Project Number: 1494
Project Acronym: RESIDUE
Project title: Risk reduction of chemical residues in soils and crops – impact due to wastewater used for irrigation

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D7.7 POSITION PAPER TO HARMONIZE POLICIES AND PRACTICES

SUMMARY

INTRODUCTION

RESIDUE is a 36-month project funded under the call "Management of Water" of the PRIMA Programme. This project addresses the urgent need to develop techniques in order to minimize the risks associated with irrigation with treated wastewater and fertilization with sewage sludge, particularly in regions with water scarcity. The main objective is indeed to improve the safety of agricultural products grown in countries that are required to use waste materials for irrigation and fertilization in agricultural practices. The concept of the project is to develop technology based on: improving soil functions to enhance in situ removal and detoxification of introduced organic pollutants, implementing new production procedures for safe soil amendments, and clear discrimination of non-bioavailable organic pollutants introduced into the soil that do not pose a risk to agriculture.

Agriculture is the production sector that requires more water resources, but population growth, urbanization, and industrial activities are responsible for the increasing deterioration of water bodies, exacerbated by climate change and the impact of emerging contaminants.
Arid and semi-arid regions around the world rely on wastewater as a source of irrigation; in fact, reclaimed wastewater accounts for more than 50% of the total irrigation water used in Israel, 17% in Spain, and 6% in California. The benefits of wastewater reuse include conservation of water that is not wasted and an alternative source of organic matter and nutrients for the agri-system. However, there are numerous safety concerns regarding the use of regenerated wastewater for crops.
Firt of all, there is apprehension about the contamination of ecosystems and croplands with organic pollutants, including endocrine-disrupting compounds, pharmaceuticals, and other synthetic chemicals. Emerging challenges are associated with the excessive and unsustainable consumption of drinking water, the treatment of water for drinking purposes, and the recycling of wastewater and sewage sludge. Some of these issues align with European directives aiming to regulate and reduce resource waste while limiting environmental damage caused by excessive consumption. However, in other cases, such as the utilization of sewage sludge and its composting into biochar, precise legislation capable of informing and raising consumer awareness is lacking[1,2,3,4].

The most recent reports of the European Commission and of the main international organizations underline the need to adequately develop measures aimed at facilitating the transition from the linear economy model to a circular economy model able to enhance an efficient use of resources.
However, each European country has its own legislation, leading to significant confusion surrounding the reuse of wastewater, agricultural irrigation, and drinking water consumption: there is no clear, precise, and comprehensive legislation that can explain how these products can be exploited, outlining their advantages, disadvantages, and potential consequences.
This results in significant limitations across different countries in the exploitation and sale of these products, which could otherwise make a substantial contribution to environmental remediation, in line with the concept of moving towards a circular economy model where waste can be effectively used.
Therefore, there is a gap in policies related to water quality and monitoring, specifically, the absence of uniform water quality standards has led each state to establish its own regulations. In the case of crop irrigation with reused water, the lack of standardization in these rules contributes to the increased technological and monitoring costs and impacts the acceptability of agricultural products from countries with rigorous standards, not allowing the development of a common market for these agricultural goods.
Bridging this gap will help promote the widespread adoption of water reuse practices, addressing the absence of harmonized standards and establishing an effective functioning of the internal market for agricultural products irrigated with treated water. This can be achieved by enabling the application of consistent sanitary standards for the food hygiene of these products.
The purpose of this **Deliverable 7.7 "Position Paper to harmonize policies and practices"** is to provide a summary of policy tools with a focus on the **PRIMA** countries: Italy, Spain, Germany, Israel and recommendations on how to implement the use of technologies in policy.

RESIDUE PROJECT

The Residue Project is part of an environmental sustainability approach that involves the maintenance of agricultural land and the reuse of wastewater.
The main objective of the project is to improve the safety of agricultural products grown in countries that are obliged to use waste materials for irrigation and fertilization in agriculture. The concept of the project is not to place limits on this practice, but to develop a technology with significantly reduced risks of transferring organic contaminants into agricultural products.
A special focus is placed to utilize locally available resources and make the new techniques easily applicable in common agricultural practice. Scientifically based characterization and optimization of treatment procedures allows application of these methods to similar waste materials available in other water-scarce locations. In this project, safe ways are proposed to improve soil functions by leading to in situ removal and detoxification of organic pollutants introduced by waste materials, including wastewater used in agriculture[2,3,4].
The project follows a three-phase approach: in the first phase, potential risks are analyzed by determining wastewater treatment products (WWTP) in agriculture, conducting experimental research to fill current gaps. In the second phase, a new composting technique developed for sewage sludge will be tested, based on the application of biochar. The biochar will be produced from locally available waste materials. The effectiveness of the new process in reducing contaminants will be verified by following the fate of selected organic substances that represent typical contaminants in sewage sludge. The last step is to experimentally test the sustainability of in situ substrate detoxification of irrigated wastewater in modified soils. Approaches will be at different scales, from laboratory experiments to outdoor field experiments conducted under realistic agricultural conditions. Laboratory and greenhouse experiments will be performed with ^{14}C radio-labeled organics to understand their fate and detoxification processes.

The countries involved are Italy, Spain, Germany and Israel, in each of which water is one of the most important factors for agriculture. In Italy, the project will support the policy on recycling routes for sewage sludge use in agriculture as low-cost organic fertilizer. Food safety implies the prevention of pollution by wastewater as source by appropriate pre-treatment before use in agriculture. However, the regulation of purified wastewater and sewage sludge in agriculture in Italy is very fragmented, especially between the southern and northern regions. For Spain, the high rate of sewage sludge and wastewater used in agriculture makes this project of extreme importance. The project will provide not only new insights into the risk associated with this practice, in relation to chemical pollution and food safety issues, but also a strategy on how to reduce this risk. For Germany, the results will also be of great value for the safety and quality assurance of sewage sludge application in agriculture. There is no current need in this country to use wastewater for irrigation, but sewage sludge application is still an important way to ensure a valuable supply of nutrients to agriculture. Sewage sludge composts may find wider application if the risk of contamination from organic contaminants can be significantly reduced. Among these, Israel is the country where, in order to exploit all available water sources, WWTP is widely used for irrigation of fields. In this country, more than 50% of irrigation is done with treated wastewater.

1. WATER CONSUMPTION, DEMAND FROM PRODUCTION SECTOR AND WATER QUALITY

In Europe, population growth, urbanization and industrial activities are responsible for the increasing deterioration of water bodies, exacerbated by climate change and the impact of emerging contaminants. According to the water status survey reported by the Nitrates Directive in 2015, 25% of groundwater had poor chemical status due to anthropogenic activities and the chemical status of 40% of surface waters was unknown, demonstrating the need for a better and harmonious water quality monitoring system.[5]

According to the EEA's Water Exploitation Index, economic activities in Europe use an annual average of about 243,000 cubic hectometers of water, mainly for agricultural uses, responsible for 40% of total consumption, a percentage that rises to 60% in the spring as production intensifies. Water stress related to agricultural use leads to severe impacts on river flows and is closely linked to the development of nutrient and pesticide pollution of about one third of Europe's surface waters and groundwater bodies. Energy production requires 28% of water annually and it is used for cooling in nuclear and fossil power plants, followed by mining and manufacturing (18%) and domestic use (12%)[6].

In Europe, drinking water consumption averages 144 liters of water per person per day. In 2019, in Italy, according to the Italian National Institute of Statistics (ISTAT), drinking water consumption for domestic, public, commercial, and industrial uses was 9.2 billion m^3 or 419 liters per day per inhabitant. According to the Regulation on the Reuse of Purified Water, Italy is the second country in Europe for fresh water consumption, preceded only by Greece[7].
National water abstraction for domestic use derives mainly from groundwater (48.9% from wells and 35.9% from springs), placing Italy in seventh place in Europe for use of groundwater sources; 15.1% from surface water (9.8% from artificial reservoirs, 4.8% from surface watercourses and 0.5% from natural lakes) and the remaining 0.1% from sea or brackish water[8].

It should be noted that there are significant differences in the amount of freshwater extracted within each of the EU member states, the result of different geographic conditions, resource availability in each country, and extraction practices and industrial and agricultural structure.
Total freshwater extraction ranges from 41 million m^3 in Malta (2018 data) and 31,260 million m^3 in Spain (2016 data) to 61,094 million m^3 in Turkey (2018 data). Between 2008 and 2018, the total volume of freshwater extracted increased at the fastest rate in Denmark (+54 %) and Turkey (+45 %). The largest decreases were recorded in Lithuania (-87 %, due to reduced cooling water requirements in electricity production), Germany (-25 % from 2007 to 2017) and the Netherlands (-24 %).
In Finland (2006 data), surface water extraction required about 24 times the volume of water extracted from groundwater resources, while the ratio of surface to groundwater resources was between 8 and 9 to 1 in Romania and Bulgaria (2018 data).
In 2018, freshwater abstraction for public water supply varied across EU Member States with a maximum of 157 m^3 of water per inhabitant in Greece (2017 data) and a minimum of 30 m^3 per inhabitant in Malta[9].
Finally, the extraction of seawater and transitional water, such as salt marshes, lagoons, and estuarine areas is common in some EU Member States, such as Sweden (11,832 million m^3; 2007 data), the Netherlands (6,165 million m^3; 2016 data), and France (5,212 million m^3; 2017 data) recording the highest volumes of water extracted from non-domestic sources.

Due to the extensive multisectoral utilization of the resource and its consequential environmental impact, there is a growing interest in wastewater reuse in certain parts of Europe. Article 12 of the Urban Wastewater Treatment Directive (Directive 91/271/EEC)[37] indicates that treated wastewater should be reused whenever appropriate.

