Water Resources, Nature of Contaminants, Impact on Health and Water Quality

Adrian Lucian Cococeanu and Teodor Eugen Man

Abstract Water, like energy, is an essential component of almost all human activities. The water supply is vital for feeding the population, for producing material goods (raising living standards) and for maintaining the integrity of the natural systems on which life on earth depends. Water use is defined as any social or economic unit that needs water of a certain quality to carry out its activity, which satisfies this need through a unitary set of constructions and installations through which the water supply is made, the use and wastewater disposal. The need for drinking water sources dates back to prehistoric times and it is an indispensable resource that we must protect and exploit rationally in a sustainable way to ensure quantity and quality for the future generations.

Keywords Water resources · Natural water circuit · Sustainable water use · Groundwater · Surface water

1 Brief History and Water Directive

The need for maintaining drinking water sources, dates back to prehistoric times. From the beginning, human settlements are connected or have been near the sources of water. The Euphrates, the Indus, the Ganges, the Tiber, the Yan-Tse are the main courses along which the first human civilizations appeared. According to archeological evidence about the existence of centralized water supply systems, during the Nippur civilization, in Samaria about 5000 years ago an arched drain was found with stones fixed by descending feathers, the water being collected through fountains and

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cisterns. In the 16th–17th centuries, with the appearance of capitalized manufactures, water supply development techniques were imposed. Thus, in the 18th–19th centuries, the first centralized water supply systems were built in cities in England, Germany, France and Russia.

Industrial development in various advanced countries has led to a high demand for water and a higher quality, respectively, which has led to the promotion and concerns related to the development of water supply systems, thus developing techniques for using coagulation-flocculant reagents for intensification of settling, rapid filtration, chlorine disinfection, etc. Hydrology has developed as an empirical science through the way in which the mathematical solution of flows interacts, on the one hand and the evaluation and physical observations of the behavior of aquifers and groundwater basins, on the other hand.

The worldwide interest in water resources management and the recognition of hydrogeology as a discipline appeared in 1960 with the publication of a large number of hydrogeology books and international journals. In 1956, the International Association of Hydrogeologists was founded and the establishment of the International Hydrological Decade of UNESCO, the forerunner of the International Hydrological Program, was established.

Water sources are a vulnerable and limited renewable natural resource and represent a natural heritage that must be rationally protected and exploited. In the conditions of global warming, the sustainable management of water resources, the preservation of the self-regulation capacity and the support of the aquatic ecosystems is very important. The European Union's Water Framework Directive is the cornerstone of Europe's water policy history. It establishes a common framework for the sustainable and integrated management of all water bodies (groundwater, inland surface waters, transitional waters and coastal waters) and requires that all impact factors and economic implications be taken into account. In this respect, the Directive requires the establishment of a program of measures to improve the quality of water quality [1–3].

The new strategy for monitoring and characterizing water quality is based on a new concept of integrated water monitoring that involves a triple integration:

- of investigation areas at hydrographic basin level: surface waters in natural regime (rivers, lakes, transitional waters/brackish waters, coastal marine waters), artificial surface waters or waters with strongly anthropogenic modified regime, groundwater, protected areas, effluents;
- of the investigation media: water, sediments to which the biological components are integrated;
- of the monitored elements/components: biological, hydro morphological and physico-chemical (qualitative and quantitative).

2 The Water Framework Directive

The aims of the water framework directives are to prevent further deterioration, to protect and improve the condition of aquatic ecosystems and, in terms of water requirements, terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems [1, 2];

- to promote the sustainable use of water based on a long-term protection of available water resources;
- the objective is the advanced protection and among others the improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions or losses of priority substances and the cessation or gradual cessation of discharges, emissions or losses of dangerous priority substances;
- progressive reduction of groundwater pollution and prevention of subsequent pollution.

