



Sources of Pollution

- overview

WHAT IS POLLUTION?

Pollution is the harm that results because of the presence of a substance or substances where they would not normally be found or because they are present in larger than normal quantities. Polluting substances may occur as a solid, liquid or gas.

The consequences of pollution may be direct, through the toxic effect of a substance. For example, an accidental spill of a pesticide entering a river may well have an immediate effect and be very harmful to the aquatic life. Or the consequences of pollution may be indirect. Nitrogen and phosphorus are essential for plant growth, but excessive plant growth can be harmful to water. For example, enhanced phosphorus levels in surface waters (that contain adequate nitrogen) can stimulate excessive algal growth. In time, the process of algal decay reduces the oxygen available in the water, harming fish and other aquatic life.

Our use of water can cause pollution, not only because of substances we put into water either deliberately or accidentally, but also by abstracting water from rivers and lakes we reduce the ability of water bodies to tolerate the presence of potentially-polluting substances. Where the volume of receiving water is low, the relative concentration of a polluting substance entering the water will be higher and consequently its impact will be greater. Hence, the reduction of water pollution relies not only on preventing potentially-polluting substances entering water bodies, but also on reducing the amount of water we use.

SOME USEFUL DEFINITIONS ASSOCIATED WITH POLLUTION

Pollutant - contaminant present in the environment or which might enter the environment which, due to its properties or amount or concentration, causes harm.

Contaminant - substance, material or agent that is unwanted in the environment.

Harm - physical injury or damage to the health of people or damage to property or the environment.

Hazard - potential source of harm.

Risk - combination of the probability of occurrence of harm and the severity of that harm.

Perceived risk - sum of calculated risk and outrage (a strong expression of concern).

NATURE OF POLLUTION SOURCES

Pollution is often described as *point source* or *diffuse (or non-point) pollution*.

Point source pollution enters a water body at a specific site and is generally readily identified. Potential point sources of pollution include effluent discharges from sewage treatment works and industrial sites, power stations, landfill sites, fish farms, and oil spillage via a pipeline from industrial sites.

SUBSTANCES THAT MAY CAUSE POLLUTION

Nutrients

Point source pollution is generally readily prevented since it is possible to identify where it is coming from and, having done so, those responsible for causing the pollution can take preventative measures through immediate remedial action or longer-term investment in treatment and control facilities.

Diffuse pollution arises where substances are widely used and dispersed over an area as a result of land-use activities such as urban development, amenity, farming and forestry.

These activities may be recent or have been carried out in the past. It is often difficult to identify specific sources of such pollution and therefore take immediate action to prevent it, since prevention often requires major changes to land use and management practices.

Examples of diffuse pollution include the leaching to surface water and groundwater of contaminants from roads, manures, nutrients and pesticides used in agriculture and forestry, and atmospheric deposition of contaminants arising from industry. A special case arises where, for example, a power station may emit sulphur dioxide and nitrous oxide to the air. Although this is a *point source*, the deposition (fallout) and, hence, impact will be over a wide area as *diffuse pollution*.

See also the accompanying *Information Note on Diffuse Pollution* which specifically deals with diffuse pollution.

Some of the major substances that may cause pollution are described below.

The main potentially-polluting nutrients in relation to water are nitrogen, ammonia (a form of nitrogen), phosphorus and sulphur. They arise from the natural breakdown of crop residues and soil organic matter, rainfall, fertilisers, urine and manure, silage, landfill sites, wastewater and industrial effluents, power generation and other fuel-burning activities.

For example, nutrients are the principal cause of eutrophication which is the enrichment of lakes, rivers and the marine environment leading to increased plant growth and the occurrence of algae.

Pesticides

These include herbicides, insecticides and fungicides that are used in gardens, in agriculture, in roadside and trackside (railway) maintenance, and in parkland and golf courses.

Heavy metals

Heavy metals are widely-used ingredients for chemical compounds used in industry. Industrial contaminated land can be a source of heavy metals leaching into the environment. They also exist naturally in soils at low concentrations. They can be found in fuel, chemicals, waste materials and batteries. In high concentrations they are toxic to humans, animals and plants.

