SUSTAINABILITY AND SUSTAINABLE WATER MANAGEMENT

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10.53478/TUBA.978-625-6110-22-9.ch03

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Abstract

In this study, sustainability and sustainable development concepts are briefly introduced. After giving some information on sustainable water management concept relating to sustainable development, information about important issues of water management such as hydrological cycle, human intervention on hydrological cycle, water treatment, wastewater collection and treatment are given. Virtual water and water foot print concept is important about indirect use, import or export of water. If in water scarce locations main income depends on export of high water demanding agricultural or industrial products, it will make water shortages even more pronounced and that is not sustainable in terms of water management as well as in terms of development. Therefore integrated water and wastewater management, demand side management approach should be adopted. Water resources protection and investment on water resources structures are important for clean and good quality water supply instead of only investing water treatment plants and processes. Waste water collection and treatment parts are also important; however before treatment water should be used multiple times for varying purposes. In this work it is also emphasized that investigations about wastewater treatment methods, water, materials and energy recoveries should be carried out in order to improve physical, chemical and biological processes involved.

Keywords
Sustainability, water management, hydrological cycle, water treatment, basic sciences

Introduction

The terms “sustainability” and “sustainable development” are widely used. Sustainability means development in a way that humanity can continue to exist within the boundaries of the earth, the only livable planet. Sustainable development is the process of achieving development within ecological boundaries. There are many different definitions of sustainable development. Sustainability can simply be defined as meeting today's needs without reducing the ability to meet the needs of future generations.

Solow (1991) defined sustainability as while meeting our own needs, it is our duty to ensure that the options or capacities of future generations to meet their needs are as good as our own, or not to weaken them. This definition brings moral responsibility for all of us to use the Earth's resources wisely and fairly. New definitions are being made regarding the concept of sustainability as the relationships between economic development and the environment are understood. Therefore, the need to define sustainability becomes important as environmental crises increase (Gray, 2015).

Sustainable development is about preventing the problems that arise, including climate change and accompanying problems, affecting the environment, humanity and ecosystem, water quality, nutritional quality, and chemical and microorganism pollution. Sustainability should take into account issues such as increasing water scarcity, problems with food production, protection of plant and animal biodiversity and habitat diversity. While economic growth increases the rate of production and consumption of goods and services, it leads to increased use of resources and an increase in the production of waste and a wide variety of pollutants. Therefore, if economic growth mechanisms are not changed, the physical, chemical and biological properties of the environment will deteriorate as a result of excessive consumption of natural resources, exceeding the ability of natural systems to assimilate waste.

Sustainability has ecological, economic and social dimensions that are interrelated with each other. All three dimensions need to be addressed to find sustainable solutions. Environmental Sustainability, which focuses on the continuity and protection of natural resources, ecological resources that is often referred to as ecosystem services. Economic Sustainability focuses on the natural resources that provide physical input to the production process of goods and services. Social Sustainability, which addresses poverty and human development, is social sustainability that ensures the continuity of ecological systems, social, cultural needs and welfare.

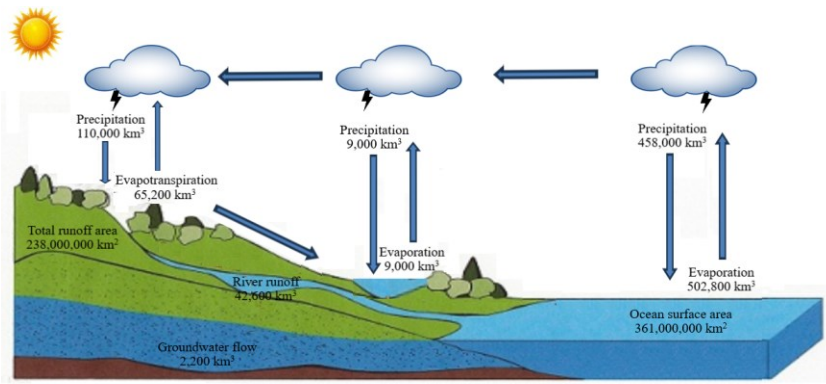
Socio-economic interactions should be fair, economy-environment relations should be livable, and environment-social relations should be acceptable. Sustainability is considered a balance in which ecological, economic and social dimensions are of equal importance. However, in practice, the economic dimension dominates through continuous growth, while environmental resources are rapidly being depleted. Since the environment and its resources cannot be expanded, society must develop within the environmental boundaries and the economy must meet the needs of society within these limits. Therefore, for a sustainable society, the environmental dimension should be more important and protected. When the economy-ecology-social balance is considered today, it is seen that the economy and social demands exceed the ecological capacity of the Earth. Therefore, it must be accepted by society that the economy must remain within the limits set by society to reflect values such as justice. This situation requires the most economical use of available water in water supply and prevention of overuse, known as demand side management, instead of supply side management, where the increase in water demand must be met with a limited volume of usable water. Increasing needs must be met by protecting and better managing water resources rather than using them more.

