GrEAT
Green Education for Active Talents

INTELLECTUAL OUTPUT 2
TRAINING MODULES AND MATERIALS

Water Management

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INDEX

1. WATER MANAGEMENT

Introduction

Today, most countries are placing unprecedented pressure on water resources. The global population is growing fast, and estimates show that with current practices, the world will face a 40% shortfall between forecast demand and available supply of water by 2030. Furthermore, chronic water scarcity, hydrological uncertainty, and extreme weather events (floods and droughts) are perceived as some of the biggest threats to global prosperity and stability. Acknowledgment of the role that water scarcity and drought are playing in aggravating fragility and conflict is increasing.

Feeding 9 billion people by 2050 will require a 60% increase in agricultural production (which consumes 70% of the resource today), and a 15% increase in water withdrawals. Besides this increasing demand, the resource is already scarce in many parts of the world. Estimates indicate that 40% of the world population lives in water scarce areas, and approximately ¼ of world's GDP is exposed to this challenge. By 2025, about 1.8 billion people will be living in regions or countries with absolute water scarcity. Water security is a major – and often growing – challenge for many countries today.

Climate change will worsen the situation by altering hydrological cycles, making water more unpredictable and increasing the frequency and intensity of floods and droughts. The roughly 1 billion people living in monsoonal basins and the 500 million people living in deltas are especially vulnerable. Flood damages are estimated in $120 billion per year (only from property damage), and droughts pose, among others, constraints to the rural poor, highly dependent on rainfall variability for subsistence.

The fragmentation of this resource also constrains water security. There are 276 transboundary basins, shared by 148 countries, which account for 60% of the global freshwater flow. Similarly, 300 aquifers systems are transboundary in nature, meaning 2 billion people worldwide are dependent on groundwater. The challenges of fragmentation are often replicated at the national scale, meaning that cooperation is needed to achieve optimal water resources management and development solutions for all riparians. To deal with these complex and interlinked water challenges, countries will need to improve the way they manage their water resources and associated services.

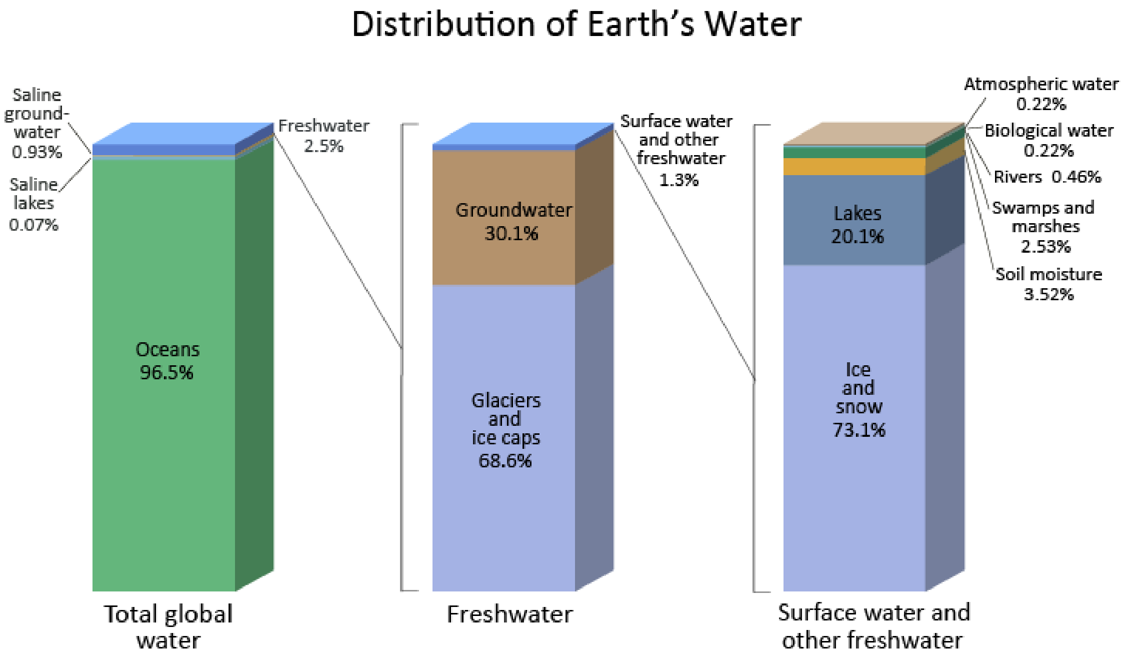
To strengthen water security against this backdrop of increasing demand, water scarcity, growing uncertainty, greater extremes, and fragmentation challenges, clients will need to invest in institutional strengthening, information management and (natural and man-made) infrastructure development. Institutional tools such as legal and regulatory frameworks, water pricing, and incentives are needed to better allocate, regulate, and preserve water resources. Information systems are needed for resource monitoring, decision making under uncertainty, systems' analyses, and hydro-meteorological forecast and warning. Investments in innovative technologies for enhancing productivity, preserving and protecting resources, recycling storm water and wastewater, and developing non-conventional water sources should be explored in addition to seeking opportunities for enhanced water storage, including aquifer recharge and recovery. Ensuring the rapid dissemination and appropriate adaptation or application of these advances will be a key to strengthening global water security.

What is water?

Water is the transparent, tasteless, odourless, and nearly colourless chemical substance that is the main constituent of Earth's streams, lakes and oceans, and the fluids of most living organisms, and that is vital for all known forms of life, even though it provides no calories or organic nutrients. Its chemical formula is H2O, meaning that each of its molecules contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is the name of the liquid state of H2O at standard ambient temperature and pressure. It forms precipitation in the form of rain and aerosols in the form of fog. Clouds are formed from suspended droplets of water and ice, its solid state. When finely divided, crystalline ice may precipitate in the form of snow. The gaseous state of water is steam or water vapour. Water moves continually through the water cycle of evaporation, transpiration (evapotranspiration), condensation, precipitation, and runoff, usually reaching the sea.

Water covers 71% of the Earth's surface, mostly in seas and oceans. Small portions of water occur as groundwater (1.7%), in the glaciers and the ice caps of Antarctica and Greenland (1.7%), and in the air as vapour, clouds (formed of ice and liquid water suspended in air), and precipitation (0.001%).

Water plays an important role in the world economy. Approximately 70% of the freshwater used by humans goes to agriculture. Fishing in salt and fresh water bodies is a major source of food for many parts of the world. Much of long-distance trade of commodities (such as oil and natural gas) and manufactured products is transported by boats through seas, rivers, lakes and canals. Large quantities of water, ice and steam are used for cooling and heating, in industry and homes. Water is an excellent solvent for a wide variety of chemical substances; as such it is widely used in industrial processes, and in cooking and washing. Water is also central to many sports and other forms of entertainment, such as swimming, pleasure boating, boat racing, surfing, sport fishing and diving.