Suspended solids

Suspended solids are mineral and organic particles that remain suspended in water. They sink only very slowly or are easily re-suspended by water turbulence. Suspended solids might be eroded soil or decayed leaves. Wastewater from sewage works and industry might also carry suspended solids into water bodies. Suspended solids cause water to be turbid and this cloudiness reduces light levels. Turbidity can also be a sign of other pollution since nutrients, pesticides and metals can be attached to the suspended particles.

Settleable solids

These are mineral or organic solids which can settle onto gravel beds where they can prevent fish spawning.

Oxygen depleting substances

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are analytical methods for measuring the amount of oxygen consumed during the microbial or chemical breakdown of oxygen-depleting substances in water, such as sewage and farm slurry. High levels of BOD and COD indicate a heavily polluted water body making it less suitable for aquatic life.

Pathogens

These are present in urine and faeces from human and animal sources, including wildlife. They can enter water through poor wastewater management or poor handling of manures, slurry and other farm wastes. They may also be carried directly off fields by heavy rainfall or enter water bodies where stock and wildlife have direct access for drinking purposes.

Temperature

Temperature is not strictly a pollutant in the general meaning of the term but is included here because it can affect the health of the aquatic environment. Shallow water tends to be warmer than deep water as it is heated more readily by the sun. For the same reason, particularly in summer, the surface water of lakes is warmer than that at the bottom. Where water is heavily abstracted for use, the remaining water can become warmer due to its reduced depth, stressing aquatic life. Treated effluent from industry and sewage treatment works is generally warmer than the receiving waters into which they are discharged, and this can cause temperature stress as well as stress due to reduced oxygen in the water, since warm water carries less oxygen than cold water.

Hydrocarbons

These include vegetable and mineral oils (including petrol, diesel, white spirit, heating and lubricating oil), and chlorinated solvents such as dry cleaning fluids. For a broader description of hydrocarbons see:

<http://encyclopedia.laborlawtalk.com/hydrocarbons>

Persistent organic pollutants (POPs)

These are chemicals that are capable of long-range transport, accumulate in human and animal tissue, and have a significant impact on human health and the environment, even at low concentrations. They include such substances as dioxin and PCBs.

SOURCES OF POLLUTION

Examples of some potential sources of pollution are given in the Table below. Legal instruments and codes of practice have been designed and implemented so that the risks of pollution from these sources are low in normal circumstances, but there will be occasions when normal conditions are exceeded, for example when there are floods.

The Table gives examples of sources of pollution and the potential pollutant discharges which could arise. It is important to note that whilst there are many potential hazards arising from the sources of pollution listed, the risks to the aquatic environment may be very small.

Examples of sources of pollution	Point source or diffuse?	Potential pollutant
Effluent discharges from sewage treatment works	Point source	Nitrogen (N) and Phosphorus (P), persistent organic pollutants, pathogens, solids, litter
Industrial effluent discharges treatment	Point source	N, oxygen-depleting substances and a broad spectrum of chemicals
Industrial processes	Point source	Broad spectrum of chemicals released to air and water
Oil storage facilities	Point source	Hydrocarbons
Urban stormwater discharges	Point source -arising from storm water runoff (from paved areas and roofs in towns and cities) entering the sewer network	N, P, oxygen-depleting substances, heavy metals, hydrocarbons pathogens, persistent organic pollutants, suspended solids, settleable solids, litter
Landfill sites	Point source	N, ammonia, oxygen-depleting substances, broad spectrum of chemicals

Fish farming	Point source	N, P, oxygen-depleting substances, pathogens
Pesticide use	Diffuse	Broad spectrum of chemicals
Organic waste recycling to land	Diffuse	N, P, pathogens
Agricultural fertilisers	Diffuse	N, P
Soil cultivation	Diffuse	Soil, N, P
Power generation facilities	Diffuse	N, Sulphur
Farm wastes and silage	Point/Diffuse	N, P, oxygen-depleting substances, pathogens
Contaminated land	Point/Diffuse	Hydrocarbons, organic chemicals, heavy metals, oxygen-depleting substances
Mining	Point/Diffuse	Heavy metals, acid mine drainage
Leaking pipelines	Point/Diffuse	Oil, sewage

