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# **Institutional structure of the agricultural utilization of sludge from wastewater treatment plants in Bulgaria<sup>1</sup>**

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## **Abstract**

The process of turning wastewater treatment plants sludge from "waste into good (product)" is conditioned by various social, economic, technological, agronomic, personal, etc. factors, an important place among them is occupied by the institutional structure in which the related agents carry out their activities and relationships. Institutional Environment and Institutions of Governance provide opportunities and set constraints for agents in the chain, structure and determine their behavior and activity, and ultimately (pre)determine the effectiveness and the degree of use of sludge in agriculture. In this study, the interdisciplinary methodology of the New Institutional Economics is adapted and an analysis and assessment of the institutional structure of WTP sludge utilization in Bulgarian agriculture is made.

The study found that over the last two decades, the institutional structure (regulatory framework, public, private, market and hybrid forms) of sludge utilization in Bulgarian agriculture has significantly improved. As a result, great progress has been observed in the agricultural use of sludge in the country. At the same time, uneven and unsustainable development of this process was found in the different regions of the country. Therefore, all factors limiting the behavior of

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the associated agents and leading to these fluctuations in sludge utilization are to be identified. In view of their relevance, interdisciplinary studies and evaluations of the institutional structure and factors of sludge utilization in agriculture have to be expanded and enriched. However, for this, it is necessary to collect a new type of micro and macro information from all interested parties, including through the official system of agro-statistics in the country and the EU. In view of the leading role of public intervention in this area, a new national strategy for the utilization of WTP sludge is to be developed, reflecting modern conditions and social priorities, and special measures be taken to support the interested parties, including farmers with tools of CAP. Trends in the development of the institutional structure and the utilization of sludge in other EU countries have to be also studied in order to assess where Bulgaria is and where efforts are to be focused in the future.

**Key words:** sludge, wastewater treatment plants, utilization, agriculture, institutional environment, institutions of governance, Bulgaria

## ***Introduction***

The process of turning wastewater treatment plants (WTP) sludge from "waste into good (product)" is conditioned by various social, economic, technological, agronomic, personal, etc. factors (Bachev and Ivanov, 2021, 2022). An important place in this complex of factors is occupied by the institutional structure in which the various agents related to the process carry out their activities and relationships. Institutional environment and institutions of governance provide opportunities and set constraints for agents, structure and determine their behavior and activity, and ultimately (pre)determine the effectiveness of agro-eco-governance as a whole, and the effectiveness and the degree of use of sludge in agriculture in particular (Bachev, 2020).

In this study, the interdisciplinary methodology of the New Institutional Economics is adapted (Bachev, 2020, 2023; Furubotn and Richter, 2005; Williamson, 2005) and an analysis and assessment of the institutional structure of WTP sludge utilization in Bulgarian agriculture is made.

## ***Research methodology***

Institutions are generally defined as the 'rules of the game', including the rights and obligations of individual agents, and the system of enforcement of those rights and rules (North, 1991; Furubotn and Richter, 2005). Their analysis covers the formal rights, restrictions and rules (regulated by various laws, regulations, etc.) and the official bodies and mechanisms for controlling, enforcing, disputing, etc. (government agencies, court, etc.). The analysis are to also include the important informal rights, rules and norms (determined by society and communities, ideology, tradition, etc.) and sanctioned through social pressure and "punishment" or self-enforced by individuals.

In addition to the "externally" (socially) imposed rules of the game (Institutional Environment), which are beyond the control of individual agents, there are also a variety of private, collective and hybrid institutions (Institutions of Governance) created by the agents themselves to manage their relationships and activities – organizational and contractual forms, professional standards and codes of conduct, etc. All of them are an important part of the institutional structure and has to be identified and analyzed.

Institutions "govern" and structure human activity, behavior and relationships in a certain (and predictable) way, creating a certain social order that ultimately (pre)determines the type of agrarian development and the extent to which socio-economic and environmental goals of sustainable development are achieved (Bachev, 2020).

To analyze and evaluate the institutional structure of WTP sludge utilization in Bulgarian agriculture, the methodological framework for studying the system of agrarian governance, presented in detail in other publications of the author (Bachev, 2020, 2023) is adapted. This approach is based on a more complete consideration of socio-economic, organizational, production, agronomic, technological, educational, informational, personal, etc. factors, and the aggregate

(production, transaction, third party, etc.) costs in the process of WTP sludge utilization in agriculture.

The holistic analysis of the institutional structure of WTP sludge utilization in agriculture includes the following elements (stages):

- Identifying the agents involved in the process and characterizing their needs, interests, preferences, capabilities and constraints.

- Identifying the various mechanisms and forms that govern the activity and behavior and relationships of agents (regulatory environment, public programs, organizational forms, contractual agreements, informal institutions, etc.), and assessing their potential, incentives, costs and constraints for sustainable utilization of sewage sludge in agriculture.

- Assessment of the results of modernization of the specific institutional structure of the WTP sludge utilization in agriculture and the (evolution of) the impact on the behavior, activity and relationships of the interested agents.

- Identification of the existing problems and challenges in the utilization of sewage sludge in agriculture (imperfections and "failures" in the institutional structure), and the opportunities for improving the institutional structure in the modern conditions of development of the sector. Justification of recommendations for the improvement of public policies and forms of intervention and of the management strategies of the interested agents to improve the efficiency and the degree of agricultural utilization of sludge.

The study is based on a qualitative analysis of the specific regulatory framework and institutional structure associated with the utilization of sludge in Bulgarian agriculture, and on the results of surveys conducted during 2020-2023. with managers and experts of Wastewater Treatment Plants (WTP), representatives of Regional Environment and Water Inspections (REWI), interested parties, and farmers using and not using sludge in Sofia and Burgas regions. Nearly half of the country's total amount of sludge is formed in the two studied regions (IEA, 2021). In addition, the WTPs in Sofia and Burgas are designated as model

(together with Blagoegrad and Veliko Tarnovo) in the National Strategic Plan for the Management of Sludge from Wastewater Treatment Plants in Bulgaria for the period 2014-2020. (NSPMSWTPB, 2014). According to official data, the largest share of the total sludge used in agriculture in the country is utilized in the Sofia region, reaching 95% in 2021 (EEA, 2021). In the later region eight farmers have been utilizing sludge from WPT in recent years and indebt interviews were carried out with the most experienced among them.