Up to 30% of total domestic water consumption could be saved by reusing gray wastewater, defined as water produced in bathtubs, showers, sinks, washing machines and kitchen sinks, in households, office buildings, schools, etc. to flush toilets. The reuse of gray wastewater from toilets has been successfully used in Germany, where it has been shown to be technically feasible, health criteria are met, and 10 to 15 L per day of water per environment are saved.
The largest application of this reuse is for crop irrigation, golf courses, and sports fields. Despite its high potential, water reuse is not without environmental and human health risks[10]. Most of the organic matter, nitrogen and phosphorus in wastewater relates to human excreta and phosphorus detergents, although many European countries have witnessed a reduction in the phosphate content of detergents and consequently in wastewater in the last 20 years.

2. CLEAN AND SAFE WATER EUROPEAN DIRECTIVES

Water management and consumption

In Europe, the management, consumption and reuse of water are regulated by a regulatory framework that is based on the water framework directive 2000/60/EC, which provides for “water efficiency measures, reuse and water saving techniques for irrigation” to help achieve good environmental status. The directive does not define peremptory constraints on the use of specific water sources, as long as the purpose does not compromise the achievement of environmental objectives for good water status.
In the year 2006, the “groundwater directive” 2006/118/EC was then established to complement the previous directive to ensure the safety of groundwater recharge with regard to contamination (e.g. Pesticides) by rainwater runoff.
Talking about urban wastewater treatment, there is the "council directive 91/271/EEC[37] "urban wastewater treatment directive" which promotes the reuse of "treated wastewater where appropriate", as long as it is not prohibited by other EU legislation and does not imply environmental degradation; no limitations are noted in this directive for the reuse of treated wastewater when quality standards are achieved. In order to meet the requirements of the previous directive, EU member states have prioritized urban areas where huge investments have been made in wastewater collection and treatment systems: they promoted the reuse of wastewater sludge whenever appropriate and supported the implementation of technologies aimed at treatment and subsequent reuse of sewage sludge. Nevertheless, the refit of the urban wastewater treatment directive (December 2019) stated that further efforts are still needed to achieve full compliance with the directive in terms of collection and secondary treatment.
Previously, the European commission (2017) determined that small-scale decentralized systems could contribute to the achievement of the stated goals by improving sludge quality and recovery as well as minimizing the consequences of pollution from stormwater overflows. This will be possible by increasing the reuse of treated wastewater while ensuring adequate water quality and reducing the energy demand of sanitation systems by using (when possible) energy from renewable resources at the treatment plant (e.g., biogas)[22].

Drinking Water Treatment

In the realm of drinking water treatment, it is challenging to enforce quality standards for small-scale water supply and sanitation systems.
When groundwater recharge is involved, discharged water is regulated by the WFD in terms of quality to maintain "good" groundwater status. For this area, there is the "Council Directive 98/83/EC[40] "Drinking Water" (DWD) (and its EU revision 2015/1787)" which covers systems that aim to produce drinking water and is the starting point for defining actions at the national level. Despite the binding nature of the directive, measures are mandatory for distribution systems serving more than 50 people or supplying more than 10 million water per day, while for small-scale systems some exemptions may apply (Art. 3(2)). Thus, domestic and small-scale supply systems (e.g. local wells or springs) for rural communities

are not regulated, nor is the ability to produce drinking water from alternative sources (e.g. rainwater and/or water vapor). In line with this directive, the WHO Joint Monitoring Program (JMP) was created, which defines stormwater as an "improved" source of water for potable uses in rural and urban areas with respect to protection from faecal matter contamination.

The main objective of EU and national water policy is therefore to ensure that all citizens have access to good quality water in sufficient quantities and to ensure the good status of water bodies throughout the territory. Pollutants and contaminants in water endanger not only natural ecosystems, but also public health, while water scarcity and droughts have serious consequences on the economy.

In Italy, the EU Water Framework Directive (2000/60/EC)[29] is the reference legislation for water and drinking water management. The Northwest and Southern regions are the primary sources providing more than half of the drinking water withdrawals. The exploitation of surface water is considerable in Basilicata, Puglia, Sardinia, Liguria and Emilia-Romagna. Lombardy is the region where the largest volume of drinking water is withdrawn (15.4% of the national total), followed by Latium (12.5%) and Campania (10.1%).

The variability over the territory is considerable, due not only to the different water needs but also to the location of the water bodies, the different water transport infrastructures and the trend of the supply service.

Water quality depends on the characteristics of the water body from which it originates, influencing the treatment of water before it is distributed to end users. Ordinary operations require a disinfection and chlorination process, but one-third of the water consumed is purified by a much more complex process that removes contaminants. Groundwater, which comes from rocks, is generally of good quality and does not require purification treatment unless anthropogenic or natural contamination events are observed. In contrast, surface water must be purified in almost all cases. Purification processes are mostly applied in Basilicata (80% of water) and Sardinia (79%) due to the withdrawal of water from surface and reservoirs. A high value is also registered in Emilia-Romagna (59,3%), Apulia (58,8%) and Tuscany (56,5%).

From studies taken from the literature, Italy ranks fifth in Europe for tap water quality, demonstrating the daily commitment of the various managers in terms of control and analysis of the resource. In order to ensure the quality of the water supplied and that returned to the environment, all phases of the integrated water cycle are subject to a complex control activity carried out both at the plants and through laboratory analysis. In particular, the integrated management of the water service on the territory allows to make water available for civil and industrial uses and consumption in all phases of the cycle: from the collection to the potability up to the distribution to the users, from the management of the sewerage network to the purification up to the return of the water to the environment[19].

Another important European directive related to water management is the Drinking Water Directive (98/83/EC)[40], which concerns the quality of water intended for human consumption. Its objective is to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is healthy and clean. This directive has been transposed into Italian legislation by Legislative Decree 31/2001 and Legislative Decree 27/2002. These two decrees establish a set of 62 (14 extra parameters compared to those required by the EU directive) microbiological, chemical and physical parameters to be monitored and tested regularly. The tests are carried out by both internal (the water service provider) and external (ASL - and Regional Agency for Environmental Protection) supervision. ASLs are responsible for judging the suitability of water for human consumption. The legislation provides for the possibility of parameters in exception to the values established within the maximum allowable values established by the Ministry of Health in agreement with the Ministry of Environment. However, these exceptions must only be maintained for the time necessary to allow the competent bodies to take measures to reduce the values of the water below the parameters required by national law. In any case, they must not exceed three years from the request to the Ministry of Health. The national legislation also provides for a final derogation period of up to three years to be submitted directly to the EU Commission. The first increase in the limits of contaminants in drinking water as a derogation to national legislation was requested in 2003 and, from 2003 to 2009, 13 regions (Campania,

Emilia-Romagna, Lazio, Lombardy, Marche, Piedmont, Apulia, Sardinia, Sicily, Tuscany, Trentino-Alto Adige, Umbria, Veneto) have requested exemptions at different times on a total of 13 parameters (arsenic, boron, chlorites, chlorides, fluoride, magnesium, nickel, nitrates, selenium, sulfate, trihalomethanes, trichloroethylene, vanadium). After six years, some regions (Campania, Lazio, Lombardy, Tuscany, Trentino-Alto Adige, Umbria) have requested a third exemption for arsenic, boron and fluorides. These requests were only partially accepted by the European Commission; in particular, the exemption for arsenic above 20 μg/L (a limit indicated by WHO as not dangerous if taken for limited periods) was refused. The unexpected refusal affected 128 municipalities and a population of about one million people.
Finally, it is important to mention the Nitrates Directive (91/676/EEC), which is an integral part of the Water Framework Directive and is considered one of the key elements for the protection of water from nitrates, a vital nutrient for plants and crops but dangerous to humans and the environment if present in high concentrations. The European directive aims to protect water quality throughout Europe by preventing nitrates from agricultural sources from polluting groundwater and surface water and promoting the use of good agricultural practices. The maximum value set by the European directive above which water is considered polluted by nitrates is 50 mg/L. Legislative Decree 2006/152[30] with article n. 92, transposes the directive into Italian legislation. The European legislation also establishes the identification of nitrate vulnerable zones, corresponding to territories characterized by waters polluted by nitrates or affected by nitrification or that could be polluted if nothing is done to prevent it. In these zones, Nitrate Action Programs (NAP), a series of measures to be taken by farmers to improve water quality, must be defined. Ministerial Decree n. 5046 of February 25, 2016 is the reference for the adoption of the NAP: it represents the National NAP to which all regions refer for the adoption of regional NAPs.

In Spain, the situation is a bit different. In fact, Spain has one major water management challenge: water scarcity, including the need to secure water supply, manage demand for competing water uses and recover over-exploited water resources, in the face of climate change. This is reflected in water planning and management system in Spain, in order to achieve the water quantitative and water quality objectives of the Water Framework Directive (WFD).

Water Resources Act 29/1985, which in practice allowed for a comprehensive inclusion of continental water resources in the hydraulic public domain by listing what would be considered commodities in the hydraulic public domain from the time it came into force, which exclusively affected groundwater compared to the contents of the previous 1879 act. Therefore, all continental water resources were simply qualified as belonging to the public domain. However, Act 29/1985 recognized the open choice for owners of private water right to choose, within a certain time limit, to continue to be privately owned and be able to change, under certain conditions and public system.
Landowners were granted use rights for rainwater (Article 52.1) and water from wells or springs (Article 52.2).
Article 45 SC establishes the rational use of natural resources (and therefore water) with penal consequences for the evolution of water legislation and policy in Spain. This "rational use" of water, seen as the need to apply saving and conservation policies, which can even go so far as to determine preferences in use claims, can also be found throughout the text of Law 29/1985, and is part of the environmental policy of the European Union, with its specific inclusions in the Community Treaty as amended in Maastricht and Amsterdam (see Article 174.1)[25].