Further information on water quality and sources of pollution:

(http://www.environment-agency.gov.uk/subjects/waterquality/?lang=_e)

MORE DETAIL ON SOME SOURCES OF POLLUTION

Landfill sites

Landfill sites can be a source of pollution into the aquatic environment through several mechanisms. Rainfall enters a site while waste is being deposited and, as it passes through the waste, it collects polluting compounds including ammonia, heavy metals, chloride and oxygen-depleting substances. Waste itself contains water and this is released during degradation processes that occur after the landfill has been sealed. The Landfill Directive requires the quantity of un stabilised organic waste disposed of in landfill to be substantially reduced in order to reduce the potential for water pollution and the emission of methane, which is an important greenhouse gas. However, this will take time to be fully effective and there are many older landfills which will continue to generate leachate for many years.

Modern landfill engineering minimises the amount of water entering a landfill and any leakage from it. However, this is not the case with older landfills where there may be no impermeable base liner or capping, enabling water to flow through relatively unrestricted. Even modern landfills can suffer from leachate problems if the integrity of the liner or capping has been compromised in some way. Leachate may be treated on site with the effluent discharged to a neighbouring watercourse, or transported to a sewage treatment works for treatment. Alternatively leachate may be partially treated on site and then discharged to a sewer for further treatment at a sewage treatment works.

Further reading on landfill sites are:

Basic information about formation and management of landfill leachate:

(<http://www.portfolio.mvm.ed.ac.uk/studentwebs/session4/7/Leachate.htm>)
(http://www.leachate.co.uk/html/all_about_leachate.html)

Environment Agency Facts and Figures on landfill sites:

(http://www.environment-agency.gov.uk/yourenv/eff/1190084/resources_waste/213982/207743/?version=1&lang=_e).

Contaminated land

Contaminated land is largely an historical legacy from former industrial activity conducted when there were few, if any, environmental regulations in force. The nature of the contamination can vary greatly from heavy metals, hydrocarbons and organic chemicals. Water contamination from these sites occurs largely as a result of rainfall which flushes chemicals, contaminated sediment and dissolved compounds into nearby streams or into groundwater beneath a site. Contamination of groundwater and surface waters can also occur where there is poor storage and handling of chemicals such as solvents or oils giving rise to spillage.

Further reading on contaminated land:

Water pollution arising from land containing chemical contaminants (Scottish Environment Protection Agency):

(http://www.sepa.org.uk/pdf/publications/leaflets/cont_land/water_pollution_guide.pdf)

Environment Agency website on contaminated land:

(<http://www.environment-agency.gov.uk/subjects/landquality/113813/?versi>)

Contaminated land publications on Defra website:

(<http://www.defra.gov.uk/environment/land/contaminated/pubs.htm>)

European groundwater and contaminated land information system:

(<http://www.eugris.info/index2.asp>)

Mining

The principal source of water contamination from mining is acid mine drainage. Coal and metal ore seams and their associated rock strata contain pyrite (iron sulphide) which oxidises on contact with air and in the presence of bacteria to form sulphuric acid. Consequently, drainage from a mine has very low pH (acidity) and contains high concentrations of sulphur, iron and a range of heavy metals such as arsenic and cadmium. This becomes more prevalent when mines are closed and water, which has previously been prevented from entering the mine through pumping, is allowed to enter unrestricted. Mine spoil dumps are also a potential source of similar contamination.

When acid mine drainage enters streams and rivers, the change in pH causes the iron to precipitate as unsightly ferric hydroxide. This is deposited on streambeds as an orange sludge, a process which also depletes the water of its oxygen, both of which impact on fisheries and insect life.

Fish farming

Fish farming is the intensive production of fish in a small area. It may be conducted in specifically constructed ponds, or in cages in inland lakes and sheltered coastal waters.

Fish farming can have a variety of effects on the marine environment, through the discharge of nutrients, solid waste, medicines and anti-foulants. Nitrogen and phosphorus from fish feed released into the marine environment in a soluble form can enhance the growth of marine plants and algae. Waste feed and faeces from fish farms can collect on the seabed under fish cages. This increase in organic matter can have an impact on the benthic environment, affecting the nature and chemistry of sediments, and can reduce the diversity of animals living there.