To evaluate the specific institutional structure of WTP sludge utilization in Bulgarian agriculture, a system of criteria is used to characterize the quality and costs of its principle components (Table 1). For example, when analyzing the quality of the institutional environment, one should assess the compliance of the country's regulations with the EU legislation, the degree of clarity and familiarity by the interested agents, the degree of actual implementation in "Bulgarian" conditions, the degree of stimulation and limitation of the behavior and activity of interested agents, degree of support from existing informal rules and institutions, "institutional" (for modernization and implementation of the regulatory framework), production, transactional, etc. costs to the participating agents and society as a whole, and efficiency in terms of potential created and utilization rate of the generated sludge in the country's agriculture. The evaluation of the forms of public interventions is to be based on their compliance with the contemporary needs of the country (for example, implementation of EU policies, correction of cases of market and private failures, etc.), aggregate (public, private and social) costs for their development and implementation, and the aggregate (social, economic, environmental, etc.) effects of the specific intervention. To evaluate market and private forms, the following criteria have to be used: variety of modes, degree of competition (many participants and forms), incentives and constraints for interested agents, aggregate (production, transaction, third party, etc.) costs , and effectiveness (socio-economic and environmental effects, potential, failures, etc.).

**Table 1. Criteria for evaluating the institutional structure of WTP sludge utilization in Bulgarian agriculture**

<b>Institutional Environment</b>	<b>Institutions of Governance</b>		
	<b>Public</b>	<b>Market</b>	<b>Private</b>
Compliance with EU legislation	Matching intervention needs	Incentives and constraints	Variety of forms
Clarity and comprehensibility		Degree of competition	Incentives and constraints
Practical applicability	Costs		Costs
Incentives and constraints	Efficiency	Costs	Costs
Supporting informal institutions		Efficiency	Benefits
Costs			Efficiency
Efficiency			

Source: the author



## **Evolution of the institutional environment and public forms**

Like other European and developed countries, effective waste management in general, and sewage sludge management in particular, is an important institutional modernization in Bulgaria<sup>3</sup>. Important factors for these fundamental changes in the country in the last two decades are the adaptation and implementation of the overall (including environmental, etc.) legislation of the EU, the "introduction" of the concept (and ideology) of "(ecologically) sustainable development" and its institutionalization in official, professional and private policies and behavior, and "proven" by science potential for sludge utilization in agriculture, land reclamation, energy, etc. areas. As a result of this radical development, in recent years there has been a significant increase in WTP sludge in various regions of the country and the "necessity" of their utilization, including as fertilizer (and soil improver) in agriculture (Bachev and Ivanov, 2021). In this sense, there is a challenge in Bulgaria and a "new" stage of institutional modernization is underway to "manage" the process of turning sludge from waste into a good (product)<sup>4</sup>. Important driving forces of this process are both the initiatives "from above" of the state (legislation, regulations, public intervention, etc.) and decentralized private and collective actions "from below" of interested

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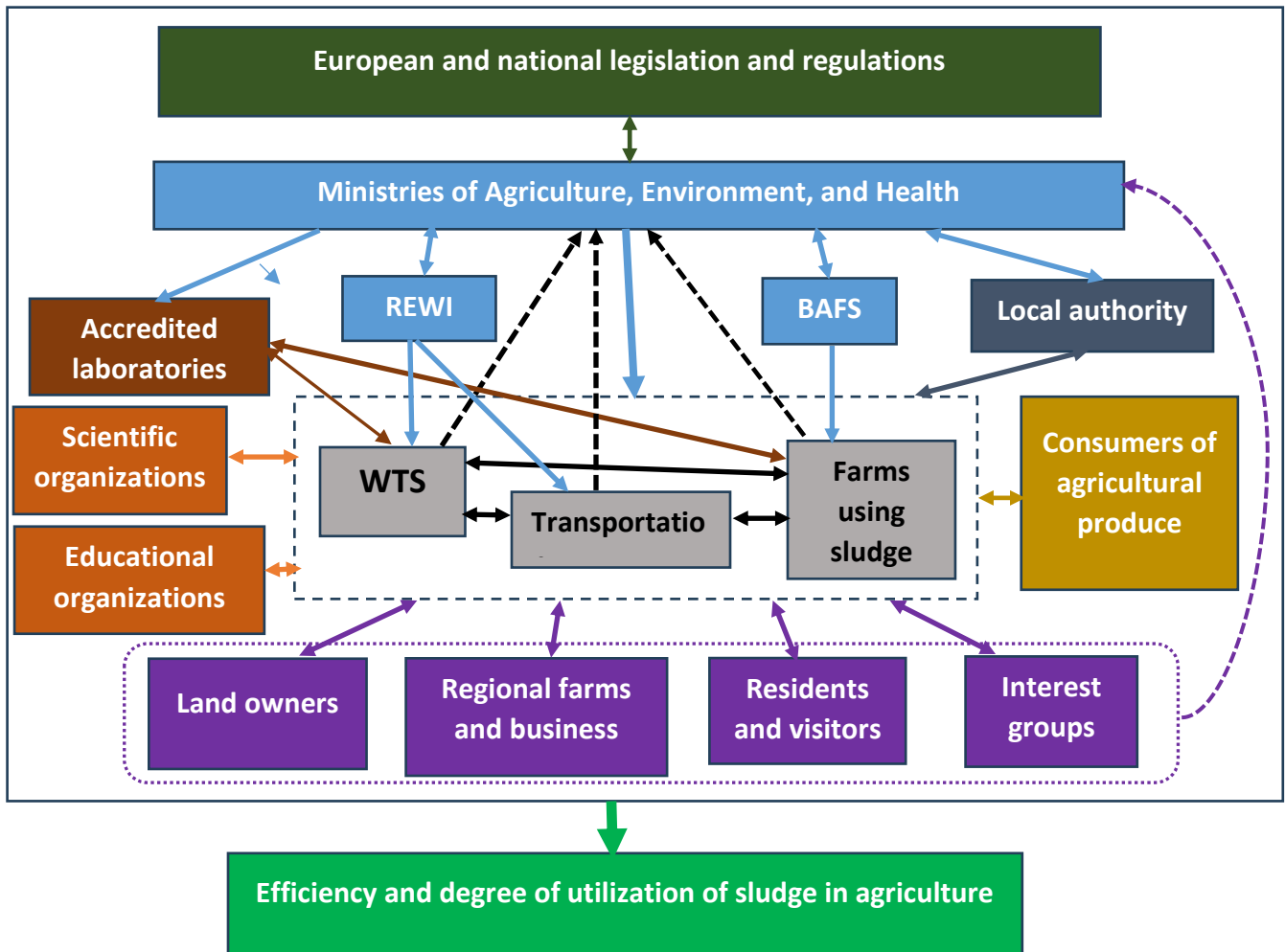
<sup>3</sup> The institutional environment for modern eco-governance in Bulgaria began to form in the country's pre-accession period to the EU and continues to improve as a result of external (European control and sanctions for non-compliance) and internal (political, interest groups, etc.) pressure and actions.