In addition, the Water Framework Directive contributes to:

- providing a drinking water in sufficient quantities, of good quality, from surface and groundwater as needed, for a sustainable, rational and equitable use;
- protection of territorial waters and marine waters;
- achieving the objectives of relevant international agreements, including those aimed at preventing and eliminating pollution of the marine environment.

The Water Framework Directive imposes a number of obligations on EU Member States, classified in terms of (a): planning; (b): adoption of regulations; (c): monitoring; (d): consultation and (e): reporting. In practical terms, the Directive requires [1, 2]:

- a wider range of tools for monitoring and classifying waters, in order to assess their ecological status;
- a system for authorization and registration of water samples and accumulations to protect the ecological status of water resources;
- an official system of planning at basin level and application of appropriate measures to limit pollution diffusion in water.

The following benefits are provided:

Environmental benefits:

- improving the protection and general improvement of the quality of the aquatic environment; promoting more efficient ways of using water in order to reduce environmental pressures on the aquatic environment;
- ensuring an efficient and sustainable management of the aquatic environment.

Social benefits:

- increasing the opportunities for involvement and influence of aquatic management by all social actors involved;

- improving the quality of available information about the aquatic environment and its management;
- ensuring the protection of the aquatic environment for the purpose of sustainable development and the provision of ecological services, including the aspects related to favoring the development of the recreational potential.

Economic benefits:

- ensures a fair cost-effectiveness approach, which will lead to a real basis for water use prices;
- favors the achievement of the balance between social, economic and environmental needs by defining environmental objectives;
- increasing the opportunities for involvement and influence of aquatic management by all social actors involved;
- improving the quality of available information about the aquatic environment and its management;
- ensuring the protection of the aquatic environment for the purpose of sustainable development and the provision of ecological services, including the aspects related to favoring the development of the recreational potential.

2.1 The Natural Water Circuits

Water is a precious commodity and is indispensable for life and constitutes more than 60% of living material. Through the cooler, water vapor, present in the mantle of gas that surrounds the earth, condenses for thousands of years. Since then, the amount of water is constant and represents a reserve of 1350 million km^3 (1 billion m^3) but 99.7% of this water is salty or stagnant. Accessible water from rivers and groundwater represents 0.3% of the total reserve.

In the natural cycle, water is regenerated in two levels,

- during evaporation, water vapor is pure, does not contain mineral salts or impurities
- on the occasion of filtration in soils: biological activity and the capacity of soils to filter restoring the clarity of water [4–7].

Filtered water does not have the same composition as water vapor in contact with the soil, some minerals dissolve in water, while water vapor does not contain minerals.

2.1.1 Evaporation: The Transformation of Water from a Liquid State into a Gaseous or Vapor State

Evaporation is the process by which water transforms from a liquid state to a gaseous or vapor state. Evaporation is the main way in which liquid water returns to the general water circuit in the form of vapor in the atmosphere [4–7]. Oceans, seas, lakes and rivers provide about 90% of the atmosphere's moisture through the process of evaporation, and the remaining 10% comes from plant perspiration. Heat is provided by the sun to evaporate. Energy is needed to break the bonds that hold water molecules together, so water evaporates easily at boiling point (100 °C) but evaporates much harder at freezing point. When the relative humidity in the air is 100% (at the "saturation" state), evaporation can no longer continue. The evaporation process absorbs heat from the environment, so water that evaporates from your skin will cool down.

Evaporation from the oceans is the main means by which water reaches the atmosphere. The large surface area of the oceans (over 70% of the Earth's surface is covered by oceans) allows large-scale evaporation to occur. On a global scale, the amount of water evaporated is almost equal to the amount of water that falls to the ground in the form of precipitation. However, this varies geographically. Above the oceans the amount of water in the form of vapor is more common than precipitation, while on the continent's evaporation is exceeded by precipitation. The largest amount of water that evaporates from the oceans falls back into them in the form of precipitation. Only 10% of the water evaporated from the oceans is transported above the earth and falls in the form of precipitation. Once evaporated, one molecule of water remains approx. 10 days in the air.