Spain is the third most water-stressed country in the EU, after Cyprus and Malta, with gross freshwater abstraction representing 28% of total available renewable freshwater resources (EuroStat, 2019c). The spatial and temporal distribution of rainfall and distribution of water resources is highly variable within the country, with annual mean precipitation ranging from 2000 mm in the North-West to less than 300 mm in the South-East (Francés et al., 2017). Climate change is anticipated to have a greater impact in Spain relative to most other EU nations (Estrela Monreal et al., 2012; Lázaro-Touza and López-Gunn

2014). Climate change is increasing temperatures and evapotranspiration rates, and significantly altering rainfall, runoff patterns and groundwater natural recharge rates; water resources are projected to reduce by 28-40% by 2050 (CEDEX, 2018). More than 74% of the Spanish territory is at risk of desertification; the regions of Murcia, Valencia and the Canary Islands are the most concerning areas, with a "high" or "very high" risk of desertification across 90% of their territory.

On the opposite side, Germany's water resources are relatively abundant, although there are shortages in some regions due to low groundwater levels and high demand from industry. Germany is among the top 3 European Union member countries in terms of compliance with the Urban Water Treatment Directive, with 100% of wastewater collected and 99.9% of it being subject to secondary treatment (European Commission, 2017). Germany fully complies with the requirements of Article 5(4) of the Directive on more stringent treatment; wastewater treatment plants achieve removal of 81% of nitrogen and 90% of phosphorus (UBA, 2014).

Despite these high rates of compliance with the DWD and UWTD, continued efforts are still needed to bring access to wastewater treatment in eastern Länder fully up to western Länder levels (OECD, 2012). The Federal Ministry of the Environment has developed a climate change adaptation strategy (German Federal Government, 2008). Storm speed and surges along the Baltic and North Sea coasts are expected to increase, which will require expanded coastal protection by the end of the 21st century. Decreased rainfall in the summer, combined with temperature rise, is expected to affect agricultural production, especially in south-west Germany and parts of the eastern Länder. The main pressure on German surface waters is flow regulation and hydromorphological alteration that affect 79% of surface water bodies (European Commission, 2017). The implementation of measures to reduce hydromorphological pressure in river basins is, therefore, likely to induce costs and investments.

The organization of the drinking water supply in Germany has been in place for more than 100 years, but it is continuously updated in line with technical and hygienic requirements.
This water must meet the high quality requirements of the law. In order to protect the drinking water supply, water protection areas are designated. In 2004, there were about 13,428 water protection areas covering a total area of about 43,100 km, or 12% of the total territory of the Federal Republic of Germany.

The Water Framework Directive (WFD) requires all water bodies to achieve good status until the year 2015. For groundwater this means having a good quantitative and chemical status. Good quantitative status means having a balance between groundwater abstraction and recovery. In Germany, this has already been achieved for 95 % of all groundwater bodies.
The WFD specifies environmental quality standards for nitrates of 50 mg / l and for pesticides of 0.1 μg / l and defines the European environmental quality standard level by determining 33 hazardous materials.
Water pollution control and surface water management in most German federal states are spread over several levels:
- The higher water authority (usually the Ministry of the Environment) with responsibility for strategic decisions.
- The upper, upper or middle water authority which, as a rule, is assigned to district committees or regional governments and is responsible for regional water management planning.
- The lower water authority (cities, towns, urban and rural districts, as well as water management offices) with monitoring, technical advice and executive functions.
The Federal State Working Group Water (LAWA), which was established in order to harmonize federal state water laws, is composed of the upper water authorities. Federal states have also formed working groups for coordination in watershed management[31].

Israel is a country with a high level of water stress. To provide its rapidly growing economy with sufficient and reliable water, it has combined institutional and regulatory reforms with massive infrastructure investment[14].

80% of the mountain aquifers, the largest bodies of water in these regions, are located in the West Bank subsoil, the remaining 20% in the Israeli subsoil. Realizing the importance of this vital resource, which currently provides 40% of Israel's agricultural needs, and almost 50% of its drinking water, after the war Israel began to change the legal and institutional status of water rights in the occupied regions. The main effect of this transfer of power was a heavy restriction on the drilling of new wells to meet the needs of the Palestinian inhabitants, in parallel with the appropriation of water to meet the needs of the Israeli population[33].

The law governing the use of water for agricultural purposes is the "Water Law, 5719-1959" (the Law) and subsidiary legislation. According to the law, water sources in the State of Israel are publicly owned and controlled by the state for the purpose of meeting the needs of Israeli residents and developing the country. The law specifically provides that "the right of a person in any land does not confer on him the right in a water resource located therein or cross it or border on it [34]."

The Water Act requires every person to use water economically and efficiently, to maintain water facilities in good condition to avoid waste, and to ensure that water sources are not clogged or depleted. A violation of these requirements may result in an injunction requiring the repair or discontinuance of water production, supply, or use pending rectification. Production of water from a water source, or desalination of water for personal use or for supply to others, requires a license issued by the Government Water Authority (GAW). The license specifies the amount of water the licensee may produce and supply and includes any other conditions determined by the GAW, including the amount of water that may be used by the licensee for agricultural purposes. This amount shall be determined according to a formula adopted by the Secretary of Agriculture in regulations.

In accordance with the Water Act, GAW may issue a declaration designating a specific region as an area subject to water use restrictions. Such a declaration may be issued when GAW has determined that water sources in the designated area are insufficient to maintain current water use. The designation of an area subject to water use restrictions must be published in the GAW. After the designation is published, GAW may determine the maximum level of water consumption allowed in the designated area for agricultural purposes[35].

The vast majority of Israeli citizens enjoy water supply through a direct connection to the national water system. However, the projected population growth and the diminishing supply of water from natural sources present a challenge for maintaining this access. Large-scale reuse of wastewater and desalination of seawater compensates for the lack of freshwater resources. Using advanced reverse osmosis technologies and improved process engineering, Israel’s five desalination plants are among the most efficient in the world, supplying over 80% of the country’s domestic urban water (i.e. water not used for irrigation). However, desalination has adverse environmental impacts. Apart from being highly energy intensive, the process produces brine. Discharges of brine into the sea can lead to increased salinity and temperature and accumulation of several potentially toxic substances in receiving waters. All Israeli desalination companies must monitor the coastal area of the Mediterranean around their plants for effects of brine disposal.

In 2012, the Water Authority published a National Long-term Master Plan for the Water Sector through 2050. It covers protection of water resources, water supply and wastewater management. The master plan defines the vision, goals and objectives of the national water sector, as well as policies on major water issues. The plan aimed to integrate engineering considerations (ensuring the quality and quantity of water) with structural, economic, environmental, social and legal ones.

The 2012 master plan provided a medium- and long-term forecast for the balance of water resources in the country. It assumed a drop in the supply of natural water and an increase in non-conventional sources, including wastewater reclamation and desalination. In 2018, the government adopted a strategic plan for coping with periods of drought for 2018-30. Main measures include increasing supply of desalinated water, reducing demand and encouraging water conservation, and reinforcing protection of Lake Kinneret.

Israel has made significant progress in implementing a 2011 EPR recommendation to improve water allocation among sectors and to nature. In 2013, the INPA, MoEP and Water Authority jointly issued a Master Plan for the Supply of Water to Nature. An inter-ministerial team prepares and approves river plans to see how much water is needed for individual ecosystems. The plan determines how much water to discharge, what type and when. Approved plans exist for several major rivers. Water plans relate to ecological, hydrological and regulatory aspects of the overall planning for a river. They determine the flow regime, water quality and actions necessary to protect the ecosystem or rehabilitate it, considering other uses and needs from upstream to downstream. In some places, they set aside a minimum quota of water for ecosystems. Such water plans align with the 2011 EPR recommendation to define water quality objectives for all stretches of rivers. A manual describes the bodies and institutional and regulatory framework involved in preparing water plans.

The Israel Centre for Aquatic Ecology, established in 2015, determines the biological standards used to assess the ecological status of the country's streams. A database with ecological and hydrological data for each of Israel's aquatic habitats (about 200 total) has been prepared. However, the methodology for water allocation for nature has been implemented at fewer than half of these sites due to lack of funding.

3. AGRICULTURE AND THE STATE OF RESOURCE CONSUMPTION

Agriculture as well as the food and beverage industry account for 78% of employment and 66% of value added in the European bioeconomy. Agriculture also contributes to the production of biomaterials such as bio-based textiles, plastics, chemicals, pharmaceuticals and liquid biofuels. Agricultural land covers 42% of the surface area of the 39 members of the EEA and a total of 245 million hectares. In the EU, the proportion is slightly higher, covering 199 million hectares or 45% of the area. Most agriculture uses the land for arable crops, especially cereals, and for permanent crops such as olives, grapes or fruits (25%), and the rest are pastures and mosaics of mixed land uses (17%). The distribution and importance of the different land cover classes varies greatly among member states. Land cover in countries such as Denmark and Hungary is strongly influenced by arable land, covering more than half of their area. Ireland and Malta, in contrast, are characterized by a high proportion of grassland and mosaics. In Sweden, Finland, and Montenegro, more than 60% of the area of each country is covered by transitional forest and shrubland, and a smaller proportion of these lands is allocated for agriculture, even though a significant portion of their forested areas is under management. In recent years, there has been a progressive decrease in agricultural lands: between 2000 and 2012, there was a net loss of agricultural land of nearly 100,000 hectares per year, while between 2012 and 2018, the rate dropped to about 50,000 hectares per year. The urban land use of agricultural land in SEE-39, which was around 85,000 ha per year between 2000 and 2012, decreased to 57,000 ha per year between 2012 and 2018. Unfortunately, this reduction in land use does not necessarily alleviate the overall pressure on the water environment or other challenges such as pollution, abstraction pressures, or hydro-morphological changes associated with the expansion of artificial areas.