Sustainability is generally viewed as fundamental to all future development goals, thus seeking to ensure equal development opportunities for future generations. Sustainability underpins the UN 2030 Agenda for Sustainable Development, which sets out 17 Sustainable Development Goals (SDGs). Adopted by all UN Member States in 2015, the SDGs are a global plan for a sustainable planet where all people can live in peace and prosperity. Goal 6 of the Sustainable Development is about ensuring the availability and sustainable management of water and sanitation for all (UN, 2015; 2021). The three headings of Goal 6 are access to water supply and sanitation, sustainable use and development of water resources, and improved water quality and wastewater management. An EU Sustainable Development Strategy including the Sustainable Development Goals (EC, 2021) was adopted in 2021. Sustainable development requires finding appropriate solutions using a range of existing and emerging sustainable technologies that may vary according to local conditions and culture. These technologies must be both reliable and effective and of minimal cost, as long as they do not harm the quantity or quality of resources, including biodiversity (van der Vleuten-Balkema, 2003).

Sustainable Water Management

Water is in constant motion due to solar energy and gravity. The sun causes water to evaporate from oceans, lakes, streams, lands and plants. The evaporated water forms clouds, which move in the atmosphere and form precipitation. About 80 percent of precipitation returns to the oceans, while the rest falls on land. This cycle is called the hydrological cycle that renews soil moisture and groundwater, feeds rivers and lakes, and provides the water needed by plants, animals and humans on land and in fresh water (Figure 1).

Figure 1.
Hydrological cycle



While the total volume of water on Earth remains constant, its quality and availability at any given location constantly changes. 97.5% of the huge amount of water on the planet is found in the oceans as salt water (Table 1). This means that only 2.5% of the available water is fresh water and 75% is stored in glaciers (Figure 2). The volume of glaciers is decreasing due to climate change. The other 24% is stored in aquifers as groundwater. It can be said that less than 1% of the total fresh water on the planet is found in surface waters such as rivers and lakes and in soil. Thus, with 0.01% of the world's water budget available in surface water and another 0.01% as soil moisture, there is a very limited amount of freshwater available for use by an ever-increasing human population. The availability and distribution of water depends on many factors, such as seasons and quality, and is not uniform. Water is absent or limited in many parts of the planet, where the population and therefore the demand is highest, water resources are often insufficient.

Table 1.
Water sources on the earth (Shiklomanov, 1993)

Water sources	Volume of water (10^6 km^3)	Percent of total water
Oceans, seas, bays	1338	96.54
Ice caps, glaciers, permanent snow	24.0	1.732
Groundwater	23.4	1.69
Lakes	0.176	0.013
Streams and rivers	0.002	0.0001
Soil moisture	0.016	0.0012
Atmosphere	0.012	0.0008
Biological water	0.001	0.0001
Swamp water	0.011	0.0008
Ground ice, permafrost	0.3	0.022

The hydrological cycle is continuous, therefore it makes water a renewable resource. Essentially, the more it rains, the greater the flow in rivers and the higher the water table rises as aquifers fill with water that percolates down through the soil and seeps into the permeable rocks below. Since water resources ultimately depend on rain, when the amount of rain decreases, the amount of water also decreases, and serious droughts occur. Therefore, resources need to be carefully managed to provide adequate amounts of water all year round. When precipitation falls in a basin, the path followed by water can be evaluated in three parts:

1- It can remain on the ground as surface moisture and eventually return to the atmosphere through evaporation. If precipitation is in the form of snow, it can be stored as snow on the surface until it melts. Snow is an important source of drinking water in some areas.