2.1.2 Water Storage in the Atmosphere in the Form of Vapors, Clouds and Moisture

Although the atmosphere is not a large reservoir of water, it is a means by which water can move the globe from one place to another. There is always water in the atmosphere. Clouds are the most visible form of atmospheric water, but clean air also contains water—water in particles too small to be seen. At any time, the volume of water in the atmosphere is approx. 12900 km^3. If all the water in the atmosphere fell at once, it could cover the earth with a layer of 2.5 cm of water [4–8].

2.1.3 Condensation: The Process by Which Water Is Transformed from a Gaseous State to a Liquid State

Condensation is the process by which water vapor in the air is transformed into liquid water. Condensation is important for the water circuit because it forms clouds. They can produce precipitation, which is the main way water returns to Earth. Condensation is the opposite of evaporation. Clouds form in the atmosphere because air containing water vapor rises and cools. The sun heats the air in the immediate vicinity of the Earth's surface, it becomes lighter and rises where temperatures are lower. As the air cools, the condensation process intensifies, favoring the formation of clouds [4–9].

2.1.4 Precipitation: The Release of Water from the Clouds

Precipitation is water released from the clouds in the form of rain, sleet, snow or hail. Precipitation is the main way in which atmospheric water returns to earth. Most of the precipitation is in the form of rain. Clouds contain water vapor and small drops of water, which are too small to fall in the form of precipitation but are large enough to form visible clouds. Water is constantly evaporating and condensing in the atmosphere. Most of the condensed water in the clouds does not fall in the form of precipitation, due to the rising currents that support the clouds. To produce precipitation, the very fine drops of water must first condense and combine to produce a drop large and heavy enough to fall from the cloud in the form of precipitation. It takes millions of particles of water to produce a single drop of rain [4–9].

2.1.5 Water Storage in Ice, Glaciers and Snow

Water stored for long periods in the form of ice, snow and glaciers are an integral part of the water circuit. Most of the Earth's ice masses, almost 90%, are in Antarctica, while the Greenland ice sheet contains 10% of the Earth's total ice mass. On a global scale, the climate is constantly changing, although this change is not happening so quickly that it is being noticed by people [9, 10].

2.1.6 Leakage of Water Resulting from Melting Snow

All over the world, the flow resulting from melting snow is an important factor in the movement of water around the globe. Where there are colder climates much of the spring runoff and river flows come from melting ice and snow. Rapid snowmelt can trigger in addition to floods and landslides and debris movements. The leakage caused by melting snow varies depending on the season and also from year to year. The lack of water accumulated in the form of a layer of snow in winter can reduce the amount of water for the rest of the year. This can affect the amount of water in downstream storage lakes, which in turn can affect the amount of water available for irrigation and water supply to the population [7–10].

2.1.7 Surface Runoff: Water Resulting from Precipitation Flowing on the Surface of the Soil to Rivers

Probably a lot of people think that precipitation that falls on the surface of the earth, drains, flows into rivers and then flows into the oceans. It is actually more complicated because rivers also lose or accumulate water from the soil. However, much of the water in rivers comes directly from rainfall runoff, defined as surface runoff. Usually some of the rainfall seeps into the soil, but when rainfall falls on a saturated or impermeable soil, it will turn into runoff on the slope. Water will flow along small formations of the hydrographic network, to then reach the larger rivers. The interaction between precipitation and surface runoff varies with time and geographical area, as well as all components of the water circuit. Only a third of the amount of precipitation that falls to ground level reaches watercourses and rivers, only to then return to the oceans. The other two thirds of the precipitation evaporate, is lost by evapotranspiration or infiltrates into groundwater. Surface runoff can also be used by people for their own needs [7–10].

