polluted discharge into the receiving water - the first-flush effect. The geological structure of the area when coupled with new forestation can also cause acidic wash-offs into the receiving waters. Trees act as large umbrellas that can collect air pollution. They monitor the effects of pollution as the pollutant will be deposited on the leaves, causing local effects, or be washed to the ground where it may affect the roots or enter the aquifer, either through the soil mass or from a water course.

8.2 Water Quantity

The amount of water flowing from a forested area is related to the type of forestation and ploughing pattern. High-density forestation increases the amount of water absorbed by the area. Losses are through leaf uptake and evaporation from the leaves (evapotranspiration), root uptake and absorption by the soil to make good the water loss due to evaporation. Cross-slope ploughing encourages the water to flow into, not over, the ground, thus reducing the amount of water leaving the forested area.

9. FUTURE PROSPECTS

9.1 Protection Zones

The use of protected zones has been mentioned in earlier sections. In addition, many European Member States have regulations to create zones that protect the quality and quantity of supply from groundwater sources.

9.2 Legislative Powers

A number of major questions have to be considered. Who would monitor and police the implemented legislation? How would the fixed and variable costs of the operation (e.g. administrative and staff costs) be supported? A major question for a poor country would be whether such an operation could be supported and if so would it be cost effective? If penalties and sanctions are to be the combat weapons, how could they be used and how effective would they be in a low-income, subsistence economy? Who would monitor the over-use of fertilizer and how would or could the low-income subsistence farmer, if caught, be sanctioned or penalized for the offence (questions of marginal pricing and social cost)? How would the politically sensitive issue of separating offenders from perhaps their only source of income and livelihood be undertaken?

A more prudent approach may be to adopt a policy of educating the polluters and the affected populations, backed by the strength of legislation when necessary. The case for a policy of education is strong because it promotes and provides a feasible longterm solution. Education, example and promotion could show vulnerable low-income farmers that the over-use of fertilizers will cause the pollution that in time will affect their livelihood. Children could be involved at an early age to look at aquatic life, flora and fauna as indicators, to note the changes that occur and to record them.

A draft "Charter on Ground-water Management" has been prepared by the Economic and Social Council of the Economic Commission for Europe, and should be read in conjunction with this paper.

9.3 Good Practice

This is good housekeeping or common sense, and covers such things as avoiding herbicide spillage, using the right amount of fertilizer for the job, properly designing storage facilities, and adopting sensible procedures to reduce the risk of accidents, errors and potential hazardous occurrences.

10. CONCLUSIONS

The interrelationship between humans and the environment is complicated, and the passage of any pollutant into an ecosystem and subsequently into the human food chain may have serious longterm effects. Time still remains to review and change the effect of the interaction that humans have on the environment.