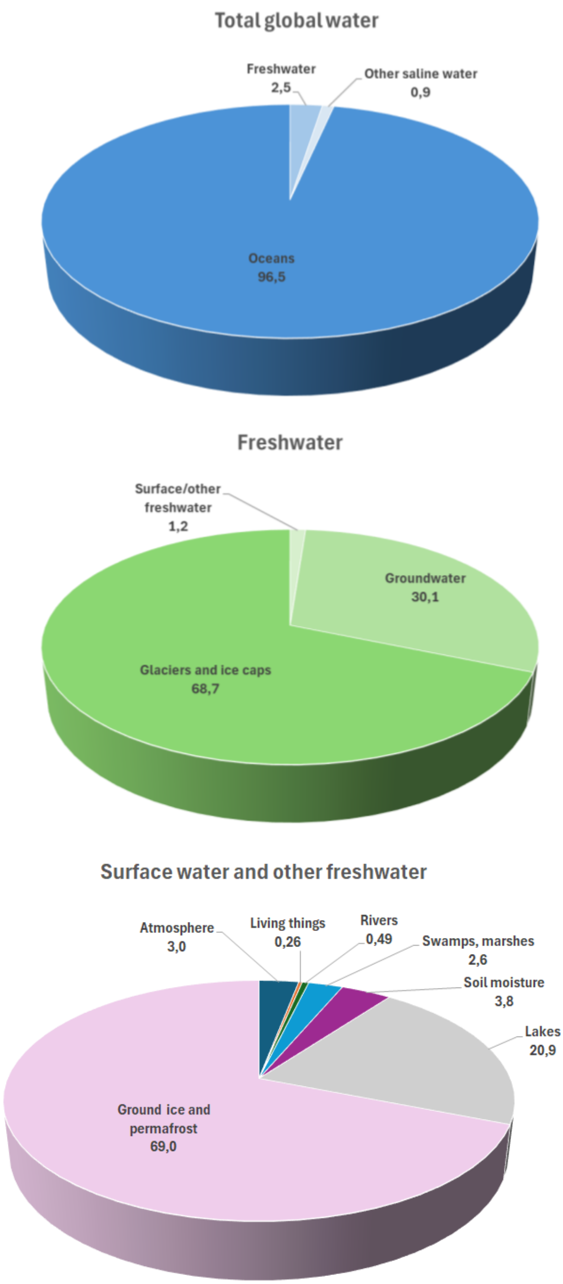
2- Precipitation flows from the surface and reaches streams and lakes. Ultimately the water returns to the sea as surface flow from rivers.

3- Precipitation infiltrates and percolates into the soil and forms groundwater, which is stored in porous media and rocks. Groundwater can persist in these porous environments for periods ranging from a few days in Karst systems to possibly thousands of years in deep confined aquifers. Eventually groundwater continues to flow through a number of natural and artificial means. These include natural capillary flow towards the soil surface, plant uptake, groundwater flowing into surface rivers and lakes or directly to the sea, or pumping out from wells.

Water in oceans, glaciers and groundwater is very old and is a depository for both minerals and pollutants. All pollutants discharged as gases, liquids or solids eventually enter the hydrological cycle and reach groundwater or the seas. As rain falls from the atmosphere to the ground, it dissolves gases such as CO_2, NOx and SOx and becomes slightly acidic. In some areas, precipitation can be quite acidic. As water flows across and through the Earth's surface through the hydrological cycle, it constantly dissolves minerals and other substances. The substances dissolved from the soil and main rock create the properties of water. Therefore, the quality of water has natural variability, largely depending on its source. Surface waters such as rivers and lakes are often vulnerable to pollution caused by anthropogenic inorganic and organic pollutants such as nutrients, metals, pesticides, pharmaceuticals and endocrine disrupting compounds, which have a negative impact on water quality.

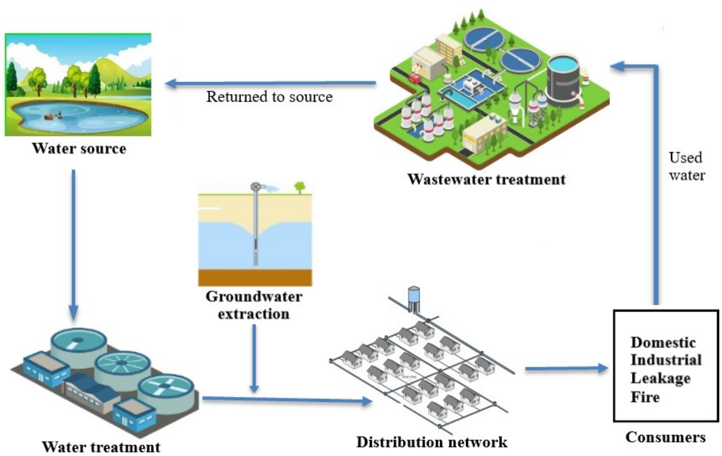
Figure 2.

Water distribution on Earth (Shiklomanov, 1993)



Water management is important in order to provide sufficient water for industry, agriculture and domestic use. Management of surface water and groundwater resources requires the supply, treatment, distribution of water and the collection of wastewater, treatment and recycling of wastewater (Figure 3). Water is taken from the hydrological cycle, used and returned to the hydrological cycle after being treated. The quality of the returned water should be close to the level of the abstracted water. The hydrological cycle is increasingly affected by climate change as rising temperatures increase evaporation. Climate change causes some areas to become wetter and some areas to become drier, increasing the incidence of drought. In higher latitudes, changes in snowfall patterns lead to spring flooding; Sea levels are rising as the proportion of water stored as snow and ice in the cycle begins to decrease.

Figure 3.
Human intervention in the water cycle



Global water problems

The world is experiencing the worst water problems ever seen. More than two billion people worldwide are constantly exposed to severe water stress (UN, 2018) and four billion people suffer from severe water scarcity for at least one month per year (Mekonnen & Hoekstra, 2016). In particular, it is estimated that by 2030, 700 million people worldwide will migrate from arid and semi-arid regions due to intense water scarcity (FAO, 2020). 2.4 billion people are exposed to epidemic diseases due to inadequate water supply and sanitation. Two million children die every year from preventable waterborne diseases. It is predicted that by 2040, one in four children under the age of 18 in the world will live in areas with extremely high water stress (Gray, 2022).