2.1.8 Water Flow Through Riverbeds: The Movement of Water in a River

The flow of water through the riverbed refers to the amount of water that flows into a river, stream or creek. Rivers are important not only for people, but also for life everywhere. Rivers are used for water supply, irrigation, to produce electricity, to transport wastewater, to transport goods and to obtain food. Rivers play a crucial role for all plant and animal species. Rivers help keep groundwater aquifers filled with water by infiltrating water through their riverbeds. And of course, the oceans retain their water because the rivers feed them constantly. The river basin is the surface on which all the water from precipitation and runoff gathers towards an end point. The size of the river basin depends on the closure point—the entire surface of the land from which water is drained and drains to this closure point represents the river basin corresponding to that point. Watersheds are important because the flow and water quality of a river are affected by human-induced or non-man-made phenomena, which occur in the river basin. in a minute. Of course, the main influence on the flow is exerted by the flow of precipitation in the river basin. The size of a river depends largely on the size of its own basin [7–10].

2.1.9 Freshwater Storage

A part of the water circuit that is obviously essential for the existence of life on Earth is the existence of fresh water at ground level. Surface waters include streams, ponds, lakes, artificial lakes and freshwater swamps. The amount of water in rivers and lakes is constantly changing due to changes in inlet and outlet flows. Inlet flows come from precipitation, surface and underground runoff, tributary flows.

Outflows from lakes and rivers include evaporation and discharge into groundwater (aquifer). Surface water is also used by people to meet their needs. The amount and location of surface water changes in time and space, either naturally or through human intervention. Life can occur even in the desert if there is a source of surface or groundwater. At the same time, groundwater exists due to the downward movement of surface water to groundwater aquifers. Fresh water is relatively rare on the Earth's surface [7–10].

2.1.10 Infiltration: The Vertical Movement of Water from the Soil Surface into the Soil or Porous Rock

Everywhere in the world, a quantity of water that falls on the surface of the soil in the form of rain and snow seeps into the subsoil and rock. The amount of infiltrated water depends on a number of factors. Some infiltrated water will remain in the first layer of the soil surface, from where it can enter a watercourse through its banks. Part of the amount of water can infiltrate deeper by refilling underground aquifers. Water can travel considerable distances or remain in the groundwater reservoir for long periods of time, returning to the surface or discharging into other bodies of water such as rivers and oceans. As precipitation seeps into the soil, an unsaturated zone and a saturated zone generally form. In the unsaturated area there is a certain amount of water present in the small holes in the soil, but it is not saturated. In the upper part of the unsaturated area, the soil has cracks created by the roots of the plants where precipitation can infiltrate. Water from this area of the soil is used by plants. Below the unsaturated zone there is a saturated zone where water completely fills the gaps between the rock and the soil particles [7–10].

2.1.11 Groundwater Discharge (Aquifer)

You can see water everywhere every day, in lakes and rivers, in the form of ice, rain and snow. There are also immense amounts of water that cannot be seen—water that is lying and moving underground. People have been using groundwater for thousands of years and continue to use it today, mainly as drinking water and for irrigation. Life on Earth depends on groundwater as well as surface water. Some of the precipitation that falls on the earth seeps into the soil and becomes groundwater. Once in the ground, some of this water circulates near the earth's surface and comes to the surface very quickly in the riverbeds, but due to gravity, much of this water continues to flow deeper into the earth. and the speed of groundwater movement are determined by the multitude of characteristics of aquifers and impermeable layers (dense rock through which water penetrates with difficulty) from the earth. The movement of groundwater depends on the permeability (how easy or difficult water can move) and the porosity (volume of holes in the material) of surface rocks. If the rock allows water to move relatively easily through it then groundwater can travel significant distances in a matter of days. But groundwater can also drain vertically into deep aquifers, from where it needs thousands of years to return to the surface [7–10].