<sup>4</sup> Both "waste management (WTP sludge)" and "waste utilization management (WTP sludge)" are part of a new scientific discipline and social practice - "circular economy management".

businesses, farmers, interest groups, scientific organizations, local communities, etc.

The main agents and relationships in the modern institutional structure of the WTP sludge utilization process in Bulgarian agriculture are presented in Figure 1.

**Figure 1. Institutional structure of the WTP sludge utilization process in Bulgarian agriculture**



Source: the author

The formal institutional environment includes the specific legislative and regulatory provisions and the system for their enforcement, which regulate the rights, ways, processes, and control of agricultural sludge utilization in Bulgaria. One of the most important factors for the effective utilization of sludge in agriculture is the availability of modern legislation and regulations (Bashev and Ivanov, 2021). It has to define the rights and obligations of the various agents

involved in the process (regulatory and control bodies, WTPs, farmers, laboratories, etc.), standards for quality and safety of sediments, soil quality and human and animal health, norms and limitations of application, etc. The institutional framework also includes a variety of state policies, programs, plans, and incentive tools to achieve certain social goals regarding the utilization of sludge in agriculture and other sectors of economy.

With well-defined "rules of the game" and adequate state intervention, conditions will be created to induce the effective behavior of the main agents and effective (and not only) utilization of sludge in agriculture (maximizing positive effects and minimizing negative effects). Conversely, inefficient regulation (for example, complex procedures and high costs of obtaining permits for use by farms) there will be no the interest to participate in the process.

In the European Union, the formal institutional regulation of the utilization of WTP sludge in agriculture has a long history, established in 1986 with the EEC Directive (Directive 86/278/EEC, 1986). The Directive encourages the use of sludge in agriculture, only on the condition that it is used in areas where it does not have a negative impact on the soil and agricultural products. The main requirements in the Directive come down to compliance with limits related to the content of heavy metals and biogenic elements in sediments and soils, as well as restrictions on the annual norms of utilization of sludge on agricultural lands. Mandatory treatment of sludge before its use for fertilization is also decreed.

In addition to this specific regulation, there is a huge legislation in the EU related to the protection of the environment (water, air, biodiversity, climate, comfort of the population, etc.), which is constantly being developed and refined for better conservation of natural resources and biodiversity, and protection of

human, plant and animal health. A detailed presentation and analysis of the evolution of European legislation and court decisions concerning the use of sludge in general and in agriculture in particular is made in NSPUS (2014). This constantly modernizing legislative framework regulates the behavior, activities and relationships of the diverse agents and stakeholders involved in the WTP sludge utilization process in the sector.

Individual EU countries also have specific policies and different "social tolerances and restrictions" regarding the use of sludge in agriculture. New concerns related to the spread of the Coronavirus-19, for example, have led some countries such as France to regulate mandatory disinfection of sludge before its use in agriculture (ANSES, 2020). As a result, the rate of sludge utilization in agriculture in EU countries varies widely, from almost zero in Malta, Slovenia and Slovakia to 80% in Ireland (EU, 2016). There are no official statistics on the number of agricultural holdings utilizing WTP sludge in Bulgaria, but our study found that at the current stage, a small proportion of farms use WTP sludge (Bachev et al., 2021).

The requirements of the European Directive for the protection of the environment when using sewage sludge in agriculture have also been introduced into Bulgarian national legislation through a number of normative documents, the main one of which is the Ordinance on the procedure and method for the utilization of sewage sludge through the use in agriculture (Regulation, 2017). This document was originally adopted in 2004 (PMS No. 339 of 14.12.2004, promulgated, SG No. 112 of 23.12.2004), and a number of progressive additions and changes to the regulations were made in 2011 (SG, No. 29 of 08.04.2011), 2016 (SG No. 63 of 12.08.2016) and 2017 (No. 55 of 07.07.2017).

The Ordinance determines the procedure and method for the utilization of sludge from sewage treatment plants and wastewater treatment facilities through their use in agriculture; the requirements for producers and users of sludge intended for utilization in agriculture in a way that ensures that their application will not have a harmful effect on the soil, vegetation, animals and humans; the procedure for accounting for unitized sludge; the permit regime for the use of sludge from the WTP; and methods for sampling and testing sediments and soils (Ordinance, 2017).

According to the regulations, "users of sludge" can only be sole traders and legal entities. The Ordinance does not allow the utilization of sludge on: meadows, pastures or areas sown with fodder crops, when they are used for grazing or the fodder is harvested within a period shorter than 45 days after the use of the sludge; soils on which fruits and vegetables are grown, with the exception of fruit trees and vineyards; soils intended for the cultivation of fruit, vegetable and other crops that are in direct contact with the soil and are consumed raw, for a period of 10 months before and during harvesting; coastal floodplains, riverbeds and protective dikes; zone I and zone II of the sanitary protection zones of the water sources and facilities for drinking and domestic water supply and around the water sources of mineral waters used for medicinal, prophylactic, drinking and hygiene purposes; and in agricultural lands in protected areas.

The utilization of sludge in agriculture is allowed on the basis of a permit. For the issuance of a permit, sludge users provide the Bulgarian Food Safety Agency (BFSA) with information and results of analyzes of the soil from the plots where the sludge will be used, about the soil characteristics: soil type, bulk density, granulometric composition of the soil, and total soil porosity. The taking of the

samples and their subsequent testing is carried out by accredited laboratories according to certain indicators. Soil testing is mandatory before the initial utilization of the sludge, and after its use - every 5 years. The permit contains: the quantities of sediments meeting the requirements for the MPC of heavy metals in the sediments expressed in tons of dry matter, which can be introduced annually into the soil per unit area; the location and size of the area on which the sludge will be utilized. The permit is issued for a one-time import of a certain amount of sediment for a specific area.