Intensive farming of fish may increase the disease pressure due to the close proximity of a large number of fish. Consequently, a number of medicines are used on fish farms to maintain fish health. Farmed salmon are susceptible to infestations of parasitic sea lice that cause considerable stress to fish and economic losses to the industry. Sea lice on farmed fish can potentially be transferred to wild salmon and sea trout reducing the health of the wild stock. Control of sea lice using chemicals may be toxic to marine invertebrates, although the application of antibiotics to treat bacterial diseases has declined in recent years due to effective vaccination programmes.

Fish farming is monitored and regulated by the regulatory authorities supported by good practice guidelines. For example, the Scottish Environment Protection Agency's Fish Farming Manual gives guidance on legislation, policy and procedures relevant to the marine cage fish farming industry in Scotland.

(<http://www.sepa.org.uk/guidance/fishfarmmanual/manual.asp>)

Further reading on fish farming:

Review and synthesis of the environmental impacts of aquaculture at:

(<http://www.scotland.gov.uk/cru/kd01/green/reia.pdf>)

The Interaction between Fish Farming and Algal Communities of the Scottish Waters - a Review:

(<http://www.scotland.gov.uk/library5/environment/algal.pdf>)

Roads, drives and car parks are large runoff-producing areas in the urban environment. This runoff is often contaminated with sediment, litter, oil and petrol, and with toxic metals from motor vehicles. Water carrying these contaminants is washed off into drains and directly into nearby watercourses. Most surface water drains are connected directly to watercourses and not sewage treatment works, hence any spillage of chemicals will tend to be washed into rivers.

Combined sewer systems carry both sewage and stormwater runoff. Combined sewers are common in urban areas. Normally, the entire flow goes to a sewage treatment plant, but during a heavy rain storm the flow in the sewer may be greater than it can accommodate and the excess flow has to be diverted to a receiving watercourse via an overflow (referred to as a Combined Sewer Overflow) to avoid serious flooding of nearby urban areas and at the treatment works.

Sustainable Urban Drainage Systems are increasingly being adopted to ensure that urban areas behave more like natural catchments through the use of porous pavement surfaces and by diverting potentially-polluted water from watercourses. The purpose is to reduce the potential for pollution caused by direct runoff and to reduce the volume of water flowing in the drainage network thereby avoiding flooding and sewer overflows.

For further information see:

The Wastewater Planning Users Group (WaPUG) workshop reports which deal with such topics as urban rainfall and runoff are available from the Foundation for Water Research:

<http://www.fwr.org>

The Environment Agency's introduction to Sustainable Urban Drainage Systems (SUDS):

http://www.environment-agency.gov.uk/business/444304/502508/464710/?version=1&lang=_e

Sustainable Urban Drainage Systems – an introduction:

<http://publications.environment-agency.gov.uk/pdf/PMHO0503BHEJ-e-e.pdf>

Sustainable Urban drainage network:

<http://sudsnet.abertay.ac.uk/index.html>

The following website from the USA offers a range of best practice guidance documents on managing storm water in urban and agricultural situations:

<http://www.mrsc.org/subjects/environment/water/SW-BMP.aspx?r=1>

Eutrophication – an example of the consequences of nutrient enrichment arising from both point and diffuse pollution sources

Eutrophication results when lakes, reservoirs, rivers and the marine environment become over-rich in nutrients arising principally due to man's activities. This can lead to an over-abundance of aquatic plants. The decay of aquatic plants depletes the oxygen dissolved in the water which, under some circumstances, can adversely affect the aquatic wildlife and fish.

The occurrence and degree of eutrophication can be seasonal. Water levels tend to be lower in the summer, increasing the concentration of any contaminants in water. The impact of a point source of nutrients will also tend to be greater when water volumes are lower and rivers are flowing more slowly, reducing the dilution effect of clean water flowing past the nutrient source. Warm water holds less dissolved oxygen than cold water and water temperatures are higher during the summer months, such that the same concentration of nutrients in water in summer will have a greater eutrophication effect than during the winter. Eutrophication is not restricted to freshwater and can occur in transitional waters such as estuaries and salt marshes as well as in shallow coastal waters where tidal flushing is limited.