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

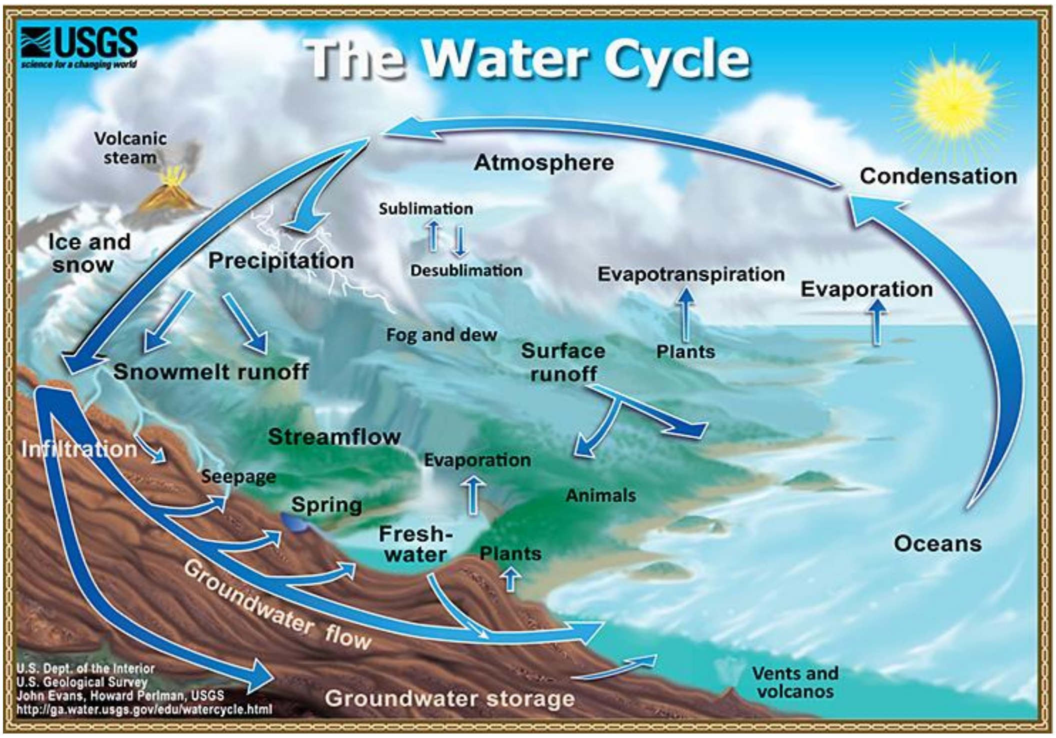
Water cycle

What is the water cycle? The water cycle describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapour to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it continuing to work; the Earth would be a pretty stale place without it.

Where does all the Earth's water come from? Primordial Earth was an incandescent globe made of magma, but all magmas contain water. Water set free by magma began to cool down the Earth's atmosphere, and eventually the environment became cool enough so water could stay on the surface as a liquid. Volcanic activity kept and still keeps introducing water into the atmosphere, thus increasing the surface-water and groundwater volume of the Earth.

The water cycle has no starting point, but we will begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates into the air; a relatively smaller amount of moisture is added as ice and snow sublimate directly from the solid state into vapour. Rising air currents take the vapour up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapour rises into the air where cooler temperatures cause it to condense into clouds.

Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes.



Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some of the water infiltrates into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Yet more groundwater is absorbed by plant roots to end up as evapotranspiration from the leaves. Over time, though, all of this water keeps moving, some to re-enter the ocean, where the water cycle "begins."

Water resource management

Water resource management is the activity of planning, developing, distributing and managing the optimum use of water resources. It is a sub-set of water cycle management. Ideally, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. As with other resource management, this is rarely possible in practice.

Water is an essential resource for all life on the planet. Of the water resources on Earth, only 3% of it is fresh and two-thirds of the freshwater is locked up in ice caps and glaciers. Of the remaining 1%, a fifth is in remote, inaccessible areas and much seasonal rainfall in monsoonal deluges and floods cannot easily be used. As time advances, water is becoming scarcer and having access to clean, safe, drinking water is limited among countries. At present, only about 0.08% of all the world’s fresh water is exploited by mankind in ever increasing demand for sanitation, drinking, manufacturing, leisure and agriculture. Due to the small percentage of water remaining, optimizing the fresh water we have left from natural resources has been a continuous difficulty in several locations worldwide.

Much effort in water resource management is directed at optimizing the use of water and in minimizing the environmental impact of water use on the natural environment. The observation of water as an integral part of the ecosystem is based on integrated water resource management, where the quantity and quality of the ecosystem help to determine the nature of the natural resources.

As a limited resource, water supply sometimes supposes a challenge. This fact is assumed by the project DESAFIO (the acronym for Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovations), which has been developed along 30 months and funded by the European Union's VII Framework Programme for research, technological development and demonstration.

This project faced a difficult task for developing areas: eliminating structural social inequity in the access to indispensable water and public health services. The DESAFIO engineers worked on a water treatment system run with solar power and filters which provides safe water to a very poor community in the state of Minas Gerais.

Successful management of any resources requires accurate knowledge of the resource available, the uses to which it may be put, the competing demands for the resource, measures to and processes to evaluate the significance and worth of competing demands and mechanisms to translate policy decisions into actions on the ground.

For water as a resource, this is particularly difficult since sources of water can cross many national boundaries and the uses of water include many that are difficult to assign financial value to and may also be difficult to manage in conventional terms. Examples include rare species or ecosystems or the very long term value of ancient groundwater reserves.

Agriculture

Agriculture is the largest user of the world's freshwater resources, consuming 70% of it. As the world population rises, it consumes more food (currently exceeding 6%, it is expected to reach 9% by 2050), the industries and urban developments expand, and the emerging biofuel crops trade also demands a share of freshwater resources, water scarcity is becoming an important issue. An assessment of water resource management in agriculture was conducted in 2007 by the International Water Management Institute in Sri Lanka to see if the world had sufficient water to provide food for its growing population or not. It assessed the current availability of water for agriculture on a global scale and mapped out locations suffering from water scarcity. It found that a fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, where there is not enough water to meet all their demands. A further 1.6 billion people live in areas experiencing economic water scarcity, where the lack of investment in water or insufficient human capacity make it impossible for authorities to satisfy the demand for water.