Globally, almost half of the population currently lives in areas with potential water scarcity for at least one month per year. By 2050, this figure is predicted to increase to approximately 4.8 to 5.7 billion. Water stress is an indicator used to measure progress in achieving Goal 6 of the Sustainable Development Goals.

Over abstraction and pollution of water resources affect not only humans but also aquatic species that depend on. In addition to the increasing demands on water resources due to the increasing population, a significant stress occurs in aquatic ecosystems due to changing precipitation patterns, increasing wastewater discharges, and temperature increases due to the effect of climate change. It is not just surface water at risk, it is estimated that one-third of the world's largest groundwater systems are at risk of critical overexploitation (Richey et al., 2015).

Water footprints

Water footprint is used to calculate the total amount of water consumed by a person, a business or a country and is the total volume of water used directly and indirectly. Direct water use at the business level is total water use, which can be easily measured with a water meter. Measuring indirect water use is rather complex and life cycle analysis needed for estimates. Indirect water is often called as the virtual water content of a product, i.e. m^3 of water per unit of a product produced, and also divided into Internal, water used for products produced within the country, and external, water used for the production of exported products (Table 2). It is not sustainable big amount export of virtual water from water scarce regions because it will make water scarcity much worse in that region. Virtual water import and export values of Mediterranean Sea Countries are given in Table 3 and Figure 4.

Table 2.

Six largest agricultural virtual water importers and exporters (Gm^3/yr) (Gray, 2022).

Net virtual importers of water				**Net virtual exporter of water**			
Country	Export	Import	Net import	Country	Export	Import	Net export
Brazil	91	199	108	US	298	137	161
Mexico	19	103	84	Australia	71	10	61
Japan	4	86	82	Argentina	58	4	54
China	55	133	78	Canada	70	27	43
Italy	38	88	50	Thailand	52	9	43
UK	15	55	40	India	66	24	42

Water use, like carbon emissions, is linked to consumption and consumer preferences, as large amounts of water are used in the production of goods and the provision of services (Gray, 2015). The water amount used in the production of unit volumes or weights of some household goods is given in Table 4. The water footprint can be examined in more detail in terms of the source and volume of water contaminated during production. There are three categories:

Blue water: The amount of used surface or ground water.

Green water: The amount of used rainwater.

Gray water: The amount of polluted freshwater.

Table 3.

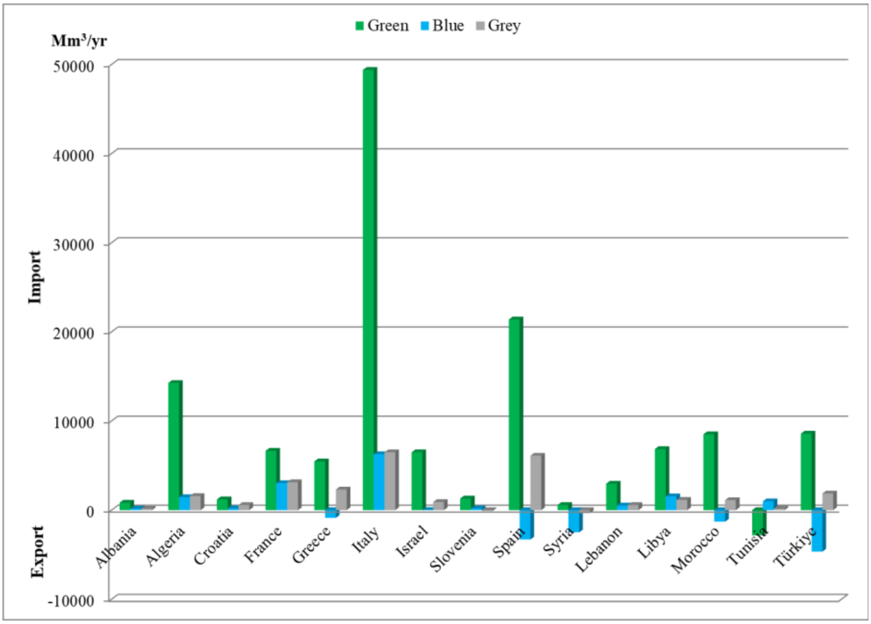
The virtual water import and export values of Mediterranean Sea Countries (Mm^3/yr) (Mekonnen and Hoekstra, 2011)