2.1.12 The Spring: The Place Where Groundwater Comes to the Surface of the Earth

A spring is the result of water coming to the surface of the earth from an aquifer filled to the brim. The size of the springs varies from small springs that flow only after heavy rainfall, to huge lakes where millions of liters flow per day. The springs can form in any kind of rock, but they are found mainly in limestone and dolomite, which they are easily eroded and can be dissolved by rains that become acidic. As the rock dissolves and crumbles, spaces can form that allow water to flow. If the runoff is horizontal, water can reach the surface of the earth, resulting in a spring. Spring water is usually clear [7–10].

2.1.13 Evapotranspiration: The Movement of Water Vapor from the Leaves of Plants into the Atmosphere

Evapotranspiration is the process by which moisture is transported by plants from the roots to the small pores on the dorsal side of the leaves, where it turns into vapor and is removed into the atmosphere. Evapotranspiration is the evaporation of water from the leaves of plants. Studies have shown that about 10% of the moisture in the atmosphere is released by plants through evapotranspiration. During the growing season, a leaf will sweat much more water than its weight. Atmospheric factors influencing evapotranspiration The amount of water that plants sweat varies greatly geographically and over time (Fig. 1).

There are a number of factors that determine the amount of water that evaporates:

- Temperature: The amounts of evapotranspirated water increase with temperature, especially during the growing season, when the air is warmer.

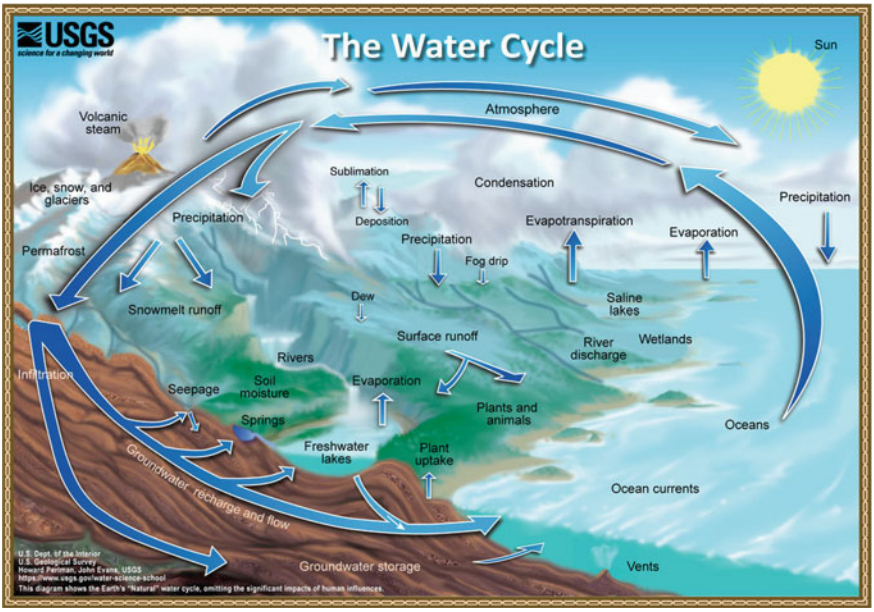

Fig. 1 The water cycle (https://www.usgs.gov—*Credit* Howard Perlman, Public domain) [11]

- Relative humidity: As the relative humidity of the air around the plant increases, the amount of evapotranspirated water decreases. It is easier for water to evaporate in drier air than in the wettest.
- Wind and air movement: A faster movement of air around the plant will lead to more abundant evapotranspiration.
- Plant type: Plants remove water by evapotranspiration in different amounts. Some plants that grow in arid regions, such as cacti, conserve precious water, sweating less than other plants [7–10].

2.2 Water Uses

Water, like energy, is an essential component of almost all human activities. The water supply is vital for feeding the population, for producing material goods (raising living standards) and for maintaining the integrity of the natural systems on which life on earth depends. Water use is defined as any social or economic unit that needs water of a certain quality to carry out its activity, which satisfies this need through a unitary set of constructions and installations through which the water supply is made, the use and wastewater disposal [3].