The report found that it would be possible to produce the food required in future, but that continuation of today's food production and environmental trends would lead to crises in many parts of the world. Regarding food production, the World Bank targets agricultural food production and water resource management as an increasingly global issue that is fostering an important and growing debate. The authors of the book *Out of*

Water: From abundance to Scarcity and How to Solve the World's Water Problems, laid down a six-point plan for solving the world's water problems: 1) Improve data related to water; 2) Treasure the environment; 3) Reform water governance; 4) Revitalize agricultural water use; 5) Manage urban and industrial demand; and 6) Empower the poor and women in water resource management.

To avoid a global water crisis, farmers will have to strive to increase productivity in order to meet growing demands for food, while industry and cities find ways to use water more efficiently.

Managing water in urban settings

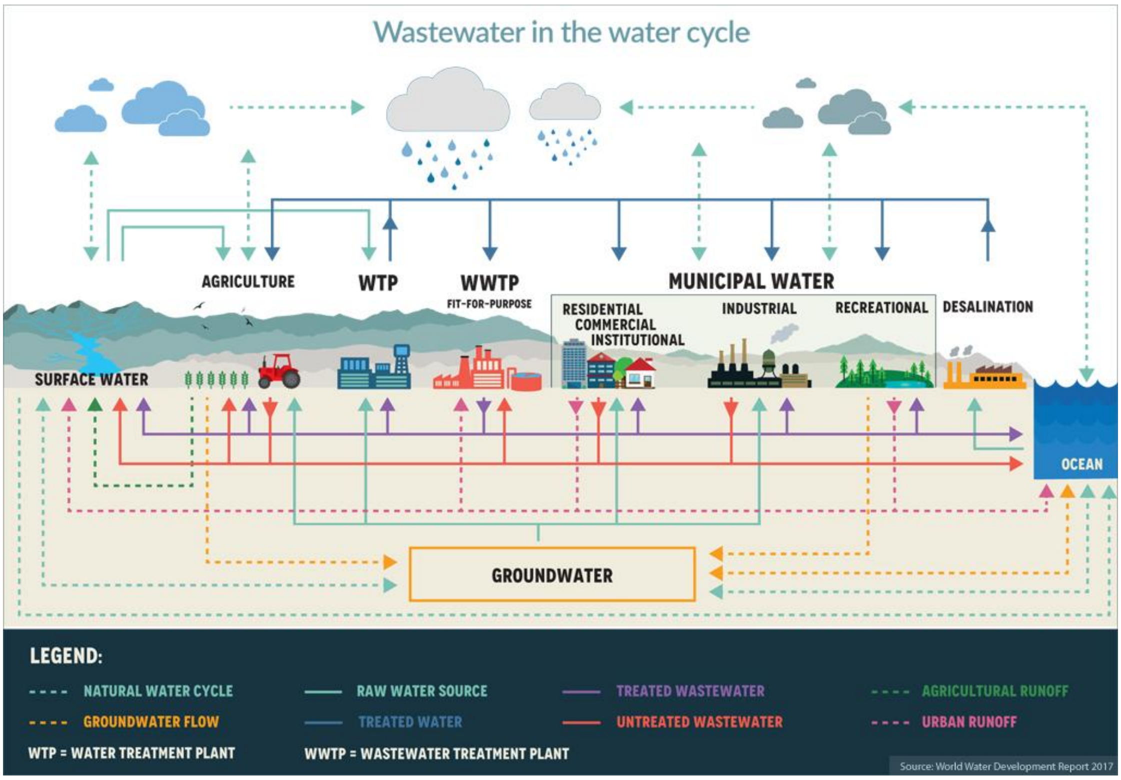
As the carrying capacity of the Earth increases greatly due to technological advances, urbanization in modern times occurs because of economic opportunity. This rapid urbanization happens worldwide but mostly in new rising economies and developing countries. Cities in Africa and Asia are growing fastest with 28 out of 39 megacities (a city or urban area with more than 10 million inhabitants) worldwide in these developing nations. The number of megacities will continue to rise reaching approximately 50 in 2025. With developing economies, water scarcity is a very common and very prevalent issue. Global freshwater resources dwindle in the eastern hemisphere either than at the poles, and with the majority of urban development millions live with insufficient fresh water. This is caused by polluted freshwater resources, overexploited groundwater resources, insufficient harvesting capacities in the surrounding rural areas, poorly constructed and maintained water supply systems, high amount of informal water use and insufficient technical and water management capacities.

In the areas surrounding urban centres, agriculture must compete with industry and municipal users for safe water supplies, while traditional water sources are becoming polluted with urban runoff. As cities offer the best opportunities for selling products, farmers often have no alternative to using polluted water to irrigate their crops. Depending on how developed a city’s wastewater treatment is, there can be significant health hazards related to the use of this water. Wastewater from cities can contain a mixture of pollutants. There is usually wastewater from kitchens and toilets along with rainwater runoff. This means that the water usually contains excessive levels of nutrients and salts, as well as a wide range of pathogens. Heavy metals may also be present, along with traces of antibiotics and endocrine disruptors, such as oestrogens.

Developing world countries tend to have the lowest levels of wastewater treatment. Often, the water that farmers use for irrigating crops is contaminated with pathogens from sewage. The pathogens of most concern are bacteria, viruses and parasitic worms, which directly affect farmers’ health and indirectly affect consumers if they eat the contaminated crops. Common illnesses include diarrhoea, which kills 1.1 million people annually and is the second most common cause of infant deaths. Many cholera outbreaks are also related to the reuse of poorly treated wastewater. Actions that reduce or remove contamination, therefore, have the potential to save a large number of lives and improve livelihoods. Scientists have been working to find ways to reduce contamination of food using a method called the 'multiple-barrier approach'.

This involves analysing the food production process from growing crops to selling them in markets and eating them, then considering where it might be possible to create a barrier against contamination. Barriers include: introducing safer irrigation practices; promoting on-farm wastewater treatment; taking actions that cause pathogens to die off; and effectively washing crops after harvest in markets and restaurants.

Most human activities that use water produce wastewater. As the overall demand for water grows, the quantity of wastewater produced and its overall pollution load are continuously increasing worldwide. Over 80% of the world’s wastewater – and over 95% in some least developed countries – is released to the environment without treatment. Once discharged into water bodies, wastewater is either diluted, transported downstream or infiltrates into aquifers, where it can affect the quality (and therefore the availability) of freshwater supplies. The ultimate destination of wastewater discharged into rivers and lakes is often the ocean with negative consequences for the marine environment. The 2017 edition of the United Nations World Water Development Report, entitled “Wastewater: The Untapped Resource”, demonstrates how improved wastewater management generates social, environmental and economic benefits essential for sustainable development and is essential to achieving the 2030 Agenda for Sustainable Development. In particular, the Report seeks to inform decision-makers, government, civil society and private sector, about the importance of managing wastewater as an undervalued and sustainable source of water, energy, nutrients and other recoverable by-products, rather than something to be disposed of or a nuisance to be ignored.