11. RECOMMENDATIONS

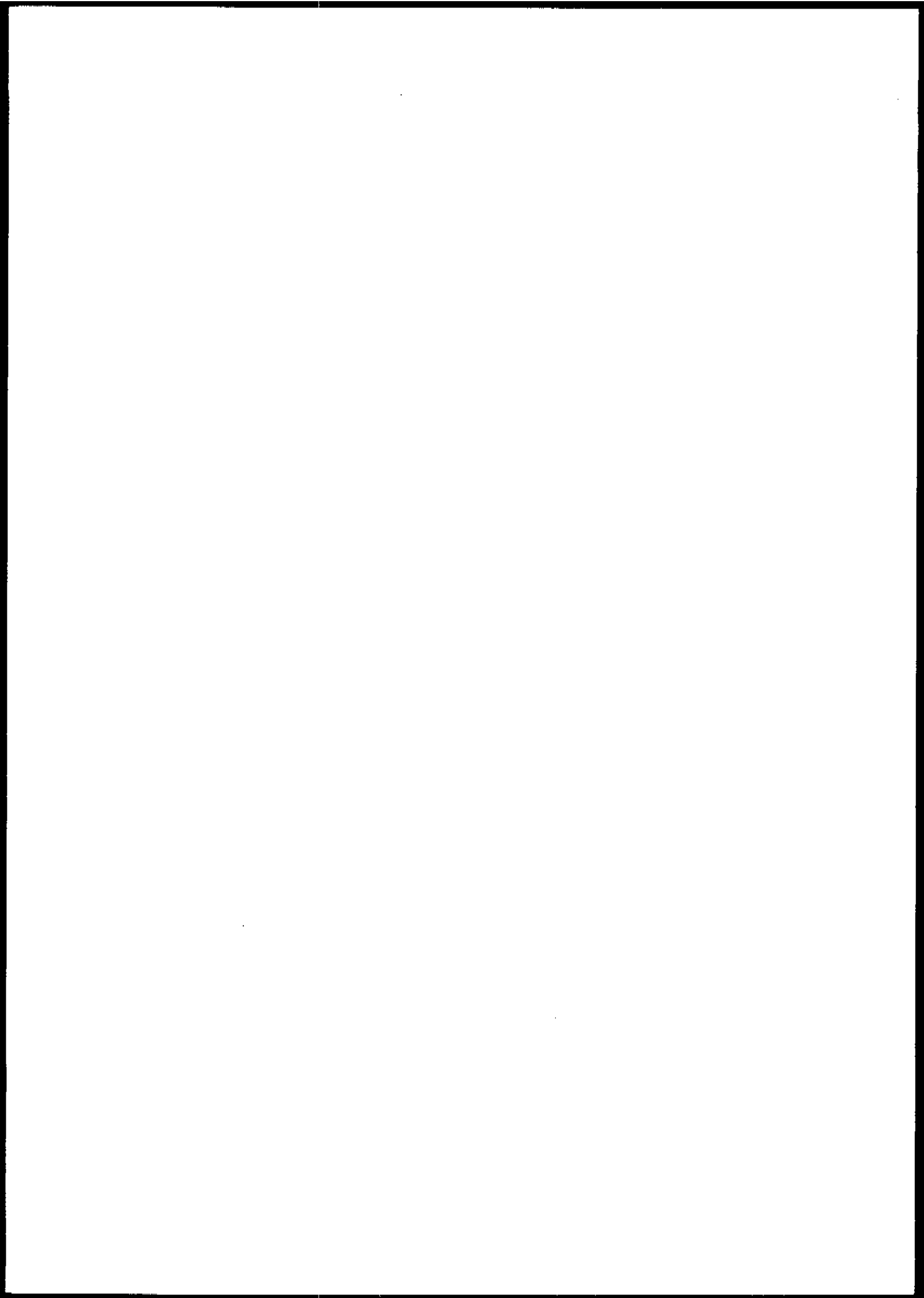
Initial stage: A few of the uses of land and the effect they have on water quality have been raised in order to set a framework and open the discussion on this complex interactive subject. Although not all the uses of land and their affects on water quality have been covered, the two are very much closely interrelated and could be considered inseparable.

The next stage: It is hoped that this paper will be sent to Member States for comment and for the addition of local specialist knowledge and advice. The aim is fourfold:

- to provide an opportunity for input from Member States
- to compile a thorough document that covers the views and experiences of the Member States
- to examine the need for guidelines and to promote the need for an overall policy within Europe
- to obtain committment to the completed document by involving representatives from each Member State at its inception.

