Water pollution

Introduction

Water has a great self-generating capacity, that can neutralize the polluting interventions carried out by humans.
However, if human activities continue this uncontrolled and unsustainable exploitation of this resource, this regenerating capacity shall fail and it will be jeopardized definitively.
Man is now aware of this and is increasingly aware of the mechanisms that regulate the water cycle, and allow rivers, lakes, seas and oceans to live, and know where and how to intervene.

Water pollution

Facts

Water pollution is intended as water quality degradation caused by the introduction of substances that alter its physico-chemical characteristics and impede its normal use. These substances having either a solid, liquid or gaseous origin have different effects according to their amount and potential danger and fragility of the environments where they are released. These substances can have a human origin, when they are introduced by humans, or a natural origin. Pollution of water of natural origin can be caused by decomposition of organic debris, saltwater invading coastal aquifers, water blackening due to landslides, earthquakes, dust erupted from volcanoes.
Pollution can either be found at the level of superficial water or subterranean water. Pollution of superficial water can differ in its features or seriousness depending on whether it affects water in a river or in a lake and the consequences are: fish fauna depletion, death of aerobic bacteria and aquatic plants, formation of pestilential odors and deteriorating material, diffusion of pathogenic microorganisms, moreover, the more the water is polluted the greater are the costs of making it drinkable.
Pollution of aquifers is very dangerous from the point of view of preservation of water as a resouce for humans. Once it's polluted, infact, subterranean water has a low depurative power and shows to employ much more time to recover original quality of water.

Substances polluting water

Water used in the agricultural, industrial and civil sectors often contains substances which will alter the ecosystem and hence must not be discharged directly into river flows.
The most common polluting agents are the following.

- **Fecal pollutants:** materials of fecal origin that reach water bodies through sewage discharges or introduction of zootechnical manure that hasn't been adequately treated. If there is a high fecal type pollution, can be observed the presence of pathogen microorganisms in water that can cause diseases as cholera, typhus fever, viral hepatitis, etc.
- **Toxic inorganic substances:** these are constituted by heavy metal ions that can poison or kill living organisms. Industries that employ these heavy metals during processing, must sanitize them to eliminate any heavy metal leftover before discharging water.
- **Inorganic harmful substances:** there are substances constituted by phosphates and polyphosphates existing in detergents, fertilizers, compounds of nitrogen and phosphorus and in some industrial discharges. These substances cause eutrophication (see paragraph on eutrophication).
- **Unnatural organic substances:** in this category are included weed killers, pesticides, insecticides, etc. These substances are convenient for agriculture but can pollute both water and soil. Among these substances are included also organic solvents used by industries, such as trichlorethylene, acetone, benzene, etc., which must be eliminated before water is discharged.

- **Free oils and emulsifiers:** these are insoluble, low density substances which for this reason form superficial oily film layers that prevent oxygen dissolution in water. It's not a rare phenomenon and it can cause real ecological disasters.
- **Suspended solids**: creating a mixture of various kinds of substances that make water murky and prevent solar light from passing through. When they deposit deep on the bottom of a water body they obstruct vegetation growth.
- **Heat, acids and strong bases:** originating especially from industrial discharges. They reduce the solubility of oxygen, modify the temperature and pH of the environment causing pathological alterations or the disappearance of living organisms or on the contrary the comparison of others.

Alterations

The different types of pollution lead to chemical or physical alterations of the water, with mechanisms which are very complex at times. Contaminants that are dispersed in the water have harmful effects on animal populations and plants, that can be classified into the following categories:

- **deoxygenation or oxygen-depleting effects**: these effects are caused by the organic substances that are present in industrial waste. When industrial waste is dispersed in the water, it is degraded by microorganisms, with an excessive consumption of the oxygen dissolved in the water. The reduced availability of oxygen in the water is the cause of death of animal and plant species that are unable to tolerate this lack of oxygen and, on the other hand, an invasion of those species that are not influenced by the lack of oxygen;
- **eutrophication effects**: eutrophication is a phenomenon provoked by compounds (mineral nitrogen and phosphorus) that favour an abnormal growth of populations of phytoplankton and algae, at the expense of the survival of other plant and animal species. Lakes and sea-coasts are particularly affected by this;
- **physical effects**: are caused by very high temperature waste waters;
- **effects caused by radiations**;
- **pathogenic and toxic effects**: are caused by waste waters with a high content of suspended toxic or pathogenic materials (heavy metals, mineral oils, hydrocarbons, ammonia, solvents, detergents, pesticides, etc.)

Water regenerates itself

When polluted, fresh water basins have the capacity to self-clean their water, i.e. to make the water return to its original quality and purity. This self-cleaning phenomenon is provoked by bacteria that, in the presence of oxygen, degrade and transform the polluting substances into inert inorganic compounds. Obviously this process is not effective on all types of pollutants and for any amount of polluting substances present in the water. In some cases, human intervention is necessary to clean the water reserves that have been polluted.

The type of treatment that must be used to clean the water depends essentially on the type of pollutant that must be eliminated. The greater the number of pollutants in the water, the more difficult it is to clean it. In some cases polluted water is extracted, purified and then returned to the water table, river or lake. In other cases water is purified on site (i.e. without removing the water from its natural site).

Also the sea has a great self-regenerating capacity, which can neutralize human polluting actions. However, if human activities continue to persevere in an uncontrolled and unsustainable exploitation of a resource that seems (but is not) inexhaustible, this regenerating capacity will cease and it will permanently jeopardize the sea's capacity to correctly carry out all the vital functions that it provides today.

Man is now aware of this and is increasingly aware of the mechanisms that regulate the water cycle , that allow rivers, lakes, seas and oceans to live. Therefore we know where and how to intervene: the problem is to succeed in improving

and spreading good practices and sustainable use of the water resource all over the world, in our communities and in those countries where respect for natural resources seems to be applicable only to the richer countries.

DDT

The history of DDT represents a significant example of the risks for humans every time they intervene on the environment without knowing inside out the balances of ecosystems. The insecticidal power of DDT was discovered in 1939 and, at the end of World War II, it was largely used in those regions where diseases transmitted by insects, such as malaria, typhus fever and yellow fever, were widespread. Moreover, once its usefulness was discovered in the fight against insects harmful for crops, it allowed to increase agricultural production in the immediate post-war period with a consequent rapid recovery of world economy. The problems related to DDT are given by its long decay times that maintain unaltered for years its toxic characteristics. By the time when this insecticide was banned and substituted by other substances, 25% had been carried by rainfall and rivers into the oceans while a great quantity was circulating in food chains.

Pollution sources

Agricultural pollution

Agricultural pollution originates from the introduction of chemical fertilizers (rich in phosphates and nitrates), pesticides (insecticides and weed killers) and manure from stables in river flows and in the soil. The discharge of chemical fertilizers in rivers, lakes and seas enhances the eutrophication phenomenon. The introduction of pesticides poses the most serious threat as these are not very biodegradable, they deposit and concentrate in river flows destroying all forms of life. A greater attention from agricultural operators could substantially reduce this form of pollution that is particularly dangerous as it can regard also aquifers. To prevent this, the contribution of nitrates must be reduced and must be favoured the use of natural manure as also must be reduced the use of pesticides introducing biological fight to avoid excessive irrigation that leaches soil and makes necessary the use of fertilizers.

Industrial pollution

Pollution of industrial origin is caused by the discharge of toxic and non biodegradable substances coming from industrial processing such as cyanides originating from industries producing pesticides and weed killers, cadmium originating from companies producing batteries and accumulators, and chromium as a leftover of plating and tanning industries.
Industrial pollution can derive from the discharge of water used in productive processes that contains high amounts of solid dissolved susbstances coming from leaching of solid waste landfills carried out by rainwater or by accidental breaks of tanks and/or pipes transporting very polluting products that flow directly into rivers or disperse in the soil and subsoil and eventually reach aquifers. To reduce industrial pollution it’s necessary to purify water through filters and treatment tanks before discharging it and favouring, when possible, natural substances in purification processes.