Future of water resources

One of the biggest concerns for our water-based resources in the future is the sustainability of the current and even future water resource allocation. As water becomes more scarce, the importance of how it is managed grows vastly. Finding a balance between what is needed by humans and what is needed in the environment is an important step in the sustainability of water resources. Attempts to create sustainable freshwater systems have been seen on a national level in countries such as Australia, and such commitment to the environment could set a model for the rest of the world.

The field of water resources management will have to continue to adapt to the current and future issues facing the allocation of water. With the growing uncertainties of global climate change and the long term impacts of management actions, the decision-making will be even more difficult. It is likely that ongoing climate change will lead to situations that have not been encountered. As a result, alternative management strategies are sought for in order to avoid setbacks in the allocation of water resources.

2. REFERENCE LAW

European water legislation

When asked to list the five main environmental issues that Europeans are worried about, averaged results for the EU countries show that nearly half of the respondents are worried about "water pollution" (47%), with figures for individual countries going up as far as 71%. This demand by citizens is one of the main reasons why the Commission has made water protection one of the priorities of its work. The new European Water Policy will get polluted waters clean again, and ensure clean waters are kept clean. In achieving these objectives, the roles of citizens and citizens' groups will be crucial. This is why a new European Water Policy has to get citizens more involved. European Water Policy has undergone a thorough restructuring process, and a new Water Framework Directive adopted in 2000 will be the operational tool, setting the objectives for water protection for the future.

Early European water legislation began, in a "first wave", with standards for those of our rivers and lakes used for drinking water abstraction in 1975, and culminated in 1980 in setting binding quality targets for our drinking water. It also included quality objective legislation on fish waters, shellfish waters, bathing waters and groundwaters. Its main emission control element was the Dangerous Substances Directive.

The European Water Framework Directive (WFD) of 23 October 2000, establishing a framework for Community action in the field of water policy, gave overall consistency to a well developed European legislation (about thirty directives and regulations since the 1970s). This directive sets out common objectives, timetable and working method for the Member States of the European Union. It starts with a very significant preamble: "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such". The European directive 2000/60/EC of 23 October 2000 defines a strategic framework for water policy for the Member States of the European Union. It has extended to all Europe the principles of basin management developed in France for more than 45 years. The WFD sets out an obligation of results: achieving before 2015 a good overall status of all waters: surface, ground and coastal waters. Extensions of timescales or less stringent objectives are possible, but they must be justified and submitted to public consultation. An adapted objective (good ecological potential) can be retained for heavily modified water bodies from the point of view of hydro morphology. The WFD requires improving water chemical quality by reversing the trend to the deterioration of groundwater quality and by reducing the discharge of priority substances into surface waters. The discharges must be eliminated before 2020 for the substances classified as "priority dangerous substances". A first list of 33 substances was adopted including metals, pesticides and hydrocarbons.

French water legislation

Although some bases of the water policy go back to the 16th century, the current organization relies on a law of 1964, which was supplemented and modernized later on. The Law of 16 December 1964 organized water management at the level of river basins. It states three essential principles, which are now recognized but which were innovating at that time: decentralized management at the level of the large river basins, concerted management, incentive financial tools. For organizing dialogue and the sharing of responsibilities, an advisory body (the Basin Committee) and an executive organization (the Water Agency) were created in each large river basin. The Law of 29 June 1984, called "Law on Fishing", organized fishing in freshwater and fish-farming management. With this law, taking into account the aquatic environment strongly progressed. It introduced the obligation of "reserved flow", i.e. a flow considered as ecological minimal flow, which is imposed to the dam managers, in order to guarantee the functioning of the aquatic ecosystems located downstream of the dams. The Law of 3 January 1992, called "Water Law", laid down the principles of true integrated water management: patrimonial nature of water (water is the "common heritage of the Nation"), management balanced between the various water uses, overall management of water in all its forms (surface, ground, marine, coastal water), conservation of aquatic ecosystems and wetlands, use of water as an economic resource, priority given to drinking water supply. This law developed planning instruments on a basin scale: the SDAGE (Master Plan for Water Development and Management) for large basins, the SAGE (Water Development and Management Scheme) for sub-basins.

The Law of 21 April 2004 transposed the WFD into French law. The Law on water and aquatic environments of 30 December 2006 renovated the whole water policy. Its objectives are: to provide the means for achieving the goals of the WFD, to improve the conditions of access to water, to give more transparency to the operation of water utilities, and to renew the organization of fishing in freshwater. It also brought two major advances: recognition of the right to water for everyone and taking into account the adapting to climate change in water resources management. It reformed the financing system of the Water Agencies and created the new National Agency for Water and Aquatic Environments (ONEMA).

The French bill of 12 July 2010 for the national commitment to the environment, known as the Grenelle 2, confirms these provisions by adding to the scheme, with sustainable management of water and sanitation services, notably concerning management of water loss in distribution networks and reduction of the use of phytosanitary products.

Spanish water legislation

Spain has old and complex legislation with regard to water, which has recently undergone some modification (the 1999 Act). The water market has been introduced, with emphasis on environmental protection aspects, while continuing traditional management through hydro basins. The current state of evolution in water law is one of vagueness, with contrasting lines of tension; in some, the old type of focus predominates but there are others in which the so-called new water culture can be detected. The National Hydrological Plan (with its proposal for a major inter-basin transfer) and the application of European Community law (water framework directive) are going to set the trail for development over the next few years, and this will resolve the above-mentioned lines of tension.

The National Hydrological Plan is a conventional, static plan, which focuses primarily on supply management. The plan is based on the explicit assumption that the world will change only incrementally during its entire economic life of 100-200 years. The analysis indicates that much of the increased water demands forecasted are unlikely to materialize due to increasing emphasis on demand management practices, major structural changes in the agricultural sector that will occur by 2020 and the requirements of the Water Directive of the European Union.

The characteristics of the plan are to alleviate the drought and the hydraulic deficiency of the Southeast of the Spanish Peninsula and the inner river basins of Catalonia. For the Spanish Southeast four possibilities are discussed in the plan. The best option for the Government would be carry water from the Ebro river, which an assumed excess capacity of 5,300 hm^3. Three hundred hm^3 would be destined to the Valencian Community (river basin of the Júcar), 430 hm^3 to Murcia and 90 hm^3 to Almería.

There are three possible options to solve the water deficiencies of Catalonia in general and Barcelona in particular. One option is to transfer 180 hm^3 from the Lower Ebro taking advantage of existing infrastructures. Another involves transferring water from the Rhone river, although it is the most expensive solution. Finally, there is the possibility of transferring water from the Talarn dam on the River Noguera Pallaresa to the north of the region.