In Europe, land exploited for agricultural activities has an area of 199 million hectares; these are exploited to grow cereals, permanent crops and pastures. In fact, Denmark and Hungary have a prevalence of arable land, while in Ireland and Malta pastures prevail and in Sweden, Finland and Montenegro we have a prevalence of forests and shrubs.

Agricultural systems can be both intensive and sustainable. There are essentially 3 criteria for sustainability, and they relate to the intensity of land use, the level of specialization on farms and the level of knowledge and use of sustainable practices. To date, it has been calculated that 66% of agricultural systems are medium/high intensive while 39% are considered semi-intensive. The highest share of total UAA managed by high intensity farms is found in the Netherlands (88%), Belgium (76%) and Malta (61%), followed by Denmark, France and Luxembourg (between 47% and 50%). In contrast, low intensity farms were found more widely in Estonia (79 %), Portugal (73 %), Latvia (70 %), Romania (69 %) Lithuania (66 %)[11].

Surface waters are often subject to several pressures from agriculture at the same time. Each pressure has a very specific environmental impact, which can be severe; a combination of different pressures can result in a greater range of environmental impacts on aquatic ecosystems, and more management strategies will therefore be needed to improve the status of surface waters. To highlight this issue, the combined intensity of agricultural pressures on water was calculated for Europe. The results show a clear east-west division with lower intensities in Eastern Europe and much higher intensities in Western Europe. The intensified use of different types of tools to improve production in European agriculture has led to impacts on multiple environmental dimensions, such as biodiversity, air quality, climate, soils, and water. The use of fertilizers, pesticides and water irrigation results in pollution, extraction and hydro-morphological pressures on water resources and aquatic ecosystems[11,21].

The loss of landscape features and the increased field sizes can contribute to heightened soil erosion and pressure on the water environment, as well as biodiversity. Although there is no agreed-upon definition of agriculture, FAO established five principles to guide the development of a sustainable agricultural system:

1) Improve resource use efficiency;
2) Conserve, protect and enhance ecosystems;
3) Protect and enhance rural livelihoods and social welfare;
4) Improve the resilience of people, communities, and ecosystems;
5) Ensure responsible and effective governance mechanisms;

Terms such as conservation agriculture, regenerative agriculture, agroecology, organic agriculture, biodynamic agriculture, high nature value agriculture, permaculture, carbon agriculture, and climate smart agriculture have been used to describe different forms of sustainable agricultural systems.
Organic agriculture is the most regulated of the sustainable forms of agriculture, but it is also expanding rapidly in response to consumer demand for sustainable food. The concept of agroecology has received increased attention in recent years, as it encompasses many principles that underlie the idea of sustainable agriculture. Agro-ecological practices aim to optimize the use of natural resources, enhance biological processes, soil and improve biomass, nutrients, carbon and water cycles. They also aim to reduce dependence on off-farm resources and increase resilience to disturbances and shocks, such as climate change, particularly by diversifying agricultural activities and production. In Europe, the network of protected sites under the Birds and Habitats Directives (Natura 2000 network) hosts some of the least intensive forms of agriculture. These include livestock farming, systems that rely primarily on forage from vegetation, as well as low-intensity arable systems, often in rotation with semi-natural fallow vegetation, low-intensity permanent crops such as traditionally managed orchards, and land under mixed farming, systems with a mosaic of low-intensity agriculture and valuable landscape features. Sustainable agriculture emphasizes the need to adopt a range of more natural, efficient resources, practices, and alternative crops. It can rely on innovations in genetic improvements, precision agriculture, and integrated agricultural tools, along with nature-based tools ecosystem-based solutions across the agricultural landscape.

In this context, the following paragraph will analyse the situation regarding the water consumption in the countries involved in the RESIDUE project: Israel, Germany, Spain and Italy.

State of irrigation water consumption in Italy, Spain, Germany, Israel

Agricultural use of water to irrigate fields represents the main form of consumption of the world's water resources and involves two-thirds of the world's freshwater availability.
Water needs in agriculture depend on many factors, including climate, soil type, cultural practices, irrigation methods, crop types, and others.

Irrigation water consumption in Italy

Water resources in Italy are distributed unevenly, with more abundant resources in the North and scarcer resources in the South. Most water withdrawals are for agriculture and industry, with only 18% of water withdrawals made for drinking water supply.In terms of water demand from the productive sector, agriculture drives the highest percentage of consumption (nearly 60%) used primarily for irrigation. In 2015-2016, the irrigated area was 2,553 thousand hectares with an average volume of 5,000 m^3 pro hectar used for irrigation. The manufacturing industry, which includes a variety of industrial sectors, such as pulp and paper, textiles, chemicals, and food and the livestock sector are respectively the second and third production sectors that require water with an estimated 3.79 billion m^3 and 317.5 million m^3 respectively in 2016. Lombardy has the highest volume of water consumption (15.4% of the national value) caused by the presence of 20% of the national irrigated area.

Irrigation water consumption in Spain

Also in Spain, the agricultural sector is the largest consumer of water; it accounted for 65% of total water abstractions in 2016 (FAO, 2020). Irrigated land accounts for 56% of total agricultural production, while groundwater represented less than 30% of Spain's irrigation (OECD, 2015b). Some regions, such as the Upper Guadiana basin, experienced intensive, sometimes illegal, groundwater extraction for agriculture, which contributes to the degradation of ecosystems (OECD, 2015a). Water resources in Spain have a high hydrological irregularity and diversity. In fact, the hydrological variability and the irregularity of the hydrological regime, space and time generate significant challenges for water management.

The areas with the highest water abundance per unit are the North and Galicia, with values above 700 mm/year. In the rest of the country, the so-called "dry Spain", water availability does not exceed 250 mm/year. The lowest water availability in Spain occurs in the Segura basin, where it barely reaches 50 mm/year (about 20 times lower than in Galicia and 5 times lower than the national average).

The total runoff (direct surface runoff plus groundwater runoff) is estimated to be around 220 mm/year, equivalent to some 111 000 Hm^3/year, with great spatial variability ranging from areas where runoff fluctuates between 1 and 150 mm/year (southeastern Spain and central areas) to other areas where it is greater than 1 500 mm/year, in the northern basins and mountainous areas of some basins (MMA, 2000). Flow is managed or controlled to some extents, as are partially regulated water systems. There is significant non-consumptive use in hydropower.

Irrigation Water Consumption in Germany

Germany's water resources are relatively abundant, although there are shortages in some regions due to low groundwater levels and high demand from industry. However, annual water abstraction per capita has been regularly decreasing and is well below the OECD Europe average (OECD, 2012).

In order to meet the growing demand for food and agricultural commodities, agricultural production is continually being expanded, leading to an increased demand for water. Germany is generally considered to be a water-rich country, with an annual water supply of about 188 billion m^3, and a usable water supply of 2292 m^3 per person per year. Although some regions have temporarily limited water supplies, extraction and distribution systems are currently able to meet water demand throughout the country[12].

In addition to the 3.60 billion m³ of groundwater used for public water supply, other sectors used 2.36 billion m³ of groundwater and spring water in 2016. Of this figure, the mining and quarrying sector has 1.14 billion m³, the manufacturing sector for 0.73 billion m³, agriculture, forestry, fisheries, including irrigation associations for 0.23 billion m³, energy supply for 0.08 billion m³, water supply, wastewater and waste disposal for 0.08 billion m³, and other sectors of the economy for 0.09 billion m³. From the total volume of 19.24 billion m³ of water used by other sectors in 2016, groundwater and spring water accounted for 12.3%.

Irrigation applies to areas of intensive agricultural and horticultural activities with annual precipitation rates below 700 mm. It is estimated that today there about 531,000 hectares of land (3% of the agricultural area) are irrigated. The irrigation methods used are primarily systems for which groundwater is generally extracted. The annual amount of water used for irrigation purposes varies between 80 and 150 mm or 425 and 800 million m³ per year, respectively.

In the future, after a reduction of more than 330,000 hectares of irrigated area in the new federal states due to inefficiency, irrigation will not steadily increase again[12].

Irrigation Water Consumption in Israel

Israel has been a global leader in the efficiency of irrigation applications, in the use of groundwater with relatively high concentrations of salts and recycled municipal wastewater, and recently in the use of large-scale seawater desalination for human consumption and irrigation[13].