Excessive plant growth can also increase the pH (acidity) of water through the removal of carbon dioxide by plants and algae during photosynthesis. These changes in the oxygen status and acidity of water will affect the type and diversity of plants and animals that can survive. Many habitats are defined by the prevailing chemistry, such as acidity in peat bogs or low nutrient status and high alkalinity in rivers flowing in a chalk catchment. Changes in chemistry will change the nature of those habitats. Equally, changing the physical nature of a water body, such as by deepening it, by making it more shallow, or by causing rapid changes in water level through abstraction or use for power generation, will impact on the plants and animals that can live in the affected river or lake.

Eutrophication can lead to quality problems associated with water abstracted for drinking water giving rise to increased treatment costs. It can also have an impact on recreational uses of rivers and lakes, such as angling and sailing, by affecting the status of fisheries and reducing the aesthetic quality of the water body.

More information about eutrophication can be found at the following websites:

'Nutrients in rivers' an Environment Agency website:

(http://www.environment-agency.gov.uk/yourenv/432430/432434/432487/438449/?lang=_e)

Environmental Change Network – eutrophication:

(<http://www.ecn.ac.uk/freshwater2/pressures.htm>)

Air Pollution Information System overview of eutrophication:

(http://www.apis.ac.uk/overview/issues/overview_eutrophication.htm)

Control of pollution

The UK water industry has invested an enormous amount in pollution control technologies and good practice over the past 30 years. The concept of effective river basin management is now accepted as standard practice and, whilst there are still many challenges to face in controlling pollution from many sources, the quality of the water environment is now better than at any time since the start of the industrial revolution in the late 18th century.

Guidance Specifying Management Measures for Sources of Non-point Pollution in Coastal Waters:

(<http://www.epa.gov/owow/nps/MMGI/>)

The Water Framework Directive and other legislation

There is a substantial amount of legislation targeted at reducing the release of polluting substances. The Groundwater Directive specifies substances that may not be released or that can only be released in limited quantities, specified as List I or List II substances. The Nitrates Directive limits when, where and how much nitrogen fertiliser and organic manures may be applied to agricultural land, with the aim of reducing nitrate leaching. The Urban Wastewater Treatment Directive requires a higher standard of wastewater treatment at large sewage works in order to reduce the amount of nitrogen and phosphorus discharged into water bodies in the treated water. The Waste Incineration and Large Combustion Plant Directives are targeted at reducing air pollution, and the Integrated Pollution and Prevention and Control Directive controls all the releases to the environment from large industrial activities. The Habitats Directive requires controls on activities affecting waters of high nature conservation value, including control of nutrients in discharges where appropriate. The Dangerous Substances Directive and its Daughter Directives are designed to improve water quality through the elimination and/or reduction of specified dangerous substances discharged to the aquatic environment and in some cases preventing their manufacture and marketing.

All these directives and the regulations that implement them target the source of pollution. The Water Framework Directive complements this by putting in place river basin management plans which will identify

the actions required for controlling potentially-polluting sources so that 'good surface and groundwater status' can be achieved by 2015. *More detailed information on the Water Framework Directive is given in the Water Framework Directive Information Notes.*

In addition to legislative instruments, the adoption of 'good practice' guidelines is common in agriculture, industry and in the home, offering advice and guidance to those using potentially-polluting substances, such as fertilisers and pesticides, in order to safeguard the water environment.

For national and local information on water quality and related issues: (See also the accompanying Information Notes: 'Sources of Pollution – Reference Library' and 'Sources of Pollution – Useful Websites').

England and Wales: Water Quality:

(http://www.environment-agency.gov.uk/yourenv/eff/1190084/water/?version=1&lang=_e)

Scotland: Scottish Environment Protection Agency - Environmental Data: Classification Scheme:

(<http://www.sepa.org.uk/data/classification/index.htm>)

Northern Ireland: Environment and Heritage Service - River Water Quality Monitoring:

(http://www.ehsni.gov.uk/environment/waterManage/quality/rivers/river_monitor.shtml)

National statistics about inland water quality and use:

(<http://www.defra.gov.uk/environment/statistics/inlwater/index.htm>)

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