Country	Import			Export			Net virtual water import		
	Green	Blue	Grey	Green	Blue	Grey	Green	Blue	Grey
Albania	1148.4	217.4	199.6	313.3	42.7	44.8	835.1	174.7	154.8
Algeria	14505.8	1551.2	1979.0	235.9	92.7	396.4	14269.8	1458.5	1582.6
Croatia	2411.1	389.0	896.4	1207.5	189.5	326.1	1203.6	199.5	570.3
France	52707.1	10467.7	15133.5	46049.2	7438.4	11998.6	6658.0	3029.4	3134.9
Greece	9007.6	1960.6	2791.7	3549.0	2830.8	477.7	5458.7	-870.2	2314.0
Italy	72465.9	13383.5	15567.0	23077.6	7105.2	9077.1	49388.4	6278.3	6490.0
Israel	7107.3	820.6	1712.4	618.5	808.9	801.1	6488.7	11.7	911.3
Slovenia	1922.4	428.8	768.3	613.7	226.7	864.2	1308.7	202.1	-95.8
Spain	40910.0	5753.7	9582.9	19523.9	9048.8	3471.1	21386.1	-3295.1	6111.8
Syria	3240.0	802.4	542.6	2664.8	3297.0	890.1	575.2	-2494.5	-347.5
Lebanon	3367.7	647.8	626.2	401.8	130.8	52.0	2965.9	517.0	574.3
Libya	6890.7	1597.6	1285.4	44.2	44.5	125.6	6846.5	1553.1	1159.8
Morocco	10082.9	1165.9	1394.3	1569.8	2647.3	269.5	8513.1	-1301.4	1124.8
Tunisia	5754.4	1450.8	893.4	8584.4	455.4	725.1	-2829.9	995.5	168.2
Türkiye	17511.2	6718.7	5229.0	8934.0	11376.8	3362.2	8577.2	-4658.1	1866.8

Spain, Syria, Morocco and Türkiye are net virtual blue water exporting countries (Figure 4). Water scarcity is already an important issue in Mediterranean Countries. Climate change estimates unanimously suggest that the water scarcity problem will be increased in Mediterranean basin. It could also be suggested that exporting virtual blue water will further increase already existing water scarcity problem.

Figure 4.

Net virtual water import export situation of Mediterranean Sea Countries



The agricultural water use accounts for approximately 92% of annual global freshwater consumption. Because crops need water, water footprints are increasingly used to compare and optimize production methods. The best-case scenario is when crops are grown using only rainwater, although growing a lot of crops, including vegetables, requires ground or surface water (blue water) for irrigation. The most sustainable situation is the practices that use the most rainwater (green water) and cause the least pollution (grey water).

Table 4.

The water amount needed in the production of common household goods per unit volume or weight (Gray, 2022).

	Used water (L)
(Per liter)	
Water	1
Bottled water	4
Milk	1000
(Per cups or glass)	
Tea	120
Orange juice	850
Coffee	1120
(Meat per kg)	
Lamb	6100
Beef	15000-70000
Eggs	3300
(Main foodstuffs per kg)	
Bread	1300
Rice	3400
Tea	9200
Roasted coffee	21000
House items (each)	
Pair jeans	10850
Cotton shirt	4500
Cotton sheet (1 kg)	11000
Disposable nappy	810
The average car	400000

Sustainability in Wastewater Treatment

Wastewater management includes wastewater generation, sewage systems that collect wastewater, and facilities where wastewater treatment is carried out. Wastewater treatment should include the recovery and reuse of byproducts, including water, nutrients (nitrogen and phosphorus), and sludge. Sustainability in wastewater treatment depends on the location, size of the facilities, amounts of pollutants, wastewater characteristics, amount of investment, easy accessibility of technology and expertise, and sensitivity of the receiving environments. Sustainable wastewater treatment systems are particularly well-suited for small and medium-sized facilities in hot regions.

The goals of sustainable wastewater treatment can be multiple, for example minimizing costs, energy use, greenhouse gas (GHG) emissions, land area required, nutrient loss and waste production, while increasing the amount of material recovered, such as water, biogas, biomass, fertilizers, compost etc. (Balkema et al., 2002). Within these goals, the selection of treatment technologies may not always be easy under certain cultural and climatic conditions. In order to overcome the problems related to the design and operation of wastewater treatment, it is necessary to select the most suitable technologies and management systems at the planning stage and operate them in accordance with the planning, and to make sustainability-related assessments to eliminate the problems. Sustainability assessments are provided by sustainability-related indicators that measure parameters that affect the operation and effectiveness of the wastewater treatment plant.