The multi-year average of natural water supply in Israel in the years 1994-2004 was 1,840 MCM (million cubic meter), the total on sources for the year 2004 was 2,085 MCB and the total pumping was 1,764 MCM. Total production from the natural water system was 2,187 MCM. Israel has also recently started

producing about 100 MCM of fresh water via seawater through the desalination plant located in Ashkelon.
The recycling of 86% of Israel's wastewater now provides 50% of the country's irrigation water. The country is composed almost entirely (93%) of dry land – meaning that most of the land has an annual aridity index or precipitation to potential evapotranspiration ratio (P / PET) of between 0.05 and 0.65.
Today in Israel, agriculture accounts for about 2.4 of GDP and about 2% of exports counting on a total workforce of 2.7 million people, of which 8.9% are employed in agriculture (6.3% in and services and 2.6% in production) [14].
The Israel Water Authority reports that over half of the irrigation water used by farmers in Israel today is derived from wastewater, allowing 130,000 hectares of farmland to be cultivated (Israel Water Authority, 2015). About half of Israel's wastewater is treated at the secondary level, typically using activated sludge technology, while the other half undergoes tertiary treatment. In addition, dryland farmers often use "brackish" waters with high levels of salinity[15].
Agriculture accounted for more than half of total water consumption in 2020, while domestic use was responsible for about a third. Israel's gross freshwater abstraction per capita is among the lowest in OECD member countries. Israel is the largest user of recycled effluent water for agriculture across OECD member countries: more than 87% of wastewater effluent is reused for agriculture, representing approximately half of total water that farmers use nationwide (Marin et al., 2017). A national bulk water conveyance system allows for optimisation of water distribution from various sources depending on demand. Massive public awareness campaigns have emphasised the value of water. Quasi-universal water metering allows for strict enforcement of water abstraction quotas.
Still, freshwater accounts for 36% of water use in agriculture, contributing to high levels of water stress. In 2018, entering the sixth year of the long drought, the Water Authority imposed permanent cuts in agricultural water quotas of up to 41% for irrigators accessing the national water system. Farmers could voluntarily waive part of the quota in exchange for support. Overall, between 2000 and 2018, agriculture's share of freshwater abstractions decreased by more than half to reach about a third of total water abstractions (OECD, 2019c).

4. RESOURCE RECOVERY: THE WASTEWATER AND SLUDGE EUROPEAN DIRECTIVES

Wastewater treatment and reuse

The Water Reuse Minimum Requirements Regulation (EP,2020) is intended to encourage the reuse of treated municipal wastewater, so small-scale decentralized systems can be legally supported in their implementation. It should be considered that for small-scale systems, it is critical to adopt the risk-based approach outlined in the Water Reuse Risk Management Plans (WRRMPs), which are also included in Proposal 2018/0169 (COD), currently being considered by the European Committees. When considering small-scale collection and treatment systems, human, technical, and financial resources are often limited, so water monitoring strategies may be challenging. However, the hazard prioritization and risk ranking introduced by the WRRPM can be a valuable monitoring strategy for a small-scale water system. Then there are the "Guidelines for the Use of Treated Wastewater for Irrigation Projects" for decentralized systems, a legal tool that can be used as a reference for technical, economic and environmental aspects. These provide scientific support by highlighting the need for a WSP risk approach to protect public health when small-scale decentralized systems are applied, and provide prescriptions for the safe management, operation, and monitoring of wastewater, excreta, and graywater in agriculture and drinking water quality. In most cases, successful implementation of WSPs is limited by several factors such as lack of financial resources and lack of legislation. It should be noted that when considering small-scale solutions, economic sustainability is a crucial factor. In addition, alternative water sources for drinking water production should also be considered. Regarding the aspects of water supply from non-conventional water sources, e.g. recycled and desalinated water, public acceptance is also mentioned as a major barrier in Europe and worldwide[22].

Sludge treatment and reuse

Quality parameters and the presence of sewage sludge have been evaluated in several reports.
The "Sewage Sludge Directive" 86/278/EEC (SSD) (and its current revision regulation (EC No. 219/2009) promotes the application of treated sewage sludge in agriculture provided that Member States implement the necessary measures to protect human and environmental health and prevent harmful effects on soil. The purpose of the Sewage Sludge Directive (86/278/EEC) is to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent its harmful effects on soil, vegetation, animals and humans. According to this directive, "sludge" is defined as "residual sludge from sewage plants treating domestic or urban wastewater and other sewage plants treating wastewater of a composition similar to domestic and urban wastewater; residual sludge from septic tanks and other similar wastewater treatment plants; residual sludge from sewage plants other than those mentioned above". The scope of this directive is therefore very broad. Regardless of the source of the sludge, the Directive prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. It also sets limit values for concentrations of heavy metals and microbial parameters (Salmonella and Escherichia Coli) in sewage sludge intended for agricultural use. However, there are no triggers for organic contaminants that may be present in sludge. The Sewage Sludge Directive is currently being revised to incorporate limit values for "classical" and anthropogenic contaminants as well[8].
The treatment/recovery of sludge and its reuse through agricultural applications is in fact a major barrier in Europe. Each country has different thresholds, and, within some countries, individual states/provinces may also have different threshold values. When considering applications of small-scale treatment systems in decentralized settings, it is necessary to implement rural community or neighborhood-based solutions for sludge treatment. In these cases, fecal sludge may be the relevant input for compost production. In this regard, the SSD sets limits on allowable concentrations (in soil and sludge) for the application of residual sludge from septic tanks. No explicit barriers are noted for the replicability of small decentralized systems[16,17].
The European legislative framework lacks ad hoc regulation for community composting and co-composting systems to fully support and regulate sludge recovery and reuse in small rural communities. SSD is often criticized as outdated and does not include limits for pathogens and organic micropollutants in soil and sludge.
Sludge is one of the main by-products of wastewater treatment and the progressive practical implementation of the SSD, as well as the number of households connected to sewers, is increasing the amount of sewage sludge requiring disposal. Since the Italian legislation, with Legislative Decree n. 36/2003, sets precise and restrictive limits for the landfilling of waste with high organic matter content (such as sludge from wastewater treatment), it is necessary to identify different options for its disposal or reuse[23].

Circular economy applications of sludge recovery

According to the European regulatory provisions of the European Fertilizer Regulation (2009b, No. 1069/2009) compost derived from digestate and sewage sludge cannot be labeled and marked as a fertilizer, a provision that limits its exploitation. One possible way to address this barrier is currently provided by several valuable works and projects.
In 2019, the report "Digestate and Compost as Fertilizer" assessed risk and risk management options. In this work, no limitation of materials or input uses for compost or digestate was found. In addition, this study shows that STRUBIAS can be considered a valuable framework for safely providing phosphorus to reduce feedstock demand from phosphate rocks. Therefore, compost produced in decentralized systems can reduce the demand for synthetic fertilizers and reduce the economic/environmental impacts associated with fertilizer production and waste disposal even in rural areas[9].
Indeed, for phosphorus use, there is a European Sustainable Phosphorus Platform (ESPP) that serves as a hub for information exchange and facilitates communication among all cross-sectoral stakeholders. Indeed, policy interest in phosphate sustainability has grown a great deal at the European level. Inclusion in the EU's list of critical materials is considered crucial in this regard. When using compost produced from waste and/or irrigating the site with reclaimed water for food crops, food safety is a crucial factor

to evaluate. In 2006, a "Commission Regulation on Maximum Levels for Certain Contaminants in Foodstuffs" was issued. Under this regulation, no relevant barriers were found for the commerciality of products irrigated with reclaimed water and/or tanned with compost from waste, since compliance depends solely on the final product. Significant constraints were noted when considering organic farming. In addition to this, under the "Organic Farming Regulation (EC) No. 889/2008 (and its revision regulation (EU) No. 848/2018)" no information is provided on the sewage sludge matrix for fertilizer production. Therefore, sewage sludge cannot be used to improve soil quality. However, "composted or fermented household waste" may be allowed as long as it contains only plant and/or animal waste.
From a renewable energy perspective there is a "Renewable Energy Directive 2018/2001/EU (EC, 2018)", according to Annex 9 of this, sewage sludge can be used to produce biogas for transportation and advanced biofuels.
There are several barriers to biogas reuse such as complex institutional and legal pathways. There is a lack of adequate legal and regulatory frameworks for the deployment of decentralized renewable energy systems, a lack of agencies to disseminate information, strict bureaucratic procedures, and a lack of stakeholder participation in decision-making. Policies in this regard are unstable and there is a lack of research and development culture, insufficient professional institutions and lack of private sector participation.

5. WASTEWATER AND SLUDGE POLICY IN ITALY, SPAIN, GERMANY, ISRAEL

In 2000, the "EU Water Directive" was defined for the protection of water resources on the basis of natural geographic information, establishing that by 2015 EU waters should be in good condition[5]. This Directive foresaw cycles of 6 years (the first from 2009 to 2015) each with precise action steps:
-2003; geographic definition of river basin districts and identification of authorities responsible for water management.
-2004; carrying out a joint economic and environmental analysis.
-2006; launch national water monitoring networks.
-2009; deadline for drawing up river basin management plans and programmes containing measures to achieve the objectives of the directive.
-2010; deadline for adoption of water pricing policies.
-2012; report of the state of the water according to which further measures were needed to reach in 2015 a 47% of waters considered in good state.
It also required that waters achieve good ecological and chemical status to protect human health, water resources, natural ecosystems, and biodiversity. The definition of ecological status was based on the abundance of aquatic flora and fish fauna, the availability of nutrients, and aspects such as salinity, temperature, and chemical pollution. Based on this assessment of the ecological status of surface waters, a classification of water status into 5 categories (high, good, sufficient, poor and bad) was provided.
To complement this directive, the "REACH Regulation on Chemicals" was then established, which includes the Directive on Industrial Emissions and Pesticide Regulations and the "Groundwater Regulation", establishing that groundwater must not have any level of pollution and that all forms of contamination must be detected and stopped.
In 2012, the "Blueprint to Safeguard Europe's Water Resources" was created, which addresses key issues such as land use, pollution, water efficiency and resilience as well as optimizing governance and identifies barriers to better water management, offers concrete solutions and sets the EU water policy agenda for the years to come[5].
According to the latest revision of the UWWTD (91/271/EC)[37], pollution from urban wastewater systems to water and soil can still be avoided. In particular, the sources of pollution are related, on the one hand, to unmonitored/untreated combined sewer overflows, small agglomerations, and unconnected dwellings