The solution supported by the Government is the cheapest one that obtains all transfers from the Ebro river. This is the option with the lowest construction costs (about 3,600 million euros) and less environmental impact when the lack of need to construct new channels or dams is taken into account. The users who benefit from the transfers will pay 312 million euros per year, 50% will be for infrastructure and the rest for the management and maintenance works. In order to compensate the environmental lobby groups, the Government has announced an ecological grant of 0.03 Euros per cubic metre transferred that will be invested in the environment. If the Ebro transfer option goes ahead, the Hydrographic Confederation of the Ebro would receive 30 million euros annually as an ecological grant.

There is great social and environmental pressure in the Ebro basin against any water transfer. Opponents to the Ebro transfer plan claim it is contrary to the new European Water Framework Directive and the sustainable development objectives adopted by regions such as California, with similar climatic and water deficit characteristics. Many environmental and other NGOs, as well as numerous academics, scientists, unions and political parties are aiming to stop the project mainly through trying to block the 40% funding from the European Union.

Italian water legislation

Italy is one of the richest countries in Europe for water availability: 500.000 cubed meters of water per squared kilometre against 170.000 cubed meters in the whole Europe. Nonetheless, water is a flow and not a stock resource, and accessibility to it changes with respect to seasons and places, while the demand for it is more stable. This implies that even in Italy the real availability is limited to 50.000 cubed meters per year, meaning a 80% usage of the resource, and that during peaks of demand (typically during the summer or in the four-months irrigation season) or where per-capita availability is lower (for instance in Tuscany and Apulia, both agriculture-addressed regions), water stress overcomes the critical threshold.

A great change in water management in Italy, descending from European Union Framework Directive 2000/60/EC, happened in 2001, when the subject was excluded from the assignments of Ministry of Public Buildings and Works to be allocated to Ministry of Environment. The reason is that – due to the new framework - the focus in water management changed from public infrastructures (i.e. dams, pipes and sinks) to ecological state of water units. The new rationale is based on the notion of “integrated management” of the water system, whose prior is the good ecological quality of water, and not the satisfaction of human needs for water. The premise is that water have different usages and that a water system is made of many elements, so that a correct water management must take into account all parts and all potential stakeholders interested in the issue. In addition, since late 1990es a wide part of water management is delegated to Regions.

The EC Directive intercepts a National framework standing on three pillars: the first one is National Law 183/1989 that introduces the notion of “water basin”, with a dedicated Authority for water planning and management separated and higher-ranked on the water subject to other political and administrative bodies; the second one is National Law 36/1994, establishing a consortium of municipalities (called “Optimal Territorial Ambit”, applying to water issue the same rationale experimented in waste management) to administer water supply, depuration, and dirty water disposal; finally, the National Law 152/2006 (the Structural Law on Environmental Protection), that transformed water basins in wider “hydrographical districts” (just eight in the whole National territory), guided by a District Authority that implements a Management Plan focused on the defence from risks such as floods and dryness. At the end, the water matter in Italy nowadays deals with four main topics:

1. defence from hydraulic risks, assigned to District Authorities and based on the implementation of a District Management Plan;

2. environmental quality of rivers, lakes, and other fresh water bodies, assigned to Regions and based on the implementation of a Regional Water Protection Plan;

3. hydro-geological conditions control, equally assigned to Regions, that implement a Regional Hydro-geological Plan addressed planning infrastructural works and enforcing thresholds and environmental norms to deal with hydro-geological instability;

4. water supply, depuration and disposal, assigned to Municipality Consortia organized in Optimal Territorial Ambits, but progressively transferred to Regions.

The institutional governance of water resource regards the first three levels, while the fourth one deals more with water management and provision to final users.

3. MAIN POLICY INSTRUMENTS

To speed up the implementation of the Water Framework Directive, water concerns must be better taken into account in other EU policies and funding mechanisms (a recommendation following the Blueprint in 2012). This will help reach the Directive's objectives of good water status. The European Commission is working closely with Member States and stakeholders to achieve a better integration of the Water Framework Directive with other EU policies. Operational and rural development programmes for 2014-2020 have been assessed to measure their contribution towards EU water policy.

While Europe is considered as having adequate water resources, water scarcity and drought is an increasingly frequent and widespread phenomenon in the European Union. The long term imbalance resulting from water demand exceeding available water resources is no longer uncommon. It was estimated that by 2007, at least 11% of Europe's population and 17% of its territory had been affected by water scarcity, putting the cost of droughts in Europe over the past thirty years at EUR 100 billion. The Commission expects further deterioration of the water situation in Europe if temperatures keep rising as a result of climate change. Water is no longer the problem of a few regions, but now concerns all 500 million Europeans.

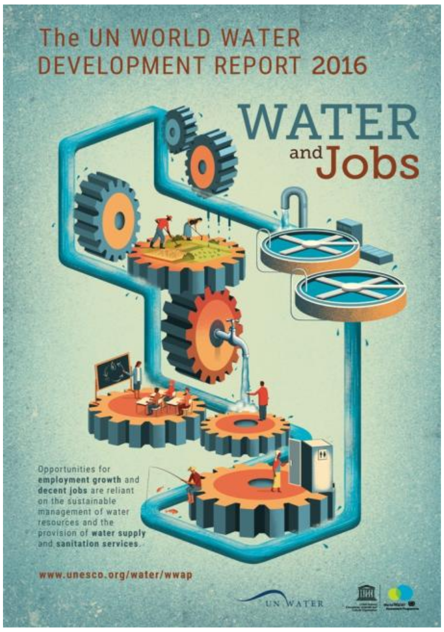
The main overall objective of EU water policy is to ensure access to good quality water in sufficient quantity for all Europeans, and to ensure the good status of all water bodies across Europe. Therefore, policies and actions are set up in order to prevent and to mitigate water scarcity and drought situations, with the priority to move towards a water-efficient and water-saving economy.

The health of our ecosystems, the source of water, needs to be maintained and enhanced and the basic human right to water and sanitation, confirmed by the UN Sustainable Development Goal on Water, should be a reality today and for generations to come. To this end, water services should be affordable and, at the same time, the level of tariffs should be appropriate. Transparency is urgently needed as to who is using and polluting water and who is paying for it. In order to ensure the necessary long term investments to maintain and renew infrastructures, the WFD principle of cost recovery should be fully implemented.