In the past, economic indicators have been the determining criteria in the selection of treatment technologies. These normally consist of investment costs consisting of land and construction costs, and operation and maintenance costs. An important factor that should not be overlooked is the lifespan of the infrastructure. Environmental indicators are evaluated in terms of wastewater quality, energy and other inputs used, and the overall impact on the environment and public health. Wastewater quality is measured in terms of removal rates of organic substances, suspended solids, nutrients, metals and other pollutants, and must be linked to environmental quality objectives, taking into account the impact on receiving waters that have limited assimilation capacity for some components of wastewater. Energy consumption is often used as a measure of carbon footprint, which depends on the electricity generation mix supplied to the facility. However, due to the potential for the release of other greenhouse gases, the total greenhouse gas emission value in terms of carbon dioxide equivalent must be calculated for the facility. Recovery and reuse of components in wastewater is an important indicator of sustainability. This enables the reuse of both water and solids in wastewater, namely biosolids or sludge content. Biosolids production is also an important indicator that determines reuse value, both positive and negative environmental impacts, in terms of volume and contaminant levels. The land requirement depends on the hydraulic loading and the technology chosen. In high-income countries, intensive high-energy systems are extremely efficient in terms of both organic and hydraulic loading, making the treatment plants very compact. In contrast, low-energy types of systems, especially in middle- to low-income countries, require large areas of land, making direct comparisons difficult, especially with respect to the price of land. The reliability of treatment systems is related to the robustness of the technology and the complexity of its operation and maintenance. System failures are included in the environmental dimension, as they often result in pollution due to inadequate treatment of discharges. Social indicators indicate wastewater treatment, biosolids disposal, and public acceptance of the physical facility. Social indicators should be considered at the social acceptance in planning stage, including post-construction indicators such as visual impact, odor and noise, among other dimensions. Smaller treatment plants and those using natural treatment systems, particularly in low- and middle-income countries, are taking a broader approach that includes local involvement with an emphasis on public health and reuse.

The main objectives of all sustainability efforts, including water management, of which wastewater treatment is an important component, are: (i) gradual reduction of waste and pollution through innovative design, (ii) continuous recovery and recycling of products and materials, limited and scarce use of resources and (iii) improving the interface between an activity and nature, preserving and regenerating ecosystems and processes.

It is divided into three basic processes (optimization, reuse, and renewal) to optimize water quality and volume within the hydrological cycle. Optimization refers to the need to maintain adequate volumes of flow in rivers and aquifers to protect and enhance water resources and ecosystems, including biodiversity. Within the hydrological cycle, water changes its chemical composition as it passes over and through soil and permeable rocks and interacts with both flora and fauna.

As it passes through soil or flows downstream in rivers, it undergoes a process of self-purification by microorganisms and plants. In order for water to be renewed by completing the natural cycle, evaporation, infiltration or flow into streams, rivers and ultimately the seas must be as clean as possible.

The most important problems affecting natural waters globally include excessive water withdrawal, especially for agricultural irrigation, and discharge of wastewater and pollutants. Excessive water extraction and discharge of pollutants damage rivers, lakes and groundwater, making their management unsustainable. The main mechanisms are based on demand-side management techniques, such as preventing excess water use through better production planning and reducing water use through improvement in efficiency, savings and management. There is huge potential for reusing water both in industry and in houses. This potential creates closed loops where water is used multiple times during production and can be reused before being treated on site. Finally, the water can be restored to its former quality and used to replenish the watershed.

For the water industry, this means viewing wastewater as a resource rather than waste, while also tackling key global challenges such as energy use, water scarcity, and nutrient release into receiving waters. With the need to overcome these problems, the industry has been undergoing major changes in recent years, particularly through the use of various management and technological solutions, largely in response to stricter environmental legislation. Water demand management practices such as education, reducing losses and leakages, using conservation measures such as measurement, using efficient water use tools such as low-volume toilet flushes, low-water-using household appliances, and water efficiency labeling in some regions ensure the effective use of water. Prevention of discharge of pollutants to wastewater collection facilities, removal of biological nutrients, better operational management and control, for example, especially the need for ventilation and prevention of NOx and CH_4 formation, advanced anaerobic treatment (AAD) using pre-treatment steps such as thermal and enzymatic hydrolysis, increase the reliability of biogas production and It enables the control of pollutants. Therefore, many of the tools needed to achieve circularity in the waste industry largely already exist. The development of long-term, viable and coherent policy and a strong regulatory environment is necessary. The International Water Association (IWA, 2016) proposes a circular economy related to the water sector, evolving the concept of wastewater treatment plants from simple purification systems to fully integrated resource recovery facilities by separating the flow of water, materials and energy into three integrated pathways. Energy and a wide variety of chemicals are used in water treatment, and chemical and energy needs can be reduced by investing in the natural infrastructure in water resources. The cleaner the water taken from the source, the fewer treatment steps are required, thus reducing both investment and operating costs.

Investing in natural infrastructure as well as water treatment facilities is important because this improves aquatic ecosystems and also protects biodiversity.

Traditionally, rainwater has been widely used for seasonal irrigation of gardens. Rainwater from domestic and commercial roofs in urban areas can be used through harvesting and storage, in addition to landscape irrigation, for some household functions such as toilet flushing, and for laundry with varying levels of on-site treatment. In this way, the capacity of rainwater collection and removal facilities in urban areas is not exceeded.