and, on the other hand, to possible toxic and emerging contaminants in sewage sludge used in agriculture.
In this regard, regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 states that "the Union could improve its responsiveness to increasing pressures on water resources through wider reuse of treated wastewater, limiting abstraction from surface and groundwater bodies, reducing the impact of discharges of treated wastewater to water bodies, promoting water saving through multiple use of urban wastewater, while ensuring a high level of environmental protection[24]. "
To date, unconventional technologies such as seawater and brackish water desalination, rainwater harvesting, atmospheric water harvesting, and wastewater reuse are used for water recycling. For the reuse of treated wastewater, potentially useful for irrigation in fields or agricultural parks, restoration of water bodies and wetlands, recharge into aquifers, and for storage, there are small-scale Decentralized Systems (on-site systems, population 1-40), which recover resources consisting of water and nutrients, and medium-scale (satellite) Facilities that can serve 20-47,000 population with a minimum capacity of 8 m^3/d and maximum flow rate of 20,000 m^3/d. Decentralized wastewater treatment systems encourage water recycling and reuse near their location, while other resources can be easily recycled such as bio-energy and nutrients. Considering sludge processing, co-treatment with organic waste may offer a promising solution from both decentralized anaerobic digesters and composting systems[22].

Wastewater legislation in Italy

The main objective of EU and national water policy is to ensure access to good quality water in sufficient quantity to all citizens and to ensure the good status of water bodies throughout the territory. Pollutants and contaminants in water endanger not only natural ecosystems but also public health, while water scarcity and droughts have serious consequences on the economy.
In Italy, the European Water Framework Directive (2000/60/EC)[29] is the reference legislation for the management of water and drinking water. This ambitious EU directive provides a strong legislative framework for long-term integrated water management in Europe, with the goal of preventing water deterioration, improving water status and promoting sustainable water use. A crucial step of the WFD is the adoption of river basin management plans, management tools to manage water resources in a defined unit of area. Legislative Decree n152/2006[30], which includes a set of standards for environmental management in Italy, transposes this directive into Italian law. It establishes eight river basin districts and their management plans that aim to achieve efficient, economic and sustainable water management. River basin authorities, chosen by the regions, oversee water management in each district.
In 2015, the six-year water monitoring period required by the WFD ended. However, the "good status" targets were not fully met not only by Italy but also by other EU countries. In 2016, the Hydrographic Basin Authorities carried out a process of revision and updating of the 2000-2015 management plans, according to DM n.294 25 October 2016[36]. The new management plans, which will be completed in 2021, provide organic water frameworks considering the geography of the rivers in each basin, the impact of human activities on the status of surface and groundwater, and economic analysis on the use of water resources. They also identify new measures to achieve water quality objectives, including considering measures required by old management plans and never achieved. This program of measures seems to be the main element of the river basin management plans and has several innovative aspects including the fact that it encompasses and harmonizes in a single policy action required by other directives in other water-related sectors (agriculture, soil protection, protected areas,...), requires the assessment of the economic and technical sustainability of the measures through specific tools such as economic analysis, cost-benefit analysis and cost-effectiveness analysis and, finally, is elaborated through a process of public participation. In 2021, these plans will be updated again, and the new watershed management plans will remain in effect until 2027.
At the regional level, each region has adopted a Water Protection Plan, the regional implementation tool for the management plans that must be updated after changes to the Watershed Management Plans are approved. After an assessment of the status of watersheds and water-related economic activities, it includes a series of measures for each region aimed at achieving the qualitative and quantitative objectives required by Legislative Decree n 152/2006 and the Water Framework Directive, such as measures to encourage water-saving technologies and water use planning and to protect vulnerable

areas. These objectives are also achieved through the improvement and implementation of sewerage and wastewater collection and treatment facilities[30].

The Urban **Wastewater** Treatment Directive (91/271/EEC)[37] defines urban wastewater as "domestic water or mixture of domestic wastewater with industrial wastewater and/or stormwater run-off". This directive, concerning the collection, treatment and discharge of urban wastewater to protect the water environment from the adverse effects of wastewater discharges and certain industrial discharges, is the reference legislation in Italy for wastewater treatment. It requires European countries to reuse treated wastewater when appropriate in order to reduce the withdrawal of surface and groundwater from natural resources. Wastewater reuse is a key issue in EU water policy as an alternative water source in regions with clear water scarcity problems. As communicated by the European Union in 2015, "the reuse of safely and economically treated wastewater is a valuable but underutilized means of increasing water supply and relieving pressure on over-exploited resources."

On May 13, 2020, the European Parliament and the Council adopted a Regulation[38] on minimum requirements for the reuse of water for irrigation purposes in agriculture, which will apply from June 26, 2023, aimed at removing certain barriers to widespread reuse, ensuring water safety, a high level of environmental and human and animal health protection. In this context, wastewater reuse has been recognized as one of the priority solutions with lower environmental impact than alternative water supply measures, such as water transfers or desalination. These guidelines are also part of the European Green Deal, which aims to reduce pollution from excess nutrients through a strategy called "producer to consumer." Water reuse and nutrient management are among the actions promoted by the new Circular Economy Plan[39].

Legislative Decree n152/2006[30], which transposes the Urban Wastewater Treatment Directive into Italian law, urges regions to adopt regulations and incentives to promote water recycling and reuse of treated wastewater. Incentive measures in this area are, therefore, the responsibility of the Region.

Italian regulations for wastewater treatment and reuse are also based on Ministerial Decree of May 2, 2006 (which replaces the similar Ministerial Decree 185/2003 issued under the previous Legislative Decree 155/99). Together, these two regulations define emission limits for wastewater, include a set of rules for its management and prevention of water pollution, and establish technical rules for the reuse of urban and industrial wastewater. According to these decrees, treated wastewater must be used in a way that is safe for the environment and public health, avoiding the alteration of ecosystems, crops and soil as well as hygienic risks to the population.

The use of treated wastewater as drinking water is not permissible. Therefore, Italian legislation is in favour of the reuse of purified water, as it allows to limit the withdrawal of water from natural sources, improving the quality of water bodies. However, it requires the monitoring of a huge number of chemical parameters and extremely strict microbiological limits for the reuse of treated wastewater. According to national legislation, emission limits do not differ depending on the end use. Regions can regulate the matter on various aspects. In fact, in addition to the possibility to define parameters and limit values to be monitored on the basis of territorial characteristics, Regions can play an important role by adopting both support policies aimed at encouraging water reuse and infrastructural measures aimed at adapting/refining purification treatments.

Wastewater legislation in Spain

Spain has an old and complex legislation in the field of water and its reuse, which underwent changes in the late 90s. The National Hydrological Plan (with its proposal for a major inter-basin transfer) and the application of EU legislation (Water Framework Directive) will set the path for development in the coming years and this will resolve the above tension lines[25].

In Spain, there are territories with an abundance of water resources and others with scarcity, where a substantial effort must be made to distribute water appropriately. The allocation of water resources for different water uses in Spain is done through the management of river basin plans (RBMPs), developed by river basin organizations. Climate change, economic development, and environmental improvement year guided recent ongoing water reforms. In 2007, RBMPs were amended to allow water legislation to become more operational in accordance with the EU Water Framework Directive. Reforms include changes to the organization of water supply and sanitation sector as well as legislative changes to fund water-related climate change adaptation projects[26].

The pressure in Mediterranean countries spread of water stress phenomena is a source of concern for the entire European continent. The Water Exploitation Index (WEI) of the European Environment Agency (EEA), which indicates the ratio between the amount of water used (withdrawal - restitution) and the total amount of freshwater resources available, returns a scenario of moderate or strong pressure especially in Mediterranean countries. For Malta, Czech Republic, Turkey and Spain the water consumption of long-term reserves is already over 20%, implying a condition of water stress already in place. In Cyprus and Greece, where episodes of severe drought have occurred, the consumption of renewable resources is equal to or greater than 40%, manifesting severe water stress and unsustainable use of available resources.

In estimated reuse of 2.4% of purified water in EU Europe, the most complete data date back to 2000[6], when against more than 40 billion m^3 of purified wastewater only 964 million were reused, around 2.4%, less than 0.5% of total annual withdrawals, compared with 15-35% in Australia and Singapore[20]. Of the 964 million m^3 recorded at the time, the two countries with the highest volume of reuse were Spain with 347 million m^3 and Italy with approximately 233 million m^3 of reused wastewater, representing 60% of the total volume reused at the European level. In terms of reuse rate, it emerges that in Spain the reuse rate was between 5% and 12%. These are volumes that, compared with the total annual withdrawals per country, are very limited and less than 1%. It can be seen that reuse measures have been developed mainly in European Union countries affected by water scarcity (Cyprus, Spain, Italy, Malta)[28].

In terms of geographic distribution, 537 schemes were identified in southern Europe, with 361, 99, and 44 schemes in Spain, Italy, and Greece, respectively. Of the 787 identified schemes, 62% are located in water-scarce countries such as Spain and Belgium. These schemes are particularly common along coastlines where freshwater resources are limited and negatively affected by environmental problems such as drought and excessive water extraction due to tourism and agricultural activities.

For example, 47% of the listed schemes are located along the Mediterranean coast, with over 200 schemes located on the east coast of Spain in the regions of Murcia, Valencia, Tarragona, and Barcelona.

In 2006, the AQUAREC project developed a mathematical model to estimate the potential for wastewater reuse in the European Union. The model, based on a mass balance that on the one hand considers the amount of regenerated water available and on the other the demand for that water by different sectors, estimated a volume of reuse of 3.2 billion m^3 of water at the European level by 2025, with Spain showing the greatest reuse potentials (over 1.2 billion m^3 of water per year)[27].

Wastewater legislation in Germany

The German system is based on its legislative structure as a Federal Republic. This means that, according to the Basic Law, all the communities (cities, districts and municipalities) are part of the respective federal state. In 2006, in the context of a reform of the German federal structure, the legislative powers of the federal government in the water sector were changed. The federal government was given full legislative powers in the water sector[31].

As a result, the provisions of the EC Water Framework Directive were transposed into both national laws (Federal Water Law) and the law of the states (regional water laws and ordinances).

The Act on the Regulation of Water Matters (Federal Water Law WHG) as the framework law of the federal government, establishes the basic provisions related to water and resource management (water quantity and quality management).

It states that water bodies, as a component of the ecosystem and habitat for fauna and flora, must be protected and managed in a manner that serves the public interest. As a general principle, water bodies (inland surface water bodies, coastal waters, and groundwater) are subject to government control. All uses of water (e.g. discharge of substances or abstraction of water) are, in principle, subject to official authorization, apart from a few significant exceptions. This is intended to prevent damage to the water regime and apply a precautionary approach to water protection. More stringent requirements, including prohibitions on discharges, may be imposed by water authorities in individual cases in light of emission considerations in order to achieve aspirated water quality or facilitate specific water uses, for example[31].

Other instruments of EU water policy are
- the Groundwater Daughter, the Directive for the Protection of Groundwater against Contamination and Degradation (2006/118/EC), the Urban Waste Water Treatment Directive.
- (91/271/EEC) obliges municipalities to clean up domestic wastewater[37];
- Nitrates Directive - 91/676/EEC related to small businesses, for the protection of water from nitrate pollution from agricultural sources, concerns the decrease of nitrate inputs from agricultural livestock;
- Bath Waters Directive (76/160/EEC and 2006/7/EC) sets the special quality requirements for baths and provides guidelines on the quality of water for human use;
- (Water Directive - 98/83 / EEC) with special quality requirements for drinking water.
- Integrated Pollution Prevention and Control Directive (IPPC Directive - 96/61 / EEC) of medium diffusion in selected industrial sectors;
- the Directive on the distribution of plant protection products (91/414/EEC).[32]

The Federal Water Act (Wasserhaushaltsgesetz WHG) of 1957, as last amended on July 31, 2009, meets the basic regulations for water management with respect to water quantity and quality. This requires sustainable management of water bodies with the aim of improving their function and efficiency with respect to public welfare.

The designation of water protection zones is another important tool of the Federal Water Act. Alongside this are a number of existing planning tools, e.g., wastewater disposal plans, pure detention orders, water management plans, and water framework plans.

The Wastewater Cost Act of 1976, as amended in 2005, requires that for direct discharge of wastewater into nonwastewater, a fee must be paid as an effluent tax. This was the first fiscal environmental protection in Germany that led to the application of the "polluter pays" principle, as the wastewater producer must compensate at least part of the external costs that are caused by water pollution. In addition, those who manage to dispose of wastewater in spite of discharging it into the environment are subject to tariff reductions The wastewater tax must be paid to the federal states and the revenues are exclusively used to finance measures for the conservation and improvement of water quality[32].

Wastewater legislation in Israel

Wastewater management is an integral part of the overall water management in Israel, as sewage and treated wastewater (effluents) are considered as a legitimate water resource which constitutes a significant part of all water uses. National policy calls for the gradual replacement of freshwater allocations to agriculture by reclaimed effluents.

Until the early 1990's, wastewater treatment was very poor, with only primary treatment applied. In 1992, new regulations set secondary quality standards for BOD and TSS. As a result, municipalities built intensive wastewater treatment plants (WWTP) with national loans of ~ 1.5 billion USD. Nevertheless, the effluent quality was still not good enough for unlimited irrigation, and stricter legislation (tertiary standards) was needed to make sure that WWTP's treat wastewater to a level appropriate for unlimited uses. Tertiary standards came into force in 2010 and advanced treatment technologies began being implemented at WWTP's, carrying out Nitrogen and Phosphorus reduction, filtration and disinfection.

Since 2000, two major processes have enhanced the wastewater and wastewater reuse sectors in Israel and although they were unrelated, they both had a dramatic influence and improved the ability of Israel to use the sewage in a better and more advanced way.

1. The budgets that were allocated in the 1990's to build WWTP's created the appropriate conditions for wastewater treatment but were not enough by themselves. Along with the funding there was a need for stricter enforcement.

2. The second process with significant importance for the water management was the legislation of the Water and Sewerage Corporations Law in 2001. The law transfer water and sewerage services from the municipalities to corporate entities. This was the first step in the transformation of the administratively managed water sector to a more commercially orientation. It ensures that income from water and sewerage services will finance infrastructure investments, enabling of private sector investments for infrastructure and the assurance of a high quality services.

Today, Israel has fulfilled its voluntary commitment, made at the 2017 United Nations Oceans Conference, to reduce the direct discharge of wastewater into the sea by the end of 2017 by 80% compared to 2012 (MoEP, 2021). Water quality has improved in Lake Kinneret as a result of a significant reduction in pollutant loads. For example, chloride concentrations are down by 18% in January 2022 from their peak in 2018. About 94% of all wastewater is collected and treated, and 87% is reused, primarily for agriculture. However, nitrogen pollution of groundwater caused by extensive fertiliser use in agriculture remains a problem. Nitrogen balance in the soil was seven times the OECD average level in 2020 (OECD, 2022a). This problem is addressed by treating well water abstracted for human consumption. As drinking water comes increasingly from seawater desalination, the government considers such treatment more cost effective than reducing the nutrient input. High nutrient concentrations are not a problem in irrigation water.

Israel has not met its target for wastewater treatment levels. By 2020, the country planned to have tertiary treatment at all its wastewater treatment plants. Two years later, less than 55% of all wastewater receives tertiary treatment due to delays in upgrading large plants in Jerusalem and Haifa.

Currently, treated wastewater constitutes about 21% of total water consumption in Israel and ~45% of agricultural consumption. Out of a total of ~ 510 million cubic meters (MCM) of sewage produced in Israel yearly, 97% of the sewage is collected and about 85% of it is reused. Local authorities, regional councils and private water corporations are responsible for the treatment of municipal sewage. In recent years, new or upgraded intensive treatment plants were set up in municipalities throughout the country. The ultimate objective is to treat 100% of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources.

Sludge policy in Italy

At the Italian level, the treatment and management of sewage sludge are regulated by Legislative Decree 99/1992, supplemented and partially replaced in 2006 by the inclusive Legislative Decrees 152/2006[30] and in 2018 by the Genoa Decree. The scope of these two decrees concerns sludge produced from treated domestic wastewater, defined in Directive 152/2006 as "wastewater from urban settlements and service industries originating primarily from human metabolism and domestic activities." They also set limit values for heavy metal concentrations according to the directive, but allow a higher value for the presence of Salmonella in sludge, which implies an increased risk of soil contamination with human and animal pathogens, and establish a limit of 1000 mg of hydrocarbons per 1 kg of sludge, without considering that hydrocarbons are a broad category that includes safe and carcinogenic, persistent, bio accumulative and toxic substances[8].

1. Legislative Decree 152/2006 (Environmental Code): This law establishes the framework for environmental protection in Italy. Part of the code covers waste management, including sludge from wastewater treatment. It sets out procedures for the management, disposal, and treatment of various types of waste, including sludge.
2. Ministerial Decree 99/1992: This decree provides specific guidelines for the use and disposal of sewage sludge in agriculture. It outlines the criteria for sludge quality, soil compatibility, application rates, and monitoring procedures. The aim is to ensure that sludge application does not harm human health or the environment.

3. Legislative Decree 31/2001: This decree, known as the "Sludge Decree," addresses the use and disposal of sewage sludge in agriculture. It sets standards for sludge quality and establishes limits on the presence of pollutants. It also requires monitoring of soil and crops after sludge application.
4. Ministerial Decree 185/2003: This decree provides further guidelines on the application of sewage sludge in agriculture. It specifies the procedures for analyzing sludge quality and determining its suitability for land application.
5. Regional Regulations: In addition to national laws, regional regulations may play a role in the management of sludge, including its use in agriculture. Different regions in Italy might have specific rules and guidelines for sludge management that complement the national framework.

Sludge policy in Spain

Sludge management in Spain was regulated by various laws and regulations aimed at ensuring proper treatment, disposal, and utilization of sewage sludge. Some of the key policies and regulations related to sludge management in Spain included:

1. Royal Decree 1310/1990: This decree establishes the basic rules for the treatment of urban wastewater. It includes provisions for the treatment and disposal of sewage sludge generated from wastewater treatment plants.
2. Royal Decree 1620/2007: This decree establishes the regulatory framework for the reuse of treated wastewater in Spain. It also includes guidelines for the quality of treated wastewater and the criteria for using sludge in agriculture.
3. Royal Decree 509/1996: This decree regulates the classification of waste, including sewage sludge. It defines different categories of waste and establishes the procedures for waste management, including collection, transportation, treatment, and disposal.
4. Regional Regulations: In addition to national regulations, various regions in Spain might have their own specific regulations and policies regarding sludge management. These regional regulations can provide additional details and guidelines for sludge treatment and utilization.

Sludge policy in Germany

Some of the key policies and regulations related to sludge management in Germany included:

1. Waste Water Ordinance (Abwasserverordnung - AbwV): This ordinance sets out regulations for the disposal and treatment of sewage sludge. It includes provisions for the quality and standards of treated sludge, as well as criteria for its agricultural and non-agricultural use.
2. Ordinance on Fertilizers (Düngemittelverordnung - DüMV): This ordinance establishes rules for the use of sewage sludge as a fertilizer in agriculture. It defines application rates, quality standards, and monitoring requirements to ensure that the use of sludge in agriculture is safe for the environment and human health.
3. Federal Soil Protection Act (Bundes-Bodenschutzgesetz - BBodSchG): While not specific to sludge, this law includes provisions related to soil protection. It ensures that the application of substances to soil, including sewage sludge, does not harm soil quality and ecosystems.
4. Regional Regulations: Germany is composed of different federal states (Länder), and each state might have its own specific regulations and policies regarding sludge management. These regional regulations can provide additional details and guidelines for sludge treatment and utilization.
5. Technical Guidelines: Germany has issued technical guidelines that provide detailed information on aspects of sludge management, such as treatment methods, quality standards, and best practices for utilization.

Sludge policy in Israel

Sludge management in Israel was regulated by various laws and regulations aimed at ensuring proper treatment, disposal, and utilization of sewage sludge. Some of the key policies and regulations related to sludge management in Israel included:

1. **Water and Sewage Corporations Law**: This law regulates water and sewage corporations in Israel, including the management of sewage and sewage sludge. It provides a framework for the treatment and disposal of sewage sludge generated from wastewater treatment plants.
2. **Solid Waste Law**: Israel's Solid Waste Law addresses various aspects of waste management, including hazardous waste and non-hazardous waste such as sewage sludge. The law establishes guidelines for waste treatment, transportation, and disposal.
3. **Water Regulations**: Israel has regulations related to water quality and wastewater management. These regulations might include guidelines for the treatment and disposal of sewage sludge to ensure that it doesn't negatively impact water resources.
4. **Ministry of Environmental Protection (MoEP)**: The MoEP is the government agency responsible for environmental protection in Israel. It may issue guidelines, policies, and regulations related to sludge management and environmental protection.
5. **Local Regulations**: Different local authorities in Israel might have their own regulations and policies regarding sludge management. These regulations can provide additional details and guidelines for sludge treatment and utilization.
6. **Permitting and Approval Processes**: Generating, treating, and disposing of sewage sludge might require permits and approvals from relevant authorities, such as the MoEP or local environmental agencies.

EU Legislation on Biochar

Currently, there is no coherent EU policy addressing the issue of biochar.
It is important to note that under EU biochar legislation, biochar is not a primary product or co-product of a pyrolysis process but is considered waste and is therefore regulated by the European Waste Directive (2008/98/EC). Since most biochar is considered a by-product of bioenergy production, it is classified as waste and must comply with waste protocols that effectively block its agronomic use.
In addition to the agricultural sector, sewage sludge can also be used as biomass to produce biogas through anaerobic digestion. The term "biogas" was introduced into national legislation with the Legislative Decree n 28/2011which implemented the European Directive 2009/28/EC on the promotion of energy from renewable sources aimed at reducing greenhouse gas emissions. Biogas" is defined by legislation as "gas obtained from renewable sources with settings and characteristics corresponding to methane from fossil resources". This technology is therefore in line with the EU's climate and energy objectives to move towards a climate-neutral economy. The latter strategy, in particular, poses new challenges to sustainable mobility by providing at least a 32% share for renewable energies by 2030-2079.
According to Legislative Decree no. 28/2011, authorization for the construction and operation of biomethane production plants and related modification work is issued by the municipalities, for plants with a maximum production of 500 mc/h standard or for modification work on pre-existing plants, or by the regions, in all other cases.
The Ministerial Decree issued on March 2, 2018 (also called Biomethane Decree) implements the provisions of Legislative Decree no. 28/2011 and defines new provisions aimed at encouraging the use of biomethane and other biofuels in the transport sector. In particular, this decree focuses on advanced biomethane and advanced biofuels, where advanced biomethane is that particular biomethane produced from biomass defined as advanced matrices. This term refers to the feedstocks listed in Annex 3 of DM 10 October 2014 and includes municipal waste, organic waste, animal manure and sewage sludge, among others. Detailed information on the provisions and incentives for biomethane production will be provided in the following sections. However, in Italy, the regulation of wastewater treatment and reuse of treated wastewater and sludge is mostly left to the regions[8,18].

Sewage sludge biochar is today authorised for use in agriculture in the following countries[36]:

- Czech Republic. By Annex 1 of Decree 474/2000 (amendment of October 2021), subject to limits on heavy metals and PAH (20 mg/kg DM PAH12 compared to 6 mg/kg DM PAH16 in the EU FPR). Biochars from sewage sludge for agricultural use must be approved by regional authorities, and must apply to obtain national End-ofWaste status. A successful registration has

been made by KARBO HF s.r.o. for sewage sludge biochar from a PYREG / HST Hydrosystemy installation at BohuslaviceTrutnov municipal wastewater treatment plant (Product name Karbofert T1).
- Sweden. Sewage sludge biochars from two PYREG installations in Germany (Unkel wastewater treatment plant, Bionero) have been successfully registered as fertilising products with the national agency KEMI (Kemikalieinspektion).
- **Italy.** Biochars from sewage sludge are covered by an Italian Standard for "Hydrothermal carbonization" chars (or biocarbons) from municipal sewage or organic industrial sludge published in February 2022. This specifies HTC temperature of 180 – 230°C (the EU FPR CMC14 specifies a minimum temperature of 180°C), limits for ash content, volatiles, nitrogen, heavy metals, and a range for "fixed carbon" of 11 – 34%. The standard does not however confer End-of-Waste status.
- Denmark. The Danish Environment Ministry has stated on 22nd June 2022 that pyrolysis of sewage sludge and certain other wastes is an acceptable pre-treatment prior to agricultural application (controlled sanitation of waste). The pyrolysis must take place at minimum 500 °C for 3 minutes. The biochar retains waste status and application is subject to Danish waste to soil regulations and limits, the same as for sewage sludge.
- Estonia: The Estonian legislation allows the agricultural use of biochar produced from sewage sludge according to Regulation No. 24/2017, which is based on the Waste Act as well as on the Product Conformity Act. Products derived from sewage sludge and/or biodegradable waste can be applied on agricultural lands, including biochar. Possible uses include certain agricultural and forest applications, landscaping and soil restoration. The regulation excludes e.g. vegetable cultivation in the first year after spreading, grazing animals or animal feed use within two months of spreading.
- UK: UKWIR is preparing and will publish soon a report "Converting sewage sludge to biochar - a review of options & feasibility". This will be summarised in ESPP eNews when published. · Norway: biochar products from sewage sludge can be used in agriculture, under the same constraints as for hygienised sewage sludge, that is subject to spreading limitations (heavy metal levels, only certain crops …) and full traceability from sewage works to field.
- **Israel.** The Israel EPA has authorised sludge biochar with a first full composting phase and then pyrolysis (600°C, 20 minutes). The biochar is no longer classified as'Sewage Sludge' according to the Israel Sewage sludge regulations [Water regulations (water pollution prevention) (Sludge use and elimination) 2004].

Regulation (EU) 2019/1009 of the European Parliament and of the Council of June 5, 2019, lays down rules concerning the making available on the market of EU fertilizer products, amending Regulations (EC) No. 1069/2009 and (EC) No. 1107/2009 and repealing Regulation (EC) No. 2003/2003. The new text entered into force on July 15, 2019, but will only apply as of the next July 16, 2022, when the current EC Regulation 2003/2003, which only regulates mineral fertilizers, will cease to apply.
The new legislative framework will be valid for those who want to place their products on the European market with the CE mark.

6. CONCLUSION

The use of wastewater and sewage sludge in agriculture is a complex topic that requires a balance between agricultural benefits, food security and environmental protection. Considering the gap between legislation in the countries mentioned, there are several solutions and future perspectives that could be considered:

- Harmonisation of regulations: One perspective could be to work towards greater harmonisation of regulations between countries. This would require the coordination and exchange of information between nations to develop international standards to ensure the safe use of wastewater and sewage sludge in agriculture.

- Research and Innovation: Investing in research and development to improve wastewater and sewage sludge treatment technologies could lead to more effective and safer solutions. For example, advanced treatment technologies could reduce the pollutant content of sludge, making it more suitable for agricultural use.
- Risk Assessment and Monitoring: Countries could develop more accurate risk assessment methods to determine the suitability of wastewater and sewage sludge use in agriculture. This could include regular monitoring systems to ensure that the environment and human health are adequately protected.
- Promotion of Sustainable Use: Countries could promote sustainable agricultural practices that optimise the use of resources, including treated wastewater and sewage sludge. This could help reduce pressure on water systems and improve soil fertility.
- Stakeholder Involvement: Involving farmers, industry, environmental experts and civil society representatives in policy formulation could lead to more balanced solutions that take into account different perspectives and needs.
- Promotion of the Circular Economy: Sewage sludge could be treated as a resource rather than waste, e.g. for biogas production or as a source of nutrients for agricultural soils.
- Education and Awareness: Education and training on best practices in wastewater and sewage sludge management could increase stakeholder awareness and promote safe and efficient use.

It is important that decisions made consider both agricultural benefits and the environment and public health. Future solutions should seek to balance these considerations so as to ensure the sustainable and safe use of wastewater and sewage sludge in agriculture.

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