The bodies related to the implementation of the Ordinance and controlling its implementation are a principle elements of the institutional structure. The control over the implementation of the regulation is entrusted to the Minister of Agriculture, the Minister of Environment and Water, and the Minister of Health according to their competences. In reality, these functions are performed by the specialized agencies and divisions of these ministries, whose functions are described in detail in the normative documents. Main among these organizations are REWI and BAFS, which issue permits (licenses) and control, respectively, the "production" and quality of sludge for agricultural utilization (REWI) and the use of agricultural sludge (BAFS).

Normative requirements for the management of sewage sludge are also contained in other official documents, the main part of which are related to waste and water management legislation. Important elements of the institutional structure of the utilization of sludge in agriculture are: Ordinance No. 1 on the order and samples according to which information on waste activities is provided, as well as the order for keeping public registers (Official Gazette No. 51 of 20.06 .2014, amended by SG No. 51 dated 19.06.2018, amended and supplemented by SG No.

51 from 28.06.2019, amended and supplemented by SG No. 30 from 31.03.2020); Ordinance No. 2 on waste classification (SG, No. 66 of 8.08.2014, amended and supplemented, No. 32 of 21.04.2017, No. 46 of 1.06.2018, No. 86 of 6.10 .2020); Law on Waste Management (Official Gazette No. 53 of 13.07.2012, amended and supplemented by Official Gazette No. 19 of 5.03.2021), Ordinance on Separate Collection of Bio-Waste and Treatment of Biodegradable Waste (Official Gazette No. SG No. 47 of 05 June 2018), Law on Soils (SG No. 89/2007, last amended by SG No. 66 of 26.07.2013), Law on Protection of Agricultural Lands (SG No. 35/1996) ., last amended by SG No. 66 of 26.07.2013), Water Law (SG No. 67/1999, last amended by SG No. 26 of 21.03.2014), Ordinance No. 6 on emission norms for the permissible content of harmful and dangerous substances in wastewater discharged into water bodies (SG No. 97/2000, last amended and supplemented by SG No. 24 of 23.03.2004), etc.

It can be concluded that Bulgaria has a modern legislative and regulatory framework for the safe use of sludge in agriculture, which is based on modern European standards. It creates a certain order and standards for the utilization of sludge from WTP in agriculture, determines licensing and controlling bodies (REWI, BFSa, etc.), accredits laboratories for testing samples of sediments and soils, regulates and limits the use (permits for doses and areas) and the users (sole traders and legal entities) of sludge from wastewater treatment in agriculture.

In-depth scientific experiments, including in field production conditions, of leading scientific institutes of the Agricultural Academy (SSA) like Soil Institute "Pushkarov", Bulgarian Academy of Sciences (Institute of Microbiology), and the Ministry of Health (National Center for Public Health and Analyses), Agrarian and other universities have repeatedly proven the agronomic and economic value and



the ecological and medical safety of the utilization of sludge in agriculture (Marinova, 2008). However, in the period until the adoption of modern regulations (up to 2005), there was practically no use of sludge in Bulgarian agriculture (EEA, 2005). Therefore, the introduction and implementation of modern legislation in the country is an important factor for the induction and expansion of the process of sludge utilization in agriculture.

In 2006 already 22,520 tons of dry matter sludge is utilized in agriculture, which represent the largest part of the total sediments formed in the country - 61% (NSPUS, 2014). For the period 2004-2010 nearly half of the amount of sludge generated in the country (49%) has already been utilized on land either for reclamation or for agricultural areas (NSPUS, 2014). After the introduction of the legislation, the share of sludge utilized in agriculture progressively increased from 31% (for the period 2006-2010) to 36% (for the period 2011-2015) and reached 48% for the last years (for the period 2016-2021) (EEA, 2004-2021).

In order to bring it into line with European standards after the country's accession to the EU, a National Strategic Plan for the management of sludge from wastewater treatment plants in Bulgaria for the period 2014-2020 was adopted. (NSPUS, 2014). This Plan envisages the recycling and material utilization of 70% of the total generated sludge from the WTP by the end of 2020 and zero landfilling and non-targeted temporary storage of sludge by 2020. For the implementation of the Plan's objectives, a number of interventions are undertaken at the national level: establishment of an institutional framework for sustainable management of sludge (this includes an institutional structure at the level of competent authorities, as well as agreements with farmers and potential users of sludge); establishment of a legislative framework - regulatory provision by amending and supplementing

normative documents in the national legislation; providing a sufficient database for sludge management planning using the chemical analyzes of sludge from all WTPs and from soil carried out by accredited laboratories and managed by an independent organization; creation of a qualified system for utilization of sludge in agriculture by 2015 in the context of the need to determine threshold utilization norms in agriculture (3.5t per hectare per year, proposed as a maximum); drawing up a professional profile and training program for workers in the WTP; creation of a monitoring and control system (ISO 9001, EMAS, ISO 14001, ISO 18001), etc.

In recent years, significant European and national funds have been invested for the modernization of WTPs in the country. However, until now, CAP instruments and public funds have not been used to financially support the utilization of sludge by agricultural producers and other agents (transport companies, intermediaries, collective organizations, etc.) of this chain. The lack of social recognition, integration into CAP and financing of this important ecosystem service "waste utilization" is one of the reasons for the slow progress of WTP sludge use in Bulgarian farms.

In addition, institutional requirements and restrictions, and standards for quality and safety of food and feed, protection of the natural environment and biodiversity, animal welfare, etc. in the EU and Bulgaria are constantly developing and "tightening", including the control for their strict compliance. This modernization also affects the monitoring and control system, and is closely "linked" to the support of farmers with the CAP tools - cross-compliance, eco-payments, eco-contracts, overall "greening", etc. At the same time, social tolerance of farm sludge use in the country shows no trend of progress due to actions of environmental interest groups, consumer organizations, affected or at-risk

businesses and local communities, etc. The dominant "outdated" treatment of WTP sludge as waste and not product for subsequent effective use in agriculture, in regulatory documents and by responsible public agencies and those working in them, also contributes to this problem.

Moreover, the newly adopted Green Deal by the European Union in 2019 sets ambitious targets for reducing greenhouse gases, limiting the use of mineral fertilizers and pesticides, and increasing the area of organic production by 2030. (The European Green Deal, 2019). In the EU countries and in the governing bodies of the Union, discussions still continue and the procedures for the implementation of these goals are being developed by means of the CAP instruments, the Strategic Development Plans until 2030, and other policies and mechanisms. In this regard, there is considerable ambiguity and "institutional uncertainty" on many issues concerning the achievement of European and national targets, and in particular how the reduction will be distributed between the individual member states of the union, sub-sectors of production, agrarian and agro-ecological regions and types of agricultural producers, whether and how the general reduction will also include the use of manure and sewage sludge, what resources will be directed to support critical areas and for green transformation of industries, areas, activities, etc. The development of incentives for agents in the chain and the degree of use of sludge in agriculture in the coming years will largely depend on the solution of all these questions.