Thermal pollution

There is also another form of industrial pollution of water that doesn’t regard the content of polluting substances but temperature: thermal pollution. Industries, in fact, pour into the sea or into rivers hot water used for their processings. Cooling water is withdrawn from seas, lakes and rivers at a certain temperature and after use is returned at a higher temperature. The temperature rise in water bodies causes the alteration of aquatic ecosystems and the variation of vital processes. Moreover, it can lead to the death of bacterial fauna which is useful in self-purification processes of water and, in most serious cases, it can also lead to the death of a great number of fish. To reduce the negative effects caused by the discharge of cooling water, hot water produced by domestic heating or for the breeding of species requiring high temperatures should be reused.

Domestic pollution

Domestic water pollution is produced by the discharge of domestic sludge containing organic substances and soaps.

These substances generally pour into superficial river flows but sometimes reach aquifers. It's possible to reduce waste water pollution thanks to purification. Discharges are channelled from sewers to treatment stations to abate pollutants before discharging water into rivers and seas. These purification systems, though, aren't always into force and, moreover, even where discharges are gathered and channelled can occur breaks or inefficies of septic pits, pipes or treatment plants that cause leakage of polluted water. Also phytopurification, which uses specific plants that work as biological filters capable of reducing polluting substances, can be employed to abate pollutants present in waste water.

Hydrocarbon pollution

It's caused mainly by accidents on oil platforms and ships used for hydrocarbon transport but also by discharging into the sea of water used to wash tanks of tanker vessels. Crude oil and petroleum products form a waterproof film on water that prevents the exchange of oxygen between atmosphere and water causing damages to marine flora and fauna.
Nowadays during transport over sea are used "double-hull" tankers to avoid leaks in case of accidents. The best international practices are adopted with regards to oil platforms to face or eventually adequately deal with any type of inconvenience.

Sea pollution

Sea and the ocean pollution

The use of seawater and the exploitation of marine resources may cause serious damages unless they are carried out in a way that guarantees its sustainable use, i.e. that guarantees compatibility between the marine ecosystems and man's activities. Unfortunately, in many cases, since the antiquity the sea has been wrongly considered as a huge dumping ground in which all waste and dirt could be freely thrown. And it is still considered as such by poorly educated summer tourists, especially those who use sailing or motorboats and throw all their waste into it.
Today, the main causes of pollution in the seas and oceans can be:

- pollutants from human activities discharged into the rivers and carried to the sea (degradable and non-degradable organic materials from urban waste, organic products of agricultural origin, such as plant chemicals and fertilisers, pollutants from industrial waste)
  oil spilled by oil tankers, following accidents or improper practices when cleaning tanks or discharging ballast water;
- radioactive substances: released during nuclear tests, by now stopped in all countries, and when producing atomic fuels;
- overheating of coastal waters, due to hot water coming from industrial cooling plants;
- excessive exploitation of fishing resources (too much fishing), that causes the fishing populations to decrease or even disappear;
- uncontrolled urban development along the coasts and uncontrolled and massive seaside tourism;
- discharge of nuclear and toxic waste;
- discharge of plastic containers and other non-biodegradable solid waste.

Heavy metal pollution

The most dangerous are: cadmium, lead, mercury that can be harmful to human health even in very low concentrations, as well as being highly toxic and non-degradable. They accumulate in those organisms that occupy the highest levels in the food pyramid: mercury pollution in the sea provokes the concentration of this metal in fish and the organisms that eat

the fish, including men. Mercury that derives from the dumping of industrial waste and that reaches the sea is ever lasting and continues its cycle by passing from one organism to another through the food chain.