New micro pollutants are emerging and pose serious risks to human health and environment. At the same time, pollution of water resources originating from agriculture (nitrates, pesticides) and industry (heavy metals, chemical substances, etc.) needs to be tackled and the European Commission needs to remain strong in enforcing the Community legislation. In addition, a source control approach must be adopted in order to prevent hazardous substances, micro plastics, nanoparticles and micro pollutants from entering the water cycle as the most cost-effective solution. The WFD polluter pays principle must be correctly applied and should be based on inclusive multi-stakeholder governance.

The European Commission has launched a European Innovation Partnership on Water with the aim to support and facilitate the development of innovative solutions to water related challenges and to create market opportunities by doing so. EIP Water have proven to be useful tools (a) to facilitate the development and stimulate the uptake of innovative solutions, (b) to guide actions in removing barriers to innovation, (c) to address social challenges, to facilitate industrial leadership in water, and (d) to contribute in raising competitiveness and economic growth.

4. JOB MARKET



The United Nations' "World water development report 2016: water and jobs" demonstrates that water is related to several other Sustainable development goals, including Goal 8, which addresses the promotion of sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. More than 1.3 billion jobs worldwide (42% of the world's total active workforce) are heavily water-dependent, including work in agriculture, mining and industries ranging from paper to pharmaceuticals. Moreover, another 1.2 billion jobs are moderately water-dependent; though they do not use large quantities, industries such as construction, recreation and transportation do need access to some. In total, 78 percent of global jobs need water.

By protecting businesses against water scarcity and volatile prices, the European Commission is helping create new business opportunities, and promoting innovative, more efficient and sustainable ways of producing and consuming. The world water market is growing by 20% every year, and it could be worth 1 trillion € by 2020. European products, services, and expertise will be available to communities around the world. The EU water sector includes 9,000 active SMEs and almost 500,000 jobs. *A 1% increase in the growth of the water industry in Europe could create up to 20,000 new jobs*. A single framework will make it easier to implement water reuse technologies around the EU.

By 2030 the transition to a water-smart society will be in full swing, driven by visionary front-running (agro) industries, rural and urban areas. These will have taken the lead in developing the migration paths towards the water-smart society of the future by implementing ambitious long-term investment and innovation programmes, as well as real life Living Lab experimental areas. They will have created a fertile innovation ecosystem for solution developers, researchers, forward-looking water users and water governing bodies to develop the leading solutions of the future. These will boost Europe's global competitiveness in the €2.5 trillion water handling market, creating numerous new green jobs in Europe while making significant contributions towards reaching the sustainable development goals for water.

The gender dimension

The female share of the workforce in the formal wastewater treatment sector is quite marginal, with women often effectively being excluded from technical and other professional positions. On the basis of studies in 15 developing countries, the International Water Association (2014) found that women accounted for an average of just 17 % of all staff. The share in the non-governmental sector was much higher than in the public and private sectors. As a result, the World Water Assesment Pogramme (2016) advises that concrete efforts are required to train female researchers in the wastewater field, and to promote a greater number of female scientists in the higher echelons of scientific institutions and decision-making in developed and developing countries alike.

Gender mainstreaming in policies for water and sanitation services is essential. This requires a better understanding of key impediments to females' entry into the water sector, as well as of what may motivate women to seek a career in the sector. Such an understanding is necessary to promote the technical careers of young women more effectively.

Scholarships at education and training institutions would also be of help. Further, recruitment procedures need to be adapted. In addition to changes in professional training, the traditional role of women in household and community water management needs to be recognized in the context of TVET (Technical and Vocational Education and Training) efforts.

The situation is very different in informal settings. In many countries and cultures, women play an important role with regard to water, hygiene and health in families. WWAP (2017) points to examples in Jordan, Tunisia, and Viet Nam, where women carry responsibility for greywater or wastewater use. This is a role that could be advantageous in improving the social acceptance of safe wastewater use and related innovative training approaches, but women's exposure to health risks is a concern. This is particularly the case in indigenous communities, where wastewater management falls heavily on women's shoulders.

5. PROFESSIONALS

Water quality technician/technologist

Water quality technicians/technologists are responsible for testing and monitoring water supplies and making certain water is safe. They perform a variety of technical duties, for example inspecting, sampling, monitoring and testing, and work with both groundwater and surface water sources. Water quality technicians/technologists also routinely monitor compliance with federally and provincially mandated water quality requirements.

Duties vary significantly from job to job, but the following list includes typical job duties one might encounter as a water quality technician/technologist:

- Monitor drinking water parameters using field equipment, for example pH, conductivity, and total dissolved solids meters;
- Calibrate equipment and verify data;
- Perform distribution-system flushing operations;
- Collect and analyze samples;
- Organize water-sampling schedules;
- Perform water pressure tests for distribution systems using pressure-recording charts;
- Conduct bacteriological and chemical testing on samples collected using standard laboratory procedures;
- Monitor wells and other water sources;
- Enter and update data in testing and results databases.

Work environment

In the lab:

- Preparing test solutions and processing samples;
- Testing and analyzing samples;
- Developing test methodology;
- Calibrating and maintaining instruments.

In the office:

- Compiling, recording and interpreting test results;
- Analyzing data and preparing various records and reports related to water quality regulatory monitoring;

- Communicating on the phone and in meetings with supervisors, clients, government departments, colleagues and other scientists.

In the field:

- Collecting samples for analysis;
- Participating in training sessions.

If you are a high school student considering a **career** as a water quality technician/technologist, you should have strong marks or an interest in: chemistry, biology, mathematics and computer science. In most cases, the minimum education requirement to work as a water quality technician/ technologist is a college technical diploma. If you are a post-secondary student considering a career as a water quality technician/technologist, the following programs are most applicable: chemistry, water resources, environmental technology, environmental science and pure and applied science.

River technician

- link to a video representing this job in France made by *Association 3PA* in cooperation with high-school students: https://www.youtube.com/watch?v=azjS4CJdTes

Hydrologist

Hydrologists study how water interacts with the earth's crust. For example, they may study how rainfall and snowfall cause erosion, create caves, percolate through soil and rock to become groundwater, or eventually reach the sea. They may also study how precipitation affects people by influencing river levels or groundwater availability. Hydrologists also help investigate contaminated sites to assess how water flow might disperse pollutants, or how polluted water can be remediated.

Groundwater hydrologists study the water below earth's surface. Most groundwater hydrologists focus on cleaning up polluted groundwater at industrial contamination sites. Others work on water supply, siting new well locations and estimating amounts of water available for pumping. They often help determine the locations of new waste disposal sites to prevent groundwater contamination.

Hydrologists use computer models to forecast future conditions concerning water supplies, the spread or remediation of pollution, floods, and other events. They may also assess the suitability of new hydroelectric power plants, irrigation systems, and waste water treatment facilities.