The main public agents in the institutional structure of sludge utilization in the country are REWI, BAFS, laboratories for testing samples, scientific organizations, local government, etc. Their capacity for and effectiveness in implementing the regulatory framework is an important factor in accelerating the

process of sludge utilization in agriculture. After the country's accession to the EU, the competence and degree of implementation and control of the procedures, standards and restrictions for the use of sludge in agriculture by the competent state authorities has significantly improved, especially in the last few years. The local authority has an active role in the overall activity in the area, and significant differences are observed regarding the use of sludge in agriculture - from complete denial (in the Black Sea coastal resort areas of the Burgas region) to complete tolerance (in the Sofia region, where the agents in the process create jobs, hire resources or provide services to the local population).

However, the administrative capacity of the responsible organizations in different regions of the country is not the same and completely adequate, due to insufficient personal and financial resources, experience, training and staff turnover, frequent organizational and personnel changes, changing and even absence of political support, etc. As a result, there is an uneven understanding and application of the regulations by different individuals and organizations in different public agencies and regions of the country.

In addition, these hierarchical type organizations demonstrate all the shortcomings of public bureaucracies such as: lack of interest, initiatives and orientation to the real problems of practice, low adaptability, high costs and time for making and implementing managerial decisions, etc. Moreover, in recent years, the efficient utilization of sludge has not been among the many "major" socio-economic and environmental problems and, therefore, of primary public and political interest and priority. This made it much more difficult to improve and implement the regulatory framework, and to improve public support through various programs, tools, public-private partnerships, etc.

In general, frequent changes (additions, amendments, etc.) in the regulatory framework create difficulties for study and implementation by both civil servants and other interested parties (WTP, farmers, interest groups, etc.). Moreover, the practical study, implementation, compliance and control of regulatory standards and restrictions is associated with significant personnel, capital and running costs. Very few (large, financially and organizationally secured) WTPs, transport companies, agricultural holdings and other businesses have the capabilities (potential, expertise, finances, etc.) to adapt to modern mandatory standards and requirements for modern transformation, transportation and utilization of sludge.

Most of the public interventions (and forms) impose constraints and create costs for the various agents along the chain, while public measures for direct (financial, logistical, etc.) support are negligible or absent. Moreover, a new long-term state strategy for the current program period has not yet been developed and adopted reflecting new needs, contains and measures to overcome identified in the old strategy and newly emerged challenges, and adapting likely scenarios for agricultural development and potential for the possible utilization of sludge in agriculture and other sectors of the economy in the medium term.

Another well-known fact is that during the years of the country's membership in the EU, there are many examples of incomplete, distorted and in a "Bulgarian way" implementation of the common policies of the Union. Moreover, there is no long-term and mass experience in the use of sludge in agriculture in the country, and almost all agents are outside or at the beginning of the "knowledge curve". This leads to unconscious errors in implementation and/or search for "effective" practical solutions outside the normative framework, etc. In addition, many of the eco-activities and eco-standards in agriculture and related fields are

difficult to be effectively controlled by enforcing bodies, due to high cost or practical impossibility (Bachev et al. 2021). This is related to the well-known "massive" non-fulfillment of certain official eco-standards and norms, etc. and the uneven application of the procedures in different regions of the country, sub-sectors of agricultural production, agro-ecosystems, and individual agents of the sludge utilization chain.

State regulatory and supervisory bodies are the main agents in the system. They implement the provisions of the legislature and the policies that the Government and the Parliament undertake. One can only assume that (like other government structures) mistakes are likely to be made, due to lack of experience in this "new" field, poor management, and incompetence of those employed. In addition, corruption is possible, as is the practice in all cases of issuing permits, control of certain practices and standards, etc. There are probably also cases of overt or hidden "conflict of interest" of heads of these units who are also interested parties. The same applies to some of the accredited laboratories, which perform important public functions, but are "small" in number private structures aimed at profit or (divisions of) underfunded public organizations, and their activity is not always in accordance with the regulatory framework (imprecise tests, buying and falsifying test results, etc.).

Apart from the regulating and controlling authorities, the main agents of the system are WTPs, transport companies and farmers using sludge. The relations of WTPs, transport organizations and sludge utilization farms with the state bodies are of "unilateral" dependence. Application is voluntary, but permits are "granted", and this involves lengthy procedures, time and labor costs, sediment and soil samples testing costs, etc. In addition to permits, other parameters of the process

are determined (restricted) - used technology, mandatory standards, time periods, prices, etc.

Control over the implementation of (various aspects of) regulatory provisions is divided between many structures in the system of the Ministry of Agriculture, the Ministry of the Environment, the Ministry of Health, etc. This complicates coordination between them, duplicates activity, and often creates difficulties for other participants. At the same time, there is a situation of few players, and the agents "know" each other well, which should facilitate relationships in the interest of "common" efficiency. This situation often contributes to the easy development of "personal ties" and (private) "coalitions" that are detrimental to the effective implementation of the regulatory framework. A major problem identified by the current study is the slow issuance of new permits by government authorities. In addition, the one-time licensing of main agents in the chain (such as WTPs for sludge production, transport companies for sludge transportation, etc.) and the infrequent (often only on received signals) control do not contribute to the effective maintenance of the quality standards envisaged in the regulatory framework.

In addition, the high asymmetry of information between the interested agents (the state, WTP, farmers, consumers, etc.) provides a great opportunity and creates incentives for non-fulfillment (violation) of the requirements of the regulatory framework, both by WTPs and by sludge-utilizing agricultural producers. So, for example, it is often practiced to provide farmers from WTPs, transport, and bring to agricultural lands incompletely treated sludge, apply higher than the allowed rates of sludge per unit of agricultural area, apply sludge also on unauthorized agricultural plots, and/or sludge is not applied in the prescribed

manner (with simultaneous burial), etc. All this is associated with a number of risks and negative effects in terms of the cleanliness of roads, soil, water and air, the health of farm workers, consumers of the farm products, etc.

