Unit 5. Water pollution

*Anthropogenic impacts on water quality**

With the advent of industrialization and increasing populations, the range of requirements for water has increased together with greater demands for higher quality water. Over time, water requirements have emerged for drinking and personal hygiene, fisheries, agriculture (irrigation and livestock supply), navigation for transport of goods, industrial production, cooling in fossil fuel (and later also in nuclear) power plants, hydropower generation, and recreational activities such as bathing or fishing. Fortunately, the largest demands for water quantity, such as for agricultural irrigation and industrial cooling, require the least in terms of water quality (i.e. critical concentrations may only be set for one or two variables). Drinking water supplies and specialized industrial manufacturers exert the most sophisticated demands on water quality but their quantitative needs are relatively moderate. In parallel with these uses, water has been considered, since ancient times, the most suitable medium to clean, disperse, transport and dispose of wastes (domestic and industrial wastes, mine drainage waters, irrigation returns, etc.).

Each water use, including abstraction of water and discharge of wastes, leads to specific, and generally rather predictable, impacts on the quality of the aquatic environment. In addition to these intentional water uses, there are several human activities which have indirect and undesirable, if not devastating, effects on the aquatic environment. Examples are uncontrolled land use for urbanization or deforestation, accidental (or unauthorized) release of chemical substances, and discharge of untreated wastes or leaching of noxious liquids from solid waste deposits. Similarly, the uncontrolled and excessive use of fertilizers and pesticides has long-term effects on ground and surface water resources.

Structural interventions in the natural hydrological cycle through canalization or damming of rivers, diversion of water within or among drainage basins, and the over-pumping of aquifers are usually undertaken with a beneficial objective in mind. Experience has shown, however, that the resulting long-term environmental degradation often outweighs these benefits. The most important anthropogenic impacts on water quality, on a global scale, are summarized in Table 3, which also distinguishes between the severity of the impairment of use in different types of water bodies.

Table 3. Major freshwater quality issues at the global scale[1]

Issue	Water body			
	Rivers	**Lakes**	**Reservoirs**	**Groundwaters**
Pathogens	xxx	x[2]	x[2]	x
Suspended solids	xx	na	x	na
Decomposable organic matter[3]	xxx	x	xx	x
Eutrophication[4]	x	xx	xxx	na
Nitrate as a pollutant	x	0	0	xxx
Salinisation	x	0	x	xxx
Trace elements	xx	xx	xx	xx[5]
Organic micropollutants	xxx	xx	xx	xxx[5]
Acidification	x	xx	xx	0
Modification of hydrological regimes[6]	xx	x		x

Comments:
xxx - severe or global deterioration found; xx – important deterioration; x – occasional or regional deterioration; 0 – rare deterioration; na – not applicable.

[1] This is an estimate for the global scale. At a regional scale these ranks may vary greatly according to the stage of economic development and land-use. Radioactive and thermal wastes are not considered here.

[2] Mostly in small and shallow water bodies

[3] Other than resulting from aquatic primary production

[4] Algae and macrophytes

[5] From landfill, mine tailings

[6] Water diversion, damming, overpumping, etc.

Pollution and water quality degradation interfere with vital and legitimate water uses at any scale, i.e. local, regional or international. Water quality criteria, standards and the related legislation are used as the main administrative means to manage water quality in order to achieve user requirements. The most common national requirement is for drinking water of suitable quality, and many countries base their own standards on the World Health Organization (WHO) guidelines for drinking water quality. In some instances, natural water quality is inadequate for certain purposes as defined by recommended or guideline concentrations. However, other water bodies may still be perfectly usable for some activities even after their natural conditions have been altered by pollution.

Due to the complexity of factors determining water quality, large variations are found between rivers or lakes on different continents or in different hydroclimatic zones. Similarly, the response to anthropogenic impacts is also highly variable. As a consequence, there is no universally applicable standard

which can define the baseline chemical or biological quality of waters. At best, a general description of some types of rivers, lakes or aquifers can be given.

Although the major proportion of all water quality degradation world-wide is due to anthropogenic influences, there are natural events and environmental catastrophes which can lead, locally, to severe deterioration of the aquatic environment. Hurricanes, mud flows, torrential rainfalls, glacial outbursts and unseasonal lake overturns are just a few examples. Some natural events are, however, aggravated by human activities, such as soil erosion associated with heavy rainfall in deforested regions. Restoration of the natural water quality often takes many years, depending on the geographical scale and intensity of the event.

Pollutant sources and pathways*

In general, pollutants can be released into the environment as gases, dissolved substances or in the particulate form. Ultimately pollutants reach the aquatic environment through a variety of pathways, including the atmosphere and the soil.

