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EVALUATION

Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

{SWD(2023) 158 final}

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GLOSSARY

Term or acronym	Meaning or definition	Term or acronym	Meaning or definition
AD	Anaerobic Digestion	**ND**	Nitrates Directive
ANSES	Agence nationale (française) de sécurité sanitaire de l'alimentation, de l'environnement et du travail	**NVZ**	Nitrate Vulnerable Zone
BWD	Bathing Water Directive	**MS**	Member State
CEAP	Circular Economy Action Plan	**PAH**	Polyaromatic hydrocarbons
CEC	Contaminant of emerging concern	**p.e.**	Population equivalent
CIS	Common Implementation Strategy	**PFAS**	Perfluoroalkyl substances
CO_2-eq	Carbon dioxide equivalent [a metric used to compare emissions from various greenhouse gases (other than CO_2, e.g. methane) on basis of their global-warming potential, by converting amounts of other gases to the equivalent amount of CO_2 with the same global warming potential	**PCBs**	Polychlorinated Biphenyls
COD	Chemical Oxygen Demand	**PCDD**	Polychlorinated dibenzodioxins
DEHP	di(2- ethylhexyl) phthalate	**SSD**	Sewage Sludge Directive
ECJ	European Court of Justice	**STRUBIAS**	Struvite, Biochar and Ash-Based products
EIA	Environmental Impact Assessment	**tDS**	Ton of Dry Sludge
EPA	Environmental Protection Agency	**tDM**	Ton of Dry Matter
E-PRTR	European Pollutant Transfer and Release Regulation	**UWWT**	Urban Wastewater treatment
EQS	Environmental Quality Standard	**UWWTD**	Urban Wastewater Treatment Directive
EQSD	Environmental Quality Standard Directive	**WWTP**	Wastewater treatment plant
IED	Industrial Emissions Directive	**WWT**	Wastewater treatment
JRC	Joint Research Centre	**WFD**	Water Framework Directive
MS	Member State	**WIND**	What if no Directive scenario
MSFD	Marine Strategy Framework Directive	**WTE**	Waste-to-energy

1 1. INTRODUCTION

1.1 1.1. *Purpose of the evaluation*

Sewage sludge is a mud-like residue resulting from the treatment of wastewater. It contains valuable organic matter and nutrients such as nitrogen and phosphorus, and therefore can have useful applications as a fertiliser or soil improver. Sewage sludge also contains heavy metals and other contaminants such as chemicals or pathogens, e.g. viruses and bacteria, which can potentially pose risk to the soil and to the human health (when humans ingest food products grown onto farmland which has been fertilised by sewage sludge) as a result of its application on soil.

The Sewage Sludge Directive (hereafter, the SSD or the Directive) was adopted to encourage the correct use of sewage sludge in agriculture and to regulate its use in order to prevent harmful effects on soil, vegetation, animals and humans. However, there are other alternative uses to sludge (see section 2.4), which are not regulated by the SSD or any other EU level legislation beyond the Urban Wastewater Treatment Directive (UWWTD).

Since its adoption in 1986, the Directive has not undergone any substantial revision[1]. However, the sector of sludge management has evolved considerably. The Directive on Urban Wastewater Treatment of 1991 introduced requirements for more systematic and more advanced treatment of wastewater, resulting in the increase of sludge production. There has also been an evolution in sludge treatment technologies as well as in the knowledge of contaminants which it can contain and its impacts. Sludge management routes other than use in agriculture have also developed, for instance, the use of it for energy recovery.

There have also been considerable changes in the European Union (EU) policy and regulatory framework. The revised Directive on waste[2] and various initiatives[3] developed under the umbrella of the European Green Deal[4], the Updated Bioeconomy Strategy[5], EU Circular Economy Action Plans adopted in 2015 and 2020[6] emphasize the economic and environmental benefits of recovery of sewage sludge, notably the recovery of nutrients in agriculture, while stressing the need to do this safely. These policy objectives go hand in hand with the Union's industrial policy[7] aiming to further its independence on extraction and imports of certain raw materials, notably phosphorus, identified as a critical raw material for the Union[8] and with regard to which sewage sludge is an alternative source. While not

[1] Changes made (through amendments done in 1991, 2003, 2009, 2018 and 2019) have related to reporting requirements and to setting a committee to assist the Commission on technical progress.

[2] Council Directive 75/442/EEC on waste was repealed by Directive 2006/12/EC, then by Directive 2008/98/EC, currently in force and last revised in 2018 by Directive (EU) 2018/851

[3] This includes notably: the Bioeconomy Strategy, the new Fertilising Products Regulation of 2019, the Farm to Fork Strategy, Zero Pollution Action Plan, Soil Strategy, the EU Biodiversity Strategy for 2030 and the on-going revision of the Urban Wastewater Treatment Directive.

[4] COM(2019)640 final of 11.12.2019.

[5] European Commission, Directorate-General for Research and Innovation, A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment : updated bioeconomy strategy, Publications Office, 2018, https://data.europa.eu/doi/10.2777/792130

[6] COM(2015) 614 final of 2.12.2015, COM(2020)98 final of 11.3.2020.

[7] COM(2021)350 final of 5.5.2021.

[8] COM(2020)474 final of 3.9.2020.

regulated by the SSD, sewage sludge has other uses, in particular, as source of energy contributing to the energy independence of the Union, an objective also at the centre of the proposal for a revised Urban Waste Water Treatment Directive 91/271/EEC (hereafter, the UWWTD)[9].

In 2014, the Directive was evaluated as part of an "Ex-post evaluation of certain waste stream directives[10]", which identified a number of shortcomings, largely related to the fact that it had been adopted 30 years earlier. The identified issues concerned the SSD contribution to the EU circular economy ambitions, pollutants in sludge, the potential need to regulate other uses of sewage sludge, and the potential impact of the revised UWWTD. In view of the various policy and regulatory developments, the Circular Economy Action Plan of 2020 called for a new evaluation of the Directive to validate and complement the results of the 2014 evaluation, to take account of the changed policy and legal landscape, and inform a possible decision to review the Directive.

1.2 1.2. Scope

In line with the Commission's better regulation policy, this report assesses the Sewage Sludge Directive along five criteria:

- Effectiveness: looking into the extent to which the actions defined under the Directive have been implemented and whether this has resulted in achieving its objectives
- Efficiency: assessing whether the obligations arising from the implementation of the Directive have been implemented in a cost-effective way
- Coherence: assessing coherence of the Directive with the EU wider policy objectives of the European Green Deal as well as possible inconsistencies and overlaps with other legislation
- EU added value of the Directive compared to what Member States could have reached acting alone
- Relevance: assessing whether the objectives and the regulatory tools of the Directive match current needs in view of the wider EU policy objectives, notably on circular economy, sustainability, resource efficiency and climate change.

This evaluation assesses these criteria in all Member States since the adoption of the SSD.

It covers the whole lifetime of the Directive, since its adoption in 1986 until now, although a strong focus is made on the period 2007-2018, as only limited data are available pre-2007. The focus of the evaluation is also driven by the changes in the policy regulatory landscape, which have changed most considerably in the last few years. On top of that, the 2014 evaluation already provided some assessment for the pre-2014 period.

1.3 1.3. Methodology, robustness and limitations

The following sources of information were used for this evaluation:

- A review of existing literature, including the previous evaluation and reports from relevant EU funded research projects.

[9] COM(2022) 541 final
[10] BioIntelligence Service et al, (2014)

- Member States implementation reports and data from Eurostat and from the European Environmental Agency.
- Additional data to those referred to above and information on the stakeholders perception of the extent to which the SSD has been successfully implemented and its relevance gathered through different stakeholder consultation activities. This included an online public consultation (OPC), targeted surveys and interviews (with expert stakeholders and with Member States) and a stakeholder workshop. A wide range of stakeholders contributed, including Member State Competent Authorities, Non-Governmental Organisations (NGOs), research organisations, farming community and Trade Associations. Trade Associations include the agricultural sector, to which specific efforts were made to reach out. More detail on stakeholder consultation is provided in Annex V.

Overall, the level and quality of evidence gathered is varied. For some evaluation criteria, in particular relevance and coherence, the evidence gathered was robust and satisfactory. Availability and quality of data was a challenge affecting in particular the assessment of the effectiveness and efficiency criteria. The following difficulties have complicated the assessment:

- data on costs and benefits are scarce, and date from quite a few years back,
- a more general lack of data from Eastern Member States,
- when available, the datasets on the use of sewage sludge in agriculture presented several gaps, and in some instances conflicting information, for instance between Member States implementation reports and Eurostat data. This made it challenging to derive trends in the use of sewage sludge over time for example,
- The response from the farming sector has been somewhat limited. In addition, it had been challenging to single out and identify their specific feedback in the consultation (in spite of the effort made to reach out to the agricultural sector as explained above).

These data gaps and inconsistencies were addressed through specific interviews with stakeholders (notably for the efficiency section), or by completing datasets with data from other sources and extrapolations. For instance, the data reported by Member States under the implementation of the SSD was used as the main data set and observed gaps were filled using Eurostat data. Where there remained too many data gaps, for instance for a given Member State for a given year, extrapolations were made based on reporting done from other years and population size. Information gathered from different sources, including input from stakeholders were compared and triangulated whenever possible. Where available literature was limited (e.g., linked to the assessment of efficiency and EU added value criteria) or conflicting (e.g., in particular for data sets), consultation responses were relied upon to answer the evaluation questions (and indicated throughout this report where it has been the case).

More details on how the evaluation was conducted are available in **Annex II** (on the methodology) and in **Annex V** (the synopsis report**,** which summarises the results of all the consultation activities undertaken for this evaluation**)** of this report.

2 2. WHAT WAS THE EXPECTED OUTCOME OF THE DIRECTIVE?

2.1 2.1. Description of the intervention and its objectives

The use of sewage sludge in agriculture was not regulated by Directive 75/442/EEC on waste, so it was deemed necessary to develop separate legislation on wastewater management and recovery of sewage sludge. The SSD was born from the need to end the discharge of sludge into the marine environment. This led to the development of the idea to use sludge on land, primarily as a means of the disposal of sludge within defined safety parameters, but also in recognition of its agronomic value. The Directive was therefore created to encourage the correct use of sewage sludge in agriculture and to regulate its use in order to prevent harmful effects on soil, vegetation, animals and humans. This was to ensure diversion of waste from disposal towards recovery. To this end, it prohibited the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil.

The legal base of the Sewage Sludge Directive are Articles 100 and 235 of the Treaty establishing the European Economic Community, relating to the common (internal) market. The objectives pursued by the Directive are those of facilitating the recovery of sewage sludge in agriculture in Europe while ensuring that this activity does not harm the environment or human health. This is the primary objective identified on the basis of its article on the purpose of the Directive. Its first recital states that the aim of this Directive is to regulate the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, while encouraging its correct use. This is in detail explained also in further recitals. Its second recital refers to the disparity between the Member States' provisions on the agricultural applications of sewage sludge that might affect the functioning of the common market and which therefore justify the introduction of minimum harmonisation at EU level. The Directive does not provide for further information on the potential barriers to the internal market that are the subject of the intervention by this Directive. However, it can be assumed that this refers to unequal conditions of competition for the treatment operators of sewage sludge for its recovery and the users of sewage sludge as a result of different levels of regulation across the Union which hamper movements of sewage sludge for recovery in agriculture across the Union. It is also to be noted that Articles 100 and 235 of the Treaty establishing the European Economic Community were consistently used as the legal basis for environmental legislation predating a specific environmental policy legal base in the Treaty.

The Sewage Sludge Directive aims to protect human health and environment by encouraging the safe use of sewage sludge in agriculture in order to prevent harmful effects. It does this by limiting heavy metal concentrations in soils, by prohibiting use of untreated sludge on agricultural land unless it is injected or incorporated into the soil, and by requiring that sludge be used in such a way that the nutrient requirements of plants and the quality of the soil and of surface and groundwater is not impaired.

The Directive imposes several requirements on the quality of sludge for use in agriculture, the quality of the soil on which sludge is to be used (Article 5) and limiting sludge application for certain purposes and during certain time periods (Articles 7 and 8). It also requires that for use on farmland, sludge is treated beforehand and account is taken of the nutrient requirements of plants. The main aim of these requirements is to limit heavy metal concentrations in soils, and to avoid nutrient loss.

The Directive limits concentrations of heavy metals in soils to which sludge is applied (Article 4, annex IA) by setting:

- maximum concentrations of the sludge in 6 heavy metals: cadmium, copper, nickel, lead, zinc, and mercury. Limits were also to be set for chromium, but the Directive has never been updated with a specific value for that metal;

- maximum concentration of those heavy metals in the soil;
- maximum annual quantities of such heavy metals which may be introduced into the soil intended for agriculture.

The Directive requires sludge to be treated before application onto land, therefore throughout this report, when referring to “sludge use in agriculture”, it will implictly mean treated sludge use in agriculture. The Directive does not define treatment, so treated sludge could in principle be product resulting from any treatment, e.g. digestate from anaerobic digestion, compost or even incineration ashes.

The Directive covers application on agricultural land and does not cover any other uses or disposal routes for sewage sludge. In particular, sludge may also be used on land not intended for agriculture, for land reclamation, land remediation, or landscaping which is regulated under the general rules of the Waste Framework Directive (WFD).

The Directive implements the overall objective of the Union environmental and waste policy to encourage the recovery and safe use of waste in the economy over its disposal where it offers the best environmental outcome. Since sewage sludge contains valuable nutrients such as phosphorus that has beneficial uses in agriculture as soil fertiliser, this Directive aims to regulate this use to encourage its use while ensuring that it does not undermine health and environmental protection.

The main activities required by the Directive to meet its objectives are as follows:

Article	Target group	Description of requirements
5(1)	Member States	Member States must prohibit of use of sludge in soils that exceed the limit values laid down in Annex 1A; and Ensure that those limits are not exceeded as a result of use of sludge.
5(2)	Member States	Member States must ensure the use of sludge does not lead to an accumulation of heavy metals in soil that exceeds the limits in Annex 1A (of the Directive) by either: Laying down the maximum quantities of sludge that can be applied per area per year whilst complying with the limits laid down for sludge in Annex 1 B (of the Directive); or Ensuring the limits for the quantities of metals introduced into the soil per area and unit of time as laid down in Annex 1 C of the Directive.
6	Operators Member States Operators	Sludge must be treated before being used in agriculture. Member States may set their own conditions allowing untreated sludge to be used if it is injected or worked into the soil. Sewage sludge producers must provide users of sewage sludge with the information required under Article II A.
7	Member States	Member States must prohibit the use of sludge or the supply of sludge for use on: Grassland or forage cops if the grassland is to be grazed or forage crops harvested before a certain period as defined by the Member State has elapsed. Soil in which fruit and vegetable cops are growing except for fruit trees. Ground intended for the cultivation of ground contact fruit and vegetable crops that are eaten raw for a period of 10 months preceding the harvest of the crops

Article	Target group	Description of requirements
		and during the harvest itself.
8	Member States and Operator	Sludge must be used in a way that the nutrient needs of plants are considered and that, the quality of the soil and surface and ground water is protected. Where soil pH is below 6, Member States must consider increased mobility and availability of heavy metals to crops and, if necessary, reduce the limit values they have defined according to Annex 1 A[11].
9	Member States and Operator	Sludge and soil on which it is used must be analysed according to Annexes II A and II B.
10	Member States	Member States must keep records of the quantities of sludge produced and used in agriculture, the composition, and properties of sludge in relation to the parameters included in Annex II A, the type of treatment carried out and the names and addresses of the recipients of sludge and the place where the sludge is to be used.
17	Member States	Member States must submit a report every four years and submit it to the Commission addressing the quantities of sludge used in agriculture, the criteria followed, and any difficulties encountered.

The SSD provides a minimum level of harmonisation on the environmental conditions to ensure safe use of sewage sludge in agriculture in the EU as its Article 12 specifically recognises that Member States may adopt more stringent measures.

The intervention logic of the Directive is represented on the next page. It shows the intended functioning, desired results and overall rationale of the Directive.

2.2 2.2. Point(s) of comparison

The Directive is assessed throughout this report against its expected outputs and impacts, or by comparison with the past situation, to the best extent possible since there is a tremendous lack of data related to the past.[12] To the extent possible, the following scenarios of reference points were developed:

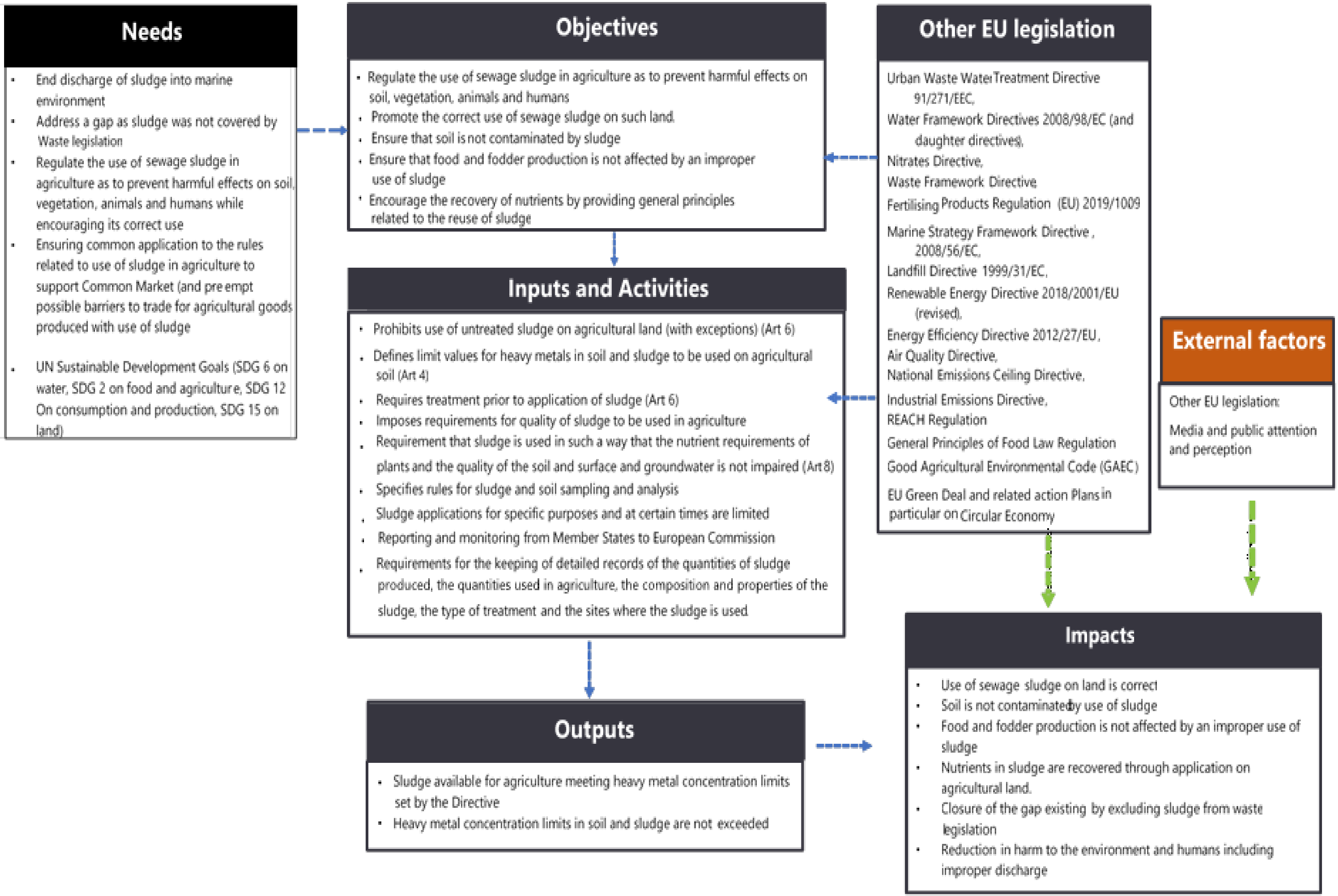
- Past scenario reflecting the situation at the time the SSD was adopted.
- Present scenario (Current Situation).
- Present scenario WIND “What if no directive” - reflecting a hypothetical present scenario whereby the Sewage Sludge Directive would not have been adopted.

Information on how these scenarios have been developed is provided in Annex III.

[11] Limit values are provided in Annex III of this report

[12] No impact assessment was carried out for the adoption of the Directive. The 2014 evaluation was not based on a baseline either. For data rel²ated challenges see section1.3 and Annex II of this report.

The intervention logic can be represented as follows:



3 3. HOW HAS THE SITUATION EVOLVED OVER THE EVALUATION PERIOD?

This section presents the state of play of the implementation, focusing on key information from the latest reporting period (2016-2018[13]), with additional information on previous reporting periods as appropriate (to the best extent possible, since data from earlier years is very scarce, if not inexistent, as explained in section 1.3).

All Member States have fully transposed the Directive into national legislation. Numerous Member States have chosen to go further than the minimal requirements set out in the Directive, notably by setting lower national limit values for the concentration of heavy metals in soil and sludge and setting limit values for additional parameters.

3.1 3.1. National limit values and requirements at national level

Member States have set concentration limit values for heavy metals in soil/sludge that are in line with the requirements of the Directive. In accordance with Article 12, **seventeen Member States have adopted more stringent requirements than those prescribed in the Directive**: Austria, Belgium, Croatia, Czechia, Denmark, France, Finland, Germany, Hungary, Latvia, Luxembourg, Malta, the Netherlands, Poland, Romania, Slovenia and Sweden.

The stricter national rules adopted by some Member States are significantly lower than the limits set out in the SSD. This difference is the greatest for lead. The graph below shows that most Member States have adopted limits for lead in soils which are lower than those required by the SSD by a factor of 5, even 10.

EU Member State limit values for the concentration of lead in soils[14]

Source: MS implementation reports for the period 2016-2018

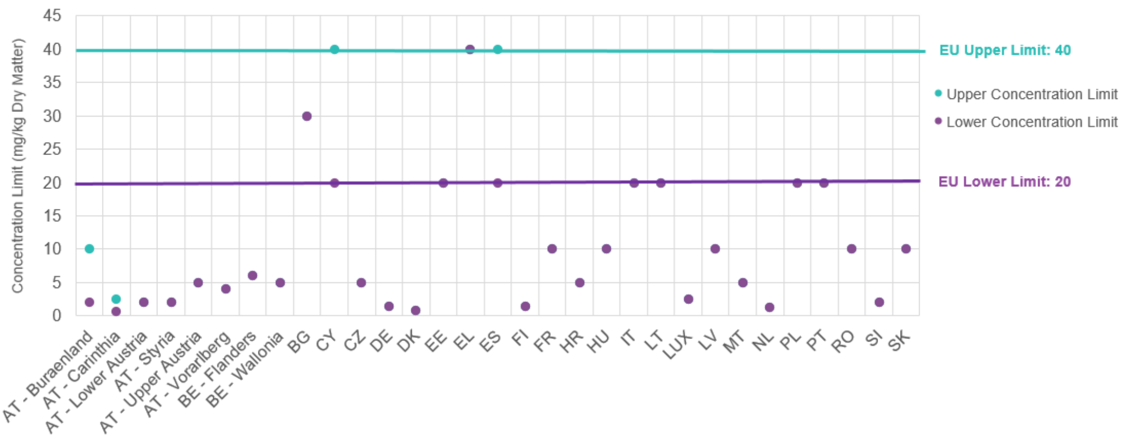
[13] More details can be found in the SSD implementation report 2016-2018. Data for that period are considered reliable, as Member States have been exhaustive in their reporting, apart from a few gaps, also described in that report

[14] No explanations are provided in the Directive on the reasons for setting upper and lower limits. It is assumed that they reflect the likely differences of views of Member States of the range of acceptable levels of heavy metals and fluctuations in sludge composition due to changing composition of wastewaters treated and the subsequent treatment.

NB: Portugal is the only country to have set a national limit value above the upper EU limit set out in the SSD. This applies to soil with a pH level consistently greater than 7. It is set in the form of a derogation in accordance with Annex IA of the Directive, footnote (2). A lower limit has been set in Portugal for soil with a lower pH level, which are aligned with the limit values set out in the SSD.

The following graph illustrates the extent to which Member States have adopted stricter limits on cadmium in sludge to be applied onto farmland:

EU Member State limit values for the concentration of cadmium in sludge



Source: MS implementation reports for the period 2016-2018

An exhaustive set of such graphs is available in the Commission report on SSD implementation for the period 2016-2018[15]. That implementation report also provides the detailed list of limit values which apply nationally or regionally. In summary, for specific parameters regulated, the following can be noted.

Member States have set limits below or equal to the upper limit set out in the SSD for the soil concentration of all the heavy metals which are regulated by the SSD. The only exception are Bulgaria, Portugal and Spain which have set limits in exceedance for soils with a high pH level, but still in accordance with the flexibility provided by the Directive in specific cases[16]. Countries having set the most stringent upper limits are Denmark (which set lower limit values for all of the heavy metals in soil), and Latvia. The Netherlands and Finland have also set stricter limits for copper and mercury respectively.

All Member States have reported limits within the upper limit set out in the SSD for the concentration of heavy metals in sludge, except Ireland and Sweden, which did not report any national limit values for the concentration of heavy metals in sludge. Apart from Spain, Greece, and Cyprus, which have typically set as limits the upper limit set out in the SSD for all metals, all Member States have set national limits below this level (most stringent limits by Denmark and the Netherlands, except for Copper, for which the most stringent limits were set by Austria, Finland, the Netherlands, and Slovenia). The limit values applicable in the Netherlands are stricter than those of the SSD across all substances.

[15] EC, Sewage Sludge Directive implementation report 2016-2018
[16] See SSD Annex IA, footnote 2, also available in Annex III of this report

Member States have reported limit values for the amount of heavy metals which may be added annually to agricultural land in accordance with the limits set out in the SSD for all heavy metals. The most stringent limits have been set by Finland, the Netherlands and Sweden. A significant number of Member States (Bulgaria, Cyprus, Croatia, Czechia, Germany, Denmark, Italy, and Poland) have not reported limits for any heavy metals.

Many Member States have also set rules for additional pollutants. The majority of Member States have set limit values for chromium in soil and sludge. Over half of the Member States have included additional substances such as additional heavy metals than those regulated by the SSD, arsenic, Polycyclic aromatic hydrocarbons (PAHs), Polychlorinated Biphenyl (PCBs), and absorbable organic halogens (AOX). Some Member States have also set limits on pathogens such as *E. coli* and *Salmonella,* and *Enterococci*[17]. Further substances in sludge considered by MS are: PCDD (Polychlorinated dibenzodioxins)/Furans, which are dioxins (7 MS), NP/NPE (3 MS), Lineal Alkyl Sulphate, a chemical commonly used in the hygiene and cosmetics industry (2 MS) and DEHP (di(2-ethylhexyl) phthalate; 2 MS).

Some Member States have banned the use of sewage sludge in agriculture, e.g. the Brussels and Flanders regions of Belgium and Slovakia (the latter has established a policy where sewage sludge is treated for energy recovery), the Netherlands (since 1995), some regions of Austria (Vienna, Salzbury and Tyrolia). Germany and Austria focus on phosphorus recycling from sewage sludge and sewage sludge ash after the incineration of sewage sludge through mono-incineration. In Germany, all urban wastewater treatment plants with over 50,000 p.e. will have to comply with this requirement from 2032.

In their implementation reports, Member States are not asked to state reasons why they apply stricter limit values or ban the use of sludge in agriculture.

Only a few countries have allowed to use of untreated sludge under certain authorized conditions (e.g. France, Sweden and Estonia). **Some have specific requirements for treatment** such as stabilization, heat treatment, composting, or digestion before use (Austria, Denmark, Finland and Poland), thereby going beyond the requirements of the Directive, which is not prescriptive about the type of treatment to be applied. In several countries the use of sludge in forests (Austria, Belgium, Germany and Netherlands) and green areas has also been prohibited[18].

Differences in sludge management practices are generally explained by different pedoclimatic conditions[19]. Other reason for setting more stringent limits is the application of the precautionary principle, or local situations, e.g. if the baseline content of soil in heavy metals is already high. About 10 Member States (e.g. the Netherlands) established their limits based on national risk assessment models that consider humans as end points. Other countries adopt and eventually adapt limits formulated by other countries. So it can be said that indirectly or directly risk-based approaches have thus lead to stricter values in Member States. Other reasons for setting stricter requirements include public perception or pursuing specific

[17] Hudcava et al. 2019 Present restrictions of sewage sludge application in agriculture within the European Union, page 111.
[18] Kelessidis & Stasinakis 2012
[19] Collivignarelli, M., et al., 2019

objectives as regards sludge management (e.g. a focus on P-recovery in Germany and Austria).

3.2 3.2. Enforcement of the Directive

The information gathered in the preparation of this report does not indicate any structural or systematic issues with infringement of this Directive. Most Member States have established a system of fines (ranging from €251 to €100,000) as a means of enforcement, with imprisonment also as a means of enforcement in around 30% of Member States. The level of fines depends on factors linked to the use of toxic sludge, waste disposal, non-compliance with record keeping or failure to measure soil and sludge parameters, sludge application which exceeds pollutants limits to soil, incorrect use of sludge, failure to effectively treat sludge, application of sludge without authorisation, overuse of sludge (which would result in its disposal rather than recovery) and environmental damage as set out in national law.

Between 1994 and 2019, the Commission has pursued three infringement cases in relation to the enforcement of the SSD, all of which are solved.[20] Overall, this indicates a positive level implementation and compliance.

42% of respondents during the targeted consultation reported that the enforcement of the SSD in their country has been fully effective, followed by 27% respondents indicating that it has been effective to some extent. Around 43% of those participating in the Member State consultation (of 19) indicated that enforcement of the SSD had been fully effective in their country, while 21% reported that enforcement had been to a large extent effective and 37% to some extent. No respondents reported that it had not at all been effective.

3.3 3.3. Sludge production and use

Depending on the source of data considered, sludge use in agriculture across the EU falls between about 30 and 50% of the total amount of sludge produced. By triangulating data, it can be estimated to be an average of around 40%. As can be seen from the figure below, the amount of sludge produced has remained relatively stable between 2007 and 2018, with production typically averaging between 7M – 8M tonnes[21]. The amount of sludge used in agriculture has also remained constant, between 2M – 3M tonnes.

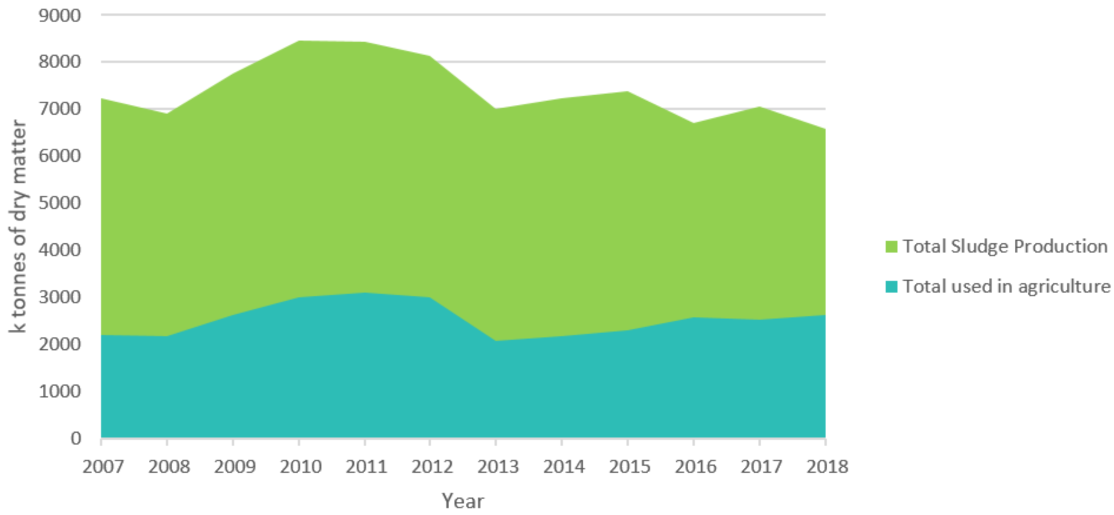
The fluctuations observed for the production of sludge could not be explained but by resulting from data gaps (see Annex II for details on data scarcity). It can be noted, however, that the percentage of sludge used in agriculture follows the pattern of sludge produced. This has been observed for evolutions examined from the three main data sources used: Member State implementation reports (submitted as a requirement of the Directive), Eurostat, and Member State overviews (files developed for each MS) prepared in the framework of the study which supported this evaluation[22].

[20] BE in 1994 (on failure in implementation), AT in 2003 (on failure in transposition and implementation), IT in 2004 (on failure to meet reporting requirements and record keeping)

[21] About 17 kg per person per year [from Anderson et al, (2021)]

[22] A graph is also provided in Annex III to show trends on the long run (1980-2018) for the EU27 according to Eurostat data.

Sludge produced and used in agriculture in the EU 2007-2018

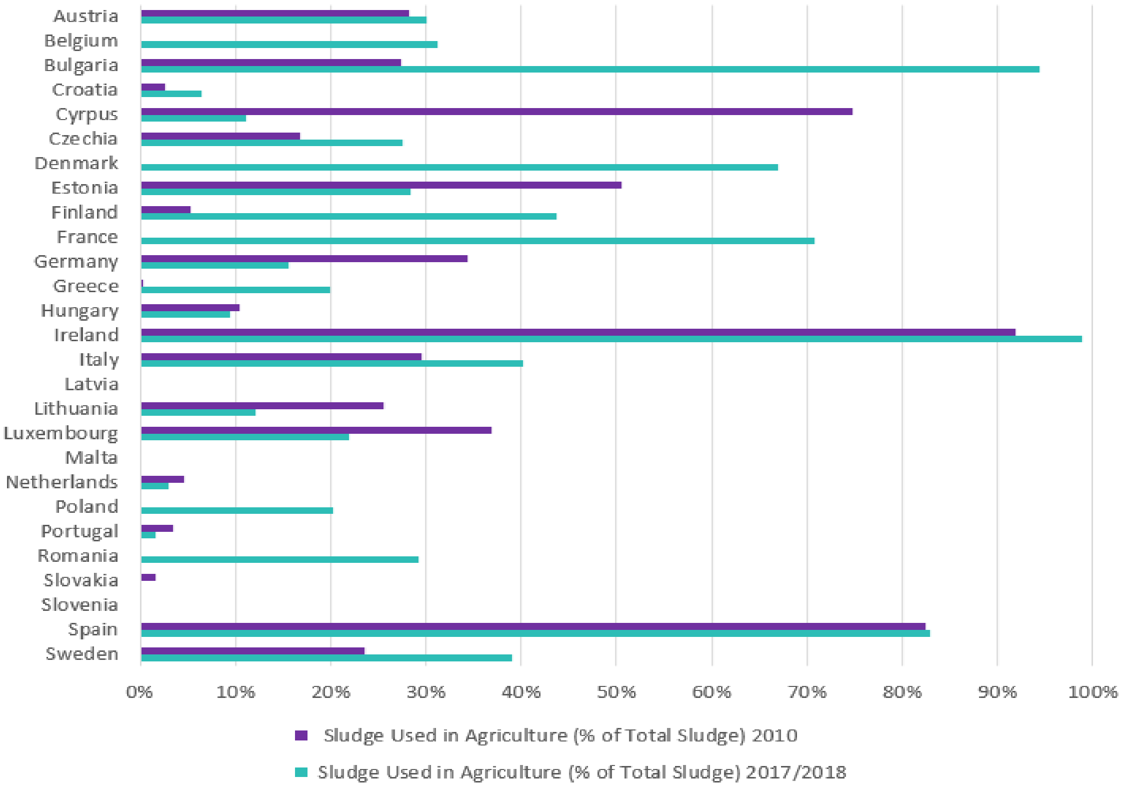


Source**:** MS reporting on the implementation of the SSD, complemented with extrapolation where information is missing for that period (see Annex II for details on how the extrapolation was made). The graph has been drawn from 2007 onwards, due to the extreme scarcity of data from earlier years. Note that even after 2007 data sets remain very incomplete, as described in Annex II. The most notable yearly change occurred between 2012–2013, when there was a sharp decrease. The decrease is a reflection of reduced total sludge production reported in Spain, Finland and Portugal. There was no information identified to explain these decreases in these countries. A further decrease is observed between 2017-2018 reflecting decrease in quantities reported by Bulgaria and Italy.

Present-day, the majority (24) of Member States use sewage sludge in agriculture (see also section 2.1). Most of them use less than 40% of their sludge in this way, for an EU average of 31%. These shares vary a lot between them, from very high use (e.g. Ireland) to low or no use in agriculture (e.g. Belgium, Malta, Slovakia and Slovenia).

The evolution and trend differs very significantly between Member States. When comparing sludge use in agriculture in 2010 and 2017/2018, for instance, we note an increase for a majority of Member States, while some report a decrease (see figure below), sometimes very significant in both cases.

Share of sewage sludge used in agriculture (as % of total sludge produced)



Source: Member State Implementation Reports

Note: The figures for Austria, Belgium and Italy are representative of the regions which provided information for the relevant years. Slovenia provided data suggesting a very small % use of sludge in agriculture which is not visible within the chart. The chart does not reflect data for Member States that did not provide information for either the year 2010 or 2017/2018. This applies to Malta and Latvia for both years. France and Denmark did not provide an implementation report for 2010-2012 but according to Eurostat data, France produced 1.025kt of sludge in 2010 and used 41% of it in agriculture, while Denmark produced 141kt of sludge and used 52% of it in agriculture for that year.

3.4 3.4. Different types of treatment and uses of sludge

Sewage sludge requires treatment before application onto land, to enable safe use and more efficient transport, for recovery (of nutrients or energy) and/or disposal. Common treatment options include thickening, stabilisation, dehydration and sometimes drying of sludge. Additional techniques include lime treatment, anaerobic digestion (process in which bacteria biodegrade organic materials in the absence of oxygen), or composting. An overview of the main types of treatment used, their main features and effects they have is provided in Annex III to this report.

Sludge dewatering in treatment significantly reduces the water content of the sludge, and therefore the volume and weight of wet sludge for disposal. Methods based on physical, mechanical, chemical, thermal and biological treatments are used to further decrease the volume of sludge. Most of them are aimed at solids solubilisation, virus inactivation, and disintegration of bacterial cells in sludge.

After treatment (usually a combination of different steps of treatments), sludge can be used or disposed of in different ways: recovery through spreading on farmland, energy recovery from incineration or landfilling. Sludge can also be recovered through application on soil other than agricultural soil as a soil improver, for landscaping or land reclamation. Some treatments, while treating sludge for its subsequent application on land, also pursue other objectives, namely: anaerobic digestion generates methane (in the form of biogas), which can then be used as (bio)fuel. Apart from incineration, such treatment options are usually taking place at the urban wastewater treatment plants (WWTP) that generate sludge, and can be used independently of the intended end use of the sludge. WWTPs may be the end-users themselves of the biogas or energy production in view of their high energy demand to process wastewaters.

Land use application has remained the main route for managing sludge in the EU as a whole, as shown by the below diagram. Incineration comes closely second.

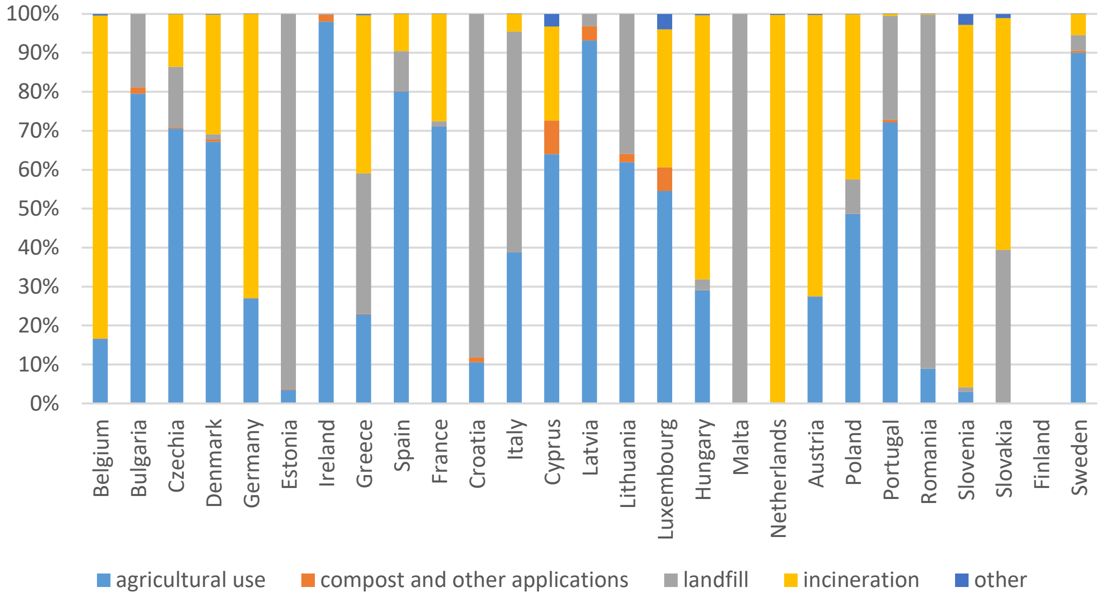
Eurostat data on the production and disposal of sewage sludge in the EU-28, 2004-2016

Source: Eurostat, 2016. Sewage sludge production and disposal [ENV_WW_SPD].

NB: Eurostat does not provide a description of the category 'other'. This is one of the factors that impacted data collection and comparison with other sources (the categories differ) for this evaluation, as described in Annex II.

However, as can be seen on the next figure, large differences in the proportional contribution of sewage sludge disposal routes exist among Member States for the final uses of sewage sludge. Some countries incinerate high proportions of their sewage sludge (e.g. Netherlands, Belgium, Germany; 82-98%), others (e.g. Ireland, Spain; >80%) apply large amounts of the sewage sludge directly on land, and some landfill significant amounts of sludge (e.g. Greece, Italy, Romania, and Croatia; 28-86%).

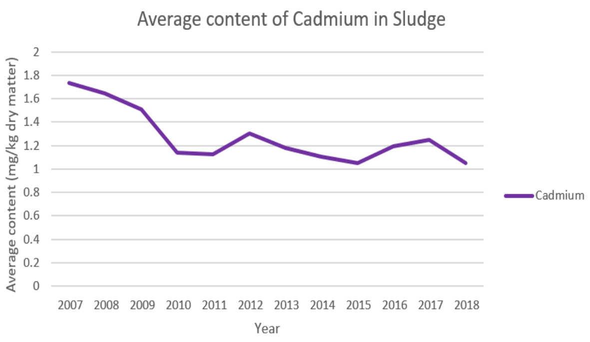
Relative importance of sludge management options within different EU Member States

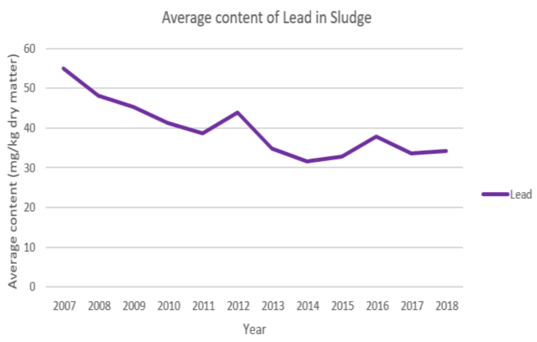


Source: Eurostat 2016 data. Data gap filling performed for some Member States based on 2010 – 2015 data.

3.5 *3.5. Metal concentrations in sludge used in agriculture and in soils where it is used*

The EU-average levels of the presence of the heavy metals regulated by the SSD in sludge all remained significantly below the limits set in the SSD over 2007-2018, very often 10 times lower. Examples are provided below for Cadmium, and Lead (average for EU-27, data taken from MS implementation reports), for which most significant decrease has been observed:





Overall for the whole EU the concentrations of lead and cadmium in sludge have decreased between 2007–2018, respectively by 54% and 18%. The levels of nickel, chromium, copper and zinc have remained rather stable. The mercury content has overall decreased too (by more than 30%), though showing the sharpest fluctuations over the period. Details on the evolution of these concentrations can be found in the 2016-2018 SSD implementation report (still bearing in mind the noted gaps in reporting).

There are no data as regards the concentration of heavy metals in soils where sludge has been used since this is not linked to a reporting requirement in the Directive.

4 4. EVALUATION FINDINGS

4.1 4.1. To what extent was the Directive successful and why?

2.1.1. 4.1.1. Effectiveness

2.1.1.1. Assessment of the success of the Directive in reaching its objectives

It has to be noted that the purpose of the Directive is not to impose sludge use in agriculture, but rather to encourage this practice where it is safe to the environment, to human health and has benefits to the circular economy through the recovery of nutrients. The effectiveness of the Directive is assessed against its objective, as stated in its Article 1, which is to facilitate the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, thereby encouraging the *correct* use of such sewage sludge. In this context, "correct" means that:

1. the limits set for the following parameters are respected:
   - concentration of certain heavy metals in soil,
   - concentration of certain heavy metals in sludge,
   - annual quantities of certain heavy metals which may be introduced into soil intended for agriculture,
2. and plant needs are respected as well as other restrictions on the application of sludge in certain times or areas.

The Directive has been effective in establishing a minimum level of harmonisation for environmentally safe recovery of sewage sludge through use in agriculture. It has also been, so far, the only legislation with soil protection as its primary objective. All Member States have set and applied limits for the parameters regulated by the SSD, ensuring monitoring of heavy metal content in sewage sludge and in agricultural land where sewage sludge is to be used.

The Directive does not require soil quality data to be reported (separately or in conjunction to the sludge used) to the Commission. There are also no other EU level data to correlate soil quality and the use of sewage sludge. Data are rather available on the quality of sludge, or on the quality of soil, but not specifying whether sludge has been applied onto them, or looking across all other sources of pollutions, not allowing to single out the contribution of sludge[23]. Some examples of review of soil quality in Lombardy and through a review of samples collected as part of the LUCAS[24] top soil survey found regional differences in the percentage of heavy metal concentration above the SSD threshold value, and also some comparison in some instances between soils where sewage sludge had been used or not. Beyond these specific examples, there are no EU-wide or country-level data identified to correlate soil quality and use of sewage sludge in a systematic way. It is as such, not possible to assess to what extent the Directive has safeguarded agricultural soils from pollution as a result of use of sewage sludge at EU level.

[23] Chengfeng, L et al, 2019

[24] Land Use and Coverage Area frame Survey, gathering information on land cover and land use across all Member States: https://esdac.jrc.ec.europa.eu/projects/lucas

There are large variations between the Member States in the extent of sludge use in agriculture with some Member States directing the majority of sludge to this use while others restricting this use considerably. But overall, sludge has been widely and steadily used to the benefit of agriculture, leading to the recovery of nutrients from 2 to 3 million tons of sludge per year in the EU.[25] However, this has contributed to improving the agronomic properties of soils and to avoiding the disposal of sewage sludge through landfilling. In the absence of the Directive setting quantitative objectives for sludge use or nutrient recovery and in view of other competing forms of soil improvers and sewage use, the reported use of sludge demonstrates that the Directive's objectives to encourage safe use of sludge in agriculture have been met.

Between 2007 and 2018, the concentration of heavy metals in sludge has steadily decreased, to levels below the limits set by the Directive. However, it is difficult to determine to which extent this is owing to its effects, or to the more stringent limits applying in some Member States, to environmental protection policies and legislation and the gradual reduction in metal emissions from effluents entering urban wastewater treatment plants from industrial facilities. The OPC results suggest that the SSD has been effective in improving the quality of sewage sludge used in agriculture: 54% of respondents (94 of 173) reported improvements which would not have occurred to an identical level if the SSD did not exist. Respondents identified as farmers were split on this question, with 9 answering positively on the role of the SSD, and 10 answering negatively[26].

Respondents to the open public consultation were divided on the extent to which the changes in amounts of sewage sludge use and the safety of its use in their country of residence can be attributed to the SSD. Nevertheless, 79% (n=122 out of 155) agreed that it had at least played a role to some extent. 53% saw other (sub-)national laws as partly or fully responsible for the changes observed. Finally, 74% believed that other non-regulatory factors were at least to some extent responsible for the changes observed.

The Member States targeted consultation asked to what extent they agreed that the SSD had led to changes or results in their country (in general). Overall, responses suggest that the SSD has had a neutral to positive impact on changes or results, such as a generally sustainable framework for the use of sewage sludge in agriculture, increased safe use of sewage sludge in agriculture, with minimisation of pollution and health risks, increased nutrient recycling and carbon sequestration, and an improvement in the quality of agricultural soils in their country/region. Targeted stakeholders generally agree that overall, such changes or results had occurred because of the SSD[27].However, an analysis made by Wood[28] based on qualitative criteria such as evolution of sludge use in agriculture in the Member States and whether they have set more stringent requirements for that use than those of the SSD, would indicate that, at least in recent years, the implementation of the SSD has influenced or still influences the

[25] If the sludge or soil content exceeds the set limit values, a decrease of that use should occur, since the use would not otherwise be "correct".

[26] 28% answered that there would have been no noteworthy improvements without EU legislation. For 26%, levels of appropriate sludge use would have improved without the SSD but would be lower than today". 12% believed that other regulations in place before the SSD explain the improvements observed; 12% did not believe that sludge quality has increased; 12% did not know, 10% thought that improvements made up until now would have happened anyway".

[27] Listed in the questionnaire as 'Led to minimisation of pollution and health risks from sewage sludge use'; 'Led to increased phosphorus and nutrient recycling and carbon sequestration'; 'Led to increased safe use of sewage sludge in agriculture'; and 'Led to a generally sustainable framework for the use of sewage sludge in agriculture'

[28] details are also provided in Annex III, EQ1

management practices of sewage sludge only to a limited extent (only in about half of Member States, according to the analysis, but this figure is to be taken very cautiously).

In accordance with Article 12 of the Directive, 17 Member States have adopted stricter limit values for the heavy metals than the SSD, some also regulating additional substances. These developments certainly contribute to the objectives pursued by the Directive beyond the requirements of the Directive. However, they may also be regarded as putting in question whether the parameters which it regulates and the limits which it sets still provide a minimum level protection that ensures high level of protection of the human health and the environment. It also makes it challenging to distinguish the effects of the SSD itself from national action.

4.1.1.2. Other effects of the Directive

Sludge not only enhances fertility of soils through its organic and nutrient content, but it can also foster soil structure and carbon concentration[29]. Lime-treated sludge can also help reduce the acidity of agricultural soils. During the OPC, over half of respondents reported measurable improvement in the quality of agricultural soils from the use of sludge.[30] Results of the consultation of Member States show a split in the opinion on the question (29% of 14 agreed to that, 29% disagreed and 43% were neutral).

Another positive effect noted for the Directive is an increased interest in sewage sludge, and the increased knowledge related to sewage sludge including the large number of research projects considering sewage sludge.

Sludge application can also present negative unintended externalities. The long-term application of sewage sludge could cause an increase in the antibiotic resistance of bacterial communities[31], although study conducted in Sweden concludes the opposite[32] . Sludge use in agriculture also generates emissions to air and water, as described below. It has to be noted that other sludge management routes can generate such emissions too[19].

Other types of pollution should be considered too, for areas where the effectiveness of the Directive could not be assessed with certainty, notably as regards the list of contaminants covered by the Directive. A study conducted by the JRC on the basis of modelling found that a relatively small set of organic pollutants may cause significant risks to both humans and soil organisms following landspreading[33]. Another study shows that around 1% of the weight of sewage sludge is made up of microplastics.[34]

The treatment of sewage sludge in WWTP (which is needed as conditioning for use of sludge on land) has been linked to increased methane emissions, mainly from the treatment of sludge by anaerobic digestion (and, mainly, leaks from these equipment facilities) account for about

[29] Börjesson and Kätterer, 2018
[30] Of 171 respondents, 55% reported a positive or very positive effect on soils and 13% reported a very positive effect, 23% reported a negative or very negative effect, 15% reported neither negative nor positive, and 8% ticked the box of 'did not know'.
[31] Qinglin, C., Xinli, A., Hu, L., Jianqiang, S., Yibing, M., & Yong-Guan, Z. 2016. Long-term field application of sewage sludge increases the abundance of antibiotic resistance genes in soil. Environment International, 92-93, 1-10.
[32] Rutgersson C. et al, 2019
[33] Huygens et al., 2022
[34] Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling, Environmental Pollution, Volume 304, 2022. https://www.sciencedirect.com/science/article/pii/S0269749122004122#aep-article-footnote-id8

three quarters of WWTPs overall methane emissions. These methane emissions can have a larger greenhouse gas footprint than the carbon dioxide emissions that are avoided by using the resulting biogas for energy generation[35]. However, not all anaerobic digestion processes are followed by sludge use in agriculture, so these emissions are not specifically linked to the SSD.

Application of sludge on land can also generate emissions of nitrous oxide (N_2O, a gas with very high greenhouse potential) and ammonia, as investigated by Milieu et al. (2010).[36] For sludge to be applied on land, there may also be exhaust emissions (of ozone depleting gases and CO_2) due to transportation[36]. Air emissions and water pollution can also result from the over-application of sludge, if it is applied in excess of plant needs. The extent to which this happens is not known, as no specific examples of MS considering the plant needs before sewage sludge is applied were identified (and this is not information which they are required to report on).

4.1.1.3. External factors of influence on sludge use in agriculture

- **Factors having positively influenced the achievement of the objectives of the SSD**

79% of 155 OPC respondents agreed that the possibility for Member States to set more stringent requirements had played a role in the effectiveness of the SSD. Over half (53% of 156) of respondents agreed that other (sub-)national laws were to a large extent or fully responsible for the changes observed in their country of residence, as a result of more stringent measures put in place by some Member States. In the targeted consultations with Member States and stakeholders, most strongly agreed or agreed that stricter limit values of one or more heavy metals concentrations in sewage sludge set by Member States had contributed to the achievement of SSD objectives.

Sludge production has increased considerably since the adoption of the Directive, and its quality has improved over time in terms of content of heavy metals legislated by the SSD[37], which is considered a positively influential factor. The evolution of sludge use on farmland follows that of sludge production, reflecting the need to dispose of sludge produced (see figure on sludge production and use in section 3.2). There have been some significant technological improvements, for example, improvements in wastewater purification and sludge treatment technologies and plants, that have been developed to meet the requirements of the Directive. The resulting improvements in sewage sludge quality have also had positive knock-on impacts for effluent, wastewater and water quality, bringing wider benefits than simply improvements for sludge used in agriculture.

Quite a few voluntary schemes have been put in place in a number of Member States. Under these systems, sewage sludge producers provide recipients with a certificate which guarantees that sewage sludge meets specific quality standards. This further improves the confidence of farmers relying on it as fertiliser, thereby supporting the use of sludge in agriculture.

[35] Daelman, M et al.

[36] Milieu et al., (2010) Environmental, economic, and social impacts of the use of sewage sludge on land

[37] See section on legislation preventing pollution at the source in section 4.1.3 on coherence. Also, emissions of heavy metals across Europe decreased since 1990 in alignment the EU commitments under the UNECE Air Convention. Between 2005 and 2019, emissions have continued to decline, with lead emissions decreasing by 44%, mercury emissions by 45% and cadmium emissions by 33% across the EU-27 Member States (EEA, 2021)

[37] European Commission workshop. (n.d.): Technology and innovative options related to sludge management.

Examples include Ireland, alongside its Code of Good Practice for Use of Biosolids in Agriculture[38], Sweden's REVAQ certification system[39] and France's RISPO Certification, which provides a guarantee that sewage sludge has 'agronomic interest', meeting environmental, health and safety requirements and which includes an audit of WWTP and agricultural operators[40].

Other legislation of the waste acquis also facilitate the recovery of sludge. The landfilling Directive (1999/31/EC), which aims at reducing the amount of waste which is landfilled, made landfilling of sludge decrease considerably over the past years, partly to the benefit of sludge use in agriculture. The Waste Framework Directive (2008/98/EC) sets a waste hierarchy requiring to prioritise nutrient recovery over energy recovery or disposal. As foreseen by that Directive, some Member States have adopted national 'end-of-waste' criteria which recognise the status of digestate (the material remaining after the anaerobic digestion) and/or of compost as products and no longer waste. This facilitates sludge use in agriculture and improves public trust in the product. However, such criteria differ among Member States and stakeholders indicate that a lack of a broader set of criteria and a harmonisation of end-of-waste criteria are a barrier for (more innovative, e.g. production of bioplastics from sewage sludge) sludge processing technologies and applications that aim at making products form sewage sludge, including for other than agriculture uses[41]. The status of sludge as waste furthermore influences its treatment and uses in view of compliance and transportation cost implications for its shipments as waste. Acquisition of a non-waste status is also a factor influencing technological developments in view of the increasing priority to tackle phosphorus depletion and EU's dependency on imported phosphate fertilisers. The SSD does not regulate the end-of-waste status of sewage sludge; it only regulates the conditions for its application on agricultural soil. The Fertilising Product Regulation 2019/1009 establishes end-of-waste criteria for EU fertilising products containing certain materials derived from sewage sludge.

As will be seen in section 3.1.2 on efficiency, the cost of sludge application is lower than tht of other sludge management options, provided that distances from suitable agricultural land are not prohibitive. When sludge must be transported, costs can become too high for a cost-effective use of sludge in agriculture, thus leading to less availability for reuse. The European Court of Auditors noted that there were significant variations among WWTPs reviewed in the cost of transport and disposal of sludge. The share that costs of transport and disposal of sewage sludge can represent in the total operation costs of the WWTP also varies, with up to 50% of the total operating costs of the WWTP, in some extreme cases[42].

- **Factors having negatively influenced the use of sludge in agriculture**

Sludge use in agriculture has typically competed with incineration and landfilling. Additionally, this use is not possible at certain periods of the year, e.g. winter, or during periods of plant growth, when the plant nutrient demands are low. This requires storage

[38] Aqua Publica Europea. (2019). Thematic Workshop: Towards a sustainable approach to sludge management: legal frameworks and technological solutions

[39] EEA, n.d. Provision of services in the area of sewage sludge and the circular economy (upcoming)

[40] RISPO. (n.d.) https://rispo.org/certifications

[41] Aqua Publica Europea. (2019). Thematic Workshop: Towards a sustainable approach to sludge management: legal frameworks and technological solutions

[42] European Court of Auditors, 2015

facilities during these periods and increases its management costs, therefore pointing in favour of other treatment routes for sludge.

Feedback from stakeholders noted the increased interest in using sewage sludge as fuel for industrial processes. It was also noted that being a biomaterial, for industries regulated under the Emissions Trading Scheme, using sewage sludge to produce energy allows to reduce emissions allowances needed. Sludge is considered to be more environmentally friendly than coal, so there are therefore less allowances to provide for the use of it, and this also provides an incentive for incineration (typically in the cement industry in this case). This sludge management route may become more prominent in view of the Union policies on energy independence and climate neutrality. Mono-incineration can also be a first processing step to recover phosphorus in a form that resembles the phosphorus density of phosphate rock, to be used in fertilising products or other applications for the phosphate industry. Therefore this sludge management route has the potential to help reduce dependency to imports of phosphorus which has been declared an EU critical raw material.

Many other types of sludge can be generated from industrial processing of animals, milk processing, or paper mills (paper sludge), or from manure in livestock rearing activities[43]. The use of these sludges in agricultural soil can be less tightly regulated as they contain a narrower spectrum of contaminants. Manure also further competes with sludge as it is commonly used in agriculture in large quantities.

Sludge also competes with bio-waste, which may be of better quality as it generally contains less contaminants, whether chemical or physical (plastics, micro-plastics) or biological (pathogens)[44]. As of 2024, when Member States are required to introduce separate collection of biowaste under Article 22 of the Waste Framework Directive, more bio-waste as compost will be available for use in agriculture and competing with the sewage sludge.

- **Other relevant factors**

Public and farmers confidence in sludge use is mixed across the EU[45] [46] [47], notably due to a lack of confidence in its safety or odour nuisances, resulting in a lower acceptance of sludge by farmers[48]. There is lack of understanding on the safety of sludge use, which may even result in resistance from food retailers or consumers' approach to crops grown on soil fertilised with sewage sludge.[49] Stakeholders have indicated that improved fact-based communication on the safety and benefits of sludge use in agriculture would be beneficial to raise confidence in such applications.[50] Research undertaken to find a link between strict requirements and public trust provides mixed results.[51] The lack of public acceptance can affect policy decisions: a link has been identified between the negative attitude of the population on the agricultural use of biosolids (e.g. France and Germany) and Member States

[43] European Commission. (n.d.). Technology and innovative options related to sludge management.
[44] Milieu Ltd; WRc; RPA. (2010). Environmental, economic, and social impacts of the use of sewage sludge on land
[45] Aqua Publica Europea. (2019). Thematic Workshop: Towards a sustainable approach to sludge management: legal frameworks and technological solutions
[46] European Commission workshop (n.d.): Technology and innovative options related to sludge management.
[47] https://www.italianostra.org/wp-content/uploads/DOCUMENTO-FANGHI-DA-IMPIANTI-DI-DEPURAZIONE.pdf
[48] European Commission. (2001). Disposal and Recycling Routes for Sewage Sludge Part 1—Sludge Use Acceptance Report
[49] European Commission. (n.d.). Workshop: Technology and innovative options related to sludge management.
[50] Aqua Publica Europea (2019). Thematic Workshop: Towards a sustainable approach to sludge management: legal frameworks and technological solutions.
[51] Collivignarelli, M., et al. (2019)

setting stricter requirements on limit values than the SSD. For those Member States with limit values similar to the SSD the public perception varies. In most cases (e.g. Ireland, Italy, Portugal, Spain), no debate was identified in the general public.[52]

Expert respondents in the OPC indicated that the perception by stakeholders and the public was still one of the most hindering factors of the use of sludge in agriculture. Results from the targeted consultation include 77% of respondents (30 of 39) agreeing or strongly agreeing that the negative perception of sludge by the food industry due to potentially contaminated soils or agricultural products hampers the achievement of the SSD's objectives. A slightly lower percentage (although still the majority) reported that the negative perception by the public was also a negative factor (62% of 39). Perceptions of sludge use by stakeholders and the general public hindered the achievements of the SSD's objective were reported by 32% of OPC respondents (48 of 152)[52]. A similar proportion of respondents, however, considered this factor to have facilitated the achievements of the SSD's objectives (31%: 47 responses) [53].

Local conditions[54] have a strong impact on sludge management and use. Geographical drivers that affect the sewage sludge management route include the local influent composition of wastewater (e.g. caused by variations in rainfall, local industry etc. which can affect sludge composition), the local climate, soil quality and nutrient needs, the availability of treatment infrastructure, the proximity of the sites for further use of sludge to the WWTP (as this has a major impact on the cost of using sludge on farmland), seasonality and location-specific legislation. For the use of sewage sludge in agriculture the most common drivers include specific benefits to soil health such as its ability to increase soil organic matter and the high energy demand of drying and alternative disposal routes. However, these benefits are opposed by the risks associated with contaminants found in sewage sludge, the costs of transporting sewage sludge from WWTPs to the rural sites of disposal and the relative benefits of alternative technologies such as incineration and pyrolysis (thermal degradation at very high temperatures and in the absence of oxygen).

2.1.2. 4.1.2. Efficiency

2.1.2.1. Costs and benefits arising from the implementation of the Directive

- **Direct costs**

The main **direct costs** associated with sludge use in agriculture relate to:

1. The **treatment**(s) of sludge before its use
   Sludge is treated in various ways at a WWTP, e.g. chemical and/or biological stabilisation, dewatering, drying. Anaerobic digestion for example has the advantages of simultaneously recovering energy to operate the WWTP itself, reducing sludge volume (which lowers transporting cost), improves dewatering and stabilises or hygienises the sludge for agricultural use.
   At present, sludge is subjected to anaerobic digestion at around 2 200 UWWTPs[55]. Around 10% of the EU UWWTPs>2 000 p.e. use anaerobic digestion for sludge treatment.

[52] 10% reported this factor had 'greatly and 22% reported it had 'hindered',
[53] 7% reported the factor had 'greatly facilitated', and 24% reported 'facilitated'.
[54] Wood, exploratory study (2022)
[55] EBA (2021) Statistical report 2021. European Biogas association.

These treatment processes involve investments into infrastructure, and operating costs, including labour costs. Such costs are usually borne by the wastewater treatment plant operators, depending on the structure of the water and sanitation sector in the region concerned. Wastewater treatment plant operators are either private companies operating for a public competent authority, public companies owned by the public competent authorities (around 60%) or mixed companies[56]. The cost for sludge treatment at the treatment plant are not included in the sludge disposal costs for the different sludge management options. It was deliberately decided not to agglomerate the costs for sludge treatment at a WWTP and the subsequent costs for the use, treatment and/or disposal of the sludge. An essential reason is that the costs and also the economic benefit of individual treatment steps such as sludge digestion at the WWTP cannot always be clearly allocated to the treatment plant or subsequent disposal of the sludge. In addition, the costs for sludge treatment at a WWTP are already subject to very large uncertainties, which depend above all on the size of the WWTP. Aggregation of the costs would not allow a clear interpretation of the costs for individual sludge management options.

2. The **transport** of the sludge,from where the sludge is generated or treated to the destination farmland

3. **Storage** of the sludge, possibly, in (fall/winter) periods when it is not permitted to spread organic materials.

4. **Application** (spreading) onto the agricultural field.

The following tables provide examples of such costs, occurring at the WWTP or associated to final use, treatment or disposal. Data scarcity was compensated through information gathered through the targeted stakeholder consultation. More detailed cost data are presented in Table 2 in Annex III.

Sludge treatment at the WWTP	Cost range, €/t DM	Year	Country	Source
Anaerobic digestion	(20-50)-200 130-510[1]	-		Stakeholder consultation; Egle et al., 2023 (under development)[57]
Mechanical dewatering	75-2-300	2016	Germany	INECTUS, 2016 ; JRC data ;
Solar drying	125-360	2018	Germany	Egle et al., 2023 (under development) ; Kabbe et al., 2018
Thermal drying	150-715	2015, 2016 2018	Italy, Slovenia, Germany	Diaz, Gracia and Canziani, 2015; Bratina et al., 2016; Stakeholder consultation; Egle et al., 2023 (under

[56] SWD(2022) 541 final
[57] Egle et al., 2023 (under development)

				development); Kabbel et al., 2018

Sludge management option agriculture	Cost range, €/t DM	Year	Country	Source
Agricultural use (wet sludge)	100-375	2018, 2021	Germany, Austria	Kabbel et al., 2018 ; Amann et al. 2021
Agricultural use (dewatered sludge)	80-175	2018, 2021	Germany, Austria	Kabbel et al., 2018 ; Amann et al. 2021

Transport	Cost range, €/t DM	Year	Country	Source
Transport with truck (15 km[3], 30 t capacity)	3-4 (dewatered sludge)			Egle et al., 2023 (under development)
➢ **Transport with tractor and trailer (15 km[3], 14 t capacity)**	60-70 (wet sludge) 8-10 (dewatered sludge)			Egle et al., 2023 (under development) Egle et al., 2023 (under development)

[1] An economic operation becomes feasible for WWTP exceeding 20 000-30 000 p.e.
[2] Cost for WWTP with capacities from 20 000 to 500 000 p.e (population equivalent) (for small WWTP anaerobic digestion is very expensive.
[3] Typical transport distance for direct sewage sludge use (Amann et al., 2021)

5. **Other costs** borne by the treatment plants, competent authorities and farmers arising from the implementation of the Directive, depending on the wastewater sector organisation, are significantly lower and distributed as follows:
   - Sludge and soil testing costs (testing service providers indicate that those represent a very small proportion of total costs). These may be incurred by the UWWTP operators and/or further treatment operators, farmers and/or competent authorities.
   - Administrative costs for wastewater treatment plant operators, for reporting purposes.
   - Administrative costs (notably for reporting) and enforcement costs, borne by Member States authorities (discussed in section 3.1.2.4.)
   - Payments by the wastewater treatment plant operators to farmers for the receipt and use of sewage sludge on agricultural land ("gate fees”).

➢ **Direct benefits**

Direct benefits linked to sludge use in agriculture:

1. The savings made by the UWWTP operators or subsequent treatment operators using the agriculture route as a sludge management option, compared to other routes[58] (discussed below).

[58] Calculating benefits in terms of savings made in this way was also the approach taken in the 2014 evaluation

2. Potential savings for UWWTP operators or subsequent treatment operators as a result of certain sewage sludge treatment operations compatible with sludge land spreading. For example anaerobic digestion reduces the volume of sludge and improves dewaterability (lower water content). This reduces the cost for transport and sludge use in agriculture.

3. The savings made by farmers for not using mineral fertilisers (partial replacements of mineral fertilisers).

Annex IV provides a more detailed overview of the cost and benefits of the Directive.

- **Comparison of costs of sludge use in agriculture compared to other management routes**

Table 2, provided in Annex III (EQ 6) presents costs and benefits of different sludge treatment options. It shows that costs are high, and costs vary inside ranges which are very broad.

However, it only shows the costs of individual treatment options. This alone does not represent overall costs of a sludge management route, as the latter includes combinations of treatments and transport costs. The cost of a sludge management route should be calculated by aggregating operator costs linked to the implementation of the SSD.

Estimating costs of each sludge management route (agriculture or other ways to use or dispose of sludge) is difficult. With equal adopted technology capital, operating and energy costs will vary not only from country to country, but also between different sites in the same country, due to differences in labour, transport distances, sludge storage requirements and conditions, energy costs, and economies of scale made according to the size if the plants. This also explains the wide ranges observed for cost data on different treatment options. Also, the treatment techniques before use or disposal may be combined in multiple arrangements (e.g. thickening, dewatering, liming, anaerobic digestion, drying at the UWWTP), further increasing cost data variability. Quantitative information on the volume of sludge treated using different techniques or combinations thereof is very scarce.

Certain costs are common across the different sludge management routes, e.g. transport costs, dewatering, drying and stabilisation. The agriculture route incurs less costs than other options as can be seen from the estimates (from the same study) reflected in the table below.

It is therefore difficult to find aggregated data, i.e. which include costs of the combination of treatment(s) applied.

Research undertaken by the JRC[59] allows to compare the costs of different sludge management options (not including the cost for processes at the WWT plants). They were based on extensive literature review[60], stakeholder consultation and own cost calculation taking into account different plant sizes and different dewatering levels of the sewage sludge:

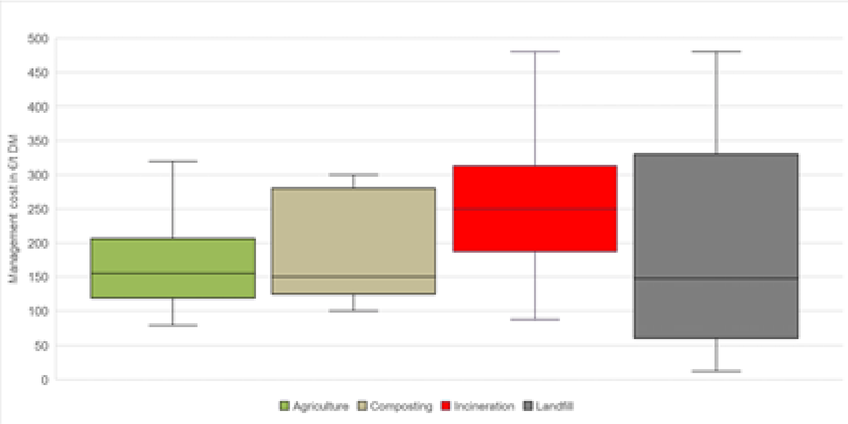
Results were synthetised in the following boxplot, which shows the different sludge managing options. In some cases, the cost of using sludge in agriculture is in the order of magnitude of

[59] Egle et al., 2023 (under development)

[60] Including, for instance, studies referred to in the table 2, presenting costs and provided in Annex III and the table below, which is an extract from it. Sometimes these studies provide averages and/or cover a very high number of observations

incineration (mainly co-incineration in coal and cement plants). However, this is mainly due to some extreme values for both sludge management options, which makes the ranges of costs very broad and makes them overlap, but not representing typical situations (in some cases, the minimum or maximum is only based on one observation or calculation). The clear difference between land spreading and incineration costs becomes clearer when looking at the 75% percentile. In 75 % of the cases, landspreading has a cost below ~200 €/tDM, whereas incineration is in 75% of the cases more expensive than ~200 €/tDM. The cost for composting can be in the range of direct agricultural use (median value around 150 €/t DM). The final use of composted sludge is often not clear. For the use in agriculture additional cost such as storing, transport and spreading need to be considered. With regard to the end use of the composted sludge, it should be noted that a large portion is not applied to cropland.

Costs of different sludge management options



NB: The range of landfill costs considered here only covers countries which still landfill sludge. As can be seen in the appendix, landfill cost can be higher than 480. But in these countries no sewage sludge is landfilled.

Overall, sludge use in agriculture broadly remains the most cost-effective option across data reviewed.

➢ **Comparison of cost-efficiency between agriculture use and incineration**

For incineration, the main alternative to sludge use in agriculture, the <u>cost differential is the most substantial</u>:

2 studies from Germany (mainly based on German data) also show the following ranges of aggregate costs for agriculture and mono-incineration (whether revenues are included is not known):

	Agriculture use (Cost-EUR/tDS)	Mono-incineration (Cost-EUR/tDS)
Wiechmann et al., 2015	125-175	175-400
Umweltbundesamt 2018	160-320	280-480

Across data reviewed, aggregated costs for (mono-)incineration come out as 1.5 to 3 times as expensive as sludge use in agriculture (even 10 times in some examples provided from the stakeholder consultation).

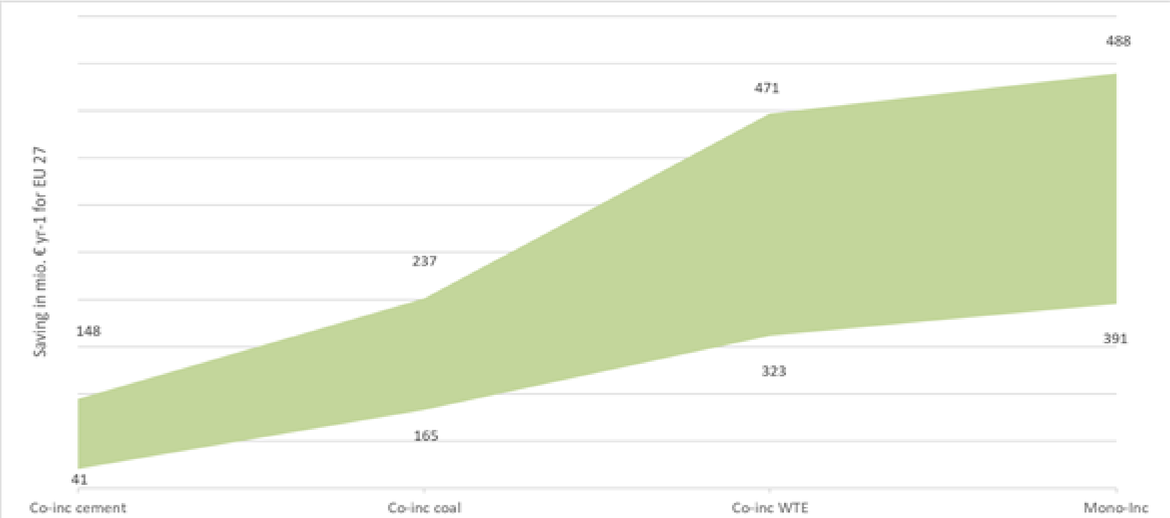
- The cost-efficiency also remains true when considering energy or other revenues from incineration. This is mostly a waste disposal option with minor benefits for other actors and downstream users. Modern incinerators recover heat and energy from the sludge, largely dependent on the pre-treatments (e.g. dewatering, drying) applied. Yet, revenues from these recovery processes by far do not compensate other capital and operational costs of the incineration plant. Some sewage sludge incineration ashes are used as a construction material (e.g. for road construction), but the economic value of ashes is negligible[61].

- This cost-efficiency remains true in the rare cases when considering revenues from P-recovery are included, as the necessary mono-incineration step is the most expensive incineration technology and equipment and operational costs of the recovery technology are high. Revenues of such production would only partially neutralise the high infrastructure and operational costs of such waste recovery process.[62]

- P-recovery is marginal, at least today: at present only a negligible share of the sludge is incinerated and processed through this route. Today, across the EU, there are only about 5 full scale plants operating or under permitting/construction, located in the Austria, Germany, Netherlands, and Sweden[63], treating currently around 60,000 tons of sludge ash, which corresponds to about (150,000 t DM, which is negligeable). Therefore, such advanced phosphorus recovery processes are hardly relevant for this backward-looking evaluation report.

Calculation of savings from using the agriculture route:

From the JRC data provided above, a graph can be derived to show the savings made by using sludge in agriculture compared to the three co-incineration and the mono-incineration options:



If a hypothetical shift from the current sludge volumes from agriculture towards incineration were to occur, the additional cost would correspond to 41 – 488 million € per year, depending on the incineration technology assumed and based on 25 - 75 percentile cost data. For mono-incineration only these additional costs would be of 391-488 million €/yr[64]. Mono-incineration

[61] Egle et al., 2023 (under development)
[62] Egle et al., 2023 (under development)
[63] ESPP (European Sustainabke Phosphorus Platform), DPP and NNP (2022)
[64] Egle et al., 2023 (under development)

represents 50% of the total sludge incinerated. Other types of incineration, as can be seen on the above graph, include co-incineration, e.g. in cement plants, possibly accompanied by energy recovery ("co-inc WTE" on the graph above).[65]

Wood[66] also estimated the benefits based on differentials between sludge use in agriculture and other options of the SSD differentials with other options of sludge use and disposal. Based on available literature from two German studies (see Annex III), it was estimated that the average cost savings between agricultural use and incineration of dewatered sludge would amount to **150 € per ton of dry sludge (tDM)**[67]. Based on the assumption (rather arbitrary) that between 30 and 70% of the sludge currently applied to agriculture would be treated more cost intensively by incineration in the absence of the SSD, the agricultural use of sewage sludge would result in **aggregated cost savings for UWWTP operators of 100-240 million € per year**[68]. However, these figures present a lot of uncertainties, as regards the methods and assumptions made for the calculation. They should be considered as very indicative.[69]

The 2014 Evaluation of the Directive had estimated that if the agriculture route were lost, to be replaced by incineration, the cost would be of the order of EUR 650 million per year[70].

- **Benefits to farmers from the land spreading of sludge**

Farmers are the other key group which is impacted by the Directive, largely incurring savings as a result of sewage sludge use. They benefit from the application of sludge on agricultural land in 3 ways:

- The use of sewage sludge provides nutrients to plants, and thus partially replaces the production and use of mineral fertilisers and associated costs;
- Sewage sludge also contains organic matter that contributes to improving soil structure and reducing soil erosion, moisture holding potential and buffer capacity. Particularly in soils of low organic matter content (e.g. in southern Europe) may be a valuable asset to contribute to soil organic matter build-up;
- In some countries, farmers are commonly paid by the wastewater treatment plant operators to accept the application of sewage sludge on their land, e.g. 100 €/tDM in Lithuania[71] and 100-560 €/tDM in Germany[72]. On-going work by JRC indicates a potential revenue of 2-10 €/t for compost[73]. Reports from Bulgaria and the UK[74] suggest that farmers do not receive payments for sludge to be used on land.

Potential savings associated with the use of sewage sludge for farmers have been estimated considering the levels of nutrients present in sludge as indicated in the Member State implementation reports and assuming that all the nutrients brought by sludge would have been

[65] Egle et al., 2023 (under development)
[66] Wood, Support to the evaluation of the Sewage Sludge Directive (2022)
[67] Wood, Support to the evaluation of the Sewage Sludge Directive (2022) Based on information received from the stakeholder responses and the literature review
[68] Wood, (2022) - Support to the evaluation of the Sewage Sludge Directive (2022); Details about the calculations are also provided in Annex III to this report, EQ6.
[69] Egle et al., 2023 (under development)
[70] Milieu, 2010
[71]NB: This figure was obtained from one interview respondent. There is mention of competition of dried sludge from industrial installations interested in co-incinerating and selling resulting carbon allowances to the market. These accept sludge free of charge and are willing to pay for longer distance transport, e.g., 400 km.
[72] This figure was obtained from one of the targeted questionnaire respondents.
[73] Egle et al., 2023 (under development)
[74] Information provided for reference, though the UK is not covered by this evaluation

provided by use of fertilisers.[75] It would range up to **96 €/tDM for nitrogen** and **44 €/tDM for phosphorus**. However, it cannot be assumed that all the sludge applied to agricultural land in Europe is associated with a pro rata monetary saving linked to avoidance of inorganic fertiliser purchases: due to the significantly lower fertiliser efficiency of sewage sludge relative to mineral fertilisers and of availability of other sources of organic waste that can be recovered on land with benefit to agriculture, namely, manure and biowaste. Also, it is not clear what proportion of sludge is applied to agricultural land with a nutrient deficit.

Other direct benefits which could not be quantified include:

- the organic matter brought to the soil by sludge (even though these amounts are small compared to the benefits from application of manure (livestock waste))
- the benefits brought by sludge as soil improver (of density, mechanical or physico-chemical properties of the soil) property of sludge.
- the potential benefits of using organic fertiliser for productivity of land over time

Finally, the implementation of the Directive allows the reduction of disposal and landfilling of sludge, which would have a positive environmental impact and an impact on the revenues of the different actors linked to the landfilling of waste. This benefit could not be quantified in view of difficulties shown at the beginning of this section on estimation of costs and with scarcity of quantitative data on sludge routes and treatment.

All in all, provided that environmental and health protection is safeguarded, encouraging sludge use in agriculture brings significant financial benefits to both UWWTP operators (or the end beneficiaries of saving made on treatment) and farmers, by allowing significant savings.

2.1.2.2. Externalities

The indirect effects of the Directive, as described in section 4.1.1, can lead to externalities which can be either positive or negative.

Positive externalities include, first, the fact that the implementation of the Directive allow to prevent pollution of agricultural soil by heavy metals as a result of recovery of sewage sludge. Since sludge has an agronomic value and it is an economically attractive waste management option for the UWWTP operators, the Directive provides a minimum level of environmental protection for such activities.

Second, the use of sludge in agriculture also prevents the depletion of natural resources which would otherwise result from mineral fertiliser use, a non-renewable and critical resource to the European Union economy.

Third, sludge use in agriculture can also have positive effects on climate change. At present, the net combined effect of sludge management through the different routes is estimated to net emissions of 1.2 million tonnes CO_2-eq[76] per year. If done in a sustainable way, sludge management has a potential to become a net sink of CO_2, following a further reduction of the global warming footprint with up to 3 million tonnes CO_2-eq per year. Using it in agriculture

[75] Wood, support to the evaluation of the Sewage Sludge Directive (2022)

[76] CO_2-equivalent

generally has a net negative carbon footprint, due, amongst others to the sequestration of CO_2 in soils and its potential to substitute mineral fertilisers, produced through energy-intensive processes. Still, the absolute footprint from sewage sludge management is relatively small in comparison to operations taking place upstream (sewage system and wastewater treatment plants), estimated at around 25-30 million tonnes of CO_2-eq per year.[77] The agricultural sector as a whole produced 426 million tonnes of CO_2 equivalent of greenhouse gases in 2015, about 10 % of the EU's total greenhouse gas emissions (excluding Land Use, Land Use Change and Forestry net removals) for that year[78] .

Other indirect effects can also cause **negative externalities**. As seen before, the application of sludge on land can generate air emissions, notably in instances of over-application of nitrogen. The potential application of sludge in excess of plant needs for nitrogen can lead to emissions of nitrous oxide (N_2O) and ammonia (NH_3), a gas with high greenhouse potential. Recent data would estimate the external cost of ammonia emissions at 2-20 EUR/ kg of NH_3-N emitted, knowing that 1 tonne of sludge could emit a up to 15-20 kg NH_3 (these losses are a continuous process, but most losses occur shortly after application)[79]. Equipment inefficiency can also lead to air emissions, e.g. methane leaking from anaerobic digesters (mainly from old installations, from poor design and maintenance) or dioxins, furans and sulphur dioxide emitted by incinerators. Note that these negative externalities are also relevant for other sludge destinations.

Other types of pollution should be considered too, for areas where the effectiveness of the Directive could not be assessed with certainty, notably as regards the list of contaminants covered by the Directive and whether the latter ensures high level of environmental and health protection. This will be discussed in section 4.3.2 of the Directive. Pollution from other contaminants (e.g. PFAS, pharmaceuticals, microplastics) that are not regulated by the SSD cannot be quantified, and neither can be the spread of antibiotic resistance (which they contribute to). Similarly, the over-application of nitrogen could also result in eutrophication though there is no evidence that this is the case from use of sewage sludge.

2.1.2.3. Factors affecting cost-efficiency

A very wide range of factors affect costs and the cost-efficiency of the implementation of the Directive, which results in a wide variety of situations in the Member States. There is no specific pattern, for instance between new or old Member States, or North to South, as this depends very much on local situations. These factors are notably:

- The size of urban dwellings (economies of scale can be made with treatment equipment of bigger capacity).
- Economies of scale.
- Agronomical characteristics of sewage sludge depending on the input material.
- Competition on a local level with other available organic fertilisers, such as manure or compost.

[77] Data from JRC policy report on the UWWTD (not yet published at the time of writing this report).
[78] Eurostat (2021
[79] Brink et al., 2011

- Distance from wastewater plants to suitable agricultural land. In practice, a study by Amann et al.[80] found that distances do not exceed 50 km (on average less than 20 km) and could be significantly lower. Transport distances to incinerators are in average significantly longer (average 150 km), resulting in higher transportation cost. For countries with lower developed incineration capacities, the transport distances can be even higher.
- Energy costs, which are notably cost drivers for thermal treatments, including incineration.
- Average labour cost. According to the Milieu 2010 study, operating costs constitute a large proportion of total sludge management costs, particularly for land spreading with values recorded between 65% and 70%. According to Eurostat, average 2019 labour costs in the wider water and waste sector range from €5-€42 / hour in different Member States[81].
- The variety of sludge treatment technologies applied across the EU. Thermal drying technology is mainly applied in EU-15 countries, composting and chemical stabilization with lime are used considerably in Finland and Poland.[82] Eurostat reports high composting rates above 25% for CZ, FR, CY, LT, HU, SK, FI, SE. The infrastructure/equipment cost is reported to be relatively uniform across the EU[83].
- Possibly: the continuous implementation of the UWWTD, resulting in higher volumes of sludge generated and to be managed where additional wastewater treatment capacity is developed. However, this remains unsure as increased sludge processing (dewatering, anaerobic digestion) may counterbalance increases due to the greater processing of wastewaters. Where the proposal for a revised UWWTD introduces stricter treatment requirements, this may also impact the amount of sludge generated as well as its composition and agronomic value (including higher level of contaminants)[84].
- Technology developments such as energy efficiency improvements or innovations such as secondary activated sludge treatments in WWTPs lead to changes in the cost structure of sludge treatment (e.g. anaerobic digestion as a technique that reduces sludge volumes).
- The structure of the water and sanitation sector. Financing structures vary considerably across Member States and local authorities. Some operate regulated tariffs which aim for cost recovery and others operate local or national subsidy systems that are often associated with significant underinvestment in equipment replacement in the sector. In some Member States, private sector operators are engaged in time-bound concession contracts and depending on the structure of such concessions, longer payback investments may be discarded to the detriment of sanitation users, taxpayers, or environmental quality stakeholders. Member States that have joined the EU after 2003 have made significant use of EU structural funds and illustrated in interviews related to Lithuania, Bulgaria, and Romania.
- Applicable rules at regional level, notably whether more stringent requirements are applied, and whether certification systems (the voluntary schemes described in section

[80] Amann et al. (2021) Operation and Performance of Austrian Wastewater and sewage sludge treatment. Water 2021, 13(21), 2998; https://doi.org/10.3390/w13212998 (indicate max 10 km for wet sludge and max 20 km for dewatered sludge)
[81] Eurostat data.
[82] Kelessidis A, Stasinakis AS (2012)..
[83] According to an interview with multinational water operator multinational water companies require suppliers to quote unique prices irrespective of MS destination.
[84] The proposal is now subject to negotiations by Council and Parliament

4.1.1) in are in place. For the latter, associated costs are small[85] as a percentage of total average costs of the agriculture application option.

Considering this heterogeneity of factors and the fact that local conditions and the individual specificities of the WWTPs strongly influence sludge management choices, the enabling and **flexible nature of the SSD is seen as a cost-efficient feature**, as it allows decision-making to be undertaken on the basis of local factors. However, the uncertainties as regards the costs and benefits of potential or affirmed indirect effects of the Directive do not allow to conclude on the overall cost-effectiveness of the Directive. Locally, cost-effectiveness will also be further affected by national or regional applicable rules and practices such as the setting of more stringent requirements. Finally, it is not clear whether negative externalities linked to pathogens or organic micro-pollutants are missed in countries that do not impose quality restrictions in relation to these aspects.

<u>Stakeholders views on cost-benefits:</u>

Results from the OPC show a tendency to value the social and environmental benefits that the SSD brings more than its costs. This statement is valid for all stakeholder types, with the following two exceptions: NGOs viewed the costs as outweighing the benefits under all sub-questions, and EU citizens were split.

2.1.2.4. Administrative costs and reporting

The administrative costs borne by Member States linked to the implementation of the SSD include monitoring, reporting and enforcement and can be estimated at around **EUR 77,000 to EUR 80,000 per year** per Member State on average[86]. This can be considered as moderate in comparison to other environmental directives. Details on how these costs were estimated are provided in Annex III, EQ 10.

However, the reporting system shows deficiencies. As noted in section 4.1.1, it only allows to assess the effectiveness of the Directive to an extent.

- On existing reporting requirements, widespread gaps were noted in reporting, suggesting room for improvement on data collection and record keeping within some Member States.
- Data reported by Eurostat and in the Member State implementation reports lack comparability and granularity. For instance, data from Eurostat indicate the quantities of sludge which undergo composting, but the destination of that composted sludge is unknown. Some of it is eventually used in agriculture, so this fraction should then be counted as sludge used in agriculture.
- Further, there is room for simplification and alignment between data reported for the implementation of the SSD, that of the UWWTD, and data provided to the EEA and Eurostat[87]. Reporting obligations could clarify analytical methods respectively prescribed by the two Directives, links between the two sets of reporting requirements[88] and align reporting cycles.

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[85] For example, for the Swedish REVAQ systems, testing costs range from €0.5-3/tDS and 0.5-1/tDS for sludge and soil respectively. Certification costs for REVAQ WWTPs range from €2-3/tDS, with an additional €0.2-5 fee for a third-party auditor.

[86] Wood report on the evaluation of the SSD (2022) - Details of calculations are provided in Annex III.

[87] "Ex-post evaluation of certain waste stream Directives", EC (2014); "Fitness check of monitoring and reporting obligations arising from EU environmental legislation", EC (2017); SWD(2019)700 final of 13.12.2019 on the evaluation of the UWWTD.

[88] SWD(2019) 700 final of 13.12.2019.

- The Directive requirement to take into account plant needs before the application of sludge on soil is not linked to any reporting obligation and it would help to monitor possible over-application of nutrients. This was also noted by some stakeholders. These aspects are closely monitored in Nitrate Vulnerable Zones under Directive 91/676/EEC, but they cover only a proportion of agricultural land in Europe.
- The Directive does not require Member States to provide reasons for adopting stricter requirements.

As of 2023, as a result of Regulation 2019/1010, which aimed to improve the transparency of environmental reporting, amending the SSD, Member States are required to report on the implementation of the Directive annually as well as to report spatial data on the agricultural areas where sludge is to be applied. This will improve the reporting scheme, which currently is not only 3-yearly, but, as shown in section 4.1.1, is limited. Such assessments will also be eased within the general framework of improvement of reporting and monitoring of environmental legislation[89], and upcoming obligations under the Common Agricultural Policy.

This will also increase costs of monitoring and reporting (for the SSD), for Member States and relevant stakeholders (UWWTPs and possibly farmers). However, in addition to the advantages described above, this cost increase can be mitigated by re-using data from existing data sources from other policy areas, such as cadastral data or data collected in the context of the Integrated Administrative and Control System for the management of the Common Agricultural Policy and Regulation (EU) No 1306/2013[90].

2.1.3. 4.1.3. Coherence

Since the adoption of the Directive, both the policy and regulatory landscapes have considerably evolved. Technology and scientific knowledge have progressed as well. It is therefore opportune to assess the coherence of SSD with related Union product and environmental legislation and flagship policy initiatives, notably in recent years, in the context of the Green Deal. This section presents the analysis of the coherence of the Directive with the key EU policies and legal instruments that have relevance to its implementation and vice versa. Additional assessments are also reflected in Annex III, Eqs 12-14.

2.1.3.1. Internal coherence of the Directive

While the literature review and the consultations carried out find the Directive internally coherent, that is, it does not include contradicting or obsolete provisions.

The legal basis of the Directive relates to the functioning of the internal market. This does not appear fully coherent with its objectives, in particular considering that the EU Treaty has changed since its adoption, and now includes a specific legal basis for environmental policy making. The defined aims of the Directive, recitals and measures which it lays down, show that the objective of recovery of waste and protection of the environment and human health is central to the Directive. This is in line with the time of adoption of the Directive when Articles 100 and 235 of the Treaty establishing the European Economic Community formed the legal basis for environmental legislation predating a specific environmental policy legal

[89] This framework also includes spatial monitoring, emissions e.g. of methane, including by means of satellites and in real time.

[90] Commission Implementing Decision (EU) 2021/2252 of 16 December 2021 amending Decision 94/741/EC concerning questionnaires for Member States reports on the implementation of certain Directives in the waste sector.

base in the Treaty. While its second recital refers to *disparities between the Member States' provisions on the agricultural applications of sewage sludge which might affect the functioning of the common market*, its potential to reduce barriers to trade in sewage sludge across Member States is very limited. Neither the design of the regulatory measures of the Directive (especially its Article 12 and the fact that it does not regulate treatment of sludge), nor the legal developments that have been pursued by the Member States or at Union level since the adoption of the Directive, ensure that any pursuit and impact of the Directive in relation to the functioning of the internal market can be effective.

The scope for removing potential barriers to internal trade in sewage sludge for agricultural use is limited to those Member States that remain at the same level of regulation. Over time this is reduced to a third of Member States only. This potential for cross-border movements of sewage sludge is also considerably limited due to the fact that the Directive maintains the waste status of sludge (which impacts the costs of transportation linked to administrative, reporting and safety requirements related to the shipments of waste) and the very low economic value of sewage sludge. Also, it appears that, like for biowaste, the distance of supply of sewage sludge to the farmland remains within 50 km from the UWWTPs where it is generated on account of the transportation costs[91]. Furthermore, following the adoption in 2019 of the Fertilising Products Regulation, the safety, quality and labelling of fertilising products derived from certain treatment of sewage sludge are subject to harmonised regulation at Union level to enable their free trade throughout the EU[92]. Article 6 of Directive 2008/98/EC on waste also provides a legal basis for the Commission to adopt Implementing Acts to develop Union level end-of-waste criteria and this mandate may cover substances and materials derived from processed sewage sludge that are not covered by the Fertilising Product Regulation. This Regulation, along with the Waste Framework Directive, therefore offers the regulatory tools at Union level to address barriers to marketing of such materials derived from sewage sludge in the EU; therefore limiting any potential *indirect* benefit from the SSD since the SSD does not aim to regulate the marketing of sewage sludge, but only its specific use on agricultural land. In view of that, and in view of the fact that the sewage sludge management policies are at the intersection of several Union policies, when the Directive is subject to a revision, the determination of the legal basis of that initiative will have to be based on the aim and the content of its measures.

With regard to the coherence of its provisions, in addition to weaknesses of the reporting requirements identified in section 4.1.2.4, certain definitions would benefit from further clarity. The definitions of sewage sludge and treatment are very broad, covering all sewage sludge and all treatment operations. This has raised questions of interpretation in terms of which sources of sludge fall within the scope of the Directive under Article 2(a)(iii) since the points (i) and (ii) are defined in a restrictive way in view of limiting inputs and therefore their likely level of contamination. With regard to the definition of sludge, there may be benefit in bringing clarity on the sources of sewage sludge, in particular, where excluding certain sources may offer more effective pollution prevention strategies. With regard to the definition and requirements on treatment of sludge, the directive requires sludge to be treated before spreading on land, but it is not prescriptive about the kind of treatment(s)which it should undergo. Some Member States regulate this in more detail in view of limiting level of

[91] Saveyn H, Eder P., 2013. JRC87124

[92] See Component Material Categories 12 and 13 of the Fertilising Product Regulation.

contaminants and facilitating its use on land. The broad rules of the Directive have also raised interpretation issues on whether the outputs from certain treatments which, according to national or Union legislation, are recognised as products (i.e. no longer waste) remain subject to the regulation of SSD, or it only concerns the use of waste sludge on land. SSD also does not address situations where sludge is mixed with other material before application onto land (e.g. composting together with another source of organic waste), which is common practice. The above aspects would benefit from clarification to reduce the discrepancies In national implementation and the conditions on the wastewater and sludge treatment operators.

2.1.3.2. Coherence with Union policies and legal instruments

Under the umbrella of the European Green Deal[93] (EGD), the SSD is at the intersection of several Union policies, notably circular economy and the industrial policy which promotes nutrient recovery and Unions strategic independence on mineral fertilisers and policies for attaining zero pollution, climate neutrality and energy independence. This section assesses coherence with the key policy frameworks and legislation which are most relevant and interlinked with he SSD. More information on coherence, notably with other instruments, is provided in Annex III.

- **Circular Economy and nutrient recovery**

Two Action Plans for Circular Economy have been developed and rolled-out over the lifetime of the Directive. Its contribution and synergies with the first one, launched in 2015, is discussed in Annex III. The new **Circular economy action plan** (CEAP)[94], one of the main building blocks of the **European Green Deal** to attain a sustainable and climate neutral economy, sets out a vision and outlines new initiatives to further the transition to a circular economy while reducing the pressure on natural resources, with a notable focus on food and nutrients, and creating sustainable growth.

The SSD pursues the core objective of the circular economy of facilitating recovery of nutrients (phosphorus, nitrogen and carbon) and thereby also contributing to the EU's strategic aim to reduce its dependency on imports of nutrients from third countries. The CEAP, in view of the on-going review of UWWTD, calls for improving synergies with SSD and increase the ambition level to remove nutrients from wastewater and make treated water and sludge ready for reuse, supporting more circular, less polluting farming, in particular, in support of the future **EU Integrated Nutrient Management Plan**[95]. It also calls for measures towards energy efficiency and carbon neutrality as well as a better application of the 'polluters pays' principle.

At present, about half of the P contained in sludge is irreversibly lost through co-incineration and landfilling. If these flows were to be fully redirected to agricultural uses, nutrient volumes equivalent to 10% of the phosphate rock used in mineral fertilisers could be substituted with sewage sludge derived materials[96].

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[93] COM(2019)640 final of 11.12.2019.
[94] COM(2020)98 final of 11.3.2020.
[95] The links with the Integrated Nutrient Management Plan initiative are detailed in Annex III.
[96] Egle L. et al. (under development)

Sewage sludge falls in the definition of waste under the **Waste Framework Directive** (WFD). The SSD facilitates the application of the waste hierarchy set by the WFD, whereby recovery takes priority over energy recovery (so called "waste-to-energy") or disposal (e.g. landfilling)[97]. The SSD complements the WFD as a *lex specialis* which translates the WFD principles of circular economy and recovery of secondary raw materials and requirements for safe management of waste for sewage sludge. The recovery of nutrients from sludge is also facilitated by the **Fertilising Product Regulation** (FPR)[98], which regulates making EU fertilising products available on the single market. It encourages the production and use of fertilising products of domestic organic or secondary raw material origin and, since July 2022, it provides harmonised criteria for end-of-waste status to certain materials recovered from sewage sludge.[99] In this way the FPR contributes to the well-functioning of the EU market for secondary raw materials for derivates of sludge as a result of incineration and phosphate salts precipitation. Compost and digestate resulting from the recovery of sewage sludge are not covered as there no EU-wide end-of-waste criteria[100].

The OPC results showed that a third of respondents agree and a similar share disagree that the SSD is coherent with the WFD and FPR. From the OPC, 27% of stakeholders (of 172 respondents) agreed. 37% disagreed and 13% were neutral. The remaining respondents did not know/no opinion. The feedback from targeted surveys showed that most stakeholders did not consider the link between the Fertilising Products Regulation and the SSD was made explicit enough (62%, n=38 thought 'not at all' or 'to some extent'). Additional comments indicated that the Fertilising Product Regulation does not cover many sludge-derived materials, thus sewage sludge is not fully in scope. Some stakeholders have indicated that the absence of end-of-waste criteria for sludge-derived materials impacts the trust in these materials[101]. This is linked to the call by stakeholders for the Commission to consider expanding the scope of end-of-waste criteria for further sludge derived substances.The objectives pursued by the SSD are also consistent with the **Farm to Fork strategy** for the sustainable production of food[102] which targets to cut nutrient losses from agriculture by at least 50%, and to reduce the use of mineral fertilisers by at least 20% by 2030. The SSD requirements aim to improve the agronomic performance of soils and limit use of fertiliser to what is required by plant nutrient needs to prevent pollution of soils and leachate (and therefore loss) of nutrients through the soil (which, in the case of nitrogen and phosphorus, would cause eutrophication). The coherence may be further strengthened, if the Directive is adapted to scientific and technical progress, notably on the set of pollutants which it regulates, and if it could be guaranteed that sludge application is aligned with plant needs through more robust regulatory tools.

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[97] Article 4 of Directive 2008/98/EC. The Sewage Sludge Directive is a *lex specialis* to the WFD and encourages recovery of nutrients regulating in detail the conditions for recovery of sewage sludge in application on agricultural land in a way that does not endanger the environment and human health.

[98] Regulation (EU) No 2019/1009.

[99] Substances recovered from sludge through thermal treatments e.g. thermal oxidation and pyrolysis.

[100] Commission Delegated Regulation (EU) 2021/2086 and 2021/2087 amending Annexes II and IV to Regulation (EU) 2019/1009

[101] Aqua Publica Europea, 2019

[102] COM(2020)381 final of 20.5.2020.

➢ Zero pollution policy

The European Green Deal develops a zero pollution vision for 2050 and the subsequent **Zero Pollution Action Plan** (ZPAP)[103], which aims at preventing pollution for air, water and soil pollution and achieve levels no longer considered harmful to health and natural ecosystems and at securing soil quality. The SSD contributes to that policy, through its objective to prevent harmful effects on soil, vegetation, animals and man, in general and specifically as regards prevention of pollution by heavy metals. ZPAP reflects the SSD's role in the nutrient recovery from wastewater supporting more circular, and, as per the objectives of the SSD, less polluting farming. The ZPAP calls for addressing emerging pollutants such as microplastics and micropollutants, including pharmaceuticals, both in the revision of the UWWTD as well as assessing the impact on nutrient recovery from sludge.

The **EU Soil Strategy** for 2030[104], adopted in 2021 as part of the European Green Deal, sets out a vision and measures to protect and restore soils and ensure their sustainable use. This Strategy refers to the evaluation of the SSD, since the latter can contribute to sustainable use of soil, and to as the only legislation with quality standards for agricultural soil at the EU level. The strategy also announces a new **Soil Heath Law**, which the Commission is working on[105]. It may offer potential to complement the implementation of the SSD, in particular, in relation to the definition of soil health, the soil monitoring provisions (e.g. for certain soil pollutants) and the requirements on sustainable soil management and by pursuing an adequate integration and coordination of soil and water management policies. The latter aspect is of particular relevance in view of the difficulties encountered in the assessment of the effectiveness of the SSD on soil protection and the role of sludge use in the overall approach to soil protection, in particular, in view of the various pollutants that are relevant. Addressing sewage sludge in isolation may lead to measures that unnecessarily penalize against other sources that are not all regulated and provide trace metals (phosphates, animal waste, fungicides).

This shows that pollution prevention policy instruments work in synergy with the Directive, towards common and complementary objectives. However, at operational level, in view of the assessment made in section 4.1.1 on Effectiveness, the adaptation of the Directive to the latest scientific and technical progress (notably on the set of pollutants to be covered and their appropriate limit values) would be needed to fully ensure alignment with the objectives of ZPAP and EU Soil Strategy, notably, it would need to be ensured that sludge use in agriculture is compatible with the objective of 30% reduction of microplastics release into the environment set by the ZPAP. Adaptation to technical progress would also foster the implementation of innovative solutions for sustainable management of sewage sludge, taking into consideration in particular the outcomes of EU funded research and innovation projects.

The **Urban Waste Water Treatment Directive**[106] sets requirements for the collection and treatment of wastewaters across the EU, to protect the environment from the adverse effects of discharges of urban wastewater. Under Article 14 of the UWWTD as it stands, Member States "shall re-use sludge whenever appropriate' and 'disposal routes shall minimise the

[103] COM(2021)400 final of 12.5.2021.
[104] COM(2021)699 final of 17.11.2021.
[105] The Call for Evidence for the initiative available here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13350-Soil-health-protecting-sustainably-managing-and-restoring-EU-soils_en
[106] 91/271/EEC

adverse effects on the environment'. The evaluation of this Directive[107] concluded that the revision of the UWWTD should consider its potential to contribute to the 2020 EU Circular Economy Action Plan for sludge management and nutrient recovery, in particular, to highlight the value of sewage sludge as a source of nutrients and improve consumer confidence and sewage sludge access to the market.

The evaluation also highlighted that (1) removing pollutants from wastewater can increase the contamination of sludge, with a risk of spreading these pollutants if contaminated sludge is used for agricultural purposes without sanitisation/decontamination steps and (2) that control at source of targeted pollutants would reduce treatment requirements. It also concluded that the two Directives are complementary, but that there is room for better alignment in two areas:

- On the definition of sludge: the two Directives define sludge slightly differently, with the SSD not being limited to sludge from urban wastewater[108].
- On reporting obligations to clarify analytical methods respectively prescribed by the two Directives, links between the two sets of reporting requirements[109] and align reporting cycles. The latter was confirmed by stakeholders who indicated that aligning reporting requirements would reduce burden and complexity as sludge is usually not dealt with by water authorities.

The extent to which UWWTP operators track pollution and pass on information to farmers on possible substances beyond those covered by the UWWTD and the SSD is also unclear. Consultation activities carried out for the evaluation of the SSD showed that Member States and stakeholders remain in agreement that the two directives are broadly coherent and that there is potential to improve coherence in reporting obligations and thus increase synergies between them.

The proposal for a revised UWWTD[110] offers opportunity to improve the coherence between the two Directives addressing the aspects identified in its evaluation. The revision of the UWWTD will certainly have implications on sludge management, in particular on the composition of sludge and, as such, nutrient recovery potential due to the diversity and level of contaminants present. This would also impact the choice of treatment options or the availability/feasibility of treatment and the potential uses of sludge. The following main impacts can be expected from the revised Directive as proposed by the Commission:

- No significant changes are expected, since the proposal does not significantly change the rules triggering wastewater treatment obligations;
- More efforts are foreseen in the proposal for a revised UWWTD to better monitor 'non domestic' (mainly industrial) pollutants in the inlets of the wastewater treatment plants. On that basis, Member States will be required to track these pollutants in the collecting networks in order to try to reduce their releases at source. When necessary, discharge

[107] SWD(2019) 700 final of 13.12.2019.
[108] Art 2(10) UWWTD: 'Sludge' means residual sludge, whether treated or untreated, from urban wastewater treatment plants
Art 2 of the SSD: 'sludge' means:
(i) residual sludge from sewage plants treating domestic or urban waste waters and from other sewage plants treating waste waters of a composition similar to domestic and urban waste waters;
(ii) residual sludge from septic tanks and other similar installations for the treatment of sewage;
(iii) residual sludge from sewage plants other than those referred to in (i) and (ii)
[109] SWD(2019) 700 final of 13.12.2019.
[110] Proposal for a revised Urban Wastewater Treatment Directive (europa.eu)

permits of industries connected to the public collecting system should be reinforced. This is expected to improve the quality of the incoming waters and consequently of the produced sludges and their likelihood for safe use in agriculture;

- On the other hand, more efforts are planned to better capture and treat stormwater overflows and urban runoff, increasing the risk of concentration of microplastics in sludge. Again a systematic monitoring of microplastic in the inlets of the plants is foreseen and should help to apprehend the potential problem. This should contribute to the assessment of microplastics in sludge and the likelihood of safe use in agriculture, should it be considered necessary to further regulate this pollutant in the revision of the Sewage Sludge Directive;
- The energy neutrality target as proposed in the revised UWWTD but also the recently adopted communication on Re-Power EU will increase the incentive for digestion of the sludge. This tendency is expected to increase also under the pressure of market price for gas. The impact on the use of sludge in agriculture would need to be further examined, but this would affect the drivers of sludge management routes: favouring anaerobic digestion would have an effect on costs and sludge quality (usually improved). It can also affect distances to farmland.
- New monitoring requirements under the UWWTD will be aligned to the parameters included in the SSD (see section above on monitoring and preventing non domestic pollution in wastewaters). Reversely, following the findings of the Impact Assessment on the revision of the UWWTD in relation to microplastics, these contaminants were identified as one of those which deserve specific attention and further examination. In view of that, the future assessments underpinning the review of the SSD should also consider monitoring or regulatory intervention on sludge use in agriculture. Besides microplastics, and based on the best practices in place in some advanced Member States (e.g. the REVAQ system in Sweden), the overall objective will be to ensure a full coordination between both directives so that sludge production and use can be monitored, tracked and improved along the whole chain–- from wastewater production through treatment up to the use of sludge in the fields and their possible impacts on soils. The first elements of this approach are included in the proposal of review of the UWWTD.

➢ **EU energy and climate policies**

The EU energy policy aims at ensuring supply and reducing dependency from imports from outside the EU, while moving towards a low-carbon economy.

The **Renewable Energy Directive**[111] sets a target for the share of renewable energy in the transport sector: it should reach 14% of the final consumption of energy by 2030. A share of this renewable energy should be fulfilled by advanced biofuels and biogas from feedstock, which includes sewage sludge.

The (revised) **Energy Efficiency Directive**[112] sets targets for energy efficiency by 2030, notably on renewable energy. In March 2022, in its **REPowerEU** Communication[113], the Commission outlined a plan to advance that target to well before 2030 in view of increasing Union's independence from Russian fossil fuels and reduce EU demand for Russian gas by two thirds before the end of 2022. The use of sewage sludge for the production of biogas or

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[111] Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources.
[112] Directive 2012/27/EU on energy efficiency.
[113] COM(2022)108 final of 8.3.2022.

for energy recovery through incineration can help achieve the target set by the two Directives and REPowerEU. These energy policy goals therefore influence national sludge management policies and stakeholder decisions and the amount of sludge that would ultimately be available and used for agricultural purposes compared to other uses.

The Directive is also of relevance to the Union's climate neutrality objectives. As seen in section 4.1.2.2 (assessing externalities), using sludge in agriculture generally has a net negative carbon footprint, due, amongst others to the sequestration of CO_2 in soils and its potential to substitute mineral fertilisers, produced through energy-intensive processes. The absolute footprint from sewage sludge management is relatively small in womparison with operations that take place upstream (sewage system and wastewater treatment plants), estimated at around 25-30 million tonnes of CO_2-eq per year.[114] The agricultural sector as a whole produced 426 million tonnes of CO_2 equivalent of greenhouse gases in 2015, about 10 % of the EU''s total greenhouse gas emissions (excluding Land Use, Land Use Change and Forestry net removals) for that year (Eurostat, 2021). In view of this, the **Methane Strategy**[115] notes that the UWWTD and SSD have a contributing impact but that they do not specifically tackle emissions of greenhouse gases. It refers to the review of the UWWTD and the evaluation of SSD as opportunities for the Commission to consider taking measures to limit the emission of greenhouse gases from sewage sludge management.

Overall, the carbon footprint for the different sludge management routes differs. The direct use-on-land of untreated or lime stabilised sewage sludge has a strong net negative carbon footprint, and can therefore act as a climate change mitigation strategy, in contrast to sludge incineration pathways[116]. However, the more contaminated sludge is, the more treatment is needed to pursue recovery over disposal and partially or completely remove the chemical pollutants as well as microplastics and antimicrobial resistance genes that may cause risks to human health and the environment (e.g. PAH, PCDD/F, long-chain PFAS) which also leads to increases in costs, and most likely lowering the net carbon footprint of the sludge management.

Anaerobic digestion (AD) is a growing treatment method as it allows the production of biogas concomitantly with sludge use in agriculture: while the process generates biogas the resulting digestate (a more concentrated, dryer and stabilised sludge) can be used on land as organic fertiliser in parallel, though not systematically, e.g. if farmland is too far from the AD digester/UWWTP.[117] While there is limited information on the quantities of sludge treated by anaerobic digestion across Member States, it is set to grow, also in view of the stakeholders consulted, in particular, in view of the EU targets for renewable energy and circular economy policies. The key limitation to AD treatment is heavy metals concentrations in sludge which are not decreased by the process and require further treatment. In certain cases such treatment may be rendered impossible due to technological feasibility to reduce contaminant levels, the

[114] Source: JRC policy report on the Urban Waste ater Treatment Directive *[not published yet at the time of writing]*
[115] COM(2020)663 final of 14.10.2020.
[116] Huygens et al., 2022
[117] From Wood, Support to the evaluation of the Sewage Sludge Directive - Exploratory study *[not published yet]*: Anaerobic digestion produces digestate and traps natural gas which can be used in combined heat and power generation or upgraded to methane for use in the grid or transport.

availability of facilities for suitable treatment or other factors, in particular linked to storage and costs.[118]

On the other hand, the policy directing sludge to incineration (or co-incineration which aims only at energy recovery) for heat production impedes the recovery of the organic nutrients in sludge. Some European countries follow such policies that discourage the application of sludge to land and/or encouraging P recovery from different feedstock, including sewage sludge. This has led to an increase of the application of incineration and other thermal treatment techniques, in most instances followed by mineral-like phosphorus recovery methods (from the ash resulting from incineration). The P recovery technologies applied following thermal treatment of sludge have the potential to recover between 85% and 99% of the P contained in the sludge and also the potential to further depollute the sewage sludge waste stream; it is a growing trend but still far from being done systematically. P recovery from sewage sludge ash is currently more expensive to implement and operate compared to the revenues generated from selling fertilisers, which limits the potential for widespread implementation[119]. This treatment route does not allow for the recovery of the organic nitrogen and organic matter contained in the sludge. Nevertheless, these practices do not always lead to diversion from the use of sludge in agriculture, since this may be the most appropriate recovery operation if sludge is not suitable for land use in view of its content or soil quality or there are other obstacles to agriculture use (during winter months other uses of sludge are pursued as it can be complicated and costly to store sludge during that period).

In view of these co-existing policies shaping the sludge use strategies, it is necessary to identify the relative importance of sewage sludge to different sustainability dimensions, of which soil and human health, resource efficiency in waste and nutrient management and climate change are the most relevant ones[120].

Stakeholder views on coherence with EU policies overall

Respondents to the OPC and to the targeted consultation of Member States and stakeholders broadly agreed that the SSD is coherent with the Green Deal. Similar patterns of responses were provided when more specifically considering the coherence of the SSD with the different deliverables of the Green Deal, albeit with some nuances: Member States tended to disagree that the SSD is coherent with the soil strategy, and targeted stakeholders tended to disagree regarding its coherence with the Farm-to-Fork strategy. Respondents from the OPC also tended to agree on the coherence with the climate objectives and in particular the methane strategy.

Respondents' awareness of the coherence of the SSD with other EU policies was rather low, with 'I do not know' answers averaging 38% across all the policies listed under the coherence question (nonetheless, specific mentions of coherence with other EU policies were made in several open questions later on). According to the respondents, the Urban Waste Water Treatment Directive is the most coherent EU policy with the SSD ("Agree" or "Strongly agree" n=86 out of 173 respondents to this question: 50%). Respondents identifying as from the wastewater treatment sector agreed more than they disagreed. [121] It is followed by the Circular Economy Action Plan and the Nitrates Directive ("Agree" or "Strongly agree" n=61

[118] Wood, 2022. Evaluation of the Sewage Sludge Directive – Exploratory study*;* Huygens et al., 2022
[119] Wood, 2022. Support to the evaluation of the Sewage Sludge Directive - Exploratory study
[120] Huygens et al., 2022
[121] 30 out of 59 (50%) agreed or strongly agreed, while 11 (18%) disagreed or strongly disagreed.

for both out of 171 and 170 respondents to this question: 36%). Respondents identifying as farmers agreed more than they disagreed that the SSD was coherent with the Nitrates Directive. [122] The lowest level of coherence was noted for the European Green Deal (n=56 out of 171 respondents to this question; 33%) and

Stakeholder views on coherence with the Green Deal:

From the 171 respondents to the OPC, 28% agreed that the SSD is coherent with the EU Green Deal, while 33% disagreed and 12% were neutral[123].

MS targeted consultation evidenced that 33% out of 18 respondents agreed that the SSD is coherent with the European Green Deal, 22% were neutral, 17% disagreed[124].

The targeted consultation with stakeholders evidenced that 44% out of 41 respondents agreed that the SSD is coherent with the European Green Deal, 7% were neutral, 30% disagreed.[125]

Similar patterns of responses were provided when more specifically considering the coherence of the SSD with the different deliverables of the Green Deal, apart from the following: MS tended to disagree that the SSD is coherent with the soil strategy, and targeted stakeholders tended to disagree regarding its coherence with the Farm-to-Fork strategy. Respondents from the OPC also tended to agree on the coherence with the methane strategy.

2.1.3.3. Coherence with Union's international obligations

The implementation of the Directive contributes to attaining of the United Nations Sustainable Development Goals: SDG 6 on clean water and sanitation, SDG 2 on ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture; SDG 12 on ensuring sustainable consumption and production patterns. Finally, the protection of soil and the limit values for heavy metals in the soil established by the SSD help the attainment of SDG 15 on protecting, restoring, and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. The nutrient recovery dimension of the SSD can also help achieve the Land Degradation Neutrality target by 2030 set by the UN Conference of Parties on Climate Change. Its goal is to protect, maintain, restore and enhance the land resource base necessary to support ecosystem functions and services and enhance food security.

4.2 4.2. EU added value

Since incorrect application of sludge on soil, in particular, in view of its contaminants and amount applied on soil, may result in soil and water pollution (eutrophication) which may have transboundary effects, action at EU level is justified to ensure minimum harmonised rules for environmental protection while creating and continuing to encourage nutrient recovery and avoid their loss. There is an ongoing need for the use of sludge in agriculture to be regulated in order to ensure that it is carried out safely and without harm to the environment.

[122] 9 out of 20 (45%) agreed or strongly agreed, while 4 out of 20 (20%) disagreed or strongly disagreed.
[123] Others did not know/no opinion (27%).
[124] Others did not know/no opinion
[125] Others did not know/no opinion

The key value of the SSD lies in its establishment of minimum level of harmonisation for promoting safe use of sludge on farmland across the EU, which complements the general rules of the Waste Framework Directive in relation to sewage sludge. Despite the fact that a large number of Member States have adopted more stringent rules than the SSD, this minimum level of environmental protection rules provide the basis for the national regulations in other Member States and candidate countries and new neighbourhood countries, where the minimum standards in the Directive have not yet been attained. Important to note that neither the literature review nor stakeholder consultation revealed any significant heavy metal pollution caused by the use of sludge on farmland, but some literature sources showed potential content of contaminants and evidence of pollution from others. There is also no absolute commonalities in the way diverging Member States have addressed contaminants of emerging concern. This suggests that a level-playing field is not ensured and that there has been unequal protection of human health and the environment across the EU, which puts in question whether the Directive ensures high level of protection of the environment and its added value on current sludge management policies and practices at national level. Also, the assessment referred to in section 3.1.1 of this report also indicates that the implementation of the SSD has influenced or still influences the management practices of sewage sludge to a limited extent. However, in view of the already existing large discrepancies in national rules, it can be argued that the inconsistencies may increase even further if the Directive were to be repealed.

With regard to the value of the SSD in preventing barriers to the internal market, as assessed in Section 3.1.3.1. on internal coherence, neither the design of the SSD in view of its minimum harmonisation, nor its specific measures provide effective rules for that purpose, in particular, with regard to those Member States that have adopted stricter rules. Also, the new Fertilising Product Regulation, adopted in 2019 now provides a more effective regulatory framework ensuring the free movement of sewage sludge derived fertilisers that are in its scope.

With regard to the Union's objective to transition to a circular and sustainable economy, the SSD is a policy and regulatory tool to drive the return of nutrients to soil. Its added value could, however, be strengthened by attaining full harmonisation in view of ensuring high level of environmental protection across the Union. Based on stakeholder feedback this would also improve the public perception which is a notable driver to sludge recovery in agriculture, in particular, in view of the increased publicly available information on the areas where sludge is used as of 2023.

During the public consultation, an overwhelming majority of respondents agreed that there is still a need for the EU to regulate the use of sludge in the agriculture sector (n=140 out of 176; 80%), while 15% of the respondents (n=27) said that it should only do so for some aspects. Explanations by the respondents pointed to the benefits of a uniform approach and a level-playing field across EU MS (n=16; 15%). An additional 10 respondents (10%) mentioned the need for a further harmonisation of regulations across MS. Other respondents expressed the need of the EU to regulate sewage sludge to protect the environment (n=14; 13%) and/or human health, including in terms of food safety (n=14; 13%). Regulation was also deemed beneficial for nutrient recovery (the fertiliser potential, phosphorous, nitrogen and organic matter were mentioned) (n=9; 9%). Another theme brought up was the need to extend the SSD's scope (include new pollutants or regulate other sludge uses) (n=15; 15%). Other forward-looking comments were submitted, including the need to better link the SSD with other EU policies (n=11; 10%), including on fertilisers, circular economy, waste, water and agriculture, and the need to improve monitoring (n=7; 7%). Conversely, a limited number of respondents (two Swedish NGOs and one Italian respondent; 3%) stated that sewage sludge should not be reused at all, or that the approach of the SSD should be changed significantly (only allow incineration or the extraction of plant nutrients present in the sludge) (three Swedish respondents, including one company; 3%).

4.3 4.3. Relevance

➢ **Relevance of the Directive**

With the stability or increase in population growth and with the increase of the UWWTP networks and the level of treatment of wastewaters, safe management of sludge in line with the waste hierarchy will remain necessary. Today, an average of 30-40% of the sludge produced in the EU is used on agricultural land, and some Member States such as Spain, Denmark, France, Ireland, and Czech Republic use the large majority of their sludge in this way. While there are also several Member States that discourage the use of sludge in agriculture, there is also a trend to divert sludge from landfilling (a sludge management route used for 10% of the sludge produced in the EU) which may benefit the agriculture route. Therefore, the Directive has remained relevant over time, notably to pursue the objectives of the circular economy to ensure compliance with the waste hierarchy which requires prioritisation of nutrient recovery over other recovery or disposal operations, also in line with the biomass cascading principle.

The quantity of sewage sludge composted is expected to remain stable in the EU[126]. As seen in section 4.1.3, the market for anaerobic digestion is set to grow, specifically due to EU targets for renewable energy and circular economy policies and because it is a treatment method that is more efficient than composting for pollutant removal even if it does not decrease the heavy metal concentrations (and of some other contaminants too, like PFAS). As regards the use of sludge on other types of land (e.g. landscaping, recultivation, tree nurseries, forestry), the trend is not clear as has not been assessed as part of this exercise. However, their use remains encouraged through the application of the general rules of the Waste Framework Directive which also prioritises the recovery of other biowaste.

Some Member States are moving away from sludge reuse in agriculture to pursue objectives of energy recovery and/or phosphorus recovery through incineration. This emerging practice can be attractive, knowing that the planet's phosphate rock reserves are finite (it is estimated that they will have been mined within the next 18 to 58 years), while the phosphorus-content in European sewage sludge could currently replace roughly 15% of the phosphate imports into the EU. This issue is gaining even more importance in the current context of the EU reducing its dependency on imports of critical raw materials such as phosphorus, and, recently, especially imports from Russia: currently the EU imports 20% of its phosphate rock from Russia.

Also as seen in section 3.1.3, energy recovery from sewage sludge treatment is also set to gain attractiveness to help achieve energy efficiency goals and energy autonomy, whether at the EU level but also at the level of wastewater treatment plants. The trend of production of biogas is also set to grow: according to the EU's long-term decarbonisation strategy[127], by 2050, the EU's annual consumption of biogases (biogas and biomethane) is projected to grow to between 54 and 72 Mtoe, from around 17 Mtoe in 2017. As referred to in the previous

[126] Wood, 2022. Support to the evaluation of the Sewage Sludge Directive - Exploratory study
[127] COM(2020) 663 final of 14.10.2020.

sections, certain treatments of sludge may serve both objectives on nutrient and energy recovery simultaneously.

- **The set of regulated contaminants require a review**

Regulating the heavy metals covered by the Directive remains relevant, as they still count as most dangerous substances to human health and the environment. However, despite no evidence pointing to pollution of soils with heavy metals due to use of sewage sludge, the varied scope of regulated contaminants and their limit values across the Member States question whether the SSD ensures a high level of protection of the environment and human health from the scientific point of view. This uncertainty impacts the trust in the Directive and the use of sludge on agriculture land by its stakeholders and also the public, which as of 2023 will have access to spatial data on the specific areas where sludge is applied.

Since the Directive was adopted, Recommendations of the World Health Organisation (WHO) and the European Food Safety Authority (EFSA) on safe intake levels of metals have substantially decreased. Furthermore, the approach taken by many Member States to set lower limits, and techno-scientific progress made in the meantime also point to the need for re-examining these limits. It is also noted that limit values for heavy metals in the EU Fertilising Products Regulation ((EU) 2019/1009) are more stringent than the limit values laid down in the SSD.

Over time a number of further contaminants have raised attention and should be examined, in particular, in view of the proposal for a revised UWWTD which aims to address pollution prevention at source and increase the treatment level of wastewaters and consequently change the sludge composition. They include the additional contaminants regulated by Member States (listed in section 2.1), including microbial parameters (against disease transmission), a need confirmed by a study on new approaches to sludge management[128]. In addition, other contaminants of emerging concern would be opportune to assess in view of some regulation by Member States. There is no definition of “contaminants of emerging concern” as such, but among those are pharmaceuticals, PFAS (known as ‘forever-chemicals’ as they are very persistent in the environment) and microplastics. In parallel, some concerns have been raised as regards its possible effects on microbial resistance, and, with the outbreak of the COVID-19 pandemic, its potential contribution to the dissemination of the virus.

The JRC also undertook modelling work[129] which identified several contaminants in sludge applied onto agricultural land which, under “reasonable worse case” scenarios, are likely to cause human health and environmental risks. These are, for instance, PFAS and PAH[130]. The pollutants associated to the greatest risks are already subject to actions and restrictions under the POPs and REACH Regulation. Risk mitigation options were also assessed: they may involve limiting the concentration of pollutants of concern in sewage sludge. Biological sludge treatment options such as composting and anaerobic digestion, may not be effective to remove the persistent pollutants of concern to below levels of concern. On the other hand, incineration in modern plants has the potential to effectively lower pollutant levels to low or negligible concentrations, after which the ashes could be used as an intermediate in P-fertiliser manufacturing processes. (This is recognised in the Fertilising Products Regulation, for instance). An alternative risk mitigation option is to reduce the volumes of sewage sludge

[128] Mininni, G. et al (2015)
[129] European Commission, Joint Research Centre, Huygens et al, 2022
[130] Perfluoroalkyl substances (PFASs) and polycyclic aromatic hydrocarbons (PAHs) are used in many products e.g. clothing, furniture, adhesives, food packaging, non-stick cooking equipment. They became of concern due to their high persistence in the environment and their presence in wildlife and humans.

spread on land relative to the modelling scenario of 5 tonnes dry matter ha-1 yr-1 applied in that JRC study. For instance, an application scenario with a maximum load of 2 tonnes of dry matter per ha every 3 years would already reduce pollutant loads by approximately a factor 10. Finally, hybrid options could be envisaged to ensure full environmental and health protection from the effects of organic pollutants.

Microplastics are an increasing source of concern. Microplastics adversely influence physical soil properties such as water holding capacity, soil aggregation, the performance and composition of the soil microbial community and soil fauna[131]. They can adhere to the surface of seeds and roots and can be taken up by plants, causing negative effects (e.g. oxidative stress, cytotoxicity, and genotoxicity[132]). Research efforts on the contamination of the environment by microplastics and its consequences are being scaled up, but at present there is little knowledge on the magnitude of adverse effects[133].

A pilot study recently undertaken by the JRC estimates that about 60 microplastic particles could be present in a gram of cultivated soil (from 50 samples collected across 7 Member States). Work is ongoing to identify whether sewage sludge was applied to the locations sampled. Sludge application in agriculture has been correlated with increasing quantities of microplastics in exposed soil[134] and it is assessed that in countries with high sludge application rates, the level of microplastics accumulated in the treated soils is expected to be higher than in countries with lower application intensity.[135] Evidence suggests that regular application of microplastics leads to significant accumulation in soils, and that sewage sludge is one of the main entry routes for microplastics into the terrestrial environment[136]. Between 360 and 1980 tons microplastics could reach municipal wastewater treatment plants every year in the EU[137], and after treatment of the wastewater in wastewater treatment plants, the majority of microplastic particles become entrained in sewage sludge[138]. The extent of the problem is yet to be thoroughly assessed but it is expected to increase with the implementation of the revised UWWTD. Lofty et al. (2022) estimate that sewage sludge applications on agricultural land introduce between 31 000 and 42 000 tonnes of microplastics (or 86–710 trillion microplastic particles) to European soils annually.

The fate of microplastics in the soil and their effect on human health (through ingesting of crops grown on soil where sludge has been applied, or irrigated with contaminated water) are still debated and will require further study before the full implications are known[139]. The Horizon 2020 EU Research and innovation Framework Programme has funded research on this subject. Its successor, Horizon Europe, (2021-2027) envisages related activities under Cluster 6 “Food, Bioeconomy, Natural Resources, Agriculture and Environment” and the Horizon Europe Mission ‘A Soil Deal for Europe’. The contribution of sludge application to the presence of microplastics on agricultural land, in comparison to other agricultural

131 Büks and Kaupenjohann, 2020
132 Li et al., 2020; Azeem et al., 2021; Mateos-Cárdenas et al., 2021; Wang et al., 2022
133 Büks and Kaupenjohann, 2020
134 Nizzetto et al, 2016.
135 Hurley, R., & Nizzetto, L., 2018
136 Büks and Kaupenjohann, 2020; van den Berg et al., 2020; Azeem et al., 2021; UNEP, 2022
137 Nizzeto et al.,
138 As much as 98% of the total influent load according to a study by the Irish EPA, 2017: Mahon, A.et al, 2017.
139 Campanale et al., 2020

practices (e.g. poly-tunnels, mulching substances, baled silage, with debris gradually degrading into smaller pieces), should also be investigated.

Research is also on-going on the impact of antimicrobial resistance (AMR) in sludge being applied to land, to better understand the risks that AMR poses to the environment[140] but also the role that sludge treatment could play in limiting those risks. The World Health Organization (WHO) has identified the spread of antibiotic resistance as one of the major risks to global public health. AMR is estimated to be responsible for about 33,000 deaths per year in the EU.[141] A study found that the long-term application of sewage sludge significantly increased the abundance and diversity of antibiotic resistance genes in the soil.[142] Sludge treatment (hygienisation, e.g. liming, digestion, composting) can mitigate the effect, but not fully. However, it should be underlined that the contribution of sewage sludge to AMR when applied on agricultural land is likely smaller compared to manure, which is spread in much larger quantities and mostly without prior hygienisation treatment[143].

There is also attention to pathogens which sludge could potentially convey, and the COVID-19 pandemic, has raised concern around the dissemination of the SARS-CoV-2 virus. The latter has been identified in wastewater[144] and primary sludge samples[145]. The Commission has recommended a common approach to establish systematic surveillance of SARS-CoV-2 in wastewater. Wastewater monitoring for early warning and tracking of disease outbreaks seems likely to continue, given its potential for widespread coverage and relatively low cost).[146] However, the search for SARS-CoV-2 RNA alone is not sufficient to determine any risk situations due to the spreading of the sludge on the soil.[147] Since transmission occurs through the respiratory tract, the concerns mainly relate to exposure to droplets and dust that could be emitted during sludge application. ANSES (Agence nationale (française) de sécurité sanitaire de l’alimentation, de l’environnement et du travail) also indicated that the risk of SARS-CoV-2 contamination could be considered negligible if sludge has undergone a disinfection process according with the regulations and provided recommendations to reinforce controls on treatment processes[148]. ANSES therefore recommend that such sewage sludge should not be applied to land without first being disinfected. However, they also note that data on the inactivation of SARS-CoV-2 in sludge and effluent are still incomplete and very little information is available to precisely define the level of contamination by SARS-CoV-2 in sludge that has not undergone some sort of disinfection treatment. Further work will therefore be necessary before a consensus is reached on the most appropriate treatment to ensure that the risk of SARS-CoV-2 contamination in sludge is low.

[140] This is notably in the context of the ERANET co-funded action AquaticPollutants, http://www.waterjpi.eu/joint-calls/joint-call-2020-aquaticpollutants
[141] European Commission - EU Action on Antimicrobial Resistance: https://ec.europa.eu/health/antimicrobial-resistance/eu-action-on-antimicrobial-resistance_en
[142] Qinglin et al. (2016).
[143] Also knowing that within the EU, the consumption of antimicrobial substances is approximately equally divided between uses for food-producing animals and humans (EMA/ECDC/EFSA, 2021)
[144] Larsen, D.A. (2020)
[145] Peccia et al. (2020).
[146] EUR 25 000 for one WWTP per year. https://op.europa.eu/en/publication-detail/-/publication/816cec6d-abbd-11eb-927e-01aa75ed71a1/language-en JRC, 2021
[147] Gianico et al.
[148] ANSES (2020, April 2)

As knowledge of contaminants and treatment technology evolves, there is need for more systematic assessment of the relevance and appropriateness of the set of pollutants covered. Stakeholders identified the relevance of sewage sludge in the transition towards the circular economy and its content in substances of concern in sewage sludge as main topics of interest. Stakeholders also voiced the need to reassess the list of contaminants during the public consultation.

The issue of emerging pollutants is not one that is isolated from the SSD and will also need to be considered in the context of other ongoing revisions of other EU legislation, including the development of a new legislative initiative on healthy soils announced in the EU Soil Strategy. The SSD may need to be flexible to respond to such changes. For instance, the review of the UWWTD may result in a higher loads of nutrients in sludge, and, is also likely to raise the contaminants content of that sludge. This will challenge the re-use (i.e. direct application on land) of sludge, and result in the need for more advanced sludge treatment for a safe application, which implies more costs and carbon footprint.

In terms of the methodology to assessing the enlargement of scope of regulated contaminants, a JRC study[149] has highlighted the importance of the distinction between "risk v hazard" approaches. Numerous studies have reported the presence of organic compounds, pathogens, pharmaceuticals, and nanomaterials in sewage sludge, albeit many of them note that further evidence is needed to fully understand how they behave when sludge is reused in agriculture and the likelihood of accumulation in soil to levels which may pose a risk to human health and the environment[150]. Thorough risk assessments should be conducted as appropriate, also taking into account of the contribution of sludge to the presence of these contaminants in the environment, compared to other sources. Most persistent and bioaccumulative organic contaminants would deserve focus[151], as confirmed by findings from that study, and previous work[152,153]. Note that these pollutants may also be regulated in the near future through on-going initiatives under the umbrella of the Chemicals Strategy for Sustainability, ZPAP and Soil Strategy.

During the expert interviews conducted during the public consultation, half of the respondents (n=26 out of 52 respondents to this question) answered the open question on the added value of EU intervention in a forward-looking manner, pointing to the view shared by many respondents throughout previous questions that the SSD needs to be updated.

- **Suitability of a stand-alone instrument / Opportunities for simplification**

The SSD has been set as a self-standing instrument to regulate the very specific issue of sewage sludge used on agricultural soil. In line with the objectives of the EU Better Regulation agenda to simplify and improve EU law, consideration should be given to a possible repeal of the Directive and/or integration of its rules into related legislation.

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[149] Huygens et al, 2022

[150] For instance, there is limited understanding of the behaviours of contaminants of emerging concern in sludge. A study of sludge from 11 WWTPs in the UK suggested that pharmaceutical residues in sludge should not lead to concentrations of concern in soils (UKWIR, 2018b).

[151] Huygens D. et al, 2022

[152] Norwegian Committee for Food Safety, 2009; Rigby et al., 2021; Smith, 2009

[153] Huygens et al, 2022

In view of the continued relevance of the regulation, a full repeal is not considered appropriate. In terms of possible simplification which would maintain or strengthen coherence with other Union legislation, the potential to exploit synergies with other legislative instruments that have close links with the SSD could be explored:

(1) other waste legislation which regulate recovery and safe management of waste, notably the Waste Framework Directive;

(2) the Soil Health Law envisaged in the EU Soil Strategy for 2030[154]. Synergies could be explored in relation to the definition of soil health, the soil monitoring provisions (e.g. for certain soil pollutants) and the requirements on sustainable soil management.

(3) water protection related legislation, e.g. the UWWTD[155]. This would offer the possibility of streamlining reporting requirements to an extent, as discussed in section 1.1.3.3. It might be possible to cover the whole lifecycle of the wastewater from production to treatment and use of the outputs of that process, also exploiting links between treatment strategies at the UWWTP and further use of sludge.

    There are direct links between designing and operating of the wastewater treatment plant and sludge management strategies to opt for, notably in terms of sludge quality and treatment facilities. Sludge management constitutes a significant share of the cost of wastewater treatment. Closer cooperation between those producing and treating the sludge and those using the sludge for agricultural or other purposed could be sought. Real-time monitoring of sludge quality at the treatment plant could be sought too. More generally, this would facilitate the streamlining of monitoring and reporting requirements between the SSD and the UWWTD. The part of the monitoring and reporting requirements of the Directive which relates to sludge quality could be covered under the UWWTD in a more holistic way. This could also allow the choice of sludge management options to be considered in strategies aiming at energy efficiency and autonomy in energy supply at the wastewater treatment plants, known to be very energy demanding. In addition, the recovery of valuable raw materials such as phosphorus, as already proposed in the revised UWWTD, could be further targeted in line with the needs of society.

(4) The Fertilising Products Regulation, as a vehicle for EU-wide end-of-waste criteria for certain sludge derived materials in EU fertilising products, where safety of such sludge derived materials is confirmed.

Stakeholders involved in the targeted consultation and Member States tend to agree that the SSD is still relevant. They also supported the benefits and opportunities for further policy integration and simplification by integrating SSD rules into the UWWTD. Notably among Member States, 37% (of 19) responded that it should be integrated into the UWWTD; 32% reporting it was still relevant as a standalone instrument; 16% reporting it should be integrated into another legislative instrument. Of 44 responses to the targeted consultation, 50% thought that it is still relevant as a standalone instrument, 9% responded that it should be integrated into the UWWTD, 18% responded that it should be integrated into another legislative instrument.

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[154] The Call for Evidence for the initiative available here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13350-Soil-health-protecting-sustainably-managing-and-restoring-EU-soils_en

[155] While the on-going review of UWWTD is not designed to take over sewage sludge use regulatory framework, it still presents an option in the future.

5 5. WHAT ARE THE CONCLUSIONS AND LESSONS LEARNED?

5.1 5.1. Conclusions

2.1.4. 5.1.1. Effectiveness

The use of sludge in agriculture has remained the main route for sludge management in the EU since the evaluation which had been carried out for the SSD in 2014. For the EU as a whole, the total percentage of sewage sludge used in agriculture falls between 30% and 50% of the total sewage sludge produced, amounting to 2-3 out of 7-8 mio tons/yr. When sludge is not used in that way, it is incinerated (this use coming closely second, 27%), composted (not known, but estimated to be 10%), or landfilled (currently 11%, but this practice is phasing out). Overall, sludge production has been rather stable in the EU over 2007-2018, and so has the share of sludge used in agriculture. Sludge has been widely and steadily used to the benefit of agriculture, leading to the recovery of nutrients from 2 to 3 million tons of sludge per year, while also enhancing the soil structure, for the benefit and sustainability of the waste and agricultural sectors.

The decrease of the level of heavy metals in sewage sludge since the SSD came into force, can be attributed to an extent to the effect of the Directive, butit is difficult to single out its actual contribution: here. Many Member States have adopted more stringent requirements, which makes it challenging to distinguish the effects of the SSD from national action. Legislation regulating pollution at the source can have had an effect too.

Limited information was identified linking overall agricultural soil quality and use of sewage sludge, in particular on potential effects of long-term of sludge application, and on the share of the impacts of sewage sludge compared to other activities that have an impact on soil quality, e.g. fertiliser, manure, background pollution. Research is going on into possible long-term impacts of sewage sludge use in agricultural land on soil quality.

A range of other factors have contributed to achieving the objectives of the Directive. First, a number of voluntary schemes of quality standards have been set up between stakeholders, increasing trust in sludge quality. Secondly, the availability of sludge of relevant quality and its benefits on soil quality, including organic matter content, and water retention capacity have promoted the use in agriculture too. In addition, the implementation of the Waste Framework Directive, Landfill Directive and the inclusion of some materials derived from sludge[156] into the Fertilising Products Regulation also contribute to the recovery of waste over final disposal.

Conversely, the objectives of the Directive have been hindered by a number of factors, which include the public perception of risks associated with sewage sludge, the lack of harmonised end-of-waste criteria for sewage sludge to be applied onto land, the competition for agricultural use with other organic waste (e.g. manure or biowaste), and the competition with other uses of sludge (e.g. for land reclamation, remediation or landscaping).

The Directive also has had other positive effects: interest and knowledge in sewage sludge and its management techniques have increased, as shown for instance by the large number of research projects for the treatment of sewage sludge with recovery of nutrients or

[156] Precipitated phosphate salts, high purity salts and ashes

transforming into other applications. Application of sludge onto farmland also seems to have an overall negative carbon footprint.

Negative unintended effects from its implementation include the presence of antimicrobial genes and microplastics in the soil, possible emissions of ammonia, methane and nitrous oxide, as well as of other contaminants which it can contain and which are not regulated by the Directive. Research is on-going to determine their fate and effect, and assess whether and to which extent those elements do actually pose a risk to the environment and the human health.

Overall, the assessment of the effectiveness was rendered challenging by data gaps and inconsistencies, including data reported under the Sewage Sludge Directive, the Urban Wastewater Treatment Directive and Eurostat. This results from unclarity in certain definitions and coherence between the reporting obligations across the two directives.

2.1.5. 5.1.2. Efficiency

The use of sludge in agriculture entails significant costs, notably linked to treatment and transport. Treatment is required to make it suitable for use on land, for reasons of safety (e.g. pathogen removal, hygienisation) or for transport since treatment allows to reduce the volume and weight of sludge, facilitating its transport.

It is very difficult to estimate the overall costs and benefits of the implementation of the Directive, notably because of the lack of data on the different treatment pathways and combination thereof, and the lack of data on externalities. However, it appears that the application of sludge to agricultural land is significantly less costly than other options for use of sewage sludge.

This is particularly true in comparison with (mono-)incineration, which is the main alternative to the use of sludge in agriculture. If a hypothetical shift from the current sludge volumes from agriculture towards incineration were to occur, it was estimated that this would result in an additional cost of **EUR 41–488 million** per year, depending on the incineration technology assumed. For mono-incineration these additional costs would be of **EUR 391-488 mio/yr** [157]

Administrative costs have been estimated to be around **EUR 77,000-80,000 per year per Member State** and appear as quite moderate in comparison with other EU environmental legislation. These costs will also slightly increase with new reporting obligations on spatial data of sewage use. Reporting has shown rather insufficient and not well respected.

The use of sewage sludge compared to mineral fertilisers (i.e., chemically produced) could also allow savings to farmers. As an order of magnitude, it was calculated, in a theoretical case where sludge would fully substitute a mineral fertiliser, that they could be up to some **EUR 96/tDS** for Nitrogen and **EUR 44/tDS** for Phosphorus.

Also, given the high dependency of sludge management policies to local conditions, and the heterogeneity of such conditions across Member States and regions or municipalities, the enabling rather than prescriptive nature of the Directive has provided a framing which has allowed, in principle, for efficient decision-making at national and regional level. In view of

[157] Egle et al., 2023 (under development)

this, the Directive is considered to be cost-efficient, in particular, as sludge treatment is a necessity for any kind of use or disposal of sludge.

The uncertainty on costs and benefits is acute for externalities, where very few data could be provided. However, these should be seen in comparison of agriculture use and other sludge management routes, as they remain very costly (several hundreds EUR tDS all costs considered on average) and entail similar externalities than the agriculture pathway

2.1.6. 5.1.3. Coherence

The legal basis of the Directive is now outdated in view of its content, not cross-border in nature, and developments of the EU *acquis* since its adoption: a specific legal base for the policies aiming to attain a high level of protection for the environment has been introduced.

Some of its definitions and rules, like that of sewage sludge and of treatment, as well as reporting granularity provide scope for more clarity, in particular in view of increasing legal certainty and the level of protection on the environment.

It complements the Waste Framework Directive: encouraging sludge use in agriculture is in line with the waste hierarchy set out in the latter, where recovery of nutrients takes precedence over energy recovery and disposal. Resource efficiency in nutrient recovery also contributes to the EU objectives of increasing independence from imports of mineral fertilisers, some of which are identified as critical raw materials for the EU economy.

The objectives of the Directive are consistent with other environmental-media specific legislation, e.g. on water and air. However, in terms of operational regulatory measures this coherence could be strengthened if it were adapted to techno-scientific progress, notably on the set of pollutants which it regulates. This would strengthen its coherence with the EU Soil Strategy for 2030, and, more generally, the Zero Pollution Action Plan.

Several legal initiatives relevant to sludge management are on-going: a proposal for a Soil Health Law, revisions of the UWWTD and other water-related directives, and of the Waste Framework Directive. The coherence of the SSD would need to be reassessed in view of such future developments. There is scope for further clarifying links between the SSD and UWWTD, notably aligning the analytical methods and reporting cycles of the SSD and UWWTD. Considering the Commission proposal for a revised UWWTD put forward on 26th October 2022, the revised UWWTD could affect the composition of sludge (notably potentially increasing its concentration in microplastics, but, on the other hand, having a positive effect on the level of contaminants which the UWWTD would reduce at the source, before the effluent enters the UWWTP) and possibly influence choices for treatment in view of energy efficiency.

The wider policy framework has considerably evolved over recent years, notably as set by the Green Deal and its deliverables. The Directive lies at the core of these ambitions and it is found coherent with the European Green Deal and EU policies on climate neutrality, circular economy, bioeconomy and nutrient and energy independence. Pursuing these objectives may influence national sludge management policies differently, depending on local conditions e.g. the agronomic needs for soils, energy mix and available infrastructure, among many other drivers for decision-making on sludge management. This can influence sludge management strategies or specific treatments (e.g. anaerobic digestion), with varying impacts on climate change mitigation. Higher levels of treatment, which may be required to abate the contaminants present in sludge before it can be applied on land, are usually associated with higher costs and a larger carbon footprint. Anaerobic digestion comes across as a very interesting option, as it allows producing biogas while treating sludge, but it is not always sufficient to remove certain pollutants. Treatment may not always be feasible, depending on the availability of treatment facilities, but also technically, depending on the type of contaminants to be abated in the sludge. In such cases, (mono-)incineration could be a last recourse, and electricity and heat can also be recovered from a renewable resource.

2.1.7. 5.1.4. EU added value

The SSD has maintained its added value, as the sole legal instrument providing an EU wide framework for the environmental conditions on soil protection for safe use of sludge on agricultural land in the EU, through setting a minimum level of harmonisation for pollution control and reducing environmental and health risks linked to the recovery of sludge in agriculture.

Despite Member States having adopted more stringent rules than the SSD, this minimum level of environmental protection rules provide the basis for the national regulations in other Member States, candidate countries and neighbourhood countries, where the minimum standards in the Directive have not yet been attained. Whilst the provisions of the Directive on limit values for heavy metals cannot be said to be obsolete, since they set an important baseline, the fact that many Member States have set stricter limit values means that the Directive is not the sole driver for limiting the heavy metal content of soils and sludge.

Also, the Directive promotes a main inexpensive sludge management route, which turns out as a cost-efficient option for wastewater operators, while allowing savings to the farming community on fertiliser use and reducing nutrient losses without deterioration in soil fertility and fertiliser use.

2.1.8. 5.1.5. Relevance

Overall, the purpose and the regulations of the SSD continue to be relevant and supported by the stakeholders. While the heavy metals currently regulated do not appear to be obsolete, limits would need review due to the age of the Directive and societal and analytical changes that have occurred since its implementation, since most Member States regulate several other substances going beyond the Directive (e.g. PCB, PAH, PCDD/F).

As to other substances, numerous studies have reported the presence of organic compounds, pathogens, pharmaceuticals, nanomaterials and microplastics in sewage sludge, albeit many of them note that exact concentrations require further monitoring. The set of contaminants regulated by the SSD would need review in this regard. Further evidence is needed to fully understand how these chemicals behave when sludge is reused in agriculture and the likelihood of accumulation in soil to levels which may pose a risk to human health and the environment. Research would be needed on possible cocktail effects with contaminants from other sources too.

5.2 5.2. Lessons learned

The objective of the Sewage Sludge Directive to encourage nutrient recovery is consistent with the Circular Economy Action Plan under the umbrella of the Green Deal. Nutrient recovery is also paramount to attain the EU policy objectives of strategic autonomy in fertilisers and in securing food supply. Certain technologies such as anaerobic digestion also allow to make sludge more suitable for use in agriculture while producing biogas, which can also help achieve the Union's objectives of energy efficiency and independence in energy supply.

Though the added value of the Directive could be challenged for those Member States having set much stricter requirements or taken policy choices such as banning the use of sludge in agriculture, it offers a minimum level of environmental protection rules for the Union as a whole. In principle, with its objective of environmental protection, the SSD would be coherent with the Zero Pollution Action Plan and the Soil Strategy, but in practical terms the risks linked to contaminants need to be reassessed. In the framework of the technical adaptation of the Directive to ensure that it pursues a high level of environmental protection, it is necessary to consider recent and upcoming research and monitoring of pollutants in sludge and soil and review the set of pollutants to be regulated. This would require identifying potential contaminants to be covered. After assessment of their impact on the soil and human health, possible risk management measures should be investigated e.g. concentration limits, treatment or application protocols (amounts over several years, application at certain periods of the year etc). Account should also be taken of the contribution of sewage sludge to the levels of such contaminants in soil, compared to other sources, information that is currently lacking.

Currently, there lacks data on the impact of sludge application on land on the environment and the human health. There is no systematic and periodic evaluation of the environmental and health risks from sewage sludge management routes, neither at EU level nor consistently within the Member States. Partly, this is an indirect consequence of the lack of sludge quality monitoring data. Yet, recommendations and limit values for the dietary intake of certain contaminants present in sewage sludge have for instance been revised at repeated occasions during the last decades (by the WHO or EFSA). At the same time, external factors have reduced other pressures to sustainable sludge management (e.g. the outphasing of certain contaminants). This points to the need for systematic and periodic evaluation of health and environmental risks from sewage sludge management to maintain the relevance of the legislation over time.

The Directive does not deliver data to assess the impact of sludge application on land and make sure that its objectives are met. The current reporting system shows room for improvement in a number of ways. It does not allow to check that sludge is spread in accordance with plant needs, which could result in a sub-optimal use of the sludge or excess of nutrients, possibly resulting in pollution of the groundwater. It is also unknown if sludge is applied outside periods of plant growth, as e.g. data on the temporary storage of sludge and capacities are missing.

Compliance with the existing reporting requirements, e.g. on sludge use and sludge quality could also be improved. There is also potential for simplification and improvement of data collection by rationalising the reporting requirements under the SSD, the Urban Wastewater Treatment Directive and Eurostat.

The SSD also has to be seen in the wider context of sustainable development, zero pollution, energy efficiency, climate change, and EU policies aiming at reducing dependency to energy and critical raw materials, as there may be synergies and/or trade-offs between these different drivers for sludge management policies or practices. Depending on local settings and priorities, specific sludge management routes or methods of treatment could be favoured. For instance, anaerobic digestion allows to produce biogas and renewable energy, while providing benefits to farmers when the digestate can be used as a value-added material on agricultural land.

Wide differences in implementation across the EU were observed. They can be explained partly by the fact that the set of pollutants regulated by the Directive is not up to date, by general policy choices by Member States, but also, to a large extent, by the fact that the choice for a given sludge management option strongly depends on local conditions. Overall, the application of a mix of established and innovative techniques, as a function of local settings and needs, may help to maximise benefits and minimise adverse impacts on the different sustainability dimensions affected by sludge management within the EU. Therefore, maintaining the flexibility for the Member States and the economic operators to have choice for sludge management policies is important. It could be explored whether more guidance or instructions on treatment at EU level would have added value, for optimised benefits in terms of nutrient recovery (and, possibly, energy recovery through biofuel production) while securing protection of health and the environment.

In view of the activities envisaged in the Union Soil Strategy and work on improving the monitoring framework on the soil health, sludge application onto land outside agriculture could be examined too, in terms of risks of soil contamination on the one hand, and enhancement of soil properties and supply in nutrients on the other hand. Whether for agriculture or other uses, it could then be explored whether the potential of sludge for nutrient recovery should be better exploited, through more incentives for such use.

Certain elements of relevance for sewage sludge management will emerge from the evolution of the regulatory context, notably the revision of the Urban Wastewater Treatment Directive and from the new Soil Health Law, in parallel to development and effects of legislation reducing pollution at its source. The Directive can currently be seen as *Lex specialis* of the EU waste legislation. In view of seeking synergies and regulatory simplification, there will be a potential to exploit synergies with future waste, soil or water protection legislation.

This should also provide the opportunity to adapt the legal base of the Directive or instrument which would regulate sewage sludge use in agriculture to the current Treaty rules reflecting the main purpose of the measures therein. The current internal market legal base is outdated.

This evaluation also broadly confirms the main conclusions of the 2014 evaluation, referred to in Annex VII, in relation to the effectiveness, efficiency, coherence and relevance criteria (the 2014 evaluation did not look into the added value of the Directive). This evaluation allowed to gather more up-to-date information on the cost-efficiency of its provisions and reflections on the changed policy and legislative landscape while maintaining the key substantive conclusions along the lines of the 2014 evaluation.

ANNEX I. PROCEDURAL INFORMATION

LEAD DG: DG Environment
DECIDE/AGENDA PLANNING REFERENCE: PLAN/2020/7406
CWP REFERENCE: Commission work programme (its annex) for 2021 (published in November 2020)

1. Derogations granted and justification

No exceptions were made to the Better Regulation Guidelines during this Evaluation.

2. Organisation and timing

The joint inter-service group created in 2017 for the Evaluation of the Urban Wastewater Treatment directive (UWWTD) and the Fitness Check of directives related to water also steered the work on this evaluation. It is set up with representatives from the following Directorate Generals:

- Secretariat General (SG)
- Legal Service (SJ)
- Agriculture and Rural Development (AGRI)
- Climate Action (CLIMA)
- Communications Network, Content and Technology (CNECT)
- Economic and Financial Affairs (ECFIN)
- Environment (ENV)
- Energy (ENER)
- European Civil Protection and Humanitarian Aid Operations (ECHO)
- Financial Stability, Financial Services and Capital Markets Union (FISMA)
- Health and Food Safety (SANTE)
- Internal Market, Industry, Entrepreneurship and SMEs (GROW)
- Joint Research Centre (JRC)
- Maritime Affairs and Fisheries (MARE)
- Migration and Home Affairs (HOME)
- Mobility and Transports (MOVE)
- Regional and Urban Policy (REGIO)
- Research and Innovation (RTD)

The group met 4 times during the Evaluation process, first to steer work related to the support studies which were carried out for this evaluation, and then on the draft evaluation. The group was also consulted in writing. The members of the group were invited to all events organised in the context of the consultation process described in Annex II of this report. Details on consultations on the Group are provided in the following table.

Date	Topic of discussion
13 October 2020	Studies supporting the evaluation - Inception report, followed by written consultation
25 February 2021	Draft interim report presented by the contractor for the supporting studies, followed by written consultation
June 2021	Written consultation on the Revised draft interim report
16 September 2021 meeting	Draft final report followed by written consultation
21 March 2021 meeting	Discussion on Draft Commission evaluation report (Staff working document for the evaluation and executive summary) followed by written consultation

3. *Consultation of the Regulatory Scrutiny Board*

Following its examination by the Regulatory Scrutiny Board on 24 May 2022, this report was modified with the following main changes:

Comment by the Board	Modifications made
The report should strengthen the cost-benefit analysis of the Directive, in particular by comparing the cost-benefit of agricultural use and incineration of sludge.	The efficiency and cost-benefit analysis was revised adding additional information from most recent studies of the JRC. The reasons for the wide ranges of costs observed were explained, also explaining how costs vary. Extensive data were harvested on aggregated costs, which are more representative and are a better basis for the assessment. A particular focus was given to the comparison of cost-benefits of agricultural use vs incineration of sludge.
The report does not draw clear and broader conclusions on the lessons learned, in particular, on the collection of data and indicators to be built for future evaluation as well as whether the regulatory set-up in this area is 'fit for purpose' in view of recent policy developments.	The lessons learned section now provides more details on the information and data which would be needed to ensure that the objective of a high level of environmental and health protection is met.
When reporting on stakeholders' views, the report should not only emphasise majority views. It should be careful to always consider all views, majority and minority, and pay more attention to the	The report now describes more extensively the results of the stakeholders' consultation. It distinguishes more systematically between the different stakeholder groups, also providing

underlying arguments of stakeholders rather than to percentages.	underlying arguments of stakeholders rather than mere percentages.
The report should make it clearer in the conclusions that the legal basis of the Directive is now outdated in view both of its content – which is not cross border in nature - and of the development of the acquis in the period since it was adopted.	This has been made more explicit.

ANNEX II. METHODOLOGY AND ANALYTICAL MODELS USED

This evaluation has been supported by studies undertaken by Wood.plc for that purpose[158], used as a basis adjusted and completed as appropriate Two studies carried out by the JRC also provided significant contributions to this work[159].

The sources of information used for this evaluation have been:

- A review of existing literature, including the previous evaluation and reports from relevant EU funded research projects.
- Member States implementation reports; data from Eurostat and from the European Environmental Agency
- Stakeholder consultations, to gather additional data and information on the stakeholders perception of the extent to which the SSD has been successfully implemented and its relevance. This included an online public consultation (OPC), targeted surveys and interviews (with expert stakeholders and with Member States), and a stakeholder workshop. A wide range of stakeholders contributed, including Member State Competent Authorities, Trade Associations, Non-Governmental Organisations (NGOs), farming community and research organisations.

A summary of the approaches used, and an overview of the findings is presented below.

Literature review

Over 300 academic journals, scientific reports, pan European studies, national reports, policy documents and legal texts, were reviewed. The literature reviewed includes Member State (MS) reports on the implementation of the SSD also analysed. It also covers information reported under the implementation of the UWWTD, where reporting of sewage sludge use is also required.

All the information collected was screened before being used. The screening phase aimed at determining the relevance of the source and took in consideration the year of publication (sources after 2014 were favoured) and the geographical scope (EU specific sources were favoured).

The literature provided evidence in relation to most of the evaluation criteria (to a lesser extent for the EU added value analysis), there were however challenges encountered during the review process which included:

- There is little/sparse information on typical sludge management processes in each country (e.g., there was no information readily available on what volumes of sewage sludge were subject to anaerobic digestion as an intermediate step before the final disposal rates were recorded).
- There are substantial gaps relating to the production and use/disposal of sewage sludge and a lack of consistency and comparability in the types of data reported.
- There are several data gaps in all the datasets identified thus affecting the quality of the data used for the assessment. There are also varying datasets on sludge volumes

[158] Evaluation support study; Exploratory on prospective elements; Report on MS implementation 2016-2018 and further information on sludge management in each MS gathered in summary fiches

[159] Huygens, D. et al (2022); Egle, L. et al., 2023 - under development at the time of writing this report

generated and used in agriculture that present, in some instances, conflicting evidence (e.g., EUROSTAT versus implementation reports). This has made it challenging to get an accurate picture of trends on use of sewage sludge in agriculture. Similarly, there are important gaps in the data reported on metal and nutrient contents in sludge.

- There are important gaps observed relating to elements of the assessment of the costs and benefits of the Directive. On that specific topic, many of the data sources in the literature review are relatively old. The literature review also revealed a scarcity of cost data from MS that have joined the EU after 2003.

Stakeholder engagement

Stakeholder engagement was necessary to ensure that all relevant and interested stakeholders were given an opportunity to express their opinions and to contribute to the study. The key objectives of the consultation process were (i) to complement already known data and literature on the implementation of SSD and (ii) to understand the extent at which the Directive has been successfully implemented, the extent to which its objectives were met, the challenges it encountered, and whether there have been trade-offs in the implementation.

The stakeholder engagement included an online public consultation, the organisation of a workshop and targeted consultation (surveys and interviews). A very brief overview is presented below. More details are available in the synopsis report in Annex I.

➢ **Online public consultation (OPC)**

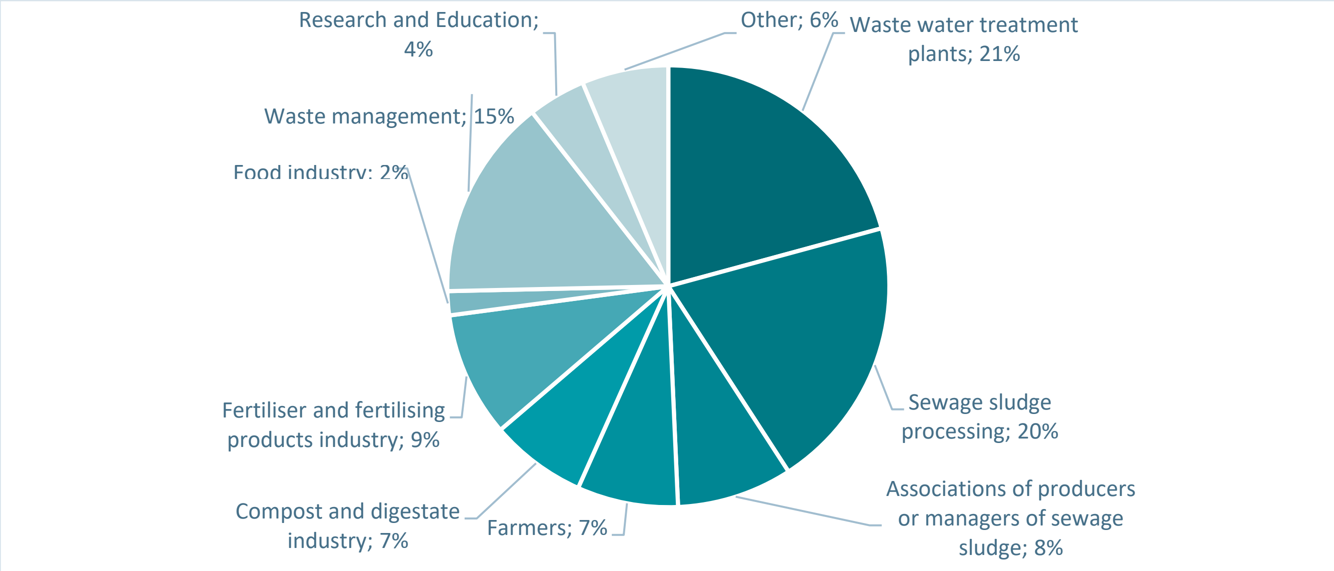
The OPC included questions tailored to examine the effectiveness, efficiency, relevance, coherence, and EU added value of the SSD. The survey was available in all EU languages and available through the EU Survey platform.[160] The consultation was conducted over a period of 16 weeks (between November 2020 and March 2021).

Respondents' profile

A total of 181 responses were received, with 22 EU Member States represented, as well as 3 non-EU countries.[161] Figure 3.1 below shows a breakdown of the respondents' sectors that were represented in the OPC.

Sector representation in the OPC

[160] https://ec.europa.eu/eusurvey/home/welcome
[161] Liechtenstein, Norway, and Switzerland



Source: OPC

Over 70% of the organisations taking part in the consultation process were involved in or directly affected by the recovery, treatment or use of sludge and/or wastewater and 80% of these respondents indicating having a good or excellent understanding of the treatment of sewage sludge, of the implementation of the SSD, and/or knowledge of its legal text.

➢ **Targeted stakeholders' engagement**

The targeted stakeholder engagement included targeted written surveys, one stakeholders' workshop and several interviews.

Targeted surveys

Targeted surveys were drafted to gather detailed feedback and data from stakeholders directly involved in the implementation of the SSD, and/or from stakeholders with a substantial expertise of the topic. A total of three different questionnaires were prepared: one directed at Member States competent authorities, one directed at other expert stakeholders and an additional targeted consultation was undertaken to gather data concerning the costs and benefits of the SSD.

There was a total of 63 responses were received from all stakeholder types (which included Member States, individuals from the wastewater treatment and sludge processing and treatment industry, agricultural associations, academics and NGOS, etc).

The findings from the targeted surveys demonstrate that respondents were in strong agreement that the SSD had led to some improvements such as:

- a generally sustainable framework for the use of sewage sludge in agriculture (73% agree or strongly agree),
- increased safe use of sewage sludge in agriculture (64% agree or strongly agree), and
- minimisation of pollution and health risks from sewage sludge (65% agree or strongly agree)
- However, respondents were less convinced the SSD had led to phosphorus and nutrient recycling and carbon sequestration, or to a measurable improvement in

the quality of agricultural soils. Further findings from the surveys are included in the analysis of the evaluation questions below.

Stakeholders' workshop

A workshop was organised to support expert discussions on key topics (such as improving energy efficiency in wastewater management and sludge management, increasing nutrient recovery, and addressing pollution from micropollutants) and to present preliminary findings of the analysis. The workshop was organised focusing on synergies between wastewater, sludge, and the circular economy.

The workshop was very well attended with 376 participants attending the one day and 290 on the other day. A workshop report is available for further details.[162]

Follow up interviews

Five expert interviews with experts were organised to fill gaps in the information including on costs and benefits, on the possibility to improve quality of sludge at source and on factors affecting trust from the public. Organisations representing farmers were also reached out to.

The interviewees included: a representative from WAREG, a Romanian Water Regulator, a representative of a wastewater operator in Bulgaria and a representative of a pilot project in Lithuania aiming at using sewage sludge digestate as fertiliser for forestry plantation. Finally, an interview was held with a representative of the European Sustainable Phosphorus Platform.

Data limitations

There are several existing datasets on the volume of sludge generated and used in agriculture that present, in some instances, conflicting information albeit coming from normally reliable sources[163]. There are also gaps in all the datasets considered, i.e., there is not one that can be considered more robust or more complete. Collectively this means it was challenging to get an accurate picture of trends on the use of sewage sludge in agriculture and other uses (e.g., amount composted or digested). In addition, there the information reported by Member States in their implementation reports is often missing, and sometimes the quality of data reported on metal and nutrient contents is of limited quality.

The following table illustrates the extent of the data gaps, taking the example of data on the production of sludge and share used in agriculture. To address these challenges, this evaluation used the data reported by Member States under the implementation of the SSD as main dataset and proceeded to fill observed gaps using Eurostat data. The implementation data was deemed most suitable as this is the data reported by the Member States' competent authorities in charge of the implementation of the SSD and those that can be assumed to be most accurate about their datasets[164]. As explained below, a further extrapolation of data was undertaken to have a complete data set to use for the purpose of the analysis.

Such extrapolation has notably been done for the graph showing the evolution of sewage sludge production and use over 2007-2018 (starting from 2007 because before that the data scarcity is too extreme), provided in the main body of this evaluation report, section 3.2.

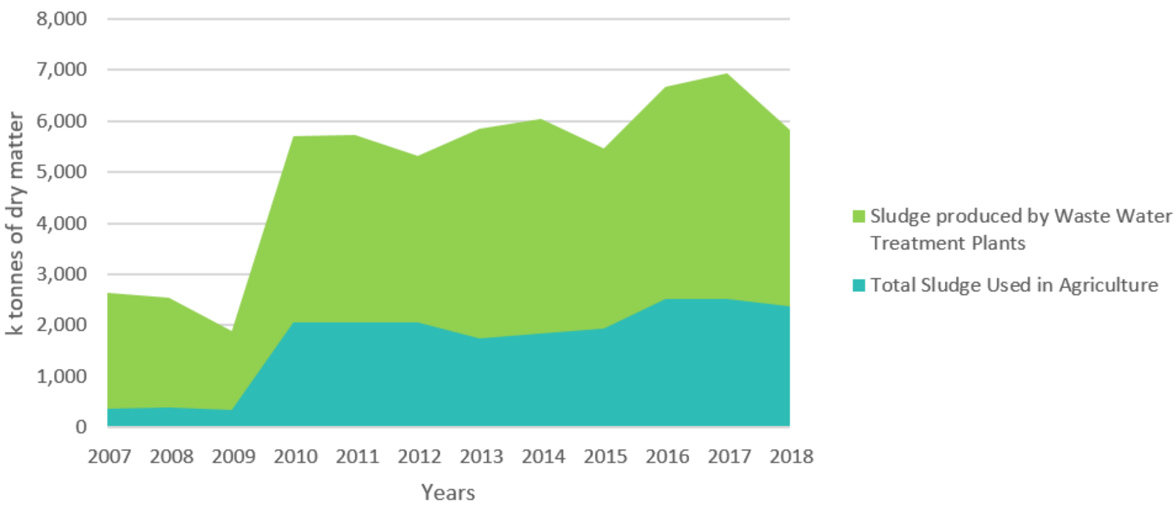
[162] Workshop report on wastewater and sludge, https://circabc.europa.eu/w/browse/907e1488-b9e3-42d7-804c-eafeca890ca4

[163] Eurostat, reporting under the SSD implementation and reporting under the UWWTD implementation

[164] In particular, the evaluation of the UWWTD noted the challenge for some competent authorities to report on sewage sludge when it is not part of the responsibilities of the water authorities in some Member States

The graph was originally as follows, when based solely on the implementation reports from Member States, before completion from other data sources and extrapolations using other years of reporting where data from Member States were missing for a given year:

Total sludge produced and used in agriculture in the EU between 2007 and 2018



Source: Member States implementation reports required by the Directive, sent to the Commission on a 3-yearly basis

This would show an increase in both sludge production and sludge used in agriculture between 2009 and 2010. Since 2010, the amount of sludge used in agriculture has stayed relatively constant, albeit with a decline and subsequent increase between 2013-15. This can be explained in part due to an absence of reporting on sludge used in agriculture during this time period by some Member States. In terms of the total amount of sludge produced, there was an increase between 2012 and 2013 followed by a subsequent decrease between 2014 and 2015, and a further increase between 2015–2016. There is a decline in 2018, which similarly has been impacted by some Member States not reporting on sludge production for the most recent year. It should be noted that reporting from the UK has not been included in the chart below.

When considering these trends one should acknowledge significant gaps in the data reported by each Member State for different years, which distort the aggregate total amounts for both total sludge production and sludge used in agriculture and, therefore, do not allow for definite identification of trends. The following table shows the gaps:

Gaps in reporting on the total sludge production and use of sludge in agriculture between 2007 and 2018

Year	Number of MS not having reported total sludge production	Number of MS not having reported quantity of sludge used in agriculture
2007	18 MS	18 MS
2008	18 MS	19 MS
2009	18 MS	18 MS
2010	5 MSs and 3 MS regions	6 MS and 1 MS region
2011	5 MS and one MS region	6 MS

Year	Number of MS not having reported total sludge production	Number of MS not having reported quantity of sludge used in agriculture
2012	5 MS and 3 MS regions	7 MS and one MS region
2013	6 MS and 3 MS regions	6 MS and 3 MS regions
2014	6 MS and 3 MS regions	7 MS and 3 MS regions
2015	8 MS	9 MS and one MS region
2016	1 MS and 3 MS regions	1 MS and 3 MS regions
2017	1 MS and 3 MS regions	1 MS and 3 MS regions
2018	4 MS and 3 MS regions	3 MS and 3 MS regions

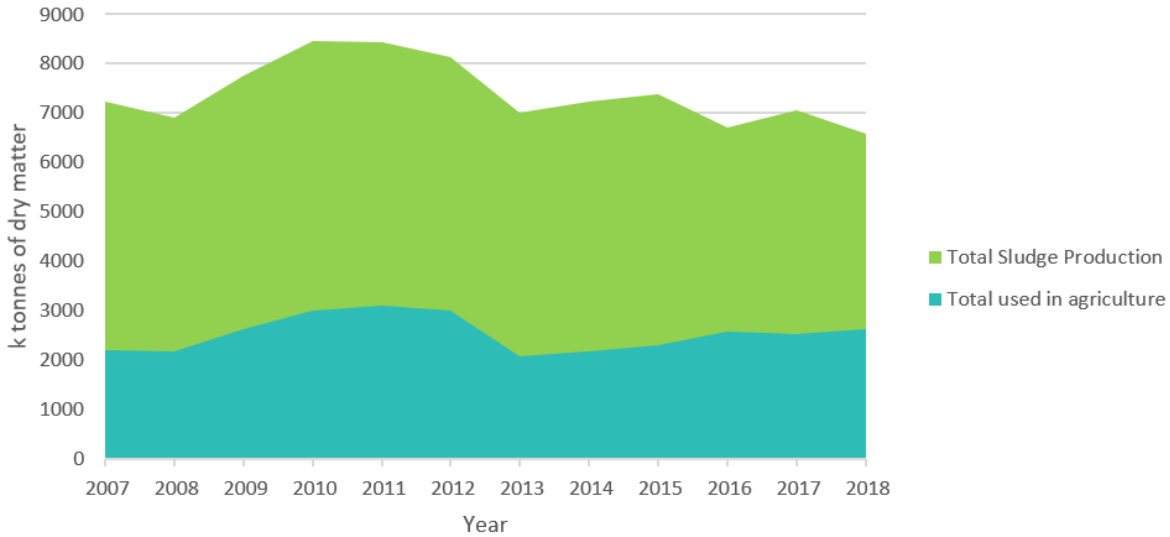
Source: MS implementation reports. The 2007-2009 reporting on sludge production and sludge used in agriculture is lacking for 18 Member States, data for the 2010-2012 period is missing for 8 Member States, data for the 2013-2015 period is missing for 7 Member States and data for the 2016-2018 period is missing for 5 Member States.

In order to avoid distortions in the representation of the data, the gaps were filled in through two steps:

- Where available, previous implementation reports were reviewed to fill any gaps
- The remaining data gaps were estimated through extrapolation of the existing data for the Member States which had not reported the data. The extrapolation was based on the population size of each Member State. The approach has therefore relied on the assumption that a Member State with a larger population has produced a greater amount of sludge and/or uses a greater amount of sludge in agriculture.

After completion with data from other sources and the extrapolation as described above, the diagram appears significantly different (this diagram is also the one provided in the main body of this report, section 3.2). The resulting figure, as provided in the main body of this evaluation report, section 3.2, is as follows:

Sludge produced and used in agriculture in the EU (2007-2018)



Source: MS reporting on the implementation of the SSD, complemented with extrapolation where information is missing for that period (see Annex II for details on how the extrapolation was made). The graph has been drawn from 2007 onwards, due to the extreme scarcity of data from before that (and although we still note that even after 2007, data sets remain very incomplete, as described in Annex II). The most notable yearly change occurred between 2012–2013, when there was a sharp decrease. The decrease is a reflection of reduced total sludge production reported in Spain, Finland and Portugal. There was no information identified to explain these decreases in these countries. A further decrease is observed between 2017-2018 reflecting decrease in quantities reported by Bulgaria and Italy.

Discrepancies between Eurostat, Member States' data on sludge use

It is challenging to conclude on trends in management of sludge in EU due to differences in the terminology and type of data collected.

Research has been undertaken to understand the reasons for these differences. Terminology is unclear, which can lead to varied interpretation. For example, all data on sewage sludge production and disposal route refers to sewage sludge dry matter, but there is no definition of dry matter in the SSD. It is noted that there has been an international standard since 1993 and a European standard since 2000[165]. Eurostat distinguishes 'agriculture' from 'compost and others'. Based on some countries' evolution of reported data it is safe to assume that in some MS the 'other' category also includes agriculture use[166]. In addition, sludge that is used to grow plants for further compost production can be classified differently in MS (i.e., 'reuse in compost', or 'other'). The literature identified challenges in interpreting and comparing the data available[167].

Each dataset has pros and cons depending on the year/period and type of data considered:

- The MS implementation reports provide a more comprehensive dataset for the years 2016-2018 (however, missing data from Germany for 2018 likely impacts considerably the 2018 reporting[168]), from 2007 through to 2016, Eurostat provides more comprehensive data.
- Eurostat only gives limited insight into sewage sludge disposal. There is little information in the data and literature studied on the full detail of the typical sludge management processes in each country. For example, there was no information readily available on what volumes of sewage sludge were subject to the anaerobic digestion treatment as an intermediate step before the final disposal fates recorded. This pre-treatment will impact on the actual volumes of sludge finally disposed of (anaerobic digestion significantly reduces volume) and the amount of energy recovered.

Data collected under the different sources are not fully coherent and can be challenging to compare. A comparison of the data concluded to a 'high degree of incongruity in 37%' of MS[169]. The incoherence of the datasets has been further identified in several references[170].

[165] ISO 11465,1993, CSN EN 12880,2000 CSN EN 15934, 2012
[166] Collivignarelli, M., Abbà, A., Frattarola, A., Carnevale, M., Padovani, S., Katsoyiannis, I., & Torretta, V. (2019). Legislation for the Reuse of Biosolids on Agricultural Land in Europe: Overview. Sustainability, 11(21). Retrieved January 21, 2021, from https://www.mdpi.com/2071-1050/11/21/6015/htm
[167] Collivignarelli, M., Abbà, A., Frattarola, A., Carnevale, M., Padovani, S., Katsoyiannis, I., & Torretta, V. (2019). Legislation for the Reuse of Biosolids on Agricultural Land in Europe: Overview. Sustainability, 11(21). Retrieved January 21, 2021, from https://www.mdpi.com/2071-1050/11/21/6015/htmet al. (2019).
[168] Considering our scenario analysis developed for the JRC, Germany used 274,603 tonnes of sewage sludge on agriculture in 2018.
[169] Bianchini, A., Bonfiglioli, L., Pellegrini, M., & Saccani, C. 2016. Sewage sludge management in Europe: a critical analysis of data quality. International Journal of Environment and Waste Management, 18(3). Retrieved February 08, 2021, from

- Triangulation was possible for most questions. The evaluation questions were covered in the OPC, the targeted consultation and were also investigated in the literature thus allowing conclusions to be drawn from a range of sources. In some cases where available literature was limited (e.g., efficiency, EU added value) or conflicting (e.g., in particular for data sets), to the evaluation relies to a large extent on consultation responses rather than on available literature. Where difficulties were encountered in relation to the robustness of the evidence upon which conclusions have been drawn, these difficulties have been identified and clearly presented in the analysis of each evaluation question.

2. Development of the scenarios of reference (for the baseline)

The scenarios of reference are:

- Past Scenario reflecting the situation at the time the Sewage Sludge Directive (SSD) was adopted. The data used are the oldest possible after 1986 (year of the start of implementation of the Directive).
- Present Scenario (Current Situation). The data was derived mainly from the information reported by MS as part of the implementation of the SSD and reflects latest data from 2016-2018 reporting period. Where necessary gaps have been filled with the corresponding most recent data from Eurostat. When MS have supplied more recent data (e.g., as part of the consultation step) these have been preferred as considered more robust.
- The Present Scenario (WIND) reflecting a hypothetical present scenario whereby the SSD would not have been adopted. The scenario is based on an extrapolation of the current situation considering qualitative criteria such as Member States adopting stricter requirements[171]. If the Member State had not adopted stricter requirements for sewage sludge, we assumed that the Present Scenario (WIND) would be 50% higher than the Present Scenario (current situation), meaning 50% more than the currently discarded sewage sludge. The choice of this value was arbitrary, based on observed variation of use of sewage sludge in countries that did not practice it before the adoption of the SSD and the current situation (e.g., Bulgaria, Estonia, Greece and Ireland). This value was chosen so that it was large enough to show a change between the Present Scenario (WIND) and the Present Scenario (current situation) and for illustrative purposes. The value of the WIND scenario is as a comparison to the current situation, and to support the analysis of the attribution of the effects observed to the SSD.

The table below presents the estimated shares for the use of sewage sludge in agriculture under the different scenarii considered. With all the precautions to be taken due to the scarcity and quality of data, this would suggest that the Directive had either no effect (13 MS) on the

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https://www.researchgate.net/publication/311273547_Sewage_sludge_management_in_Europe_a_critical_analysis_of_data_qualityet al., 2016.

[170] Bianchini, A., Bonfiglioli, L., Pellegrini, M., & Saccani, C., 2016. Sewage sludge management in Europe: a critical analysis of data quality. International Journal of Environment and Waste Management, 18(3). Retrieved February 08, 2021, from https://www.researchgate.net/publication/311273547_Sewage_sludge_management_in_Europe_a_critical_analysis_of_data_qualityet al. , 2016 .

[171] Modelling work had originally been envisaged for the development of a baseline scenario. However, the scarcity of data on sludge use, sludge quality and soil quality did not allow this. Instead, extensive efforts have been made to gather as many data as possible and present a comparison past situation/present situation.

percentage of sludge use in agriculture, or that it would cause a decrease of that percentage (6 MS).

Past, Present (Current Situation), and WIND scenario for the share of sewage sludge used in agriculture

Member State	Past Scenario, %	Present Scenario (Current Situation), %	Present Scenario (WIND), %
Austria	33.0[1]	30.0[14]	30.0
Belgium	22.0[1]	65.0[11]	65.0
Bulgaria	0.0[2]	56.1[11]	84.2
Croatia	5.0[3]	6.1[11]	6.1
Cyprus	89.0[4]	11.1[11]	16.7
Czechia	43.0[5]	31.0[11]	31.0
Denmark	62.0[1]	67.0[14]	67.0
Estonia	0.0[6]	71.1[11]	100.0
Finland	60.0[7]	43.7[14]	43.7
France	62.5[1]	24.7[14]	24.7
Germany	46.0[1]	15.3[14]	15.3
Greece	1.0[1]	20.0[14]	30.0
Hungary	20.0[8]	7.4[14]	7.4
Ireland	10.0[1]	98.9[14]	100.0
Italy	45.0[9]	40.2[14]	40.2
Latvia	42.0[6]	17.4[14]	17.4
Lithuania	33.0[6]	14.0[11]	14.0
Luxembourg	55.0[1]	20.7[14]	20.7
Malta	0.0[6]	0.0[14]	0.0
Netherlands	42.0[1]	3.0[14]	3.0
Poland	9.0[10]	20.3[14]	30.4
Portugal	4.0[11]	2.0[11]	3.0
Romania	0.0[6]	32.6[14]	32.6
Slovakia	80.0[5]	0.0[14]	0.0
Slovenia	6.0[12]	0.0[11]	0.0
Spain	52.0[1]	78.0[11]	100.0
Sweden	29.0[13]	39.0[11]	39.0

Notes :
1 - https://ec.europa.eu/environment/water/water-urbanwaste/implementation/implem_report_1/chap6.html
2 - https://moew.government.bg/static/media/ups/tiny/file/Waste/sewage_sludge/BG_DE_seminar/Presentation_NSMP_Schneider_Bulgaria-4.pdf
3 - Based on earliest data identified for 2010
4 - Based on latest Eurostat data available for 2009
5 - https://www.ircwash.org/sites/default/files/821-EUREAST94-14809.pdf
6 - https://pubmed.ncbi.nlm.nih.gov/22336390/
7 - Based on EC, First implementation report of the UWWTD and https://ec.europa.eu/environment/water/water-urbanwaste/implementation/implem_report_1/chap6.html and 2014, Puhdistamolietteen ja biojätteen käsittely ravinteita kierrättäen
8 - https://dea.lib.unideb.hu/dea/bitstream/handle/2437/214183/file_up_5-Wastewater Treatment and Sludge Utilisation in Hungary-1.pdf?sequence=1
9 - Assuming a gradual reduction in use over time, e.g., 35% of use in 2010
10 - https://www.mdpi.com/2071-1050/12/9/3686/pdf
11 - Value provided by Member State
12 - https://cdr.eionet.europa.eu/si/eu/colqa8jlq/colqwzskg/envqwzsra/Directive_86_278_sewage_sludge.htm
13 - https://ec.europa.eu/environment/archives/waste/sludge/pdf/part_iii_report.pdf
14 – Calculated from quantity of 'sludge used in agriculture' and 'total sludge use' data in order of preference: Member State-provided data, 2018 Implementation data, Eurostat data (2018, 2017 or 2016 in order)

As can be seen above from the details on the data sources, it has shown extremely difficult to gather information to fill that table. As a result, it was decided to focus this baseline on sludge use (i.e., not developing it for other parameters such as sludge heavy metal content) and on a comparison "situation / present situation" rather than an evolution.

ANNEX III. EVALUATION MATRIX AND, WHERE RELEVANT, DETAILS ON ANSWERS TO THE EVALUATION QUESTIONS (BY CRITERION)

5.3 1.1 Evaluation matrix

In line with the Commission's better regulation policy, this report assesses the Sewage Sludge Directive along five criteria: effectiveness, efficiency, coherence, EU added value, and relevance. These criteria were operationalised via elaborating questions specific to this Directive, which were systematically answered to assess the different criteria in a way that is specific to the Directive (how these criteria translate in the context of this Directive). This set of (18) questions was also provided in the Roadmap published at the start to inform citizens and stakeholders to allow them to provide feedback on the evaluation initiative.

These questions were broken down into sub-questions, and, for each of them, assessment criteria, indicators, approach to take for the analysis and sources of information to use to answer the questions were identified. This resulted in the evaluation matrix presented here.

5.3.1.1 **Evaluation matrix - effectiveness**

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
EQ.1 What progress has been made over time towards achieving the objectives and targets set out in the SSD in the various Member States? To what extent have the objectives been met?				
1.1 What has been the effect of the SSD on the use of sewage sludge in agriculture?	Member State Regulation of sewage sludge in agriculture. Proportion and volume of sewage sludge discharged to the marine environment has reduced in the EU and Member States. Reduced reports of sewage sludge in the marine environment. Reporting of annual concentrations of heavy metals in sludge. It will be important to decouple quantity of use and achievement of the objectives, a decrease of use might be due to other substances present in the sludge and not necessarily a failure to achieve objectives	Number of Member States implementing regulations concerning sewage sludge use in agriculture. Member States having set other requirements in their national legislation (i.e., stricter) including limit for maximum quantity of sludge Proportion and volume of sewage sludge used in agriculture in the EU and Member States as one indicator to be completed by analysis. Proportion and volume of sewage sludge discharged to the marine environment.	Quantitative analysis of sewage sludge use globally and in comparison, with the EU and MS. Qualitative analysis of MS reported data	Implementation report Eurostat JRC modelling Feedback from stakeholders (including Roadmap)
1.2 What has been the impact of the SSD on the quantity of sewage sludge used in agriculture?	Overall perception that sewage sludge is used effectively in agriculture Demand for sewage sludge for agriculture has increased and demand for other fertilisers has reduced. It will be important to decouple quantity of use and achievement of the objectives, a decrease of use might be due to other substances present in the sludge and not necessarily a failure to achieve objectives	Trade statistics Proportion and volume of sewage sludge used in agriculture. Number of sewage sludge producers providing sewage sludge to agricultural users. Quantity of nutrients recovered from sludge compared with those from manure.	Quantitative analysis of sewage sludge quantities in agriculture, by MS. Comparison of sewage sludge with other fertiliser / nutrient sources including manure	Implementation report Eurostat JRC modelling Feedback from stakeholders (including Roadmap)

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
1.3 How effective has the SSD been regarding the concentrations of heavy metals in soil?	MS Regulation of use of sludge in soil where concentrations of heavy metals exceed the values laid down in the SSD Reports of concentrations by MS	Concentrations of heavy metals in soils in different MS where different quantities of sludge are used.	Quantitative analysis of concentrations of heavy metals in soils reported within MS and at EU-level.	Implementation report Eurostat JRC modelling Literature review
1.4 How effective has the SSD been in encouraging the correct use of sewage sludge in agriculture?	Changes observed in the correct use of sewage sludge in agriculture Actions used in MS to encourage correct use and uptake for agricultural use.	Size of actions for encouragement	Quantitative analysis of usage data and trading data Qualitative analysis of consumers views, citizens views and producers' views. Qualitative analysis of communication methods in MS.	Stakeholder consultation
EQ.2 - What factors have contributed to or hindered their achievement?				
2.1 How effective has the transposition of SSD been at MS level?	National laws implemented by MS and their content.	National laws implemented by MS and their content.	Qualitative analysis of MS national laws and legal frameworks for implementing the SSD.	National laws MS Reports to the Commission Literature review
2.2 What are the other factors that have contributed to the achievements of the objectives?	The interpretation of the Directive has been straightforward. Other factors as identified by stakeholders to have contributed to the achievements of the Directive (e.g., effective record keeping, effective sharing of information)	Court case jurisprudence	Qualitative analysis of legal infringement and enforcement	EU Court cases National proceedings
EQ.3 - How effective has the implementation and enforcement of the SSD been in the 28 Member States and to what extent has this safeguarded agricultural soils from pollution?				
3. 1 How effective has enforcement	Competent Authorities in MS have access	Cooperation between	Qualitative comparison of	Consultation with

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
of the SSD in the Member States been?	to reports and the tools to undertake enforcement in MS.	Competent Authorities and MS. Feedback from Competent Authorities.	enforcement activities between MS.	competent authorities, producers, and users MS reports concerning enforcement Infringements at EU level
3.2 How effective has MS implementation of the SSD been?	Implementation of key obligations at national level, and consistent in MS across the EU National law fully includes obligations of the SSD Additional actions have been taken by MS to facilitate SSD implementation	Awareness and understanding of regulation amongst users of sewage sludge in agriculture, and citizens.	Qualitative analysis of viewpoints from Competent Authorities across MS.	Stakeholder consultation (including Roadmap)
3.3 Have agricultural soils quality been safeguarded from the implementation of the SSD?	Link between the adoption of the legislation and quantity of the quality of soil Findings on overall heavy metals concentration in agricultural soils in EU 28 and through time	Reporting on 'Quality of soils'	Qualitative analysis of views of users and producers of sewage sludge. Qualitative analysis of Competent Authority viewpoints Comparison with other non-EU countries where sewage sludge use is not regulated	Stakeholder consultation (including Roadmap)
EQ.4 - What have been the (quantitative and qualitative) effects of the SSD?				
4.1 Have the amounts of sewage sludge used in agriculture changed?	Levels of sewage sludge in the marine environment have changed Levels of sewage sludge used in agriculture have changed Proportion of use is greater in agriculture than discharged to the marine environment There are changed disposal patterns	Levels of sewage sludge used in agriculture Proportion of sewage sludge discharged in the marine environment Comparison of sewage used in agriculture vs other uses	Quantitative analysis of levels of sewage sludge Qualitative analysis of other pollutants affected implementation of SS Qualitative analysis of impacts of soil contamination on health	Literature review Stakeholder consultation (including Roadmap) Datasets and reports

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
	There are changes in health risks from use of sludge on agricultural land.			
4.2 What has been the public perception, media reporting and food industry views concerning sewage sludge use in agriculture and how did it influence it?	Positive / negative public viewpoint reported Position of food industry on use of sewage sludge	Viewpoints of citizens in MS Newspaper articles and communications	Qualitative analysis of viewpoints of citizens	Open Public Consultation Literature review
4.3 What are the other effects of the SSD?	Other effects either quantitative or qualitative that can be linked to the implementation of the SSD Other effects into pollutants Effects on human health Wider effects on the environment and health effects of contaminated soils are better understood	Indicators to be set based on the effects identified WHO information on human health	Qualitative and quantitative analysis of the effects identified	Literature review Targeted stakeholder consultation/interviews
EQ.5 - What have been the unintended / unexpected effects of the SSD?				
5.2 Has there been a shift to alternative uses or disposal routes of sewage sludge other than use in agriculture?	Other available uses or disposal routes other than of sewage sludge in agriculture (biosolids) Impact of the national rules on such a use of alternatives, if available. Rules set by Member States to regulate other uses/disposal routes	Different uses / disposal routes / Types of waste-derived products available MS rules on management of sludge	Qualitative analysis of available products Quantitative analysis of products used Qualitative analysis of sewage sludge users' preferences and viewpoints and market demand where applicable.	Literature review Targeted stakeholder consultation/interviews
5.2 What are the other unintended / unexpected effects of the SSD	Other unintended or unexpected effects that can be linked to the implementation of the SSD New treatments available	Indicators to be set based on the effects identified	Qualitative and quantitative analysis of the effects identified	Literature review Targeted stakeholder consultation / interviews.

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
	New technologies available Changes in emissions of GHG linked to application of sewage sludge on agricultural land.			

5.3.1.2 Evaluation matrix – efficiency

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
EQ.6 - To what extent has the SSD been cost-effective? Are the costs related to the SSD proportionate to the benefits?				
6.1 What are the costs and benefits arising from implementation of the Directive? **6.2 How proportionate were the costs of the intervention borne by different stakeholder groups considering the distribution of associated benefits?**	To what extent are costs arising from regulatory requirements minimised? What is the cost? What are the benefits? How do the costs and benefits compare in total and across stakeholder groups?	<u>Administrative costs</u> to operators for maintaining up to date records on quantities of sludge. Administrative costs to authorities associated with provision of the consolidated report on implementation of SSD (Article 17). Administrative costs to farmers. <u>Operational costs</u> to operators for the following treatment options: - Transporting and spreading raw sewage sludge on land - Transporting, treating, and spreading sewage sludge on land - Dewatering and incinerating of sewage sludge - Landfilling of sewage sludge (incl. relevant pre-treatment) Operational impacts on farmers from using	Quantitative assessment of administrative costs to authorities (if considered significant, using aspects of the standard cost model methodology). Quantitative assessment of operational costs to operators, depending on the treatment option. Quantitative assessment of cost saving to farmers based on the comparison with costs of using alternative fertilisers. Comparison of the above costs with the benefits (as specified in Table 3.3.)	Literature review of grey literature including the previous evaluation (Bio Intelligence Service, 2014) Targeted stakeholder consultation. A number of case studies covering representative causes of variations across Member States including: - Population connected to urban wastewater treatment in relation to

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
		sludge: - Constraints and increased planning requirements for agricultural activities, time costs - Net cashflow impact integrating financial flows related to sludge use / disposal and change in chemical fertiliser expenditure. Changes in soil quality and fertiliser uptake efficiency resulting from use of sludge as compared to other fertilisers. Impacts on human health resulting from the effectiveness analysis. Impacts on the environment using effectiveness analysis.	Avoided contamination caused by regulation of sludge use. Comparison of nitrous oxide and methane emissions resulting from different treatment options (spreading on land, incineration, or landfilling).	suitable agricultural soil in the country - Historic developments related to phosphorus and nitrogen excess or deficit in soils - Distance from wastewater treatment plants to suitable agricultural lands.
EQ.7 - To what extent do the requirements of the SSD influence the efficiency with which the observed achievements have been attained? What other factors influence the costs and benefits?				
7.1 How much have actions changed implementation costs while maintaining control and quality standards of the Directive?	Are there examples of good practices?	Approaches to implementation and associated implementation costs.	Qualitative review of implementation to identify examples of cost savings.	Targeted stakeholder interviews Case studies
7.2 What are the non-regulatory drivers of costs and benefits?	What non-regulatory factors have influenced the efficiency with which the observed achievements have been attained?	Technological developments to improve the quality of wastewater and sewage sludge treatment and recovery. Technological developments for the feasibility of the analysis and removal of	Case studies to review what technological and scientific developments there have been, the extent to which the SSD has been driver of	Literature review of grey literature including the previous evaluation (Bio Intelligence Service, 2014)

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
		substances/contaminants in sewage sludge. Member State use of more stringent measures (Article 12).	these developments, and a review of the associated costs and benefits Screening to review costs and benefits arising from Member State use of more stringent measures.	Targeted stakeholder interviews
EQ.8 - Are there opportunities to simplify the legislation or reduce unnecessary regulatory costs without undermining the intended objectives of the intervention?				
8.1 To what extent are there opportunities for synergies and cost savings with related EU legislation?	There are opportunities for synergies, there is opportunity for simplification and / or to remove unnecessary regulatory costs.	Objectives and outputs of related EU legislation (UWWTD, EPRTR, Other): - Overlaps of reporting requirements - Relevance of reporting requirements - Approach of measuring and reporting on compliance (i.e., are reporting requirements appropriate in matters of frequency, measurement technology relevant).	Qualitative review of related EU legislation to identify synergies, e.g., with requirements for Nutrient Management Planning and support for Precision Farming.	Desk based review of evaluation studies for related legislation Targeted stakeholder interviews
8.2 How have different monitoring and enforcement techniques / approaches differed?	Are there different approaches to monitoring and enforcement across the Member States and how do they differ in terms of their cost effectiveness?	Approaches and techniques used for monitoring and enforcement across EU Member States	Qualitative analysis of the approaches used and their associated costs and benefits.	Targeted stakeholder interviews
8.3 How are SMEs affected by the Directive?	Are SMEs disproportionately affected by incurred costs?	Administrative cost estimates in relation to business size. Evidence on the use of Article 11 exemptions Differentiation in use of sludge across	Analysis of the involvement of SMEs in the value chain. Application of Article 11 exemptions across Member States (reduced reporting for	Targeted stakeholder questionnaire Targeted stakeholder interviews

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
		different farm enterprise sizes.	sewage treatment plants with a treatment capacity below 300 kg BOD5 per day, corresponding to 5 000 person equivalents).	
EQ.9 - Are there significant differences in costs (or benefits) between Member States, and if so, what are the underlying causes? How do these differences link to the SSD?				
9.1 How do costs and benefits compare between Member States that have set more stringent sludge quality standards and those that have not?	How do the costs and benefits compare between MS? Do more stringent standards drive different technology choices and as a result the associated costs?	Comparison of costs incurred by operators Member States (see indicators used in EQ6).	Comparison between costs and benefits arising from Member State use of more stringent measures and those arising from standard implementation.	Desk based review of previous evaluation study (BIO Intelligence, 2014) Targeted stakeholder interviews Case studies
9.2 What bearing do local and geographical factors have on costs and benefits?		Background concentrations of heavy metals in soil. Background excess of nitrogen and phosphorus. Member State use of more stringent standards.	Qualitative review to assess the extent to which varying local and geographical factors require stricter conditions to meet the requirements of the Directive.	Desk based review of previous evaluation study (BIO Intelligence, 2014) Targeted stakeholder interviews Eurostat data Infringement processes vs MS linked water contamination WHO Soil and marine contamination?
EQ.10 - How timely and efficient is the process for reporting and monitoring?				
10.1 Should Member State	Is reporting and monitoring		Assess the significance of	Review of E-PRTR data

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
records be reported to the EU annually?	proportionate to the scale of sewage sludge use and its environmental pressures?		releases to land from the use of sewage sludge in relation to releases from facilities reporting to the E-PRTR.	and Member State sewage sludge records LUCAS
10.2 To what extent is reporting and monitoring aligned with technological and scientific developments?	To what extent does annual recording and the consolidated reports (issued every four years) cover new substances and re-use?	Identification of new substances that may be found in sewage sludge. Reporting on re-use of sewage sludge.	Screening of new substances compared with Member State record keeping and reporting. Screening of re-use compared with Member State record keeping and reporting.	Desk based review of evaluation studies for related legislation

5.3.1.3 Evaluation matrix - coherence

Evaluation question	Assessment criteria	Indicators	Data analysis approach	Data source / data collection methods
EQ.11- To what extent is the SSD internally consistent and coherent				
11.1 To what extent is the SSD internally consistent and coherent	The Directive is delivered in a coherent and simple manner with no requirements unnecessary, unclear, or contradictory A standalone Directive continues to be relevant	List of elements in the Directives which are not internally coherent and their potential consequences Assessment of the completeness of the Directive as a self-standing legislation	Review of the objectives and provisions of the Directives	Data from literature review Consultation and questionnaire analysis Public consultation
EQ.12 - To what extent is the SSD coherent with other existing EU legislation such as the Urban Wastewater Treatment Directive (UWWTD), the Fertilising Products Regulation, Waste Framework Directive, the Water Framework Directives (and its daughter directives), the Marine Strategy Framework Directive, the Landfill Directive, the Nitrates Directive, Renewable Energy Directive, the Energy Efficiency Directive, Air Quality Directive, National Emissions Ceiling Directive, Industrial				

Evaluation question	Assessment criteria	Indicators	Data analysis approach	Data source / data collection methods
Emissions Directive, the REACH Regulation, General Principles of Food Law Regulation?				
12.1 Is the SSD coherent with the UWWTD?	The Directive and UWWTD are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and the UWWTD	Qualitative analysis and comparison of the objectives and provisions of the SSD and the UWWTD	Data from literature review Consultation and questionnaire analysis Public consultation
12.2 Is the SSD coherent with the Fertilising Products Regulation and other agricultural policies such as the Nitrates Directives?	The Directive and Fertilising Products Regulation and other agricultural policies are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and the Fertilising Products Regulation and other agricultural policies	Qualitative analysis and comparison of the objectives and provisions of the SSD and the Fertilising Products Regulation and other agricultural policies	Data from literature review Consultation and questionnaire analysis Public consultation
12.3 Is the SSD coherent with other waste legislation including the Waste Framework Directive, the Landfill Directive?	The Directive and the waste legislation are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and the waste legislation	Qualitative analysis and comparison of the objectives and provisions of the SSD and the waste legislation	Data from literature review Consultation and questionnaire analysis Public consultation
12.4 Is the SSD coherent with chemicals legislation?	The Directive and wider chemicals legislation is coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and the wider chemicals legislation	Qualitative analysis and comparison of the objectives and provisions of the SSD and the wider chemicals legislation	Data from literature review Consultation and questionnaire analysis Public consultation
12.5 Is the SSD coherent with water and marine policies?	The Directive and wider water and marine (WFD, MSFD, EQSD)	List of elements that may lead to weaknesses, overlaps or	Qualitative analysis and comparison of the objectives	Data from literature review Consultation and questionnaire

Evaluation question	Assessment criteria	Indicators	Data analysis approach	Data source / data collection methods
	legislation are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	inconsistencies when considering the SSD and the wider water and marine (WFD, MSFD, EQSD) legislation	and provisions of the SSD and the wider water and marine (WFD, MSFD, EQSD) legislation	analysis Public consultation
12.6 Is the SSD coherent with energy efficiency legislation?	The Directive and energy efficiency legislation (Energy Efficiency Directive, Renewable Energy Directive) are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and energy efficiency legislation (Energy Efficiency Directive, Renewable Energy Directive)	Qualitative analysis and comparison of the objectives and provisions of the SSD and energy efficiency legislation (Energy Efficiency Directive, Renewable Energy Directive)	Data from literature review Consultation and questionnaire analysis Public consultation
12.7 Is the SSD coherent with air quality and industrial emissions policies?	The Directive and air quality and industrial emissions policies (Air Quality Directives, National Emissions Ceiling Directive, Industrial Emissions Directive) are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between these.	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and air quality and industrial emissions policies (Air Quality Directives, National Emissions Ceiling Directive, Industrial Emissions Directive)	Qualitative analysis and comparison of the objectives and provisions of the SSD and air quality and industrial emissions policies (Air Quality Directives, National Emissions Ceiling Directive, Industrial Emissions Directive)	Data from literature review Consultation and questionnaire analysis Public consultation
EQ.13 - To what extent is the SSD coherent with wider EU policy?				
13.1 To what extent is the SSD coherent with wider EU policy (e.g., agricultural, trade)?	The Directive and wider EU legislation are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between the SSD	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and related downstream legislation	Qualitative analysis and comparison of the objectives and provisions of the SSD and related downstream legislation	Data from literature review Consultation and questionnaire analysis Public consultation

Evaluation question	Assessment criteria	Indicators	Data analysis approach	Data source / data collection methods
	and related downstream legislation			
13.2 To what extent is the SSD coherent with the objectives of the EU Green Deal	The Directive and the published and upcoming strategies and action plans are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise.	Review of the objectives of the different action plans and strategies and identify points of synergies with the SSD	Qualitative analysis and comparison of the objectives and provisions of the SSD and EU Green Deal policies	Data from literature review Consultation and questionnaire analysis Public consultation
EQ.14 - To what extent is the SSD coherent with international obligations				
14. 1To what extent is the SSD coherent with international obligations?	The Directive and international legislation are coherent, there are no weaknesses, gaps, overlaps or inconsistencies that may arise as a result of incoherence between the SSD and considered international legislation (e.g., marine water conventions and SDGs)	List of elements that may lead to weaknesses, overlaps or inconsistencies when considering the SSD and considered international legislation	Qualitative analysis and comparison of the objectives and provisions of the SSD and considered international legislation	Data from literature review Consultation and questionnaire analysis Public consultation

5.3.1.4 **Evaluation matrix - relevance**

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
EQ.15 - To what extent is the SSD still relevant and does it correspond to the needs within the EU, in particular as regards the stated policy ambitions in the European Green Deal, as well as national ambitions as reflected in the observed changes in the national legislation and management of sewage sludge?				
15.1 What contribution has the	Monitoring data on	Soil concentrations of named SSD	MS reporting for infringement	MS monitoring data for both

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
SSD made to the correct management of sewage sludge, in particular minimising harmful effects to the soil, water (fresh & marine), vegetation, animals or man?	concentrations of harmful aspects defined in SSD to demonstrate control or otherwise. Compliance data from MS to illustrate that SSD is enforced.	substances are lower (heavy metals, pathogens etc) compared to pre-implementation and neighbouring/similar non-EU geographies	activities to demonstrate how successful SSD is at preventing contamination. Sludge and soil monitoring data generated under SSD. Literature review to similar geographies in non-EU countries as comparison (i.e., Ukraine, non-EU Baltic states, Turkey etc)	sludge and soil, over time to show trends. Non-EU monitoring data as comparison. Data on infringement activities to demonstrate frequency of exceedances.
15.2 What new needs have been identified since the implementation of the SSD? And how are these needs managed within the existing SSD?	Biological and chemical hazards to soil from sewage sludge are suitably controlled.	Biodiversity indicators demonstrate no negative impacts from sewage sludge. Monitoring data for emerging substances does not exceed critical thresholds (DNELs).	Combination of three approaches: Review of national legislation to understand how and where it exceeds SSD and why? literature review to look at key emerging substances and whether the approach under SSD addresses them suitably; and stakeholder engagement to test the relevance of the SSD to modern demands.	Literature review for substances of greatest concern for sewage sludge. Stakeholder engagement to gather views on whether the SSD is suitably addressing the most relevant issues.
15.3 Have new technologies / techniques emerged that supersede the approaches and requirements set out in the SSD?	The scope of the SSD suitably covers all management options for sewage sludge. (in particular in light of the EU Green Deal, circular economy, and related planning)	All identified management techniques for sewage sludge (especially related to agriculture) still fit within the SSD. Any new management techniques identified as having adverse effects for soil, vegetation, animals, or man.	Combination of three things: Firstly, development of data on management techniques. Secondly comparison of SSD to all techniques identified. Literature review for reports, journal articles, grey data on any risks associated with new management techniques	Industry data for management techniques. Policy analysis and comparison to SSD. Industry guidance on risks/managing negative issues. Stakeholder response on relevance of SSD for current practices.

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
EQ.16 - Does the set of pollutants covered in the SSD still cover the most important pollutants in sewage sludge? If not, what are the missing pollutants in the SSD or pollutants that no longer need to be covered and why?				
16.1 Does the set of pollutants covered in the SSD still cover the most important pollutants in sewage sludge?	There is clear feedback that the limit values and the pollutants covered by the Directive are relevant and correct.	Assessment of the current limit values, the quality of the sludge and objectives of the Directive.	Quantitative analysis of concentrations and limit values. Qualitative analysis of relevance of limit values.	data and information reported by Member States on implementation Collection of data and literature review Consultation and questionnaire analysis
16.2 What are, if any, the missing pollutants in the SSD or pollutants that no longer need to be covered and why?	The national legislation does not cover additional parameters or pollutants The feedback received supports a view that the SSD is complete	Assessment of the current limit values, the quality of the sludge and objectives of the Directive.	Quantitative analysis of concentrations and limit values. Qualitative analysis of relevance of limit values.	data and information reported by Member States on implementation Collection of data and literature review Consultation and questionnaire analysis
EQ.17 - Has the initiative been flexible enough to respond to new issues and emerging risks (e.g., contaminants of emerging concern? Does the SSD contain moot or redundant stipulations?				
17.1 Has the initiative been flexible enough to respond to emerging risks (e.g., contaminants of emerging concern?	There is scope for covering emerging pollutants as part of the Directive	List of the provisions relevant for emerging pollutants Analysis of these provisions and whether they are fit for the purpose of addressed emerging pollutants	Qualitative analysis of the Directive and evidence gathered	Data from literature review Consultation and questionnaire analysis
17.2 Has the initiative been flexible enough to respond to new issues?	The Directive continues to be relevant facing new issues and opportunities	List the provisions of the Directive identified as being flexible Contribution of the Directive to the new issues in particular considering reuse of resources, nutrient recycling, and circular economy	Qualitative analysis of the Directive and evidence gathered	Data from literature review Consultation and questionnaire analysis

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
17.3 Does the SSD contain moot or redundant stipulations?	All the provisions of the SSD are relevant and necessary	List the provisions of the Directive identified as being flexible	Qualitative analysis of the Directive and evidence gathered	Data from literature review Consultation and questionnaire analysis

5.3.1.5 Evaluation matrix – EU added value

Sub-questions	Assessment criteria	Indicators	Data analysis approach	Data sources/Data collection methods
EQ.18 – What is the added value of the Directive compared to what Member States could have reached without the Directive?				
18.1 What is the added value of the Directive compared to what Member States could have been reached without the Directive?	Environmental impact of the sector; technological development in sewage sludge value chain; level playing field	Views of stakeholders on benefits compared to the situation without the SSD	Qualitative analysis of the extent that the changes in the production, treatment and use of sewage sludge be credited to the SSD	Data from literature Consultation and questionnaire analysis Expert meeting
18.2 What has changed regarding the SSD's EU added value compared to its 2014 evaluation study? [172]	The 2014 ex-post evaluation of the SSD did not examine its EU added value. The EU added value of the SSD in the 2014 evaluation is identified and compared with current implementation	List of achievements credited to the SSD in the 2014 evaluation List of achievements credited to the SSD after the 2014 evaluation	Qualitative analysis of the differences between the achievements of the SSD before and after the 2014 evaluation	Data from literature Consultation and questionnaire analysis Expert meeting
18.3 Are there any emerging risks that could hamper the	Emerging risks are identified and are screened against the Directive	List of emerging risks that can hamper the added value of the SSD	Literature review of reports, journal articles, grey data on any	Data from literature Consultation and questionnaire

[172] Please note, we include this sub-question to cover a requirement to consider changes, however we note the 2014 evaluation did not explicitly include an assessment of EU added value.

SSD's EU added value?		Contribution of the Directive to addressing the identified issues	risks associated with new approaches Qualitative analysis of the risks identified and the Directive's approach to address them	analysis Expert meeting
EQ.19 – Have the various rules regulating sewage sludge set up by MS led to an unequal protection of human health and the environment across the EU, and if so to what extent?				
19.1 Have individual MS sewage sludge regulation rules led to unequal protection of human health and the environment across the EU, and if so, what is the extent of this difference?	Varying environmental and health impacts in different MS resulting from different rules	List of aspects related to human health and environmental protection that differ between MS and emerge due to sewage sludge regulation	Quantitative analysis of environmental and health values across individual MS Qualitative analysis of the links of these values with the MS rules	Data from literature Consultation and questionnaire analysis

5.4 1.2 Brief answers to the evaluation questions (EQs) and details of the evidence-base

Effectiveness

EQ. 1 & 3 - What progress has been made over time towards achieving the objectives and targets set out in the SSD in the various Member States? To what extent have the objectives been met?

How effective has the implementation and enforcement of the SSD been in the 27 Member States and to what extent has this safeguarded agricultural soils from pollution?

Answer:

The use of sludge in agriculture has remained the main route for sludge management in the EU. Sludge has been widely and steadily used to the benefit of agriculture, leading to the recovery of nutrients from 2 to 3 million tons of sludge (which is also waste) per year, while also enhancing the soil structure, for the benefit and sustainability of the waste and the agricultural sectors.

Overall, the level of heavy metals in sewage sludge used in agriculture has improved since the SSD came into force, which can be attributed to an extent to the action of the Directive.

Limited information was identified linking overall agricultural soil quality and use of sewage sludge.

Evolution of sludge use

Depending on the source of data considered, sludge use in agriculture across the EU is estimated to lie between about 30 and 50%:

	Sludge used in agriculture as a % of total sludge produced (2017)	Quality of the data
Total agricultural use in literature	29% and 50%	Fragmented and different among each data source
MS implementation report	30%	Comprehensive in 2016-2018
Eurostat	29%	Comprehensive 2007-2016 Limited insight in sewage sludge disposal

EurEau's survey	49.2% (4.5 million tonnes)	Unable to assess
Joint Research Centre (2020)	37% (10 million tonnes)	Unable to assess

Table 1: Quantities of sludge used in agriculture according to different data sources

Contribution of the SSD to sludge use in agriculture at national level

Details on the analysis was made to group Member States in categories reflecting the impact that the SSD have had on the national practices related to management of sewage sludge, including its use in agriculture: data gathered were used in conjunction with other qualitative elements.

Member States were grouped in categories reflecting the impact that the SSD has had on the national practices related to management of sewage sludge, including its use in agriculture. Data gathered were used in conjunction with other qualitative elements. The criteria were qualitatively assessed and included:

- the level of use of sewage sludge in agriculture at the time of adoption of the Directive: countries that already had an established practice of using sewage sludge were considered to be less influenced by the SSD,
- the adoption (or not) of stricter requirements: countries that adopted more stringent requirements were considered to be less influenced by the SSD,
- the evolution of the use of sewage sludge in agriculture since adoption of the Directive: countries where the use of the sewage sludge markedly increased or decreased were considered to be more influenced by the SSD (assuming that a marked increase related to an enhancement of the use of sludge in agriculture, and that the Directive impedes the use of sludge when applicable limits cannot be met; noting the contradictory impact that the Directive had in both supporting in some Member States and hindering in others the use of sewage sludge, and
- the feedback from Member States' competent authorities in the targeted consultation.[173]

As be seen below, most of the Member States (14 out of 27) can be considered to have not been influenced in their national approach to sewage sludge management by the adoption of the SSD.

[173] Not all MS provided a response, see the synopsis report on consultation for more details.

Assumed influence of the SSD per group of Member States on sewage sludge management practices

Categories	Member States
Management practices of sewage sludge not or minimally influenced upon by the SSD	Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Italy, Latvia, Luxembourg, Malta, Portugal, Slovenia, Sweden
Management practices of sewage sludge highly influenced upon by the SSD	Bulgaria, Estonia, Hungary, Ireland, Romania, Slovakia
Management practices of sewages sludge moderately influenced upon by the SSD	Croatia, Cyprus, Greece, Lithuania, Netherlands, Poland, Spain

This analysis is supported by the feedback from OPC expert respondents who were divided on the extent to which the changes in amounts of sewage sludge use in agriculture and the safety of its use in their country of residence can be attributed to the SSD and its transposition into (sub-)national law.

EQ.2 - What factors have contributed to or hindered the achievement of the objectives and targets set out in the SSD?

Answer:

In addition to tighter limits at national level, a number of voluntary schemes of quality standards have been set up between stakeholders, increasing trust in quality of the sewage sludge. The availability of sludge of relevant quality, the support that sewage sludge provide to organic matter in soil have promoted the use in agriculture too. The implementation of the waste framework Directive probably influcenced too, as it promotes the recovery of waste over final disposal (e.g. landfilling). Conversely, factors hindering the achievement of the objectives have included public perception of risks associated with sewage sludge, the lack of harmonised EU-wide end-of-waste criteria for sewage sludge for agricultural land application, the competition for agricultural use with other organic waste (e.g. manure or biowaste), and other uses of sewage sludge (e.g. for land reclamation, remediation or landscaping).

EQ. 4&5 What have been the (quantitative and qualitative) effects of the SSD? What have been the unintended/unexpected effects of the SSD?

Answer:

Additional positive effects include the increased interest knowledge related to sludge. Application of sludge onto farmland also seems to have an overall negative carbon footprint.

Negative unintended effects include the presence of antimicrobial genes in the soil, possible emissions of methane, as well as from other contaminants which it can contains and which are not regulated by the Directive. More research is needed to figure out whether and to which extent those elements do actually pose a risk to the environment and the human health.

Efficiency

EQ.6 &7 To what extent has the SSD been cost-effective? Are the costs related to the SSD proportionate to the benefits? To what extent do the requirements of the SSD influence the efficiency with which the observed achievements have been attained? What other factors influence the costs and benefits?

It is very difficult to estimate the overall costs and benefits of the implementation of the Directive. But it is shown that the application of sludge to agricultural land is significantly less costly than other options for use of sewage sludge. This is particularly true in comparison with (mono-)incineration, which is the main alternative to the use of sludge in agriculture. Costs and negative externalities of alternative options for sludge management are also comparable to those of use in agriculture.

Given the high dependency of sludge management to local conditions, and the heterogeneity of such conditions across Member States and regions or municipalities, the enabling rather than prescriptive nature of the Directive has provided a framing which has allowed, in principle, for efficient decision-making at national and regional level.

Costs and benefits for different sludge treatment options and P-recovery technologies

Assumptions for the calculations:

- **Water content of sewage sludge** : Wet sludge : < 5 % DS ; Dewatered sludge : 25% DS ; Dried sludge : > 85 % DS
- **Labour cost:** 29 €/man*h (great differences in Europe ranging from 7-42 €/man*h). This has an effect on labour intense processes as e.g. composting (1/3 of costs are associated to labour)
- **Economy of scale** : Calculations were performed for plants with different treatment capacities (small, medium, large) whereby for e.g. a small composting plant has a capacity of 15.000 t input and a small mono-incineration plant has 70.000 t input/year.
- All cost **without revenues**

Table 2: Overview of costs linked to sludge management (treatment, transport, recovery and disposal of sludge)

Sludge treatment at the WWTP	Cost range, €/t DM	Year	Country	Source
Anaerobic digestion (at the WWTP)	(20-50)-200 130-510[1]	 -		Stakeholder consultation JRC
Mechanical dewatering	220-300 75-180 180-240	2016 -	Germany - Germany	INECTUS, 2016 ; JRC Source open
Solar drying	125-200 270-360	- 2018	- Germany	JRC ; Roskosch et al., 2018[174]
Thermal drying	189 255-715 150-500 250-310 (with gas) 220-360	2015 2016 - - 2018	Italy Slovenia - - Germany	Diaz, Gracia and Canziani, 2015 ; Bratina et al., 2016 ; Stakeholder consultation JRC Roskosch et al. 2018

Sludge management option agriculture	Cost range, €/t DM	Year	Country	Source
Agricultural use (wet sludge)	200-320 100-175	2018 2021	Germany Austria	Roskosch et al., 2018 ; Amann et al. 2021
Agricultural use (dewatered sludge)	125-175 80-150	2018 2021	Germany Austria	Roskosch et al. 2018; Amann et al. 2021

[174] Roskosch, A., Heidecke, P., Bannick, C.G., Brandt, S., Bernicke, M., Dienemann, C., Gast, M., Hofmeier, M., Kabbe, C., Schwirn, K., Vogel, I., Voelker, D., Wiechmann, B., 2018. Sewage sludge management in Germany. Umweltbundesamt (UBA), Dessau-Roßlau, Germany.

Composting (all technologies)	100-500 125-280 150-300	 2002 2021	 EU Austria	Stakeholder consultation Eunomia, 2002 ; Amann et al. 2021
Composting (open windrow, simple technology)	125-230	-	-	JRC
Composting (closed windrow, advanced technology e.g. exhaust gas treatment)	155-350	-	-	JRC
Co-Incineration				
- Waste to energy plant	280-370 (dew. sludge)	2012, 2021	Germany	Wiechmann et al., 2012
- Coal industry	200-300 (dew. sludge) 120 (dried sludge)	2012, 2014	Germany	Wiechmann et al., 2012 Montag et al., 2014
- Cement industry	180-220 (dew. sludge) 80-110 (dried sludge)	2012, 2014	Germany	Wiechmann et al., 2012 Montag et al., 2014
Mono-incineration	260-400 280-480	- 2018		JRC ; Roskosch et al., 2018
Landfill[2] (in countries with 0 or <5% sewage sludge landfilling)	250-280 40-620 (**median 230**)	- 2002, 2013	- EU	JRC ; Eunomia, 2002 ; EEA, 2013
Landfill[2] (in countries with >5% sewage sludge landfilling)	15-360 (**median 90**)	2002, 2013	EU	Eunomia, 2002 ; EEA, 2013

Transport	Cost range, €/t DM	Year	Country	Source
Transport (truck capacity unknown)	0.3 €/km 1.3-1.6 €/km	2016	Italy Slovenia	Diaz, Gracia and Canziani, 2015 Bratina et al 2016
Transport (truck, 30 t)	1.5 €/km (1.2 €/km : Eastern Europe, 1.8 €/km : Western	2018, 2021	Germany ; EU	BME, 2018 ; The Ti et al., 2021

	Europe)	
Transport with truck (15 km, 30 t capacity)	3-4 (dewatered sludge)	JRC
Transport with tractor and trailer (15 km, 14 t capacity)	60-70 (wet sludge)	JRC
	8-10 (dewatered sludge)	JRC

[1] cost for WWTP with capacities from 20.000 to 500.000 population equivalent (for small WWTP anaerobic digestion is very expensive)
[2] with country specific landfill tax

Potential savings:

- E.g. Reduced disposal costs for a mono-incinerators if SSA is used in fertiliser industry or by recycling facility operators

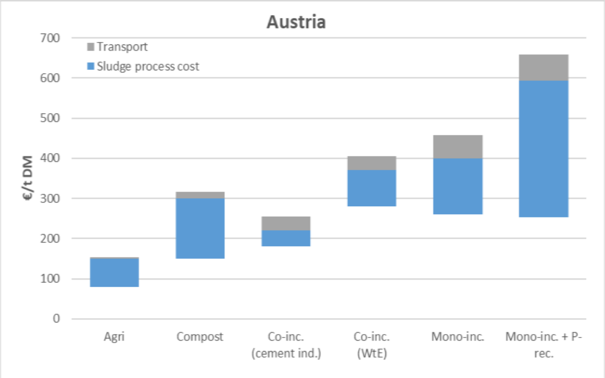
Potential revenues (examples):

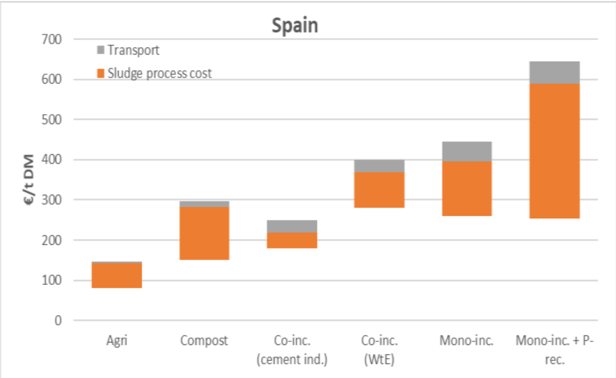
- Energy
    - CHP of biogas from anaerobic digestion: Electricity: ~65 €/t DM; Heat: ~80 €/t DM
    - Incineration of sewage sludge: ~ 75 €/t DM (Electricity: ~20 €/t DM; Heat: ~55 €/t DM
- Compost: 2-10 €/t compost

Examples of costs in Austria and Spain[175]

[175] NB : also taken into account to derive the figures provided Table 2 above

Cost range for different sludge treatment options incl. transport and product revenues





Assumptions:

Labour cost:

- Labour cost per hour in Austria: 37 €/h
- Labour cost per hour in Spain: 23 €/h

Percentual share of labour cost of the sludge processes:

- Agriculture: 30%
- Composting external plant: 32%
- Co-incineration: 5%
- Mono-incineration: 10%
- P-recovery: 5%

Transport distances, truck load and transport cost:

- Agriculture: 15 km
- Composting external plant: 50 km
- Compost to agriculture: 15 km
- Co-incineration: 120 km
- Mono-incineration: 200 km
- P-recovery: 0 km (located at the incinerator plant)
- P-recovery products to end-user 50 km
- Truck load: 25 t/load
- Transport cost Austria: 1.8 €/km
- Transport cost Spain: 1.6 €/km

Revenues:

- Compost: 8 €/t DM
- P-recovery: 262 €/t DM (includes Calciumphosphate, FeCl / AlCl for a WWTP)
- Energy: none so far

Investment costs: similar

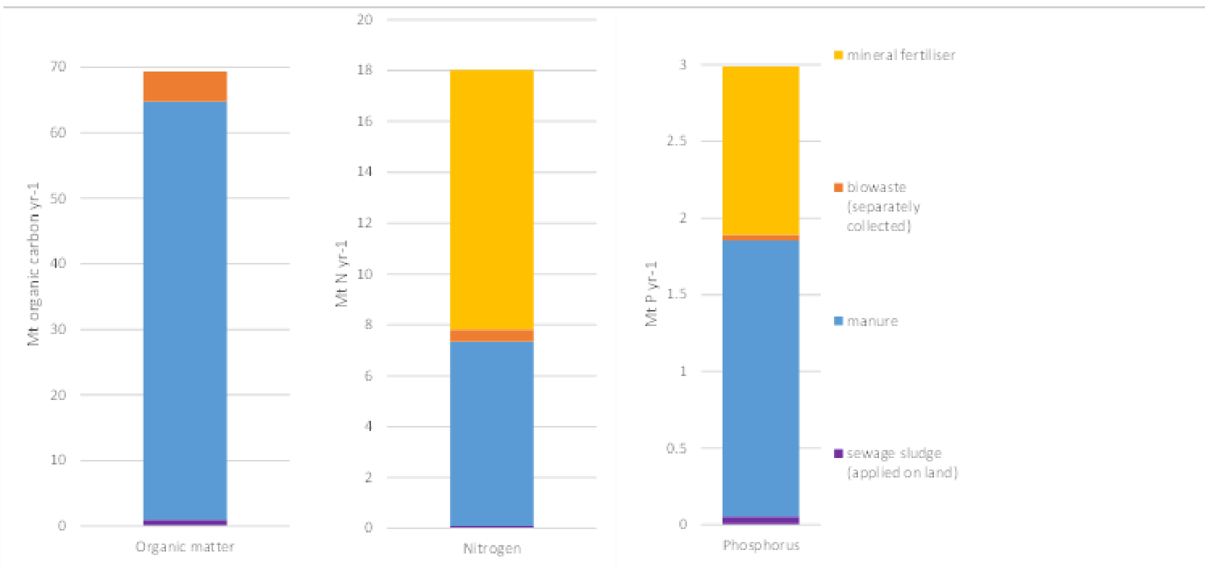
Additional cost for the shift from direct agricultural sludge use to other sludge treatment processes

Shift from[1]:	**Austria**	**Spain**
direct agri to composting and then agri	+102 %	+100 %
direct agri to co-combustion (cement)	+97%	+115%

direct agri to co-combustion (WtE)	+201%	+230%
direct agri to mono-inc	+225%	+249%
direct agri to mono-inc and P recovery	+309% (if rec. technology is economic → +225%)	+342% (if recovery technology is economic → +249%)
co-inc (cement) to mono-inc (and P-recovery)	+65% (+108%)	+62% (+106%)
co-inc (WtE) to mono-inc (and P-recovery)	+8% (+36%)	+5% (+34%)

[1]based on the average values of the sludge processes

Comparison of nutritive properties of sludge and other types of fertilisers



EQ.8 Are there opportunities to simplify the legislation or reduce unnecessary regulatory costs without undermining the intended objectives of the intervention?

Answer:

No such opportunity was identified

EQ.9 Are there significant differences in costs (or benefits) between Member States, and if so, what are the underlying causes? How do these differences link to the SSD?

Answer: Sludge management is very highly dependent on local conditions (e.g. climate, size of dwellings, availability of land, quality of soil and of sludge) and there are considerably different situations across different Member States and regions. Treatment equipment costs, one the major source of costs, are reported to be rather uniform across the EU. Operating (including energy) and labour costs, on the other hand, vary a lot across countries. Another source of cost is the transport of the sludge from the UWWTP to the agricultural land (or from the UWWTP to other means of disposal if the sludge is not suitable for farmland use) which also obviously depends on distances local situations.

EQ.10 How timely and efficient is the process for reporting and monitoring

Answer: There is room for improvement on reporting: there are significant data gaps and inconsistencies in reporting, including in the reports provided by Member States under this Directive and other reporting systems, notably the UWWTD. The reporting system also only allows to assess the effectiveness of the Directive to an extent. This will be improved when new reporting requirements start to apply, as of 2023, making spatial data on the application of sludge available.

Details for the estimation of administrative costs:

Estimate for administrative costs were identified in the literature review supplemented with very few estimates provided by stakeholders as part of the consultation.

The fitness check of environmental reporting and monitoring[176] (later referred to as 'fitness check') provides a global estimate of the administrative costs from the implementation of European legislation. Its estimate covers usefulness, double reporting, frequency of reporting, and estimates that the annual administrative burden attributable to **reporting and monitoring obligations** associated with the SSD to be between €30 000 – 100 000 p.a. It should be

[176] European Commission. (2017). Actions to Streamline Environmental Reporting. Retrieved August 6, 2021, from https://ec.europa.eu/environment/legal/reporting/pdf/Reporting%20and%20monitoring/support_fitness_check_report_annexes.pdf

noted that this cost is not specific to the SSD, but it is an estimation based upon the administrative burden of a group of 17 regulations, of which the SSD is part.

Considering reporting costs more specifically, according to the EC 2017 Fitness Check, the **reporting** obligations of the SSD are estimated to require 20 days per MS to copy information which is already available / in own legislation or through data collection necessary for other purposes. It is estimated that the EC would require 40 days to collate information from 28 MS. These actions were repeated every three years [177] and will be repeated annually further to the introduction of Regulation 2019/1010 on the alignment of reporting obligations in the field of legislation related to the environment. The costs outlined here are specific to the costs borne as a result of the SSD, although detail as to the exact nature of these costs has not been provided. The SSD evaluation questionnaire has received 14 responses to the question on the cost of **reporting requirements** associated with the SSD. Of these, 12 MS CA suggested that they do not hold this information, one respondent stipulated "none" and another respondent provided an estimate of 3 days p.a., which would amount to a cost of around €500 per year[178]. While this figure is considerably below the fitness check estimate above, it is not clear whether this estimate is representative for the EU27.

With regards to the **enforcement costs of the SSD**, 13 answers were received to the relevant question of the Member State questionnaire. Of these, 12 stipulated that such information is not available and one provided information on costs associated with the implementation of the SSD (presented below).

From the consultation of stakeholders, two quantitative estimates were provided:

- One respondent indicated that the enforcement costs of the SSD (without describing the scope of the activity under 'enforcement') was equating to two full-time equivalent staff for an average competent authority ;
- One respondent indicated that reporting costs specifically for the SSD were 3 days per annum, which amounts to a cost of around €500 per year (as above).

[177] European Commission. (2017). Actions to Streamline Environmental Reporting. Retrieved August 6, 2021, from https://ec.europa.eu/environment/legal/reporting/pdf/Reporting%20and%20monitoring/support_fitness_check_report_annexes.pdf

[178] EUR 487 per year, assuming an 8 hour day and a cost per hour of €20.3 as reported in Eurostat dataset LC_LCI_LEV, weighted average data for EU27(2020) for the sector "Administrative and Support Service Activities."

We calculated an estimate for overall administrative costs based on the information identified, of €77,000 – 80,000[179] per year per Member State[180]. While based on very scarce data, this estimate is within the range of the estimate calculated under the Fitness Check. It is important to note that administrative costs depend on country size or national versus regional structure of approval systems in place.

The estimate represents the sum of the enforcement and reporting costs identified to form a general administrative cost and uses the following data:

- The lower end of the range represents possible administrative costs using the two full time equivalent staff on enforcement and the 3 days per annum reported by one stakeholder on reporting
- The upper range uses the two full time equivalent staff on enforcement and the 20 days estimate from the fitness check on reporting

Beyond competent authorities, water operators have employees in charge of managing the administrative costs associated with approving the spreading of sewage sludge on agricultural land. Separating the part related to the SSD from other national requirements (covering other legislation) is not possible[181]. One wastewater operator suggested a cost of €250,000 per year and others explained that the costs are exacerbated by lengthy land application approval processes, with reported delays between 10 months and years. However, it is unequivocal that the costs reported by the operators are linked to national requirements, many of which exceed those of the SSD.

No information on administrative costs to farmers has been identified as part of the study process, including the stakeholder consultation.

As such, total administrative costs, including implementation, reporting and enforcement by national and regional competent authorities, wastewater operators and farmers are likely to reach figures of hundreds of thousands to millions Euro per Member State per year. Separating the costs of national legislation and SSD implementation and enforcement is not possible.

Coherence

EQ.11 - To what extent is the SSD internally consistent and coherent?

Answer:

[179] The upper range includes the 20 day administrative estimate which equates to around €3,200 in costs per MS per year.

[180] This is based on the labour cost of €20.3/hour, as per footnote **Error! Bookmark not defined.** and on the assumption of 8-hour days and 47 working weeks per year; Glossary: Labour force survey (LFS) - Statistics Explained (europa.eu), Statistics | Eurostat (europa.eu)

[181] Interview with wastewater operator and multiple targeted stakeholder questionnaire responses.

The Directive is found internally coherent, broadly speaking, but its internal market legal base is arguable.

EQ.12, 13, 14 - To what extent is the SSD coherent with other existing EU legislation, with wider EU policy and with international obligations?

Answer: The Directive works coherently and in synergy with the general policy and regulatory framework it fits in, notably with environmental legislation and initiatives set under the Green Deal and Circular Economy Action Plan. However, for sludge management, there can be trade offs between objectives of zero pollution, waste and nutrient recovery, energy recovery and climate change mitigation.

Coherence with the EU Green Deal and its sector specific policies

The European Green Deal[182] is the EU action plan to make its economy sustainable and make EU the first climate-neutral continent by 2050. In particular, it sets policy goals for an efficient use of resources, for a just and inclusive transition towards a clean and circular economy. It sets policy objectives for different policy areas that have relevance to sewage sludge use, including sustainable agriculture, biodiversity, pollution, and clean energy.

The SSD can contribute to the policy areas covered by the EU Green Deal:

Coherence with the Circular Economy Action Plans

In 2015, the European Commission adopted its first circular economy action plan[183]. It included measures to help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs. The 54 actions established by the plan have been implemented, with measures covering the whole life cycle: from production and consumption to waste management and the market for secondary raw materials and a revised legislative proposal on waste. A significant number of these measures are very relevant to the Sewage Sludge Directive, although the latter was not specifically mentioned in the Plan. They included:

- developing quality standards for secondary raw materials where they are needed (in particular for plastics), and improving rules on 'end-of-waste'.

[182] (2019) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: The European Green Deal

[183] COM(2015) 614 final - Closing the loop - An EU action plan for the Circular Economy

- the revised EU regulation on fertilisers, to facilitate recognition of organic and waste-based fertilisers in the single market and thus support the role of bio-nutrients in the circular economy.
- the legislative proposal on reused water
- options on the interface between chemicals, products and waste legislation, including on how to reduce the presence and improve the tracking of chemicals of concern in products.

The new circular economy action plan (CEAP)[184] was adopted in March 2020, as one of the main building blocks of the European Green Deal. It is also a prerequisite to achieve the EU's 2050 climate neutrality. It sets out new initiatives for EU's further transition to a circular economy, to reduce pressure on natural resources and create sustainable growth. The new action plan announces initiatives along the entire life cycle of products, promoting circular economy processes, waste prevention and the preservation of the resources in the EU economy, with a notable focus on food and nutrients.

By promoting safe resource re-use and nutrient recovery, the SSD concurs to the objective of the Circular Economy Action Plan: it promotes the re-use and recycling of a waste material (sewage sludge), and thereby re-use of primary phosphorus, nitrogen and organic matter, while also contributing to the EU's strategic aim to reduce its dependency on nutrients from third countries.

The CEAP actually specifically refers to the SSD. It foresees that the Commission would consider reviewing directives on wastewater treatment and sewage sludge. In the context of the on-going UWWTD review, now on-going, it also specifies that this review should work in synergy with this evaluation, and help increase the ambition level to remove nutrients from wastewater and make treated water and sludge ready for reuse, supporting more circular, less polluting farming. Steps will be taken towards energy efficiency and carbon neutrality as well as a better application of the 'polluters pays' principle. The CEAP also calls for the UWWTD review to look at improving access to sanitation for all and to information. It also demands that the review should support the concrete implementation of the future **Integrated Nutrient Management Plan (INMAP)**, which is one of the actions of the CEAP[185].

The **Integrated Nutrient Management Plan (INMAP)** will seek to ensure more sustainable application of nutrients and stimulating the markets for recovered nutrients. The action will include looking at the indicators and tools for monitoring to improve assessment and comparability, and at best practice sharing to increase effectiveness. This will feed into an integrated assessment of nutrient pollution and progress tracking, e.g. through the Zero Pollution Monitoring and Outlook reports. The action plan will aim to focus the efforts of Member States on nutrient pollution hotspots in order to reduce pollution effectively and minimise the gaps to targets. It will also look at creating tools to improve application of environmental and climate legislation in

[184] New circular economy action plan (CEAP)
[185] To be updated -

full. It will aim to maximise synergies with the common agriculture policy, making best use of the new green architecture. The holistic approach proposed will also contribute to achieving targets for non-CO_2 emissions from the agriculture sector, as proposed in the 'Fit for 55' package[186]. Action may range from regulatory initiatives, including evaluating and revising legislation (if necessary) and complementing legislation to achieve a more holistic approach to nutrient pollution, to non-regulatory initiatives facilitating cross-sectoral approaches and drawing on technological developments. The requirement of accounting of nutrient needs of the plants before authorising the application of sewage sludge, including its amount, also contribute to the INMAP. This latter obligation ensures that waste is recovered only to the amounts that are strictly necessary for plant needs, and prevents leachate (that is, loss, and a risk of pollution by eutrophication). However, as was seen in the analysis of the Effectiveness of the Directive, the SSD does not foresee means to ensure that this principle is respected. If it were not, then sludge use in agriculture would, not, in operational and (compliance) terms, be fully consistent with recovery objectives and could be seen as a disposal operation in practice.

Among nutrients, Phosphorus is to be emphasised: it is also included in the list of critical raw materials which the EU has created to reduce its dependency on materials of high importance to the economy, when there is high risk of short or discontinued supply. The importance of phosphorus recycling is also emphasised by the European Economic and Social Committee consultative communication on the sustainable use of phosphorus[187]. It highlights the value of cutting the use of primary phosphorus, increasing the use of organic matter, and recycling substances rich in phosphorus, but currently classified as waste, such as sewage sludge[188]. Phosphorus can be derived from sludge not only through direct application onto farmland, but also through its incineration of sludge. In this way it comes out in a form which competes with the organic form found in sewage sludge and very precious for the phosphate industry: it can enter in the composition of industrial fertilisers and have more efficient nutritious properties for plants, or be used for many other applications in the phosphate industry. In this way sludge application onto land competes with incineration, which creates a lack of coherence with the SSD.

The OPC results showed that of 171 respondents, 36% (61) agreed or strongly agreed that the SSD is coherent with the Circular Economy Action Plan. A share of 31% disagreed or strongly disagreed that the SSD is coherent and 12% were neutral. Others did not know or had no opinion (22%).

Stakeholder views on coherence with the Green Deal:

[186] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550

[187] Opinion of the European Economic and Social Committee on the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Consultative communication on the sustainable use of phosphorus'.

[188] TRENECON. (2021). Preparatory study on sewage sludge management in the Danube Region

From the 171 respondents to the OPC, 28% agreed that the SSD is coherent with the EU Green Deal, while 33% disagreed and 12% were neutral[189].

MS targeted consultation evidenced that 33% out of 18 respondents agreed that the SSD is coherent with the European Green Deal, 22% were neutral, 17% disagreed[190].

The targeted consultation with stakeholders evidenced that 44% out of 41 respondents agreed that the SSD is coherent with the European Green Deal, 7% were neutral, 30% disagreed.[191]

Similar patterns of responses were provided when more specifically considering the coherence of the SSD with the different deliverables of the Green Deal, apart from the following: MS tended to disagree that the SSD is coherent with the soil strategy, and targeted stakeholders tended to disagree regarding its coherence with the Farm-to-Fork strategy. Respondents from the OPC also tended to agree on the coherence with the methane strategy.

Coherence with legislation related to water and air pollution

<u>Water Framework Directive</u>

The WFD is the main instrument for the EU water policy, it aims to get polluted waters clean again, and ensure clean waters are kept clean. It uses a combined approach of emission limit values not to be exceeded, pollution sources and quality standards to be achieved for waters. Since the SSD was adopted with a view to the protection of agricultural land and human health as a result of use of crops grown on such land and since it was adopted long before Union policy was developed for the protection of water environment, it does not include explicit objectives or measures aiming to prevent negative impact on water as it does for soil pollution. However, the parameters and the limit values it sets for use of sludge on agricultural land contribute to restricting pollution of water as a result of sewage sludge runoff or penetration to groundwater. The new spatial data reporting could help identify the sources of pollution if linked to sewage sludge application.

The **Nitrates Directive**[192] (ND) aims at reducing water pollution derived from nitrates of agricultural origin and further preventing such pollution. It requires Member States to identify risk areas and to develop action programmes accordingly, to control fertiliser (including sewage sludge) application. The two Directives are coherent in their objectives of protecting the soil and surface and ground water and are complementary to each other since the SSD does not address the specific concerns of vulnerable areas that may be linked to agricultural soil areas as a result of nitrogen application. However,

[189] Others did not know/no opinion (27%).
[190] Others did not know/no opinion
[191] Others did not know/no opinion
[192] Directive 91/676/EEC.

the SSD requires the quantity of nitrogen to be analysed as part of the tests to be performed on sludge; thereby also contributing to limiting the risk of excessive fertiliser application that may result in pollution since high quantities of sewage in water bodies can cause eutrophication. Therefore, a balanced application of fertiliser is required both by the ND and SSD.[193] For the purposes of environmental protection, the implementation of ND may result in a decrease in the amount of sewage sludge applied on land in areas identified as at risk[194,195]. The new reporting requirements for spatial data for the SSD could help further identify the sources of pollution if linked to sewage sludge application.

Stakeholders generally agree on the coherence between the SSD and the Water Directives.

The coherence of the Directive with **other legislation, related to water and air**[196], as well as with the **National Emissions Ceilings** and the **Industrial Emissions Directive**, was also assessed. Details are provided in Annex III. In brief, these legislative instruments, aiming at protecting water and air from pollution, work in synergy with the SSD. They can be seen as completing it in a way, as it is not explicit in its environmental objectives or measures to ensure safeguarding of the air and water environments. The parameters and the limit values it sets for use of sludge on agricultural land contribute to restricting pollution of water as a result of sewage sludge runoff or penetration to groundwater. This coherence would be strengthened if the measures set by the SSD were shown sufficient to protect the environment and health, which cannot not be fully demonstrated, as discussed in section 4.1.1 on effectiveness. Also, a number of these legislative instruments are in the process of being revised, therefore any follow-up to this evaluation will need to take that into account.

A number of laws and policy initiatives contribute to prevention of pollution by hazardous substances at the source, indirectly helping to reduce the amount of contaminants present in sludge.[197] It is noteworthy to mention the link with the Chemicals Strategy for Sustainability towards a Toxic-Free environment[198] and the REACH Regulation[199]. The REACH Regulation, by regulating the use of chemicals used in products that may enter wastewater systems and consequently in sewage sludge, contributes to reducing the levels of hazardous substances (including heavy metals) contained in sludge, therefore complementing the SSD and leading to an increased confidence in sludge users.[200] In addition, one of the key actions to be taken by the

[193] SWD(2019) 439 final of 10.12.2019.
[194] Milieu Ltd; WRc; RPA. (2010).
[195] SWD(2019) 439 final of 10.12.2019.
[196] The Water Framework Directive, the Directives on groundwater, on the marine environment (and the UWWTD, discussed earlier on). More details are provided in Annex III EQs-12-14.
[197] These, inter alia, include the REACH Regulation (EC) No 1907/2006, European Union Strategic Approach to Pharmaceuticals in the Environment (COM(2019)128 final of 11.3.2019), A European Strategy for Plastics in a Circular Economy (COM(2018)028 final of 16.1.2018), and product related legislation like the Commission proposal for a Eco-design for Sustainable Product Regulation and the upcoming initiative on microplastics.
[198] COM(2020)667 final of 14.10.2020.
[199] Regulation (EC) No 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
[200] Milieu Ltd; WRc; RPA. (2010)

Commission under the Chemicals Strategy for Sustainability is the restriction of PFAS under REACH for all non-essential uses[201]. Further regulation of PFAS substances are also considered under other Union waster policy legislation to monitor and control pollution.[202] As addressed in section 3.3 on relevance, PFAS, so-called "forever chemicals" due to their persistence in the environment, count among contaminants in sludge; therefore any follow-up to this evaluation will need to take into account such developments to ensure consistency and a holistic approach across different policy frameworks; this has also been supported by the stakeholders.

As part of the European Green Deal, the EU is currently revising the Air Quality Directive, by aligning the EU quality standards with scientific evidence, improving the legislative framework, and strengthening air quality monitoring, modelling, and plans[203]. The coherence of the SSD will have to be considered with regard to the revised legislation.

The OPC results showed that of 164 respondents, 15% (24) agreed or strongly agreed that the SSD is coherent with the IED. A share of 15% disagreed or strongly disagreed that the SSD is coherent and 26% were neutral. The remaining (and the most) respondents reported that they did not know/no opinion (45%).

The literature review and OPC did not highlight elements of incoherence between the SSD and the Industrial Emission Directive.

Relevance

EQ.15, 16, 17 - To what extent is the SSD still relevant and does it correspond to the needs within the EU, in particular as regards the stated policy ambitions in the European Green Deal, as well as national ambitions as reflected in the observed changes in the national legislation and management of sewage sludge?

Does the set of pollutants covered in the SSD still cover the most important pollutants in sewage sludge? If not, what are the missing pollutants in the SSD or pollutants that no longer need to be covered and why?

Has the initiative been flexible enough to respond to new issues and emerging risks (e.g., contaminants of emerging concern)? Does the SSD contain moot or redundant stipulations?

[201] COM(2020) 667 final of 14.10.2020.

[202] Directive on *Environmental Quality Standards (Directive* 2008/105/EC), the Groundwater Directive 2006/118/EC and Directive on drinking water (EU) 2020/2184.

[203] European Commission - (2020). *Revision of the Ambient Air Quality Directives.* https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12677-Revision-of-EU-Ambient-Air-Quality-legislation

The objectives of health and environmental protection and of nutrient recovery of the SSD remain of utmost relevance. Under the Green Deal, sludge management is at the intersection of several Union policies, notably circular economy and Union industrial policy which promotes nutrient recovery and the Union's strategic independence on mineral fertilisers and policies for attaining zero pollution, climate neutrality and energy independence.

The limits set for heavy metals by the Directive and the set of pollutants which it covers would need review, to potentially cover other organic contaminants. Further screening of contaminants, notably contaminants of emerging concern, is needed, to assess whether the set of contaminants covered by the Directive should be broadened, based on risk assessments as appropriate.

The Directive has remained flexible, allowing Member States to adopt stricter requirements and adopt sludge management policies or practices adapted to local situations. Some Member States are moving away from sludge use in agriculture, to take advantage of other uses which can be made of sludge.

EU added value

EQ.18 &19 - What is the added value of the Directive compared to what Member States could have reached without the Directive?

Have the various rules regulating sewage sludge set up by Member State led to an unequal protection of human health and the environment across the EU, and if so to what extent?

The Directive has provided a framework for safe use of sludge in agriculture at EU level, setting minimum standards for environmental and health protection, bringing benefits of transboundary nature. However, the Directive has a limited influence on sludge management in some Member States. Requirements differ across Member States, but further assessment would be needed to establish whether this has lead to unequal environment and health protection across the EU.

ANNEX IV. OVERVIEW OF BENEFITS AND COSTS

Table 1. Overview of costs and benefits identified in the evaluation									
Cost of sludge (pre-)treatment and transport before land application									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment	Quantitative	Comment	Quantitative	Comment	Quantitative	Comment
Direct financial cost	**Recurrent**	Potentially a share of this amount, indirectly	Depending on the financing structure of water and sanitation services.	**EUR 120–210/ tDM** (or a share of this, see comment)	Depending on the financing structure of water and sanitation services.	Potentially a share of this amount, indirectly	Depending on the financing structure of water and sanitation services.	Potentially a share of this amount, indirectly	Where farmers are paid for accepting sludge on agricultural land, some of the savings are thereby transferred to the farmers.
Avoided costs per year by avoidance of incineration									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment	Quantitative	Comment	Quantitative	Comment	Quantitative	Comment
Indirect financial benefits (cost-differential compared to other sludge management routes)	**Recurrent**	Potentially a share of this amount, indirectly	Depending on the financing structure of water and sanitation services.	**EUR 41 – 488 mio/yr** [**EUR 391-488 mio/yr** in comparison with mono-incineration more specifically**]** (or a share of this, see comment)	Savings accrue for wastewater operators and indirectly with municipalities or customers, depending on the structure of water and sanitation services.	Potentially a share of this amount, indirectly	Depending on the financing structure of water and sanitation services.	Potentially a share of this amount, indirectly	Where farmers are paid for accepting sludge on land, some of the savings are thereby transferred to

									the farmers.
Savings on fertilisers									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment	Quantitative	Comment	Quantitative	Comment	Quantitative	Comment
Direct benefits	**Recurrent**							Potentially up to **EUR 96/tDS** for Nitrogen and EUR **44/tDS** for Phosphorus	Benefit depends on whether the farmer would have applied fertilisers in the absence of sludge.
Avoided resource depletion in relation to fertiliser use									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment						
Indirect benefit	**Recurrent**	Not quantified	Benefit depends on whether the farmer would have applied fertilisers in the absence of sludge.						
Avoided pressure on landfills and potential reduction in landfill costs									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment						
Benefit (Direct and Indirect)	**Recurrent**	Not quantified	Benefit depends on alternative use of sludge allowed and selected by operators, compared to other options like						

			incineration.						

Payment to farmers for taking on sludge application onto agricultural land

		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment	Quantitative	Comment	Quant.	Cmt	Quantitative	Comment
Direct benefit (for farmers) Direct costs (for sludge handlers)	**Recurrent**			**€100/tDS** in Lithuania and **€100-560/tDS** in Germany, according to two stakeholders, respectively. Or no cost: reports from Bulgaria and the UK suggest that farmers do not receive payments for sludge to be used on land	Farmers can be paid to accept the application of sewage sludge on their land. The evaluation could not assess the extent of this practice across the EU. These figures are provided based on individual examples.			**EUR100**/tDS in Lithuania and **EUR 100-560**/tDS in Germany, according to two stakeholder,respe ctively. Or no revenue: e.g. reports from Bulgaria and the UK suggest that farmers do not receive payments for sludge to be used on land	Farmers can be paid to accept the application of sewage sludge on their land. The extent of this practice across MS is not known.. These figures are provided based on individual examples.

Reporting

		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
						Quantitative	Comment		
Direct Cost	**Recurrent**					**€77,000-80,000 per year per Member Stae**	Between 3 person days / year to two full time equivalent staff at MS level, 20-40 days for the EC, reporting on other Directives in		

							parallel		
Reduced emissions to air, compared to incineration									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment						
Indirect benefit	**Recurrent**	Not quantified	Incineration is associated with SO_2 and NOx emissions which are ten times higher than land spreading options						
Increased GHG emissions due to potential excess applications (compared to plant needs)									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment	Quantitative	Comment				
Indirect cost	**Recurrent**	Not quantified							
Other chemicals and antibiotic resistance									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Quantitative	Comment						
Indirect cost	**Recurrent**	Not quantified							
Odour nuisance									
		Citizens/Consumers		Wastewater operators		Administrations		Farmers	
		Qualitative	Comment						
Indirect cost	**Recurrent**	Not quantified	Can affect quality of life, impact on						

			tourism						

TABLE 2: **S*implification and burden reduction (savings already <u>achieved)</u>***
*Report any simplification, burden reduction and cost savings **achieved already** by the intervention evaluated, including the points of comparison/ where available (e.g. REFIT savings predicted in the IA or other sources).*
No simplification or burden reduction was identified

PART II: II <u>Potential</u> simplification and burden reduction (savings)
*Identify further potential simplification and savings **that could be achieved** with a view to make the initiative more effective and efficient without prejudice to its policy objectives[204].*

Description: Simplification of reporting systems with UWWTD, EEA and Eurostat	Citizens/Consumers/Workers		Businesses		Administrations		[Other…] _ specify	
	Quantitative	Comment	Quantitative	Comment	Quantitative	Comment	Quantitative	Comment
Recurrent								
					Not quantified			

204 This assessment is without prejudice to a possible future Impact Assessment.

Annex V. Stakeholders consultation - Synopsis report

This Annex provides an overview of the consultation activities carried out in line with the consultation strategy for this evaluation, as well as the responses and results received.

Consultation strategy

The Consultation Strategy[205] for the evaluation of the Sewage Sludge Directive presented the context of the evaluation, the objectives and scope of the consultation, the relevant stakeholder groups, the consultation methods to be used to collect stakeholder input, and relevant sources of information.

The key objectives of the consultation process were (i) to complement already known data and literature on the implementation of SSD and (ii) to understand the extent at which the Directive has been successfully implemented, the extent to which its objectives were met, the challenges it encountered, and whether there have been trade-offs in the implementation.

The consultation methods and tools outlined in the Strategy have been followed, as described in more detail in the following sections. The following table presents the stakeholder groups mapped against each consultation activity carried out for this evaluation.

Stakeholder groups consulted by each consultation approach

Stakeholder type	**Consultation activity**			
	Roadmap/OPC	**Targeted consultation (Survey)**	**Interviews**	**Workshop**
EU Member States and their public authorities	X	X	X	X
Waste expert group and UWWTD expert group	X	X		X
Industrial/economic actors	X	X	X	X
Non-Governmental Organisations	X	X	X	X
International organisations	X	X		X
Academia	X	X		
Citizens	X			

[205] https://ec.europa.eu/environment/pdf/waste/sludge/Stakeholder%20Consultation%20Strategy%20-%20Evaluation%20of%20SSD.pdf

Methodology and tools used to process data

Data gathered through different consultation tools required different methodological approach for their respective analysis. All data gathered as part of questionnaires (i.e., the OPC or the targeted surveys) were systematically cleaned and checked before their analysis. No duplicate responses were spotted. In addition, no significant update of formatting / data structure was required. Qualitative information was received through a number of channels: surveys; the open text response to the OPC; and position papers uploaded as part of the feedback requested for the targeted stakeholder survey, the OPC, and the Evaluation Roadmap. The analysis of the responses provided was conducted according to the evaluation criteria (effectiveness, efficiency, relevance, coherence, and EU added value). As the answers cannot be considered as statistically representative, they have been interpreted with caution for the evaluation of the Directive.

Evaluation roadmap

A Roadmap[206] for the evaluation of the SSD was published on 16 June 2020 and was open for feedback until the 25th of August 2020. A total of 69 responses were submitted through the online portal (and one directly to DG Environment by email).

Feedback has been received from 70 respondents, from company business or organisations (n=26), business associations (n=14)[207], EU citizens (n=9), public authorities (n=8), NGOs (n=7), anonymous (n=3) and academic or research institutions (n=2)[208].

Several of the comments actually included suggestions for potential changes and future revision (i.e., forward-looking), which is not the focus of the evaluation. These comments were analysed separately and fed into the evaluation where appropriate, keeping in mind that suggestions for changes mean that one sees failures or shortcomings in the current system. In particular, the feedback submitted, and evidence attached in position papers were extracted and assigned to each evaluation criteria and contributed to the evidence base of the analysis and the evaluation matrices. Other forward-looking feedback that could not be used for the evaluation will be used in a follow up to the evaluation.

Online Public Consultation

The OPC included questions tailored to examine the effectiveness, efficiency, relevance, coherence, and EU added value of the implementation of the SSD. It consisted of introductory questions related to respondent profile, followed by a questionnaire divided into five parts. From these six sections, five were addressed to all participants regardless of their level of knowledge of the Directive and its implementation, while one was only targeted to respondents with specific interest and more in-depth knowledge of the topic of sewage sludge.

[206] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12328-Sewage-sludge-use-in-farming-evaluation_en

[207] Business associations are umbrella organisations

[208] All the contributions received are available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12328-Sewage-sludge-use-in-farming-evaluation/feedback_en?p_id=8009680

The survey was uploaded in all EU languages on the *Have your say*[209] portal the European Commission website. The consultation ran for 16 weeks, from 20 November 2020 to 5 March 2021, longer than the usual 12 weeks to accommodate stakeholder needs which have arisen due to the restrictions resulting from the Covid-19 pandemic. A total of 181 responses were submitted, with respondents' profile synthesised below.

Feedback received

After some questions regarding the profile of respondents in section 1, sections 2-4 of the questionnaire were addressed to all respondents. They covered their understanding of the SSD, its costs and benefits, its added value and its relevance. Section 5 targeted specialised respondents and included more in-depth questions on implementation, adequacy in the approach taken, and potential gaps in the coverage of the directive or its implementation. Respondents could also share additional publications or other information in section 6. As most of the questions were not mandatory, the total number of responses for each question varies throughout the report.

Respondents' profile

181 responses were submitted. Out of these, 100 respondents indicated their country of origin. Overall, 22 EU Member States were represented,[210] as well as 3 non-EU countries[211]. The most-represented country was Germany (n=17; 17% of those who reported their MS), followed by Italy and Sweden (n=13; 13% each). Business associations were the most represented category of respondents (n=30; 30% of those who indicated the category of respondent to which they belong), followed by individual company/business organisations (n=28; 28%), meaning that 58% of respondents belonged to the private sector. All other categories of stakeholders were represented, including public authorities (n=11; 11%), EU citizens (n=7; 7%), NGOs (n=5; 5%) and academic/research institutions (n=3; 3%). Private sector respondents were predominantly located in Germany, Italy, and Sweden. This aligns with replies on the country of origin of respondents, as the same three countries are most represented. The top three areas of operation of private actors were wastewater treatment plants, sewage sludge processing and waste management. Above 70% (n=120 out of 167 responses to this question) of the organisations were involved in or directly affected by the recovery, treatment or use of sludge and/or wastewater. Most respondents stated that they have a good or excellent knowledge of the treatment of sewage sludge (n=141; 80% of the 176 respondents to this question), of the implementation of the SSD (n=123; 69% of the 179 respondents to this question), and of its legal text (n=131; 74% of the 179 respondents to this question).

Effectiveness

As can be seen in Figure 1 below, most respondents generally believed that (i) there is room for further use of sewage sludge generally speaking, (ii) sewage sludge is in general appropriately treated before being used, and (iii) sewage sludge is used effectively in line with the waste hierarchy. On the other hand, stakeholders agree less on

[209] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12328-Sewage-sludge-use-in-farming-evaluation/public-consultation_en

[210] No respondents reported Bulgaria, Croatia, Cyprus, Latvia or Slovenia as their country of origin or the country where their organisation is located

[211] Liechtenstein, Norway and Switzerland

whether sewage sludge is a source of pollution as 74 out of 175 respondents (42%) disagreed or strongly disagreed with this statement and 69 (39%) agreed or strongly agreed. Comparing the responses across stakeholder types[212], private actors were more inclined to disagree that sewage sludge is a source of pollution, whereas the opposite was true for academic/research institutions and NGOs. EU citizens as well as public authorities were split.

Figure 1 In your country of residence, to what extent do you think that sewage sludge [.] is .?

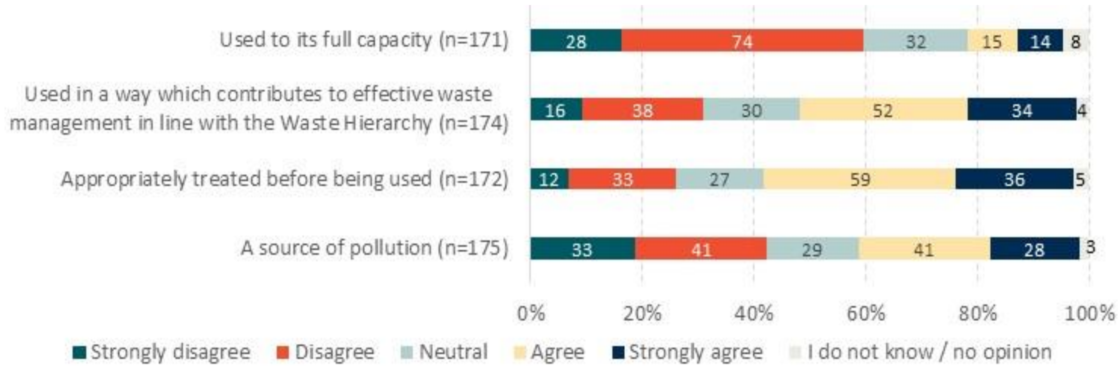


Figure 2 In your country of residence, to what extent do you think that sewage sludge [...] is a source of pollution?

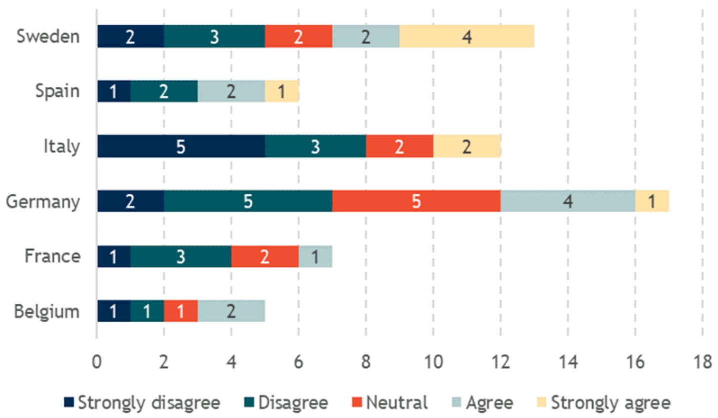


Figure 2 highlights those responses are quite divided within MS, perhaps with the exception of France and Italy, where comparatively less respondents considered sewage sludge to be a source of pollution. Hence, responses to this sub-question vary more across stakeholder type than across MS.

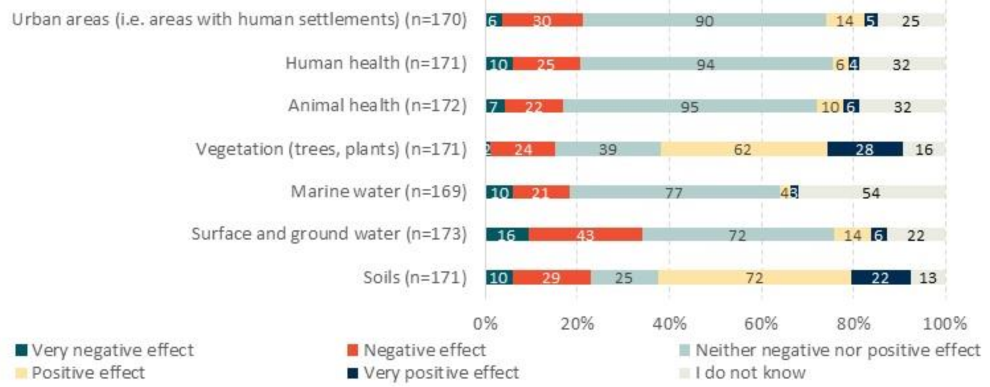
In terms of experiencing negative impacts from the use of sewage sludge in agriculture, over half of the respondents to this question indicated that they have not experienced a situation in which the use of sewage sludge in agriculture has resulted in negative effects on the environment or on human beings (n=93 out of 172; 54%), whereas almost a third had experienced such a situation (n=54; 31%). Personal experiences of negative effects

[212] When the type was specified by the respondent

were also shared by respondents, and related to olfactive nuisance, effects on human health, and environmental effects (including water pollution, soil pollution, and the presence of certain pollutants).

As can be seen in Figure, over half of the respondents (n=90 out of 171 respondents to this question; 53%) noted that the use of sewage sludge in agriculture had positive effects for vegetation (trees, plants) and for soils. Academic/research institutions, business associations, companies/business organisations, environmental organisations and public authorities voiced more positive than negative opinions, whereas NGOs voiced more negative opinions than positive ones, and with EU citizens divided. Responses on vegetation (trees, plants) and on soils were somewhat homogeneous across the six most-represented MS, [213] except in France where no negative response was recorded. With regards to effects on surface and groundwater, only either neutral of negative effects were reported by respondents from Sweden, Germany and Belgium, whereas positive effects were reported by a limited number of respondents from Spain (n=2), Italy (n=3) and France (n=1).

Figure 3 In your country of residence, and since the entry into force of the Sewage Sludge Directive (SSD), to what extent do you think that the use of sewage sludge in agriculture has had either a positive or a negative effect on ...



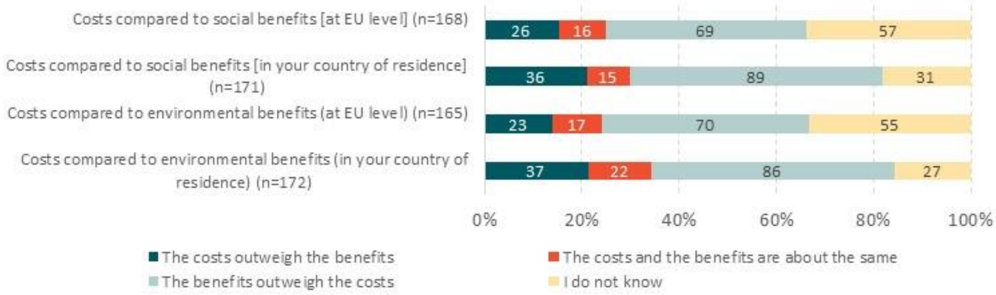
Efficiency

In terms of the costs and benefits of the Directive, there was a tendency to value the social and environmental benefits that the SSD bring more than its costs, considering the cost-benefit balance at both national and EU levels. This statement is valid for all stakeholder types, with the following two exceptions: NGOs viewed the costs as outweighing the benefits under all sub-questions, [214] and EU citizens were split on whether the costs outweigh the environmental benefits in their country of residence. In addition, the results highlight that respondents were more aware of the costs and benefits of the SSD in their respective countries of residence than at EU level, irrespectively of their stakeholder type.

[213] Belgium, France, Germany, Italy, Spain, Sweden.

[214] In total, 3 NGOs answered to this question. Due to this low representation, results should not be generalised.

Considering the benefits of the SSD in terms of ensuring the safe use of sewage sludge in agriculture and the costs of its implementation [...] in your country of residence and at EU level, would you say...?



Added value of the SSD

Responses related to the added value of the SSD highlight a consensus that the Directive led to improvements in quality of sewage sludge used in agriculture and that there is still a need for the EU to regulate sewage sludge use.

According to most respondents (n=94 out of 173 respondents to this question; 54%), improvements in quality of sewage sludge used in agriculture can be attributed at least to some extent to the SSD. Respondents who identified as farmers were split on this question, with 9 answering positively on the role of the SSD, and 10 answering negatively. In open replies, respondents explained that although the SSD had contributed positively to improvements in the quality of sewage sludge used in agriculture, many national regulations are stricter. Finally, there was an overwhelming consensus that there is still a need for the EU to regulate the use of sludge in the agriculture sector (n=140; 80%), with replies discussing how the SSD could be improved in the open field responses.

Relevance

Overall, the relevance of the SSD to the needs of various sectors was deemed to vary. Responses on the extent to which the SSD is still relevant to address current needs of a list of sectors at local, national, and EU levels were broadly divided. Comparing answers to all sub-questions, respondents judged the SSD to be most relevant to the needs of the wastewater treatment sector and of circular economy. On the other hand, respondents judged the SSD to be currently least relevant about its capacity to protect biodiversity and health. Results for the agriculture sector, which is of primary relevance to the SSD, suggest the existence of divided opinions on the relevance of the SSD for agriculture at the local level, with 47% (n=82 out of 173 respondents to this question) of respondents judging it little or not relevant at all, and another 47% (n=82) of respondents conversely judging it largely or fully relevant.

Coherence

Respondents’ awareness of the coherence of the SSD with other EU policies was rather low, with ‘I do not know’ answers averaging 38% across all the policies listed under the coherence question (nonetheless, specific mentions of coherence with other EU policies were made in several open questions later on). According to the respondents, the Urban Wastewater Treatment Directive is the most coherent EU policy with the SSD (“Agree” or “Strongly agree” n=86 out of 173 respondents to this question: 50%). Respondents identifying as from the wastewater treatment sector agreed more than they disagreed. [215] It is followed by the Circular Economy Action Plan and the Nitrates Directive ("Agree" or "Strongly agree" n=61 for both out of 171 and 170 respondents to this question: 36%). Respondents identifying as farmers agreed more than they disagreed that the SSD was coherent with the Nitrates Directive. [216] The lowest level of coherence was noted for the the European Green Deal (n=56 out of 171 respondents to this question; 33%) and the Fertilising Products Regulation: of 172 respondents, 27% agreed that the SSD is coherent with the Fertilising Products Regulation. 37% disagreed and 13% were neutral. The remaining respondents did not know/no opinion. Additional comments indicated that the Fertilising Product Regulation does not cover many sludge-derived materials, thus sewage sludge is not fully in scope. Aqua Publica Europea (European Association of Public Water Operators) also sees this as hampering trust in these materials[217].

Expert specific questions

The expert questions were responded to by 160 respondents, who self-identified as experts in the area. Respondents indicated that the perception of sewage sludge use in agriculture by stakeholders and the general public was the factor most hindering the achievement of the SSD's objectives (n=48 out of 152 respondents to this question: 32%). However, once again views diverged as 31% (n=47) believed that perceptions of sludge use have facilitated or greatly facilitated the achievements of the SSD's objectives. The three factors deemed to have greatly facilitated the most these achievements were the "Technologies and infrastructures in place at wastewater treatment plants" (n=34 out of 150 respondents to the question; 23%), "Requirements relating to concentrations of heavy metals in sludge" (n=35 out of 152 respondents to the question; 23%) and the "maximum annual quantities of such heavy metals which may be introduced into soil intended for agriculture" (n=34 out of 151 respondents to the question; 23%).

Expert respondents were also divided on the extent to which the changes in amounts of sewage sludge use in agriculture and the safety of its use in their country of residence can be attributed to the SSD and its transposition into (sub-)national law. Nevertheless, 79% (n=122 out of 155 respondents to this question) agreed that it had at least played a role to some extent. Over half of respondents (n=82 out of 156 respondents to this question; 53%) agreed that other (sub-)national laws were to a large extent or fully responsible for the changes observed in their country of residence, as a result of more stringent measures put in place by some MS.

Respondents were divided on whether the difference in approaches taken by EU MS to implement the SSD has had any negative impacts, with 44% of respondents (n=70 out of 158 respondents to this question) answering "yes", and 35% (n=55) answering "no". The most-mentioned negative impact was the creation of an uneven level-playing field. When asked about whether they knew of any unintended effects (positive or negative) which the SSD has had, the most mentioned unintended negative effect was that the SSD led to an increase in awareness about sewage sludge and its use in agriculture, which

[215] 30 out of 59 (50%) agreed or strongly agreed, while 11 (18%) disagreed or strongly disagreed.
[216] 9 out of 20 (45%) agreed or strongly agreed, while 4 out of 20 (20%) disagreed or strongly disagreed.
[217] Aqua Publica Europea, 2019

paradoxically led to more fear and/or misinformation about safety, as people were previously unaware that sludge was used. Linked to this first point, other respondents explained that the SSD has even led to the prohibition of sewage sludge use by buyers/processors of agricultural products or public authorities. The most mentioned unintended positive effect of the SSD was that it led to an increased interest in – and knowledge about – sewage sludge, including looking at new methods to reuse sludge.

For each pollutant regulated by the SSD, over half of the respondents fully agreed that there is still a need to regulate at EU level (varying between n=80; 56% for Copper and Zinc to n=105; 72% for Mercury), [218] highlighting a consensus on the relevance of continued EU regulation. Opinions were more divided on the appropriateness of the limit values. Although for all pollutants, more respondents believed that the threshold was fully appropriate than not appropriate at all (across the six pollutants, the average proportion of 'not appropriate at all' was 20%, and the average proportion of 'fully appropriate' was 37%), we can deduce a general trend whereby respondents believe that there is room for setting more stringent thresholds. Moreover, a majority of expert respondents thought that some pollutants are missing from the SSD (n=116 out of 154 respondents to this question; 75%), with a variety of pharmaceuticals, pesticides and herbicides, plastics, chemicals found in personal care and household cleaning products, and substances used during wastewater treatment (including flocculants) listed in the open replies. Linked to this, expert respondents believed that the SSD has not been – up until now – very successfully in dealing with new and emerging risks. The lowest rated elements were its capacity to deal with pollutants of emerging concern and with substances other than the heavy metals already regulated.

Anaerobic digestion was the method considered the most suitable for sewage sludge pre-treatment / processing by respondents, with 38% (n=58 out of 154 respondents to this question) judging the method as fully suitable. The second favoured method was composting, with 25% (n=38 out of 155 respondents to this question) assessing this method as fully suitable. [219] Land spreading for agriculture was considered the most suitable method to dispose of sewage sludge, with 30% (n=46 out of 153 respondents to this question) of respondents finding it fully suitable. [220] Finally, the most favoured option for nutrient recovery was the precipitation of phosphoric minerals from sludge, although the combined answers "fully" and "to a large extent" failed to reach 50% (n=76 out of 152 respondents to this question: 46%). [221]

Half of the respondents (n=26 out of 52 respondents to this question; 50%) answered to the open question on the added value of EU intervention in a forward-looking manner, pointing to the view shared by many respondents throughout previous questions that the SSD needs to be updated

[218] Total answers received: n=143 for Copper, n=144 for Zinc, n=145 for Mercury

[219] The methods presented in this question were: drying, lime treatment, heating for pasteurization, composting, and anaerobic digestion. Respondents could also specify other methods.

[220] The methods presented in this question were: gasification, incineration, landfilling, land spreading for landscape, land spreading for forestry/re-forestation, and land spreading for agriculture. Respondents could also specify other methods.

[221] The methods presented in this question were: precipitation of phosphoric minerals from sludge, recovery of nutrients from incineration ashes, and pyrolysis. Respondents could also specify other methods.

Final questions

The answers provided in this open field overwhelmingly focused on forward-looking recommendations or remarks (n=57; 74%). A quarter of respondents to this question (n=19; 25%) discussed pollutants in sewage sludge. Respondents also assessed and compared different sewage sludge recycling use, recovery use and disposal routes (n=21; 27%), with a tendency to agree that land application of sewage sludge is an appropriate and cost-effective method for nutrient recovery, provided that sewage sludge has been treated prior application. However, the reliance on more costly and energy-intensive methods is needed when sludge is too contaminated (incineration, pyrolysis), and can lead to energy recovery or phosphorous recovery. Finally, a large number of respondents made other recommendations regarding how the SSD could be improved, with the most often mentioned themes being the need to explicitly focus on nutrient recovery (N and P) (n=13; 17%), the need for an updated approach to control, with some discussing Quality Assurance systems (n=6; 8%), and the need to improve coherence with ambition of the EU policies (n=22; 28%).

Targeted consultations

Targeted stakeholder consultations were conducted via surveys, interviews, and a workshop. The aim was to gather detailed feedback and data from stakeholders directly involved in the implementation of the SSD, or from stakeholders with a substantial expertise on the topic. The survey was composed of one section addressed to all targeted stakeholders and five additional sections each addressed to a specific stakeholder group. [222]

Surveys of Member States' authorities

The survey was disseminated to stakeholders on 3rd January 2021, apart from the Member States authorities, and remained open until 2nd April 2021. The survey directed specifically to Member States' competent authorities was distributed on 23rd March 2021 and remained open until 25th April 2021. An additional targeted consultation of water regulators was undertaken between the 3rd of June and 15th of July to gather data on costs and benefits of the SSD. There were 63 responses to the targeted survey, including by company / business organisations (n=18; 29%), national government / administration (n=13; 21%), business associations (n=12; 19%), academic or research institutions (n=5; 8%), national authorities (n=5; 8%), and NGOs (n=3; 5%). For the additional consultation with water regulators, the consultation consisted of a written questionnaire with an offer to discuss the responses through an interview. However, no response to the questionnaire was received to date. Although cost and benefit estimates from water regulators would have added a higher degree of confidence to the analysis, they are not considered crucial for discerning conclusions.

[222] Namely: 1. Stakeholders from the wastewater treatment and sludge processing and treatment industry and sewage sludge producers and intermediate users. 2. Agricultural associations, consumer organisations, and sewage sludge end users. 3. Academics and health and environmental experts. 4. NGOs and international organisations. 5. Member State competent authorities.

Workshop

In order to allow for expert discussions on key topics and to present preliminary findings, a workshop was organised focusing on synergies between wastewater and sludge and circular economy. The workshop was attended by 376 participants and was split in two half-days: 20th of April in the afternoon and 21st of April in the morning. Following the workshop, participants had the opportunity to send further comments. The workshop summary report is available on circabc[223].

Interviews

Individual interviews were held with five stakeholders, including a business association, a representative of a pilot project and a wastewater operator. The aim of the interviews was to address very specific data gaps remaining after the literature review and analysis of the other consultation activities (e.g., costs and benefits).

Feedback received

Feedback from targeted surveys

The written surveys received 63 responses, of which the largest number of replies came from Belgium (n=10), followed by Finland (n=9) and France (n=9). The remaining top 10 participants (Germany, Spain, Sweden, Italy, Austria, Lithuania, and the Netherlands) had a relatively similar, small number of participants (between 2 and 6). Remaining countries had no more than one respondent, and there were no respondents from Cyprus, Hungary, Ireland, Malta, and Romania.

Respondents' profile

Most of the respondents came from a company/business organisation (n=18), national government/administration (n=13) or a business association (n=12). There was equal share of representatives from the academic/research institution/health and environment experts and national authority sectors (n=5), and similarly proportional representation in the NGO and 'Other' sectors (n=3) and equal representation in the environmental organisation and regional government/administration (n=2). All but one company/business organisation respondents were directly involved in the wastewater or sludge management activities, with one involved in fertiliser products. While all stakeholder groups were represented, a majority came from the private sector (company/business organisations and associations) or national public bodies (national government/administrations and national authorities).

General part of the questionnaire

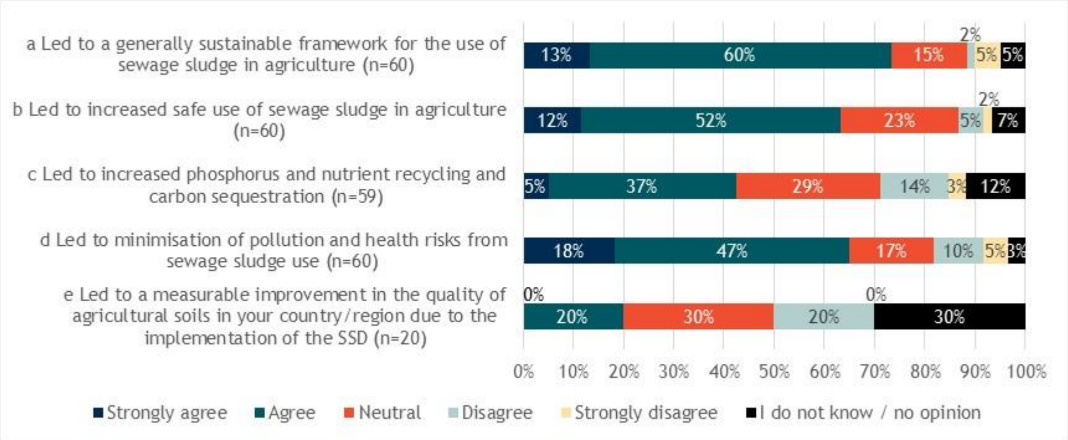
Respondents were in strong agreement that the SSD had led to a generally sustainable framework for the use of sewage sludge in agriculture (73% agree or strongly agree), had led to increased safe use of sewage sludge in agriculture (64% agree or strongly agree), and led to minimisation of pollution and health risks from sewage sludge (65% agree or strongly agree) (see Figure 0 2). They were less equivocal that the SSD had led to phosphorus and nutrient recycling and carbon sequestration, or to a measurable improvement in the quality of agricultural soils.

[223] Circabc (europa.eu)

Some other key findings from the responses to the questions of the general questionnaire include:

- While 14 of 39 respondents (36%) did not think the SSD has led to any other changes than those described above, 5 stakeholders identified the SSD as providing a source of organic matter for soils as a key additional significant change
- The most supported positive factor contributing to achievement of the SSD's objectives was stricter limit values of one or more heavy metals concentrations than would have been without the SSD (n=39; 65%)
- The most supported negative factor seen to hamper the achievement of the SSD's objectives was the negative perception of sewage sludge by the food industry due to potentially contaminated soils or agricultural products (n=19; 33% strongly agree)
- Enforcement of the SSD was considered fully effective or largely effective by 42% of respondents (n=25)
- A majority of respondents (55%, n=22) indicated that no unnecessary operational burdens or complexities have stemmed from the SSD implementation.
- Most stakeholders did not consider the link between the Fertilising Products Regulation and the SSD was made explicit enough (62%, n=38 thought 'not at all' or 'to some extent').
- Stakeholders thought the strongest coherence of the SSD was with the New Circular Economy Action Plan, the Waste Framework Directive, and the Water Framework Directive
- Stakeholders generally thought the SSD was coherent with national legislation (65%, n=40 reported 'fully' or 'to a large extent')
- 67% of respondents (n=41) reported that there are important pollutants found in sewage that the SSD does not currently take into account (examples include organic pollutants (pharmaceutical goods), endocrine disruptors, microplastics, polymers/polyelectrolytes, and pathogens)
- 34% of respondents reported that there are pollutants that no longer need to be regulated by the SSD.
- 85% of respondents expected anaerobic digestion to be the treatment technique most likely to grow over the next decade, and 64% expected incineration to increase over the same period.

Responses to: From your experience, to what extent do you agree that the SSD has led to the following changes or results in your country (or on average in the EU if you represent an EU-level organisation)?



Specific stakeholder surveys

Out of the 63 respondents to the targeted consultation surveys, the following number of respondents addressed the subsequent questions targeting specific stakeholder groups:

- 28 respondents addressed questions targeting sludge producers
- 3 respondents addressed questions targeting sludge users, of which 2 reported they operated at national level and one at EU level
- 5 respondents addressed questions targeting academics, 2 of which were from Finland, and one each from Germany, Sweden, and Italy
- 4 respondents addressed questions targeted at NGOs and international organisations
- 20 respondents addressed questions specifically targeting Member State authorities.

Key points made by different stakeholder groups can be summarised as follows:

- Most sludge producers indicated that the demand for sewage sludge in agriculture has remained more or less the same (n=12, 43% of respondents) or has decreased (n=11, 39% of respondents) over the past five years in their country or in the EU27 on average.
- Most sludge producers maintained that the SSD is "not at all" (n=12, 45% of respondents) fit for purpose with respect to technical and scientific progress, while nine (or 33% of replies) and four respondents (or 15% of replies) found the SSD to be "to some extent" and "to a large extent" fit for purpose, respectively. None of the sludge producers who participated in the survey believed that the SSD is fully fit for purpose.
- Most sludge producers believed that in the future there will be an increase in treatment costs of sewage sludge (93% of 28 respondents), in nutrient recovery from sewage sludge (93% of 28 respondents), in energy produced from sewage sludge (82% of 28 respondents), and in production of sewage sludge (75% of 28 respondents). Three out of three sludge users who participated in the survey agreed that sewage sludge production will increase while demand will decrease.
- Two out of three sludge user respondents mentioned that the risks associated with the spreading of sewage sludge on agricultural land are managed properly in their

respective Member States, while one was of the opposite opinion due to the low threshold values set by the SSD.

- Two out of three sludge user respondents agreed that the use of sewage sludge in agriculture has reduced the cost of fertilisation for farmers, and one disagreed pointing out that the long-term costs overweigh the short-term benefits.
- Four out of five academics and all four NGOs that replied the respective questionnaires agreed that at least to some extent, the SSD provisions have been effective in ensuring that sewage sludge is used safely on agricultural soil. Although most respondents (n=4 academics and n=4 NGOs) believed that the SSD, at least to some extent, still covers the most important pollutants relevant for protection of the environment and human health, three academic respondents and two NGO respondents mentioned that limit values of pollutants set by the SSD are no longer appropriate and should be more stringent, which was also raised by many respondents in the OPC.
- Most of the Member State authority representatives that answered the dedicated questionnaire believed that the SSD provisions are only “to some extent” (n=7, 37% of respondents) burdensome for national/regional/ local administrations/authorities or “not at all” burdensome (n=5, 26% of respondents).
- Most Member State authority representatives also stated that limit values set by the SSD are not stringent enough (n=13 or 65% of respondents), while 6 (or 30% of respondents) believed that they are adequate.

Position papers

Stakeholders were given the opportunity to submit with additional feedback. In total, 26 position papers were received, where 25 of them (at least to some extent) provided relevant input. Regarding the inputs directly relevant for the evaluation, a number of issues were raised, mainly in relation to substances of concern (e.g., micropollutants, microplastics, pharmaceuticals, POPs, etc.). More specific points were also raised by stakeholders concerning the absence of limits on dangerous substances in sewage sludge and the need to consider the introduction of the ‘extended producer responsibility’ (EPR). Three other points on different aspects were raised in position papers: (i) the revision of the SSD should focus on encouragement of recovery of raw materials from sludge (n=3); (ii) consistency with other relevant EU instruments should be ensured during the revision of the SSD (n=2); and (iii) the responsibility to regulate the topic should be left in the hands of Member States Competent Authorities (n=1).

Expert interviews

Additional interviews with experts were organised to fill very specific gaps in the information including on costs and benefits, possibility to improve quality of sludge at source and factors affecting trust from the public. Organisations representing farmers were also contacted and invited to participate. A total of 5 interviews were held and more than 20 stakeholders were reached out for interviews.

The information received from the targeted consultation did not include cost data from Member States that have joined the EU after 2003. The study team reached out to the European Water Regulators (WAREG), private sector operators in Bucharest and Sofia. The interview with WAREG indicated the priorities of WAREG and the types of cost categories that have been published. A questionnaire was circulated with WAREG members and presented at the WAREG board. To date, no cost information other than published data on depreciation timeframes was received by the study team from WAREG members. A detailed interview was conducted with a representative of the operator for Bulgaria who provided detailed cost and operating context information as well as follow up documentation.

A detailed interview was conducted with a representative of a pilot project in Lithuania aiming at using sewage sludge digestate as fertiliser for forestry plantation. The interview identified some information on costs involved in the pilot project.

Finally, an interview was held with a representative of the European Sustainable Phosphorus Platform.

Workshop

The first half of the workshop (20th of April) focused on current challenges encountered in terms of wastewater treatment and sewage sludge management. The discussion focused around how the 'circularity' of sludge management can be improved while ensuring a safe use of sludge notably in agriculture. Three thematic sessions were planned, addressing the subjects of 1-micropollutants, 2- safe production and use of sludge and 3- methods for the recovery of nutrients and raw material from sludge. There were 376 participants registered, representing 27 countries from the EU and 3 non-EU countries.

Key points of discussion revolved around the persistence of contaminants and their accumulation. Participants were asked using Sli.do which micropollutants should be made mandatory to track in wastewater and/or sewage sludge by EU policy and could give any answer they wished. A total of 99 participants provided an answer, and the most cited micropollutants were pharmaceuticals, microplastics, heavy metals, PFAS/PFOS.

There were discussions on sludge regulation, how to determine that sludge is safe and quality control. Stakeholders were particularly interested in how sludge was considered 'safe' and what happens when it was not up to standard. Generally, the approach of using sludge for land reclamation instead of agriculture when it fails compliance was regarded as an acceptable approach. During the final session of the day, alternative uses of sludge were discussed such as incineration and land restoration. Particularly incineration discussions showed a divide between participants who were strongly for or against incineration as a common practice for sludge use.

The second half of the workshops (21st of April) focused on energy efficiency and GHG emissions from wastewater collection and treatment, followed by a series of breakout sessions. Two of the breakout sessions were particularly relevant for the SSD: addressing micropollutants in sludge and impact on soil where it is applied, and recovery of raw materials from wastewater sewage sludge. Regarding micropollutants the discussion was focused around PFAS and their long-term accumulation rates, which stakeholders generally noted as a concern for sewage sludge application. The lack of a standardized methodology for detecting and quantifying micropollutants was also raised as a concern. Generally, stakeholders felt that there needs to be more information available on contaminants in sewage sludge as well as an improvement in treatment technology and more source control. Finally, there was much discussion and support for applying a blending obligation for phosphorus to drive a market for phosphorus from wastewater, and a general demand for the promotion of coherence between resource recovery policies at EU level.

Annex VI. Overview of the requirements of the Sewage sludge Directive

Key features of the SSD

Art.3

- Sewage sludge may be used in agriculture provided that it adheres to any conditions that the Member State may deem necessary to protect human or environmental health. Sludge may also only be used if it is regulated by the Member State.

Art.5

- Prohibits the use of sludge where the concentration of one or more heavy metal in the soil exceeds limit values set down in Annex I A.
- Member States must either lay down maximum quantities of sludge applied to soil or will ensure that the limit values for the quantities of heavy metals added to soils, as described in Annex I C, are adhered to.

Art. 6

- Sludge must be treated before it is used in agriculture, although Member States may authorise the use of untreated sludge providing their own conditions are met and that the untreated sludge is injected or worked into the soil.

Art. 7

- Sets out a period of time after using sludge before which it is prohibited to allow grassland to be grazed or forage crops to be harvested.
- Member States may set their own period of time depending on climate and geographical location, but it must never be below three weeks.
- It is also prohibited to use sludge or supply sludge for use on soil in which fruit and vegetables are growing (with the exception of fruit trees) and on ground intended for the cultivation of fruit and vegetables intended to be eaten raw for a period of 10 months before the harvest.

Art. 8

- Requires that sludge is used in such a way that takes into account the nutritional needs of the plants and the quality of the soil. In the case of soils with a pH of below 6, Member States may be required to reduce the limit values in accordance with Annex I A to account for an increase in mobility and availability to the crops of heavy metals.

Art. 9 (and Annex II)

- Sets out limit values, sampling methods and analysis.

Art. 10

- Details the requirements on records keeping (the quantities of sludge produced and quantities supplied for use in agriculture; composition and properties of sludge in relation to Annex II A; the types of treatment carried out; and the names and addresses of recipients of the sludge and the place where the sludge is stored).
- Records should be available to the competent authorities.
- Information on the treatment and results of analyses should be released upon request to the competent authorities.

Art. 11

- Sets exemptions from Article 6 (b) and Article 10 (1) (b), (c) and (d) and paragraph 2 for, sludge from sewage treatment plants below 5,000 population equivalents as these are primarily for the treatment of domestic waste water.

Art. 12

- Allows Member States to take more stringent measures than those provided by the Directive.
- When this decision is taken, Member States are required to inform the Commission.

Annexes

- Set out the frequency of sludge and soil analysis as well as the parameters that have to be tested.
- For the sludge analysis is to be at least every six months unless results do not vary over a full year in which case every 12 months.
- Analyses should cover the following parameters: dry matter, organic matter, pH, nitrogen and phosphorus and cadmium, copper, nickel, lead, zinc, mercury and chromium.
- For soil, the analysis is to be set upon a national frequency.
- Analyses should cover pH, cadmium, copper, nickel, lead, zinc, mercury and chromium.

Limit values established by the Directive

The Directive imposes several requirements on the quality of sludge for use in agriculture, the quality of the soil on which sludge is to be used and limiting sludge application for certain purposes and during certain time periods. The main aim of these requirements is to limit heavy metal concentrations in soils. Limit values have been defined in the Annexes of the Directive:

- concentrations of heavy metals in soils to which sludge is applied (Annex IA)
- heavy metal concentrations in sludge for use in agriculture (Annex IB)
- maximum annual quantities of such heavy metals that may be introduced into soil through sludge use in agriculture (Annex IC).

[ANNEX I A of the SSD]

LIMIT VALUES FOR CONCENTRATIONS OF HEAVY METALS IN SOIL

(mg/kg of dry matter in a representative sample, as defined in Annex II C, of soil with a pH of 6 to 7)

Parameters	**Limit values** (1)
Cadmium	1 to 3
Copper (2)	50 to 140
Nickel (2)	30 to 75
Lead	50 to 300
Zinc (2)	150 to 300
Mercury	1 to 1,5
Chromium (3)	—

(1) Member States may permit the limit values they fix to be exceeded in the case of the use of sludge on land which at the time of notification of this Directive is dedicated to the disposal of sludge but on which commercial food crops are being grown exclusively for animal consumption. Member States must inform the Commission of the number and type of sites concerned. They must also seek to ensure that there is no resulting hazard to human health or the environment.

(2) Member States may permit the limit values they fix to be exceeded in respect of these parameters on soil with a pH consistently higher than 7. The maximum authorized concentrations of these heavy metals must in no case exceed those values by more than 50 %. Member States must also seek to ensure that there is no resulting hazard to human health or the environment and in particular to ground water.

(3) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission, within one year following notification of this Directive.

ANNEX I B of the Directive

LIMIT VALUES FOR HEAVY-METAL CONCENTRATIONS IN SLUDGE FOR USE IN AGRICULTURE

(mg/kg of dry matter)

Parameters	**Limit values**
Cadmium	20 to 40
Copper	1 000 to 1 750
Nickel	300 to 400
Lead	750 to 1 200
Zinc	2 500 to 4 000
Mercury	16 to 25
Chromium (1)	—

(1) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

ANNEX I C of the SSD

LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO AGRICULTURAL LAND, BASED ON A 10-YEAR AVERAGE

(kg/ha/yr)

Parameters	Limit values (1)
Cadmium	0,15
Copper	12
Nickel	3
Lead	15
Zinc	30
Mercury	0,1
Chromium (2)	—

(1) Member States may permit these limit values to be exceeded in the case of the use of sludge on land which at the time of notification of this Directive is dedicated to the disposal of sludge but on which commercial food crops are being grown exclusively for animal consumption. Member States must inform the Commission of the number and type of sites concerned. They must also ensure that there is no resulting hazard to human health or the environment.

(2) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

ANNEX VII. KEY CONCLUSIONS RELATED TO THE SSD FROM THE 2014 EX-POST EVALUATION STUDY

Evaluation criteria	Conclusions from 2014 study
Effectiveness	"The Sewage Sludge Directive (SSD) has been effective in achieving its initial objectives, by increasing the amount of sludge used in agriculture and by contributing to reducing environmental harm by ensuring that heavy metals in soil and sludge do not exceed the limits set by the Directive. All Member States meet the requirements of the Directive in terms of heavy metals limit values, although there is considerable variation between Member States in the limits applied (both in soil and in sludge). There are also large variations in the amount of generated sludge used in agriculture in the Member States, ranging from none to well over 50%. " The heavy metal limits of the SSD are less stringent than those set in many Member States.
Efficiency	"The principal benefit of the Sewage sludge Directive is its role in the protection human health and the environment against the harmful effects of contaminated sludge in agriculture. Other benefits include the use of sludge in agriculture as a cheaper disposal option compared to landfill and incineration and it is an effective replacement for chemical fertilisers, especially phosphorus. Estimates from the 2010 study assessing the Sewage Sludge Directive indicate that if sewage sludge use in agriculture were no longer an option, to be replaced by incineration, the cost would be of the order of EUR 650 million per year. Despite these clear benefits to using sludge in agriculture, rising negative media and public attention in recent years has hampered its potential beneficial use on land and in agriculture. The main unavoidable costs of the Directive include the treatment and management costs of sludge to ensure it meets the Directive's (or Member States' more stringent) quality standards. "
Coherence	"The Directive complements EU waste legislation by encouraging the safe use of sludge (moving it up the waste hierarchy), by promoting health and environmental protection (by placing limits on heavy metals), and by contributing to resource efficiency (through the recovery of useful nutrients)." "There is strong complementarity and an adequate level of coherence with the UWWTD (although the link between the two is not explicit within the Directives themselves)." The coherence of the SSD with the EU circular economy objectives should be assessed.
Relevance	"In general, the retention of the SSD as a separate legislative instrument is supported by the majority: only a small number of stakeholders felt that sewage sludge management could in principle be integrated into other EU legislation (e.g., on soils, biowaste or fertilisers)."

Evaluation criteria	Conclusions from 2014 study
	Relevance is limited due to the limited scope of the Directive (which addresses only the agricultural use of sludge), and the lack of provisions on quality assurance and adequate monitoring. Additional contaminants / substances in sludge have been identified that could be monitored, however there is not broad support for introducing additional limit values in the Directive.

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