Key outcomes have been investigated in an EU project called Smart-Plant (2021). In this project, the main outputs are listed and the efficient use of resources is emphasized to ensure that less raw materials and energy are used in water and wastewater treatment, and thus minimize material losses, as well as in saving water for a sustainable management. It can be reduced by eliminating or minimizing pollutants at the source of production, replacing pollutants with more sustainable products, and encouraging minimizing waste flows directly from homes, businesses and industry through better management.

The water industry uses huge amounts of energy, and one of the key factors in achieving sustainability and “net zero” emissions is to reduce this dependence by increasing the use of renewable energy, seeking low-energy alternatives to reduce fossil fuel consumption. The largest use of energy in houses after space heating, is for laundry, food preparation, and heating water for beverages. The use of low-water appliances, such as washing machines and dishwashers, and water-saving measures at home, such as water-saving showers and taps, can be encouraged, which forms the basis of water efficiency labeling. There are many opportunities to save energy as well as produce energy within the energy route. Where pressures and flows are high in water distribution networks, microturbines can be installed to generate electricity. Heat recovery is possible in the sewer system, for example from laundry and other hot wastewater streams. Wastewater can be up to ten degrees warmer than ambient temperature in winter. The high carbon content allows Biosolids to be used as an ideal fuel after processing. These processes include biogas production, gasification, pyrolysis, or simple biomass combustion after dewatering and drying. The remaining solids and ash are rich in nutrients and trace elements and can be used as fertilizer or further processed to recover certain materials such as metals. Water and wastewater treatment plants are often located in large areas, such as water resources. In recent years, these sites have been increasingly used for renewable energy production using wind turbines or solar panels. By combining biogas production with renewable energy production, wastewater treatment plants can be turned into green power plants that become self-sufficient in energy use and even produce more electricity than they need.

Emerging Technologies

Emerging technologies in wastewater treatment are almost exclusively associated with the enhancement of traditional biological and/or physicochemical processes (USEPA, 2013), but algal technologies have become widely accepted as low-cost, sustainable, and effective alternatives for the treatment of emerging contaminants (Shah et al., 2020). Natural treatment systems have not been fully exploited or sufficient research and investment has not been made. However, it is still a sustainable "net zero" wastewater treatment alternative. An important element of the circular economy is the recovery and reuse of wastewater components. Current processes used and developed also include energy recovery: Biogas as biofuel, on-site wind and solar power generation, combustion of biosolids, heat pumps, microalgae, wastewater hydroelectric power and bioelectric systems. Nutrient reuse: Application of biosolids to agricultural lands, use of wastewater in irrigation of agricultural and landscape areas, struvite production. Water reuse includes options such as use as irrigation water, indirect potable water reuse, industrial reuse and domestic reuse, direct potable water reuse.

Fertilizers are largely produced by the chemical fixation from atmospheric nitrogen to ammonia. This extra nitrogen, in the form of ammonia or oxidized nitrogen, enters the hydrological cycle due to overuse in agricultural areas and triggers eutrophication. Discharges from wastewater treatment plants play an important role in transporting nitrogen to surface waters. Initially, to prevent toxicity to fish, it was thought sufficient to oxidize the ammonia and convert it to nitrate, which could be safely discharged into surface waters with sufficient dilution. However, as the population increased, the need to remove nitrate and phosphorus became imperative to prevent eutrophication, often resulting in solutions with high energy needs.

Basic Sciences and Water Management

Chemical Experiments allow us to understand how our environment works and how to identify potential problems to the environment and human health. The scientific community has attempted to define and identify environmental problems for long time since environmental awareness. Processes in the Biosphere is like a reactor, which can be assumed as a closed system in which reactions take place, atoms and molecules are not created or destroyed.

Atoms and molecules are always present in our environment, combining into various compounds, existing in different physical states, being transported or accumulated in organisms. Air and water are used as moving and stabilizing medium for Biotic and abiotic chemical transformations in nature. All chemical reactions that occur in the environment and related to the natural cycles and transformation of elements on Earth are defined in Chemistry. The transformations or chemical interactions and processes of substances, natural compounds or living organisms released into the environment as a result of human activities are also considered within environmental chemistry and ecology. In the natural cycles of elements and molecules, biochemical and chemical transformations have been recycling substances and enabling ecosystems and organisms to coexist for thousands of years.