Water uses:

- human and animal food about 10%
- irrigation in agriculture approximately 50%
- natural resource of fish or aquaculture
- means of transport
- energy source
- for cooling or raw material in industry about 50%
- agreement

For domestic water, the distribution is made as follows:

- for drinking—1%
- for food preparation—6%
- washing cars and gardens—6%
- washing machine—12%
- dishwasher—10%
- sanitary—20%
- bathrooms, showers—39%
- miscellaneous—6%

Water use in agriculture—for irrigation is the supply of water in addition to those from natural conditions to ensure high agricultural production [3].

Water use in industry

- energy industry as a source of energy in hydropower plants, for the production of steam necessary for the operation of thermoelectric and nuclear power plants

- in manufacturing processes: as a hydraulic agent for the transport of materials, for ore processing, in the chemical industry, as a raw material in the food industry
- as a cooling or heating agent to ensure the development of a technological process in good conditions [3].

2.3 Water Resources Types

From the administrative point of view, the waters are classified as follows:

- **international waters**; are the waters on which our state is riparian with other states, those which enter or cross national borders, as well as those on which the interests of foreign states have been recognized by international treaties and conventions;
- **territorial waters (inland maritime)**; are the waters comprised between the part of the shore of the country to the sea, the extent and delimitation of which is established by national law;
- **national waters**; are the inland waterways, rivers, canals and lakes, as well as the waters of the border rivers and streams from the Romanian shore to the border line established by international treaties and conventions.

According to the criterion of objective location and destination, the waters are classified as follows:

- freshwater resources—surface and groundwater;
- water for the population—fresh water necessary for the life and ambiance of human settlements;
- drinking water—surface or groundwater, which, naturally or after physicochemical and/ or microbiological treatment, can be drunk;
- domestic wastewater;
- water for industry;
- industrial wastewater;
- water for irrigation—from surface water sources;
- Drying water.

The establishment of the quality status of the different water categories is made only on the basis of the quality indicators correlated with the different uses of the water, from the legislation in force [3, 5, 6].

2.4 Groundwater

Groundwater is the water inside the earth’s crust that circulates in rocks through cracks and pores and accumulates in the form of aquifers. The aquifers (permeable rocks soaked in water) overlap layers of impermeable rocks made of clays, marls, crystalline and porous rocks. Groundwater arises from precipitation that seeps into the ground, or water infiltrates from the bed of running and stagnant water (rivers, streams, lakes), this penetration of water through the permeable layers will be stopped by impermeable rock that plays the role of a channel this system of canals can be superimposed [12–16].

Groundwater categories

The groundwater origin differs, but usually is formed by precipitation that infiltrates deep into the earth's crust (muddy waters). Sometimes they are caught between two impermeable layers and are called captive aquifers. When a groundwater table or a deep aquifer is intersected by a valley, water comes to the surface and flows. The place where an underground water appears is called a spring.

According to the water drainage regime, the following are classified:

- springs with continuous flow
- springs with intermittent flow (springs, geysers)

Outbreaks—occur in karst regions and give a large amount of water
Geysers—are intermittent hot springs in volcanic regions
The sources are classified:

- by water temperature:
  - cold—with water temperatures equal to or lower than the average air temperature
  - warm—with water temperatures higher than average air temperatures
- according to the amount of dissolved mineral substances
  - fresh water—salt content less than 1 g/l
  - mineral waters containing up to 5 g/l
  - brines—waters with mineralization higher than 50 g/l

Causes that endanger the quality of groundwater Human activities can negatively influence the quality (by air, soil or surface water pollution) and the amount of groundwater (by irrational use of water). The natural causes are primarily drought due to the small amount, or lack of precipitates [12–16].