Euthrophication of the sea

Oxygen, light and mineral substances are very important for the sea, as they allow organisms to develop. These nutrients melt into the water and their excessive presence makes the sea particularly rich in organisms. In fact the result is an intense growth of algae and aquatic plants that develop rapidly, altering the balance of the ecosystem. Herbivores that eat algae and plants are not enough and do not manage to control these vegetal populations, that form a large quantity of decomposing material as they die. The decomposition and fermentation of dead organisms means consumption of oxygen, which is less and less available in the environment for those organisms that need it to survive. As a consequence the number of organisms drastically drops.
This situation might occur in the Adriatic sea, where the Po river waters collect the agricultural, industrial and urban waste coming from the plain of the Po. These polluted waters are rich in nutrients and in the summer of 1989 a phenomenon of euthrophication occurred in the Adriatic sea, which was largely covered by a layer of mucilage produced by unusually growing algae.

Preservation of the water resource

Avoid polluting

In many countries to avoid pollution of water of industrial, domestic and agricultural origin in recent years have been introduced more and more restrictive laws that commit companies and public administrations to give particular attention to prevention, control and reduction of water pollution. New technologies and new products have hence been studied and introduced to allow to produce goods and services limiting and eliminating completely water pollution. Also many international organisations, including the European Commission, have dictated a set of simple recommendations for a sustainable management of water resources. Recommendations range from undertaking reforms of institutions that govern water resources to the definition of an adequate price for water to promote a more cautious and less waste-oriented use for water. Sustainable use of water, infact, is based also on waste reduction or its recycling in productive cycles: these practices can increase availability and improve quality of water existing in a given area.
The problem remains, instead, in those countries where these laws haven’t been adopted yet or where serious controls are not undertaken on their application. In this case it’s desirable that, being aware about water pollution that often is a supranational problem and not only a local one (if pollution enters in the water cycle it can spread also to substantial lengths), industrialized countries should find efficient ways to transfer clean technologies and adequate environmental laws also to poor countries that don’t apply them either due to cost issues or because necessary knowledge and training are lacking. This kind of behaviour would lead us closer to a situation of sustainable use of this natural resource at a world level.

Italian legislation on water

In the ‘70s, with the Legge Merli, was perceived for the first time the exigency to indicate in detail polluting substances posing limits to their discharge into water and their concentration regulating the topic of discharges.
The D.P.R. 236/88 is the first example of the enforcement of a Community Directive (Directive 80/778 EEC regarding the quality of water destined for human use) from the Italian State. This law regulates the quality of water destined for human consumption and defines maximum allowable concentration (MAC) and guideline values (GV) for different chemical and microbiological parameters, indicated by the law itself. Moreover, it establishes protected areas for water resources distinguishing between complete preservation areas, areas of respect and areas of protection.
Law N. 36 of January 5, 1994 (the so-called Galli Law) regarding provisions concerning water resources establishes that all superficial and subterranean water is public and human consumption is overriding other forms of consumption. In Italy

with this law has been launched a substantial modernization and reorganization process of the hydric sector. The establishment of the Optimal Territorial Ambits (ATO) and Responsible Authority for each ATO has introduced a subject regulating alone the management of all public services of collection, adduction and distribution of water for civil uses, sewage and purification of waste water.
But it's only Draft Law N. 152 of May 11, 1999 "Dispositions on the safeguard of water from pollution and enforcement of Directive 91/271/EEC concerning the treatment of urban waste water and Directive 91/676/EEC regarding the protection of water from pollution caused by nitrates coming from agricultural sources" that establishes an organic legislation on water regulation. This decree and its following integrations consist of a draft law aiming to preserve all water (superficial, marine and subterranean) to prevent and reduce pollution, enforcing recovery of polluted water bodies, gaining an improvement of the state of water and pursuing sustainable, long-lasting uses of water resources. This law envisages a distribution of competencies at central (State) and peripheral (Regions, Provinces, etc.) levels of the state and a system of administrative and criminal fines to guarantee the respect of the legislation.
With regards to discharges, the decree identifies three types of waste water, industrial, domestic and urban, establishing for each of them a different type of control. Discharges are differentiated in:

- Discharges on the soil, banned except particular exceptions;
- Discharges in the subsoil and subterranean waters, generally banned, even if there are exceptions prior authorization;
- Discharges in superficial water, differently regulated according to their type.