Figure 4 illustrates, in schematic form, the principal pathways of pollutants that influence freshwater quality.

Pollution may result from point sources or diffuse sources (non-point sources). There is no clear-cut distinction between the two, because a diffuse source on a regional or even local scale may result from a large number of individual point sources, such as automobile exhausts. An important difference between a point and a diffuse source is that a point source may be collected, treated or controlled (diffuse sources consisting of many point sources may also be controlled provided all point sources can be identified).

The major point sources of pollution to freshwaters originate from the collection and discharge of domestic wastewaters, industrial wastes or certain agricultural activities, such as animal husbandry. Most other agricultural activities, such as pesticide spraying or fertilizer application, are considered as diffuse sources. The atmospheric fall-out of pollutants also leads to diffuse pollution of the aquatic environment. The various sources of major pollutant categories are summarized in Table 4.

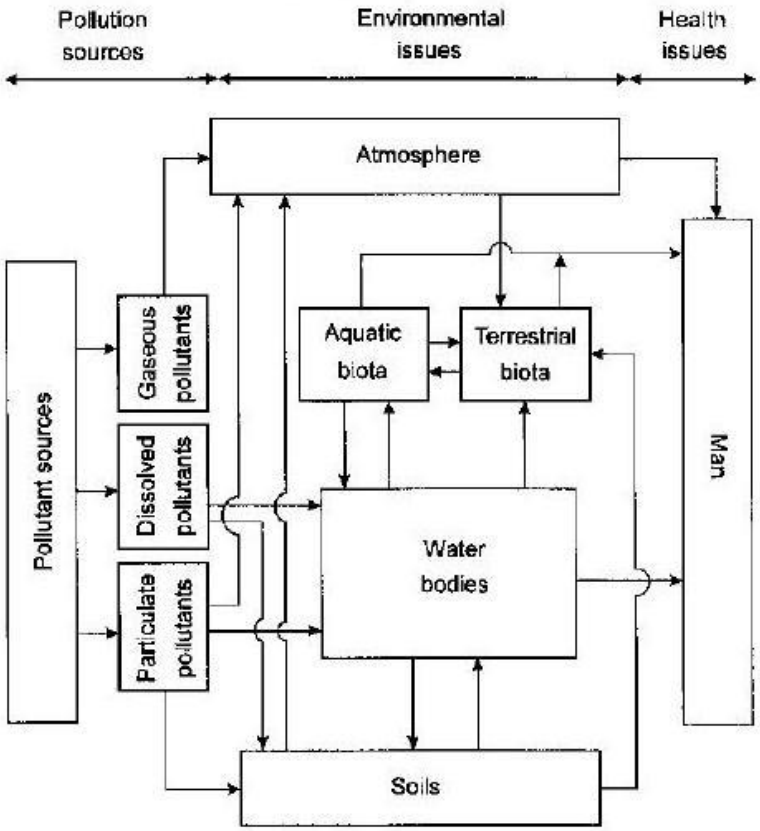

Figure 4. Potential pollutant pathways related to the aquatic environment

Atmospheric sources

The atmosphere is proving to be one of the most pervasive sources of pollutants to the global environment. Significant concentrations of certain contaminants are even being observed in Arctic and Antarctic snow and ice, with high levels of bioaccumulation magnified through the food chain to mammals and native human populations. Sources of anthropogenic materials to the atmosphere include:

• combustion of fossil fuels for energy generation,

• combustion of fossil fuels in automobiles, other forms of transport, heating in cold climates and industrial needs (e.g. steel making),

• ore smelting, mainly sulphides,

• wind blown soils from arid and agricultural regions, and

• volatilisation from agriculture, from waste disposal and from previously polluted regions.

Table 4. Anthropogenic sources of pollutants in the aquatic environment

Source	Bacteria	Nutrients	Trace elements	Pesticides/ herbicides	Industrial organic	Oils and

					micro pollutants	greases
Atmosphere		x	xxxG	xxxG	xxxG	
Point sources						
Sewage	xxx	xxx	xxx	x	xxx	
Industrial effluents		x	xxxG		xxxG	xx
Diffuse sources						
Agriculture	xx	xxx	x	xxxG		
Dredging		x	xxx	xx	xxx	x
Navigation and harbours	x	x	xx		x	xxx
Mixed sources						
Urban run-off and waste disposal	xx	xxx	xxx	xx	xx	xx
Industrial waste disposal sites		x	xxx	x	xxx	x

Comments: x – low local significance; xx – moderate local/regional significance; xxx – high local/regional significance; G – globally significant

These sources, together, provide an array of inorganic and organic pollutants to the atmosphere which are then widely dispersed by weather systems and deposited on a global scale. For example, toxaphene[1] and PCBs (poly-chlorinated biphenyls) have been described in high Arctic ice (Gregor and Gummer, 1989[2]). The source was believed to be Eastern Europe and the former USSR. Deposition of pollutants from the atmosphere, either as solutes in rain or in particulate form, occurs evenly over a wide area; covering soils, forests and water surfaces, where they become entrained in both the hydrological and sedimentary (erosion, transport and deposition) cycles. This may be termed secondary cycling, as distinct from the primary cycle of emission into the atmosphere, transport and deposition.