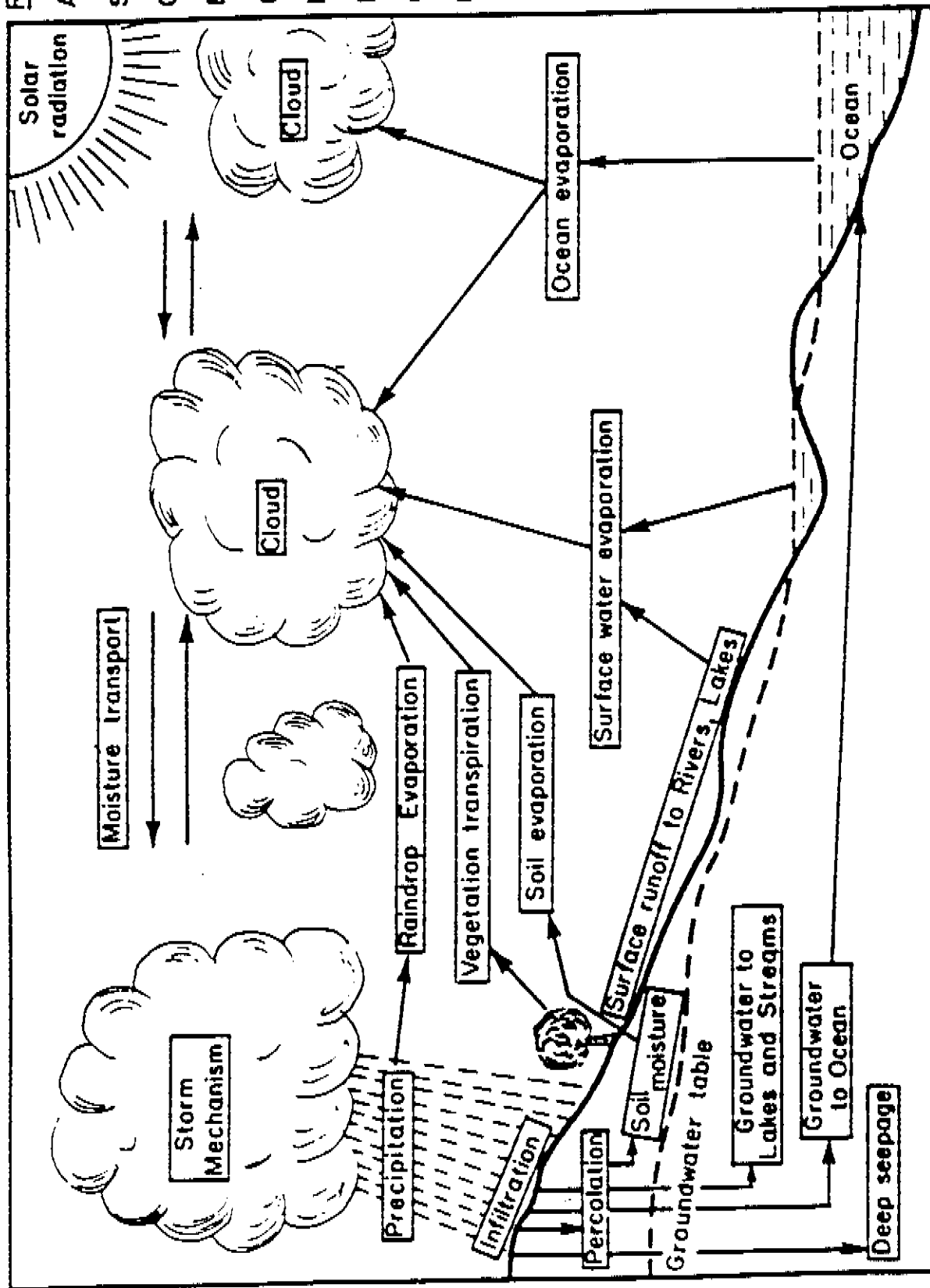
APPENDIX

The Hydrological Cycle



Relevant sciences

- Astronomy
- Solar physics
- Cloud physics
- Meteorology
- Climatology
- Hydro - meteorology
- Environmental sciences
- Geography
- Engineering
- Agriculture
- Biology
- Economics
- Surface water hydrology
- Limnology
- Oceanography
- Soil physics
- Ground water hydrology
- Geology



The hydrological cycle and relevant sciences.