While a bachelor's degree is sufficient for some entry-level jobs, most hydrologists will need a graduate degree in the natural sciences. Since there are very few undergraduate programs in hydrology specifically, students interested in this career path should seek out hydrology concentrations within geosciences, engineering, or earth science programs. Coursework typically includes math, statistics, physical sciences, computer sciences, and life sciences. Courses in environmental law or public administration may be helpful for communicating with project partners from other fields. Computer modelling, data analysis, and digital mapping are highly marketable skills for hydrologists.

Water Treatment Plant Manager

Water treatment plant managers oversee the treatment, distribution and daily operations of water treatment facilities. They supervise teams of operators, institute plant policies and procedures, direct training programs and complete employee performance reviews. Managers ensure that the plant and its operators comply with state health standards by regularly testing the water supply and keeping meticulous records. They're also responsible for maintaining a safe work environment and ensuring all equipment is in proper working condition.

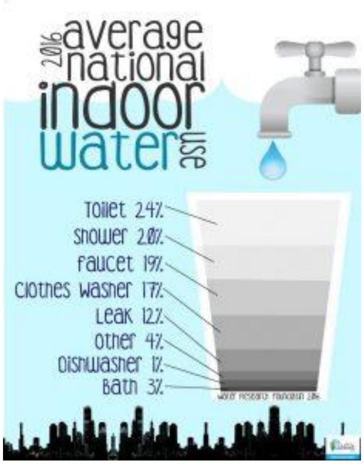
A career as a water treatment plant manager is physically demanding and often involves working outdoors in all types of weather. They often work in hazardous conditions surrounded by loud machinery and dangerous chemicals. According to the BLS, water treatment plant employees suffer from an unusually high rate of occupational injuries. Since water treatment plants operate every day, plant managers often work days, evenings, weekends and overtime hours.

While the typical requirement for an entry-level position in a water treatment plant is a high school diploma, employers may prefer applicants with a certificate or associate's degree in water treatment. An educational program in this field focuses on water analysis and treatment procedures. Coursework may include water chemistry, microbiology and hydraulics. Students may also receive leadership training with coursework in communications and employee supervision.

Many water treatment plant managers begin their careers in an entry-level position, such as a **plant operator**. To become a manager at a plant, a certificate or associate's degree in water treatment, combined with a few years of work experience, are required.

6. CASE STUDIES

BioMicrobics company – RECOVER® system

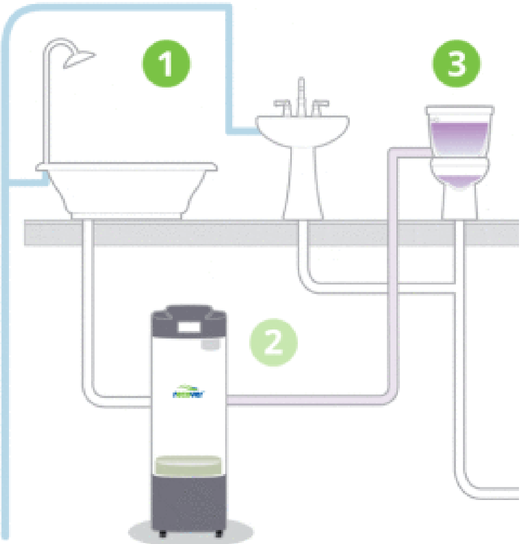


BioMicrobics is known for its sustainable water management systems and decentralized residential and commercial wastewater (blackwater/ greywater) treatment technologies. International certified and proven, these systems have performed exceptionally well in achieving the new higher levels of nitrogen removal, achieve net-zero water, and optimal effluent quality with automated, energy efficiency that is required today. Whether design-build projects or retrofits for property owners or “green-builders” wanting environmentally responsible on-site blackwater and/or greywater treatment systems, their expanded product offering can help to provide clean treated wastewater for water reuse opportunities for sustainable home landscaping irrigation to meet onsite water conservation goals.

Recover® Greywater Treatment System

Greywater can come from drained water from showers, baths, or sinks. Normally, this greywater used once travels through the plumbing mixing with blackwater (from toilets or kitchen sinks) to be combined as the total wastewater accumulated on a property. The combined sources of wastewater then gets treated at municipal sewage treatment plant or with an onsite wastewater treatment system.

If you can capture a portion of the greywater (say from the shower and/or bath drainage) and automatically treat and recycle for toilet flushing, this can conserve the water consumption by up to 30%! Toilet flushing is the most suitable application for greywater, since in most homes the volume of water used to flush toilets closely matches the volume of greywater produced in a day from bathing. This allows for a smaller tank size since all the greywater generated is used that same day.



The Recover® system captures the greywater instead of leaving the home or building, applies filtration and adds a small amount of chlorine for disinfection. The greywater is then stored in a tank to be used to flush toilets, thus reducing potable water consumption for non-potable uses. The control panel auto-detects toilet leakage*, has an “Away” mode for shut off, an AI feature to learn the behaviour of shower to toilet activity of the occupants, and a self-cleaning function of the screen for low maintenance and operation. It’s not just about the cost of water, it’s the amount of fresh water sources that can be saved due to the volume and frequency of greywater produced and the number of times the toilet is flushed.

7. TRACKS FOR ACTIVITIES IN CLASS

Where do we find water on Earth?

Duration	1 h
Target group	Age 14+
Number of participants	6+
Material	For each participant : • sheet of millimetric paper For each group: • a photocopy from the chapter 9 Annex of “Fiche XIII” For the class : • world map
Budget	None
Background/issue	Where do we find water on Earth?
The main objective	• To know how the various states in which water is found are divided on Earth • To understand that drinkable water is precious
Dominant feature	Geography and science
Skills	• To respect instructions in autonomy, to know how to use units of measurement, how to use the tools of measurement, to make the conversions, to create a simple graphic presentation
Glossary	Freshwater, drinkable water, salty water, water infiltration, groundwater (phreatic) water
Preparation work	None
Activity steps:	1. Introduction 2. Individual research 3. Document research 4. Pooling 5. Written notes 6. Conclusion
1. Introduction	The facilitator introduces the topic by asking the question : *We say that the Earth is a « blue planet », do you know why ?* Participants answer quickly that it is because of huge amount of water on Earth. So facilitator asks another question : *In this case, why do we say that water is precious and we should not waste it ?* Discussion leads towards that water