Point sources

By definition a point source is a pollution input that can be related to a single outlet. Untreated, or inadequately treated, sewage disposal is probably still the major point source of pollution to the world's waters. Other important point sources include mines and industrial effluents.

As point sources are localised, spatial profiles of the quality of the aquatic environment may be used to locate them. Some point sources are characterised by

[1] Toxaphene - a synthetic amber waxy solid with an odor of chlorine and camphor, used as an insecticide. It is a chlorinated terpene.

[2] Gregor D.M., Gummer W.D. Evidence of atmospheric transport and deposition of organochlorine pesticides and polychorinated biphenyls in Canadian Arctic Snow. Environ. Sci. Technol. – 1989. – V. 23. – P. 561-565.

a relatively constant discharge of the polluting substances over time, such as domestic sewers, whereas others are occasional or fluctuating discharges, such as leaks and accidental spillages. A sewage treatment plant serving a fixed population delivers a continuous load of nutrients to a receiving water body. Therefore, an increase in river discharge causes greater dilution and a characteristic decrease in river concentration. This contrasts with atmospheric deposition and other diffuse sources where increased land run-off often causes increased pollutant concentrations in the receiving water system.

Non-atmospheric diffuse sources

Diffuse sources cannot be ascribed to a single point or a single human activity although, as pointed out above, they may be due to many individual point sources to a water body over a large area. Typical examples are:

• Agricultural run-off, including soil erosion from surface and sub-soil drainage. These processes transfer organic and inorganic soil particles, nutrients, pesticides and herbicides to adjacent water bodies.

• Urban run-off from city streets and surrounding areas (which is not channelled into a main drain or sewer). Likely contaminants include derivatives of fossil fuel combustion, bacteria, metals (particularly lead) and industrial organic pollutants, particularly PCBs.

Pesticides and herbicides may also be derived from urban gardening, landscaping, horticulture and their regular use on railways, airfields and roadsides. In the worst circumstances pollutants from a variety of diffuse sources may be diverted into combined storm/sewer systems during storm-induced, high drainage flow conditions, where they then contribute to major point sources.

• Waste disposal sites which include municipal and industrial solid waste disposal facilities; liquid waste disposal (particularly if groundwater is impacted); dredged sediment disposal sites (both confined and open lake). Depending on the relative sizes of the disposal sites and receiving water bodies, these sources of pollution can be considered as either diffuse or point sources, as in the case of groundwater pollution

• Other diffuse sources including waste from navigation, harbour and marina sediment pollution, and pollution from open lake resource exploitation, in particular oil and gas.

The time variability of pollutant release into the aquatic environment falls into four main categories. Sources can be considered as permanent or continuous (e.g. domestic wastes from a major city and many industrial wastes), periodic (e.g. seasonal variation associated with the influx of tourist populations, or food processing wastes), occasional (e.g. certain industrial waste releases), or accidental (e.g. tank failure, truck or train accidents, fires, etc.). The effects of these various types of pollutants on receiving water bodies are rather different. The continuous discharge of municipal sewage, for example, may be quite acceptable to a river during high discharge periods when dilution is high and biodegradation is sufficient to cope with the pollution load. During low discharges, however, pollution levels and effects may exceed acceptable levels in downstream river

stretches. Lake volume and initial dilution are also factors codetermining the prevalence of the pollutant in the lake.

* according to Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. 2nd Edition / Edited by D. Chapman; UNESCO/WHO/UNEP. London: F & FN Spon, 1996. 651 p.

Task

1. *Remunerate the essential pollutants of waters*.

2. *Find correct items for water pollution sources*:

Agricultural run-off	organic pollutants
	pesticides and herbicides
Navigation, harbours	trace elements
	oil and gas
Waste disposal	soil particles
	bacteria
Urban run-off	derivatives of fossil fuel combustion
	metals

3. *What environmental problems can occur as a result of the water pollution*?

    - Eutrophication
    - Acidification
    - Humification
    - Salinization
    - Erosion