2.5 Surface Water

Surface waters are waters that run on the surface of the soil. Surface waters are produced by the general drainage of rain or the appearance of groundwater on the surface. Once the surface water appears, it follows the road that offers minimum resistance and can be flowing, as in the case of rivers and streams, or stagnant as in the case of lakes or ponds. The quality of rivers and streams varies depending on seasonal flows and can change. significantly due to the precipitation and runoff they receive. Lakes and ponds generally have less sediment than rivers and yet are subject to greater impact in terms of microbiological activity.

Surface water characteristics

Surface water differs in many characteristics: its flow and variations (in flowing ones), temperature, concentration and nature of dissolved or suspended substances, biological and microbiological content, each body of liquid water with its bed and its living beings being a different ecosystem. Surface waters have a special role both for the behaviors of nature and for human life. Rivers contribute to the drilling of relief influences the formation of climate and vegetation, soils. The quality of natural waters is determined by their physical, chemical and biological characteristics. Next, only those indicators will be described that allow, on the one hand, the general characterization of the water and on the other hand determine the water treatability and the choice of the corresponding technological treatment flow [12–14, 17] (Table 1).

3 Conclusion

Water managers and planners are slowly beginning to change their perspective and perceptions about how best to meet human needs for water; they are shifting from a focus on building supply infrastructure to improving their understanding of how water is used and how those uses can best be met. There is growing interest on the part of water managers around the world to implement these approaches to lessen pressures on increasingly scarce water resources, reduce the adverse ecological effects of human withdrawals of water, and improve long-term sustainable water use.

Table 1 Substances in natural waters

Provenance	Positive ions	Negative ions	Colloids	Suspensions	Gases
Contact of water with ores, soils and rocks	Calcium (Ca + 2) Iron (Fe + 2) Magnesium (Mg + 2) Manganese (Mn + 2) Potassium (K +) Sodium (Na +) Zinc (Zn + 2)	Bicarbonates (HCO_3^-) Carbonates (CO_3^{2-}) Chlorides (Cl^-) Fluoride (F^-) Nitrate (NO_3) Phosphate (PO_4^{3-}) Hydroxide (OH^-) Sulfate (SO_4^{2-}) Silica (H_3SiO_4) Borates ($H_2BO_3^-$)	Clay silica (SiO_2) Ferric oxide (Fe_2O_3) Aluminum oxide (Al_2O_3) Manganese dioxide (MnO_2)	Clay mud sand and other inorganic soils	Carbon dioxide (CO_2)
From the atmosphere through the rain	Hydrogen (H +)	Bicarbonate (HCO_3^-) Chlorides (Cl) Sulfate (SO_4)		Dust pollen	Carbon dioxide (CO_2) Nitrogen (N_2) Oxygen (O_2) Sulfur dioxide (SO_2)
Decomposition of organic matter in the environment	Ammonia (NH_3) Hydrogen (H) Sodium (Na)	Bicarbonate (HCO_3^-) Chlorides (Cl^-) Acid sulfides (HSAcid sulfides (HS^-) Nitrate (NO_3) Nitrite (NO_2^-) Organic radicals	Colored vegetable matter, organic residues	Topsoil, organic residues	Carbon dioxide (CO_2) Nitrogen (N_2) Oxygen (O_2) Hydrogen sulfide (H_2S) Ammonia (NH_3) Hydrogen (H_2) Methane (CH_4)
Living organisms from the environment			Bacteria algae viruses	Algae, diatoms, fish tiny organisms	Carbon dioxide (CO_2) Ammonia (NH_3) Methane (CH_4)

(continued)

Table 1 (continued)

Provenance	Positive ions	Negative ions	Colloids	Suspensions	Gases
From industry, agriculture and other human activities	Inorganic ions, heavy metals	Inorganic ions, organic molecules, dyes	Inorganic, organic, colored solids, chlorinated organic compounds, bacteria, worms, viruses	Clay, silt, coarse sand or other inorganic solids, organic compounds, petroleum, corrosive compounds	Chlorine (Cl_2) Sulfur dioxide (SO_2)

Note Substances in natural waters data from Rojanschi et al. [5]

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