	which is available it is not drinkable. Drinkable water is rare and essential…..so precious. In this discussion, the class put together the definition of the drinkable water. For example : *Water is drinkable when it can be consumed by humans without danger.* Particularly, we can evoke what water can contain, what makes it not drinkable : salt, bacteria, pollution, etc. After that, facilitator leads the discussion towards the various states of water *(which ones?)* and the various reservoirs of water on Earth : *Where do we find the water ? In which state is this water ?* The world map helps class to picture the oceans, lakes, long rivers and polar ice caps.
2. Individual research	• Participants describe the dimensions of the various water reservoirs on Earth how they picture them • For example : one strip of cloth of 10 cm depicts the total amount of water on Earth. Participants have to divide this strip in four parts, where each part depicts one reservoir of water. We can also mark the pieces of strips with colours for each strip in order to make the comparisons easier. • After that, individually, each participant goes back to his/her millimetric paper and draw how he/she imagines the various amounts of water reservoirs on Earth.
3. Document research	• Facilitator gives one photocopy of Fiche XIII to each group of participants. This paper represents the various reservoirs of water on Earth, like that the corresponding amounts brought back to 10 l of water (a bucket). Firstly, participants have to convert the amounts in order to have the same units everywhere (in this case - dl).
4. Pooling	• Pooling helps to be sure that everybody have understood how to convert litres, decilitres and millilitres. Calculations help to have the chart with one unit (dl). Fiche I **Reservoir of water – Comparison, brought to 10 l (100 dl))** Oceans, seas, salty lakes,… 97 % - Bucket of salty water = 97 dl Glaciers, polar ice caps … 2 % - Freshwater, frozen = 2 dl Groundwater …. 0,9 % - Fresh water, mixed with soil = 0,9 dl Freshwater's lakes, rivers, soil humidity 0,1 % - Freshwater = 0,1 dl
4. Written notes	• Individually, each participant goes back to his/her millimetric paper and draw the real amounts of water reservoirs on Earth (in percentage). • What we can see: freshwater surface is really rare because we are not even able to represent it on the graphic, it would take a line just 1/10 of a millimeter thick !
5. Conclusion	• Participants altogether become aware of rarity of the freshwater on Earth, and also the biggest part of this freshwater is not directly available (it is in state of ice or underwater). Finally, freshwater which is directly available represent only 0,1 % of all water on Earth. • Facilitator speaks again about the difference between freshwater and drinkable water. Just one small part of the freshwater can be

	considered as drinkable. Drinkable water is, thus, very rare.
Pursuit of the activity:	• This session can give rise to a manipulation allowing to represent more concretely the proportions quoted above. With a bucket of 10 l of water, salt, a measure glass, an ice cube's box, a small glass and a soup spoon, we imagine the various reservoirs of water on Earth.

Water in the housing

Duration	1 h
Target group	Age 12+
Number of participants	5+
Material	For each participant: - a photocopy from the chapter 9 Annex of "Fiche II" - a photocopy from the chapter 9 Annex of "Fiche III"
Budget	None
Background/issue	Where is water in the house?
The main objective	• To locate the different water points used in the house • To find out how to economise water
Dominant feature	Science and technology
Skills	Knowhow to observe, to do a survey, speak out about your ideas and solutions
Glossary	• Habitat, water overuse, drinkable water, freshwater, waste
Preparation work	None
Activity steps:	1. Survey in the house 2. Pooling 3. Survey in the classroom 4. Pooling 5. Conclusion
1. Survey in the house	• Students/participants will be focusing on water usage in the housing, firstly, they will check the water points in every room of their house/ apartment, the devices which need water point and rejection of the used water, etc. • They should not forget about the connexions which are less visible like garden taps, etc. Document « Fiche XIV » will help them with this survey.
2. Pooling	• The results of the survey-chart will be compared and discussed in the class. For the moment we forget about « *What does the used water in the house contains?*» because this information will be discussed at the end of the workshop. We should speak about that we use a lot of water in our daily life (for example in France it is 150-200 l of water per person per day). It means freshwater...and often drinkable water which as we know it

	is not necessary in most cases. • We point out that more and more drinkable water is polluted by faeces, food waste, cleaning and washing products, etc. • The facilitator asks the class the question : *Do we need that the water should be always drinkable for all these kinds of usage?* We will close with that for the gardening, car washing, toilette, we don't need drinkable water. But for the drinking, cooking, dish washing, personal hygiene, we should have the drinkable water in the house (by law).
3. Survey in the classroom	• The facilitator asks students to think together if there are some solutions in order not to use the drinkable water for not-dietary use : *Which solutions can we find ? Can we imagine more water circuits for different kinds of use? Where can we find freshwater except in water taps?* • Rainwater collection is evoked easily. So the facilitator give each participant the document Fiche XV which shows a house with different water points. Each student draws two circuits (rainwater collection, drinkable water distributed by city) while taking care to connect the right devices with the right circuits.
4. Pooling	• We check all together if the water circuits have been done correctly. Facilitator makes sure that students have realized that the elementary treatment of rainwater is necessary. For example, we have to install filters in order to not transport the residues of soil, leaves, stones, etc. • This reflection is the chance to look at student's survey-charts again *« What does the used water in the housing contains?»* We focus on water which is polluted and we point out that this kind of water should be filtered before being thrown back in the nature. • It is important to make them think about water pollution, for example: to put used paints, oils, etc., in the recycling centre rather than in city's sewers, to use less polluting cleaning products.
5. Conclusion	• Class's conclusion will be posted in the notebook or on the wall, it could be for example: *To protect the nature water resources we have to avoid the waste (close the water taps, take a shower rather than a bath) and to use as little as possible the polluting products. We can collect rainwater and use it for toilettes, clothes washing, gardening.*
Pursuit of the activity:	• Work in the field of water management: filtration, decantation, etc. • Bring an invoice of the water consumption and calculate the average consumption per person. Compare it with the amount of water used for drinking (two litres per day and per person).

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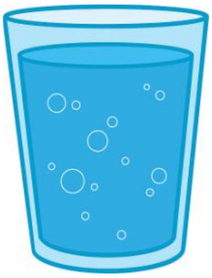
9. ANNEX

Fiche I

Convert the amounts of water in right column in the unit of decilitres, in order to have the same measurement unit in each line.

Distribution of water on Earth : the various « reservoirs »	Comparison, brought to 10 l of water
 **Oceans, seas, salty lakes, …..**	 **Bucket of salty water : 9,7 l**
 **Glaciers, polar ice caps, ...**	 **Freshwater, frozen : 2 dl**
 **Underground water**	 **Fresh water, mixed with soil : 90 ml**

 **Freshwater's lakes, rivers, soil humidity**	 **Freshwater: 10 ml**

Fiche II

* Fill in the chart by observing different water points in your house/apartment :

Room	Water point or device connected to the water point ?	Is used water drinkable or not?	What does used water in the housing contains?	Drawing

Fiche III

* Draw two water circuits (drinkable water, rainwater) by using two different colours: