eni scuola

Water as a resource

Water, a resource

Water plays a crucial role in the survival of living organisms (animals and plants) on Earth. Where there's water, there's life. Even in the driest regions of our countries, even under the deserts, there is always water, even if sometimes it is too deep to be possibly used. Springs, running waters, glaciers and lakes provide animals and plants with that amount of water that is indispensable for their life cycle. Man is interested in particular in drinking water, which is becoming less and less as the population of the world increases and because of pollution. Plants have been installed, especially along the coasts of dry regions, that make seawater drinkable to make up for the shortage of drinking water on the continents.
Water is important in all its forms also because it is an integral part of the earth's landscape, because it largely contributes to its shaping, because it contributes to determine its climate.
Finally, fresh as well as salty waters are inhabited by micro-organisms that decompose much of the waste produced by man. This biological cycle is also of crucial importance.

Chemical properties of water

The chemical formula of a molecule of water is H2O: two atoms hydrogen (H2) linked to one atom oxygen (O). The atom electrons (particles with a negative charge) establish links between themselves. Oxygen is more able to keep them close to it than hydrogen. The water molecule results to be charged negatively near the atom of oxygen and positively near the atom of hydrogen. Since opposites attract, the water molecules tend to join together like magnets.

Water can melt many substances

Water is called the universal solvent since it can solve more substances than any other liquid. And we are very lucky it can: if it could not, we could not drink a cup of hot sugared tea, because the sugar would remain at the bottom of the cup. This is why the waters of rivers, streams, lakes, seas and oceans that may look pure at first sight contain in fact a huge number of solved elements and minerals released by rocks or by the atmosphere. Wherever it flows, above ground, underground or inside our body, water solves and carries an extremely high amount of substances. Water thus performs a precious task: that of carrying, sometimes to long distances, the substances it encounters along its way.
Pure water, like distilled water, has a pH of 7 (neuter). Seawater is essentially alkaline, having a pH of around 8. Most fresh water has a pH between 6 and 8, apart from acid rains, of course, whose pH is below 7.

The physical properties of water

Water has a high specific heat, i.e. it needs a lot of heat to heat up and takes long to lose the stored heat and get cold. This is why it is used in cooling systems (for instance in car radiators or to cool industrial equipment). And this is also why in coastal (or lake) regions the temperature of the air is milder: in these areas, as seasons change, the temperature of the water 'mitigates' the temperature of the air, since it decreases or increases more slowly than that of the air. Water has a high surface tension: that means that, once poured on a smooth surface, it tends to form spherical drops instead of expanding into a thin film. Without gravity, a drop of water would be perfectly spherical. Surface tension allows plants to absorb the water contained in the soil through their roots. And it is surface tension, again, that makes blood, which is largely composed of water molecules, flow through the blood system of our body.

Only liquid water?

In addition, water can normally be found in a liquid state, but can easily become solid or gaseous. Pure water goes from liquid to solid, i.e. freezes, at 0 degrees centigrade, while at sea level it boils at 100°C (the higher the level, the lower the temperature at which water starts boiling). The water boiling and freezing values are taken as a reference point to calibrate thermometers: in centigrade scales, 0° on the centigrade scale is the freezing point and 100° is the boiling point.
When freezing, water expands, i.e. its density decreases while its volume remains the same: this is why ice floats on the water or a bottle filled with water and placed in a freezer breaks up.

Water is a special natural resource since it is the only one on earth to be found in all of the three physical states depending on the surrounding temperature: liquid, solid (ice) and gaseous (water vapour).
The whole of the processes that make water leave the oceans, get into the atmosphere, reach the emerged lands and flow back to the oceans later on is called hydrological cycle and is fuelled by the energy of the Sun.

Water cycle

In the oceans, water is in the liquid state. Solar heating causes a portion of surface water to evaporate and turn into steam, go up into the atmosphere and be carried by the wind. When a mass of water, that is already rich in water vapour, receives more water and saturates, or when it encounters a colder mass of air, water vapour condenses in the atmosphere, i.e. vapour turns into water again (or snow and ice, depending on how cold it is). This is how precipitations originate, through which liquid or solid water (rain, snow or hail) partly reaches the continents and partly gets straight back to the oceans. The water fallen through precipitations on the emerged land still has to go a long, often winding way before going back to the oceans and close the cycle. Some of this water seeps through the soil, and part of it remains in the soil, part feeds the water-bearing stratum (deep flow) to resurface later in rivers or springs.
Part of the water that had remained in the soil evaporates into the atmosphere, while part of it is absorbed by plant roots and carried through to the leaves to be released again into the atmosphere through transpiration. These two processes together are called evapo-transpiration.
Finally, some of the water fallen through precipitations remains on the Earth's surface and originates lakes and rivers, through which it gets straight back to the seas and oceans (surface flow).

Hydrological cycle

The amounts of water that are moved through the hydrological cycle can also be estimated and evaluated in numerical terms. The tool we use is the global hydrogeological balance of the Earth. The total amount of water that evaporates from the surface of the oceans is more than the water that gets straight into them from precipitations. The difference is part of the amount of water that falls down on the continents. The total amount of water that falls on the continents actually consists of that which has evaporated, not only from the seas or oceans, but straight from the soil as well.
The global hydrological balance differs according to climatic conditions - especially the extent of precipitations – and is different, therefore, in each region of our planet. If we take, for instance, the equatorial climate, we can see that there are no water shortages during the year: there is always plenty of water available since the precipitations can easily cover the losses. Conversely, in the hot desert climate, the high temperatures promote the evapo-transpiration that the few precipitations cannot make up for: in this case, there are serious shortages all through the year and little water available.
The differences found between the hydrological balances of these two types of climates have immediate repercussions on the vegetal and animal species that live there, whose survival is closely linked to the amount of water that is available and usable.

Hydrosphere

What distinguishes the Earth from the other planets is the presence of the seas and oceans. Satellite pictures show the Earth as a "blue" planet, because two thirds of its surface are covered by huge masses of water.
The whole of the earth's environments where water is present in its liquid, solid or gaseous state is called hydrosphere. Most water can be found in the oceans, underground waters and in its solid state as ice in polar hemispheres. Water contained in the atmosphere as water vapour is instead just a very small part of the total amount. But this small part is very important in order to maintain the climate and feed the underground layers.
Generally speaking, the hydrosphere can be divided into two different environments: salty water basins (seas and oceans) and fresh water basins. The main feature that distinguishes salty water basins from fresh water basins is their high salt content (or salinity), which is generally 35 grams per litre. Fresh water basins (or continental waters) can be

divided into surface waters (rivers, lakes, lagoons, marshes) and underground waters (deep layers, surface layers and springs). You can explore the Lakes of the world on the graphs.

Continental waters

Continental waters consist of water bodies like glaciers, rivers and lakes. Differently from seawaters, they are characterized by a low salinity and they move towards the sea because they are not too deep.
See the different landscapes that we can encounter when we have a walk on the beach, on the mountains or on the hills.

- **Glaciers** form above the permanent snow line due to the accumulation of water at a solid state (snow that transforms into ice). The line varies according to the latitude on which continental glaciers (that uniformly cover wide areas) and mountain glaciers (that occupy mountain valleys) form. Below the permanent snow the ice melts and the water is present in a liquid state.

- **watercourses**, streams and rivers collect the water that flows on the Earth's surface and that is in continuous contact with groundwater

- the **lakes** are temporary deposits of water on continental depressions. They are supplied with water by watercourses called tributaries. The water flows into the out-flowing streams, streams or rivers that originate from the lake. Lake water has a low salinity, but has plenty of suspended material, and its temperature depends on local climate conditions. Also the water of big lakes can move and originate variations called seiches, due to differences in atmospheric pressure.

Not all the water that comes back to the mainland through precipitations is collected by the rivers, lakes or trapped in glaciers. A part of it filters on the soil and goes down into it due to the force of gravity until it reaches a layer of waterproof rocks that stop the passage of water: a water-bearing stratum is created. When this condition does not occur, in order to reach the water-bearing stratum artesian wells are built and the water can be extracted as it reaches the surface after being subject to a high pressure.
The continuous exploitation of underground water determines the emptying of water-bearing stratums and lowering of soils. This occurs in Venice as a consequence of the extraction of water used for industrial aims in Marghera port area. Instead, when the exploitation occurs near coastal regions, the seawater filters underground to occupy the free spaces left by fresh water: this generates serious damages to agriculture and vegetation, as it is happening along Ravenna coast, where wide pinewood areas are dying.

Seawater

The main characteristics of seawater are:

- **salinity**: it refers to the total salt content in 1000 grams of seawater and it has a value of around 35 grams. The percentage of the different substances that are present in the solution depends on the river contribution, on chemical reactions that occur in sea sediments, on volcanic activity and on the decomposition of organisms. In fact, the quantity of salt is stable only at a certain depth, while on the surface and coastal areas it is also subject to seasonal variations;

- **melted gases**: oxygen and carbon dioxide are necessary for the life of water organisms. Oxygen is largely present on the surface, since water is in contact with the atmosphere and where photosynthetic organisms live, and deep underwater, where water temperature is very low. Carbon dioxide is a very soluble gas that easily spreads from the atmosphere into sea water, transported by river water to the sea, and which derives from decomposing organic materials;

- **the temperature**: as well as mitigating the climate of coastal regions, temperature influences the chemical and physical characteristics that are responsible for the vertical movement of water masses. On the most superficial layer (50-200 meters) the temperature is similar to the superficial one; on the thermocline layer (200-1000 meters) the temperature rapidly diminishes; on the deep layers it keeps on diminishing, but very slowly. The thermocline is an important surface as far as the spreading of organisms in the oceans is concerned. It represents an obstacle for many animals, plants, and tropical algae that need a temperature of 15 – 20°C;

- **brightness**: it depends on the ability of the light to penetrate in the water and light up only the superficial part even though the water is clear. This area is called photic zone (0-200 meters of depth), and it is where most of marine life and phytoplancton are concentrated.

The wind and the waves

Wave motion is caused by the wind and its action on the sea surface. In the open sea a floating object is lifted and lowered when a wave passes, but it does not move laterally since during the wave motion only the shape of the wave is transmitted. Therefore the water keeps still: individual water particles move according in a circular direction without moving from their original position. The wave motion does not spread deep underwater; on the contrary a submarine at a certain depth can quietly move even if there is a storm on the surface.

The Beaufort Scale describes the wind force according to 12 levels: level 0 refers to calm conditions, when the sea has no waves at all; level 6 refers to a fresh wind that forms big waves with white foam crests; level 12 indicates the presence of a hurricane with the air full of foam and splashes, and the sea is totally white.

Near the coast the waves break because the water depth diminishes and the particles do not manage to keep their circular movement.

Often coasts are not straight and the waves break first on promontories and then on bays. This provokes water movements parallel to the coast that originate currents called coastal drift currents. If the seabed has sand mounds submerged under the water, suck currents might form, that drag off-shore also the most export swimmers.

Tides

Tides are periodical lowering and lifting of water. They are due to the gravitational attraction of the Moon and the Sun. In the Mediterranean sea the sea range varies from 20 to 50 centimetres, but there can be different ranges according to the seabed morphology.

The tide can create some particular phenomena. In some estuaries in the North Sea and in the English Channel the water manages to go upriver against the current, with repercussions on the river navigability. Instead, when the wind persistently and strongly blows towards the coast, it can make the sea level lift, even more than tides: “the high water” in Venice, “storm surges” in the North Sea that provoke damages on Dutch and German coasts, “raz de marée” on French coasts. In particular, the “high water” in Venice is due to various factors: sirocco wind that raises the water by up to 90 cm, tides that can have a maximum height of 60 cm, and seiches, the presence of low pressure and seasonal variations that can reach 20 cm.

Sea currents

Huge masses of water displace for long distances due to the wind action. The direction of the movement is determined by the earth rotation (Coriolis force), which creates circular movements. In the Atlantic Ocean, regular and constant winds, the trade winds, move superficial water masses towards the Equator where they are diverted to the west by the

Coriolis force (North-Equatorial current); when they reach the American continent they are pushed to the north and accumulate in the Gulf of Mexico. The water continues to flow towards the Atlantic ocean and form the Gulf current along the coast of the United States, and then divide into two:

- one current goes towards the Canary islands and starts the tour again, as we have already described
- the other current moves to the north-east, reaches the north-western coasts of Europe and mitigates their climate.

In polar areas the water cools down, becomes more dense, falls deep down and moves to the Equator. As it gets warmer, it becomes less dense and lighter and tends to rise to the surface. This movement, that forms deep sea-currents, is very slow: it takes even a thousand years to a water mass to go back to the surface.
The Mediterranean Sea is very salty as compared to the Atlantic ocean, as a consequence its water is denser. Water masses in the Mediterranean go deep down and enter the Atlantic ocean through the Strait of Gibraltar. Ocean waters, which are lighter, enter the Mediterranean by moving on the surface. The Black sea is connected to the Aegean Sea through the Bosporus strait and the Dardanelles, that is crossed on the surface as its water is less dense and salty. The water that comes from the Aegean Sea is dense and moves deep underwater, but it does not manage to reach the Black sea because the Bosporus is not deep enough. As a consequence, the water exchange in the Black sea is poor and limited.

Drought and desertification

Due to the extent of damages and the number of people involved, drought is the number one natural catastrophe. A dry period is marked by less frequent precipitations compared to the annual average of the area. Drought is considered as serious when the average farming production decreases by 10% and catastrophic when it decreases by over 30%.
Dry periods have become more frequent and more intense over the last few decades, involving almost all of the emerged areas
This tendency to drought has not only affected the dry or half-dry areas of Africa and Asia, that have been the most seriously affected by the different dry spells of the last 30 years, but also the mild and northern countries.

More or less one half of the surface of the emerged lands can be defined as dry or half-dry. Both ecosystems are extremely fragile and vulnerable. If exposed to drought for long periods, they can be affected by desertification, i.e. they can turn into deserts. At present, approximately 70% of the Earth’s dry areas – equal to 3,600 million hectares – is degraded. In Africa alone, 45% of the population – equal to approximately 325 million people – live in dry areas. It is therefore absolutely important to protect these regions.

The causes

The history of the biosphere has been marked, during the different geological ages, by natural climatic fluctuations that have altered the width of deserts. Exceptionally dry periods have become more frequent and more intense over the last few decades: from 5 a year in the Seventies to 12 a year in the Eighties. There are many complex causes for such increase: it must however be borne in mind that man’s pressure, through a bad or improper use of the land, can heavily alter the characteristics of the soil, of the vegetal covering and the low atmosphere, thus irretrievably affecting the delicate balance of the hydrological system.

The effects

Desertification reduces the ability of an ecosystem to survive when the climate changes, with dramatic consequences, such as:

- loss of productivity of the soil;
- degradation of the vegetal covering, through to its total disappearance;
- dispersion of solid particles in the atmosphere – sand storms, air pollution – with a negative impact on man's health and productive activities;
- reduction of farming and breeding production: malnutrition and hunger;
- migrations of people and wars.