With rapid population growth, ever-changing and expanding demands for activities, products and services, humankind has increased the use of raw materials and thus environmental pollution. A lot of the contaminants are natural compounds but at higher concentrations. Therefore, the natural chemical cycles have been altered by releasing into environmental mediums large amounts of compounds that cannot be assimilated, transported, or transformed at the same rate as before human influence. This has led to adverse effects on the environment and health due to high concentrations of natural compounds and elements in a particular environmental medium, region or organism. High concentrations may exceed the toxicity levels of organisms or cause overgrowth of one organism relative to others. This changes reproductive rates, food chains, energy and mass balances in ecosystems. In addition to natural elements and molecules, man-made synthetic compounds have been produced that are beneficial to humanity and they are usually not natural substances. Pesticides are intentionally released into the environment while others have been discharged into the environment accidentally or as waste, partly due to a lack of awareness of their potential detrimental environmental impacts in the long or even short term. Pollutants released into the environment can undergo abiotic or biotic transformations and turn into harmless compounds that do not pose a health hazard. However, most xenobiotic compounds are toxic and can undergo partial transformations into even more toxic derivatives. Parent compounds or their derivatives are transported in the biosphere and then partially degraded in the environment by waste decomposition reactions. It is important to understand the chemistry of abiotic and metabolic processes and the biochemistry mechanisms of xenobiotic compounds and natural compounds in biotic processes. It helps to determine which chemicals do not pose a hazard to the environment and human health, which may be beneficial for human, and which chemicals are dangerous to use and carry a high risk for humanity.

Water plays an important role in the transport of elements in global biogeochemical cycles. Water acts as a reagent in the chemical transformations and as a medium in the transport of dissolved and solid compounds to different sources. The water cycle consists of the movement of approximately 600,000 km^3 of water through the cycle per year. Water is separated from its solutes through the processes of evaporation or freezing, mixing and reacting again with other compounds in its stream as it moves and condenses as rain or snow. Water flows on and under the ground until it reaches the oceans. Considering the water cycle, it is understood that it is almost impossible to find pure water in nature.

After addressing the problems, determining the degree of risk in the worldwide ecology-health system becomes a priority issue. The standards and regulations regarding the levels of environmental pollutants in application today are mostly guidelines. In every region of the world, in every country, the priorities of pollutants need to be evaluated according to their risk levels to human health. In terms of human health, exposure to pollutants mainly occurs in four ways: drinking water, air, soil and food.

Analyzing and cleaning or preventing the disposal of all priority pollutants that have a negative impact on human health in a region can be followed, but this entails incredibly high costs. At the beginning of the twentieth century, it was realized that we were on the verge of a global ecological crisis that threatened the existence of humanity. Industrial production still remains at the top of the sectors that produce high waste. For this reason, the concepts of sustainable development and circular economy have developed, an understanding that focuses on preserving ecological balance, trying to combine social, economic and ecological systems. When talking about drinking water quality, first of all the quality of drinking water supply sources should be considered and protected. The solution to existing problems regarding the protection of ecosystems from pollution and damage caused by humanity should aim to find new technical solutions and not only overcome the problems, but also prevent the causes that lead to negative ecological consequences.

Processes Affecting Water Composition

The composition of water in each region depends on its geological environment as well as the dissolution and chemical reactions of solids, liquids, and gases during the water cycle. Therefore, no generalization can be made for the composition of natural waters as there are many interdependent variables. Various processes cause the mixing of different compounds that affect the properties of natural waters.

Many pollutants can be broken down by certain microorganisms, that is, biodegradable, while others are very difficult or impossible to break down or assimilate through metabolism. Types of substances that degrade very slowly are called non-biodegradable or persistent substances. Although transformations of organic compounds can occur in the environment, such processes rarely completely transform organic compounds into inorganic substances. These processes usually occur through oxidation, hydrolysis or photolysis reactions. Biological processes can partially transform organic pollutants at discharge sites or during transportation. Biological transformation is largely carried out by microorganisms and causes changes in the structure and toxicological properties of pollutants. In order for microorganisms to continue their activities, they need organic or inorganic carbon sources, nitrogen, phosphorus, sulfur, some trace minerals, water and an energy source. Various conditions must exist for biodegradation to occur. The organism must be present in the environment and it must have the necessary enzymes, and the target substance must be within the physical reach of the degrading organism.

The abundance of microorganisms in an environment is related to physical and chemical factors such as the presence of carbon, oxygen and nutrients, temperature, pH and salinity. Biodegradation enables the transformation of organic compounds into inorganic substances, called mineralization. Microorganisms are important for biodegradation processes in contaminated soil, water and sediments because they mineralize anthropogenic organic compounds. Microorganisms cause biodegradation in many different environments. Wastewater treatment systems, soils, chemical waste disposal, groundwater, surface waters, oceans, sediments and estuaries are places where pollutants are eliminated by microorganisms. Microorganisms can degrade and mineralize different types of natural and synthetic organic pollutants.

Conclusions

Increasing population, increasing economic and industrial developments bring about increased use of natural resources. The waste generated for these reasons and the excessive use of resources create intense pressure on natural resources, biodiversity and ecosystems. It is important that economic and industrial developments occur in a sustainable manner, within the boundaries of ecosystems and without pushing the boundaries. Sustainable development and environmental protection can be possible through approaches such as effective use and reuse of resources, recovery of waste generated, and reuse of as much of it as possible. It is very important to improve and develop the physical, chemical and biological processes that are effective in these processes for the sustainability of energy and clean water resources, the treatment of wastewater and the recovery and reuse of the energy, organic substances and nutrients it contains. Developments and research in basic sciences are important.

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