All discharges must be authorized allocating jurisdiction to the release of authorizations from Provinces except for discharges from public sewage system which require authorization of controlling bodies.
Draft Law of February, 2 2001 (enforced on December 25, 2003) in implementation of Directive 98/83/EEC on the quality of water destined for human consumption, substitutes and partly modifies Draft Law 236/88, eliminating the concept of guideline values and maximum allowable concentration and introducing parameter values. Finally, within Draft Law N. 152 of April 2006 that contains different laws concerning environmental safeguard, an important part is dedicated to water preservation from pollution and management of water resources. The targets of water preservation from pollution are prevention and reduction of pollution of polluted water bodies as well as their recovery; protection of water destined for specific uses; pursuing of sustainable uses of water resources and maintaining natural self-purification capacities of water bodies.

Should water be purified?

Once it's used, water is returned strongly deteriorated. It contains, infact, many polluting substances (for example leftovers of detergents used to wash dishes or clothes) or other organic substances (for example human excrements). In many countries (unfortunately not all yet) this water is gathered from the sewage system and sent to a purifier that eliminates or reduces at levels compatible with the health of the environment, concentration of polluting substances; water is finally poured again into natural water flows (rivers and lakes) to return into the sea.

Phytodepuration

In the last decades is being undertaken a "biotechnological solution" which is capable of removing polluting agents from water: **phytodepuration** is based on **self-purification capacity** of aquatic ecosystems through physical, chemical and biological processes carried out by vegetal organisms and bacteria. Plants involved are macro and microphytes which are specifically selected according to some characteristics as their capacity to adapt to the environment which needs to be decontaminated and their rapid growth with formation of biomass; in any case, the species employed for phytodepuration are water plants or **hygrophilous** plants which grow in moist environments. In particular, according to the type of phytodepuration system which is under construction, are used different types of floating, submerged and emergent microphytes alone or in group.
The type of phytodepuration system established depends on the direction of the water flow. Surface flow systems consist of tanks or channels from 40 to 60 cm deep and recreate an ecosystem similar to ponds covered by floating hygrophilous

plants. In sub-surface flow systems, instead, flowing water isn't in contact with the atmosphere and an inert stand is inserted in the tanks where the roots of macrophytes will grow. Water flows under the inert stand to favour movement in the tank, which is 70-80 cm deep and is inclined.
Phytodepuration systems are a valid alternative to wastewater treatment for small rural communities and seasonal sewers as those of camping sites, hotels and holiday villages or for the treatment of industrial wastewater, percolates coming from landfills and run-off water coming from roads and motorways. Construction costs are very variable but, anyhow, are never higher than those of conventional depuration plants whereas management costs are incredibly low as energy consumption can even be nonexistent.

Sustainable management of water

Possible actions to manage responsibly such an important resource as water could be many, here are some examples.

- Purification of polluted water. It's possible to restore a lake, as occurred in Switzerland. If the lake is acidified, for example, immission of carbonates neutralizes acidity of polluting substances.
- Pollution prevention. Prevention is indispensable for those water tanks that are not recoverable as aquifers or oceans. In Italy exist different laws referred to pollution prevention including: ban on the use of atrazine herbicides, rationalization of herbicides, fertilizers and pesticides, analysis of potable water, ban of discharging dangerous substances directly or indirectly in aquifers.
- Prevention of the waste of individual water. Paying little attentions in everyday life, we can all commit to saving of this precious resource.