The contradictions and conflicts of the interested agents (and the individual, economic and social effects) in the process necessitates the development of a special system for the management and control of sludge utilization in general and in agriculture in particular. This is associated with additional costs for individual agents and society as a whole (taxpayers) - for maintaining state bodies, for studying and complying with the regulatory framework, for taking soil samples, for obtaining permits, for relations with state institutions, etc. The introduction of a system of permits and control is also associated with the development of "dependency relations", as well as the possibility of unauthorized payments (and corruption) for quick and/or illegal obtaining of permits, for understated or ineffective control of the implementation of legal norms and restrictions, and as a result of insufficient or ineffective utilization of sludge in agriculture. Our study also found that there are also "conflicts of interest" as managers and experts of WTP are simultaneously interested farmers.

The degree of actual non-compliance with regulatory restrictions in the country as a whole is difficult to assess, since the agents involved are not interested in sharing this type of information, and the exact "measurement" of this type of effects is impossible to carry out by third parties (researchers, independent experts, etc.).

Scientific research in this "new" field has been episodic, underfunded, unrepresentative, on a small-scale and merely on experimental plots, with "ideal" instead of real samples, and without the involvement of sludge-producing and



transport organizations and sludge-using farms (high distrust, lack of interest, reluctance to publish the results, etc.). Moreover, systematic inter- and multi-disciplinary research is rarely carried out, combining the efforts of experts working in this field from different organizations (SSA, BAS, universities, etc.) in order to completely evaluate the achievements and reveal the diverse challenges.

An important factor for increasing the utilization of sludge in agriculture is the availability of versatile, up-to-date and reliable information about the opportunities, ways, conditions, effects, challenges and risks related to utilization of sludge in agriculture. Adequate normative, scientific, experimental and practical information is important not only for farmers, but also for all other participants in this process – government bodies and employees, WTPs, farmers, interested parties, end users and the general public.

This research found that such information in Bulgarian (only available to the majority of agents) and about the specific conditions of the country and its individual regions is very scarce and often contradictory. Very few publications are widely available, mostly in little read by farmers, business, the general public, etc. academic publications that are mainly based on experimental and laboratory experiments, most often presented in a foreign language. For example, a Google search can turn up a small number of publications in recent years by a limited number of authors. Episodic information may appear in the media, mainly about regulatory documents or publications induced by interested parties.

Moreover, comprehensive assessments of the real socio-economic and co-effects of sludge utilization among farmers of different types, specializations and locations are virtually absent. Furthermore, the results of published scientific, experimental and laboratory trials and tests are based on ideal conditions (optimal

agricultural techniques, correct fertilization rates, good management, etc.), which differs significantly from real farm practice. So, for example, the experiments are done with perfectly treated sludge, while in practice the sludge is often delivered and imported in a state different from the normative requirements – not treated or partially treated, with increased humidity, etc.

The survey found that many farmers are partially aware of the possibility of sludge utilization, but there is a strong lack of information about the necessary conditions, potential effects, risks, costs, etc. The lack of adequate information on these issues also negatively affects the attitudes of the population, producers in the area, and intermediate and final buyers of the farm products. The information deficit is most often "filled" with false information about the possible effects of agricultural utilization and resistance from both farmers and other interested parties.

In some scientific institutes of the SSA and other institutions there are long-term studies of the chemical-biological and agronomic effects of the use of sludge in agriculture. However, the scope and nature of these studies do not correspond to the modern needs of farmers and society. There are no interdisciplinary studies devoted to this important problem. There is a lack of independent tests and demonstrations, and promotion of practical sludge utilization in experimental or farm settings, and specific guidelines for optimal application in farms of different specialization, size, ecological and geographical location, etc.

The country still lacks reliable information on the quantity and quality of the formed sediments and their utilization in agriculture. There are huge discrepancies between the figures in different "official" sources and in general inaccuracy in the actual and estimated data on the amounts of sludge generated, treated and utilized

in Bulgaria (NSPUS, 2014). It is often even difficult to use officially available information - for example, the 2017 and 2020 reports of the EAA on sludge utilization are unavailable, many official documents and assessments are not published, etc. With few exceptions (Ivanov et al., 2021; IAI, 2021; Marinova, 2008; Syarov, 2020; Ivanov and Bachev, 2021), in-depth assessments and studies of the diverse benefits, effects and critical factors of sludge utilization in agriculture are also missing. There are also no assessments of alternative and hybrid forms of utilization of WTP sludge in different conditions. It is well known, for example, that in the long-term other alternatives for sludge utilization are to be sought, such as co-composting with bio-waste, bioenergy production by self-incineration of sludge and additional phosphorus use from the ash or directly during the liquid phase in GPSOV (NSPUS, 2014).

Official estimates show that the utilization of sewage sludge in the non-food sector of agriculture will not have problems related to land shortages, even in a scenario of significant reduction of sludge utilization rates per hectare (NSPUS, 2014). However, there are no institutional guarantees that the same lands will be used for the cultivation of non-food crops in the future, and therefore no reliable assessments of the risk of permanent soil contamination.

All these information problems do not allow informed decisions to be made by the different agents and at different levels of management, and creates mistrust and resistance to the expansion of the sludge utilization process in agriculture and other sectors of the economy. The information vacuum of public sector failure is often filled with incomplete, contradictory or unreliable information in the media of various kinds from incompetent or private sources, and in private, group or corporate interest.

The utilization of sludge in agriculture is a complex and dynamic process that also requires long-term specialized training and counseling of farmers. Our research found that there is no specialized training and consultation dedicated to the utilization of sludge in agriculture in the country. For example, there are no highly qualified experts and courses for long-term training and counseling of interested farmers in the Agrarian and other universities, SSA and National Agricultural Advisory Service. Some farmers also indicated that they "don't trust the native institutes" and therefore do not seek their services. All this greatly complicates the effective transition to the utilization of sludge in agriculture.

Some of the farmers using sludge in agriculture conduct their own experiments, find their own solutions and/or seek and find the necessary information and training, including abroad. Some of them consult each other, exchanging experience and useful information, or seek external advice from private consultants, WTP experts, scientific workers, etc. At the same time, depending on personal qualities (management experience, qualification, innovativeness, etc.), self-learning or "learning through experience" requires different time and gives different results for individual farmers, and in some cases can lead to incorrect or inefficient use of sludge, and not infrequently even the refusal to use sludge in farms.

However, our study found that most of the sludge-using farmers are reluctant to share their experiences for various reasons – lack of time, reluctance for publicity, company secrecy about yields and profits from competitors, etc. An important reason for this is also that they do not want new farmers to increase their interest in using sludge, as this will increase the demand in the area, increase

the "price" and reduce the "profitable" access to the limited resource "sludge". This further slows down the spread of this new practice in the country.

### ***Private initiatives and modes***

Main private agents involved in the utilization of sludge in agriculture are the organizations in the chain – WTPs (producing sludge), transport companies (transporting sludge from WTPs to farms) and agricultural producers using sludge. In addition, landowners, farmers and businesses in the area, residents and visitors to the region, traders, processors, end users, interest groups, etc., also occupy an important place in the institutional structure. (Figure 1). An important component of the analysis of institutional structure is the interests and incentives of the agents involved and the nature of their relationships.

The relationship between WTPs and user farmers is contractual, based on one-year or multi-year private agreements. Like all contracts, the parties are "free" to specify (negotiate) the terms of exchange and terminate their relationship in the absence of interest. In practice, however, there is a lack of a free market (many participants) of sludge for utilization, dominated by regional monopolies in the production (WTP), and a small number of potential carriers (for specialized transport) and end users - only farms with the status of sole traders and legal entities (cooperatives, corporations, etc.). Moreover, each of the participants in the chain has to be licensed by a competent state authority to guarantee the public interest (obligatory permits for treatment, transport and agricultural utilization of sludge).

Therefore, there is a typical hybrid organization with the participation of a third party (the state) in licensing and controlling the transaction agents and a number of technological characteristics (precisely defined areas and volume of sludge application in the licensed farm) of the transactions. Moreover, many of the

characteristics that the product must meet and the method of its utilization are (pre)determined by the regulations. By means of the private contract between the WTP and the farmer, the "right to utilize treated waste - sludge on areas cultivated by the farm authorized by a competent state body" is transferred. Very often, the right to agricultural utilization is provided "bundled" with services from the WTP - for example, "arranging a permit for the use of sludge", transporting the sludge, and spreading the sludge on agricultural lands, etc.). Sludge is usually provided to the farmer free of charge, with the user only paying the fuel costs for transportation and spreading (example in Sofia region). The absence of price and payment for the sludge is an expression of the mutual benefit of this non-commercial (non-monetary) exchange.

In principle, all WTPs should have an interest and developed strategies for effective management, and in the modern stage for effective utilization of sludge. When the amount of sludge formed is significant, this makes technologically modern and economically advantageous treatment possible and opens up the possibility of alternative utilization (instead of landfilling and incineration). The incentives for WTPs to provide sludge to farmers free of charge are a strategy for long-term corporate development, public relations (positive eco-image, lack of dissatisfaction from the local population), strong public pressure, lack of landfill sites, and also significant savings on costs for disposal, destruction, alternative use, payment of sanctions for violations of the regulatory framework, etc.

The benefits for farmers utilizing sludge are multiple positive economic, agronomic, production, ecological and other effects, presented in detail in another publication of ours (Bashev and Ivanov, 2021). Our study found that all sludge users are large producers who have a strong interest in minimizing the costs of chemical

fertilization and have the capacity to bear the additional costs of "external" relationships with WTPs and government authorities, experimentation, training, reorganization of the production process and management, risk taking and potential losses, etc. necessary for the agricultural utilization of the sludge. The introduction of sediments into agricultural lands requires a change in farming techniques, and a new better organization and management of production, which is the reason why it is mainly undertaken by innovative agricultural entrepreneurs.

Even when the transportation is carried out by a specialized (market) agent, for example a transport company, this must necessarily be preceded by the licensing of the chain agents and the conclusion of a contract between the WTP and the farm using the sludge. In this case, a price for the (transport) service is negotiated, which is paid individually or jointly by the WTP and/or the farmer using the sludge. In view of the great potential for business expansion, a transport company in the Burgas region has been making great efforts to increase the agricultural utilization of WTP sludge, including by lobbying for supporting agricultural producers through the CAP measures.

At first glance, there is a (quasi) monopoly situation in the contractual relations between the WTP and the sludge utilization farms. However, our research found that these relationships are of "mutual" (symmetric) dependency - capacity, location, time, etc. due to high transportation costs and other restrictions. The agricultural utilization of sludge in the country is at an initial stage, and the assets of the WTP for treating the generated sludge and the resulting "product" appear to be partially or completely highly bilaterally dependent on the assets (agricultural lands with received permits) of the user farms in the area. The degree of this dependence is determined by the amount of sludge for "agricultural" utilization,



and the (limited) number of permits for the use of sludge on certain farmers' land. There is often a strong bilateral dependency between the production of sludge and its transport to the farm by specialized transport. This is the reason why some large WTPs integrate these assets and activities and realize economies on transport and transaction costs (as is the case in Sofia region).

High symmetrical dependence is the basis for the development of long-term relationships between the same partners. Our survey in the Sofia region confirmed that most of the farms using sludge have been doing so for a long period of time, reaching in some cases up to two decades. Long-term cooperation between the same partners promotes good familiarity, development of trust, willingness for cooperation, restriction of opportunism, sharing information, and creation of mechanisms for coordination and conflict resolution, and minimizing transaction costs. This further facilitates relationships, reduces associated costs, and increases the efficiency of sludge utilization in agriculture.

Along with the economic benefits for farms, sludge utilization comes with additional costs for dealing with WTPs, regulatory bodies, soil sampling, etc. For example, contracts between WTPs and farmers are not comprehensive, require additional costs to coordinate and overcome potential conflicts, etc. Imperfect contracts also allow for unilateral "violation" of the agreement by the WTP at the expense of farmers - untimely delivery, supplying sludge in different quantity and quality, temporary suspension of supply to appease public discontent, etc. In addition, WTPs usually apply standard contracts not adapted to the conditions of specific farms. This further increases the costs in the sludge utilization process of adaptation, coordination between partners, contestation, etc.

The widely applied practice of one-year land rent agreements of large farms with numerous (hundreds and even thousands) of landowners also creates an additional risk of losses (e.g. one-time long-term investments related to the supply and use of sludge), in case of refusal to renew the rent-contract by of the land owner on areas with sediments or permits, during the new agronomic season (alternative use, sale, provision to another tenant, reluctance to deposit sediments, etc.).

On the other hand, (profit-oriented) WTPs also seek to minimize their costs for agricultural sludge utilization and prefer as counterparties large farms in the vicinity of sludge landfills - savings in negotiation and relationship costs, obtaining permits (no fees on the "paperwork" and the wait is long), soil samples, to transport sediments, etc. In all cases where the transaction costs for farmers and/or WTPs are very high, the agricultural utilization of sludge is reduced or completely blocked, regardless of the potential (production, economic, etc.) benefits for both parties. For example, the survey in the Burgas region found that a large farmer who used sludge in the past stopped this activity due to high costs for permits, soil samples and transport.

In the future, the effectiveness and incentives for the application of sludge instead of mineral fertilizers in agriculture will depend strongly (in direct proportion) on the price dynamics of mineral fertilizers of different types (mainly N and P, the substitute of which is sludge). In addition, interest in the use of sludge may increase with mandatory or voluntary (against receipt of public subsidies) restriction of the use of mineral fertilizers in certain regions, industries or farm types in the EU. An important limiting factor is the institutional uncertainty related

to the implementation of the Green Deal, the evolution of public tolerance, and the development of markets and consumer attitudes.

Some WTPs plan to sell the sludge to interested farmers in the future, for example in the Sofia region. In this way, sludge supply contracts will be commercialized and converted into "product (sludge) purchase and sale" contracts, with a price paid by the farmer or other intermediate wholesale buyer for the transfer of the "right to utilize".

However, many of the farmers surveyed felt that if the sludge was not provided for free but sold as a fertilizer product, this would further limit its agricultural use. There is no market for a similar product in the country, and the supply will be monopolistic (single supplier) in the relevant WTP areas. At the same time, this product is not highly farm-specific, as there are many alternatives among other (mineral, manure, etc.) fertilizers. Moreover, the competition with and among the companies supplying mineral fertilizers is high, and usually mineral fertilizers are sold in a "package" with additional services (credit, deferred payment, consulting, provision of seeds, etc.). Therefore, a strong development of the "sludge market" and trading of sludge at high prices cannot be expected in the coming years. Therefore, the increased and growing costs for efficient utilization of sludge in general and in agriculture in particular will continue to be mainly covered by WTPs (and respectively by water users) and/or by public programs (respectively by European, national or local tax payers).

Other stakeholders (landowners, neighboring farms and businesses, local population, interest groups, consumers, etc.) are also involved in "relationships" with the WTP, sludge-using farmers and public authorities. However, individual agents do not have the "power" to change the prevailing practices, due to

insignificant sizes of the (negative) effect on them, high individual costs and possibilities for "free riding" (one invests costs and all benefit if action is successful), difficulties for common "collective actions" of agents with divergent interests, power positions of and "dependence" on the large (producing, transporting and using sludge) agents in the area, etc. Only when the effect is highly negative and direct (for example, a strong smell during the delivery and spreading of sludge) are practically possible strong collective actions of the population in the area, which often lead to the cessation of sludge supplies for short periods of time (before their resumption after this).

Most often there is a psychological barrier, due to the "special nature" of this fertilizer (soil improver), both in the farmers themselves and in the landowners (leasing their land to a farm using the sludge), the residents of the area, the local farming (livestock, organic or ecological agriculture, etc.) and other interested businesses (tourism, etc.), interest groups (ecologists, healthcare, consumer protection, etc.) about the potential negative effects of using sludge in agricultural lands on soil quality and biodiversity, and the health of plants, animals and people. These informal rules of the game and how they affect each of the stakeholders are to be thoroughly analyzed. In other EU countries, for example (e.g. Northern France, Nederland, etc.), in areas with highly developed animal husbandry and mass application of manure, there is also a higher tolerance for the application of sludge in agriculture, both by farmers and the general population.

The market and buyers are also not yet "open" to the broad application of sludge in agriculture. Many wholesale buyers and end users question the safety of produce produced using sludge. This is often associated with reduced selling prices of farm produce and high marketing costs (including fraudulently declaring the use

of sludge). Last but not least, the farmers themselves and other interested parties are concerned about the long-term effects of the use of sludge on the natural environment - cleanliness and quality of soils and waters, the trampling of agricultural lands, the protection of natural biodiversity, maintaining the ecological sustainability of farms, etc.

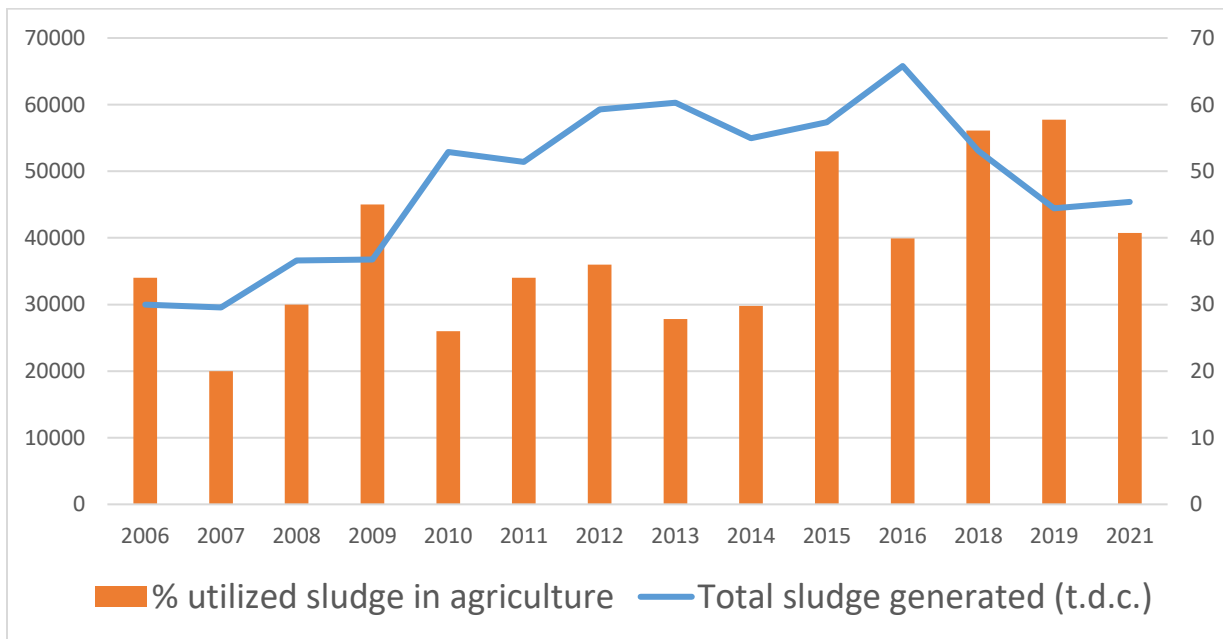
Interested agents can and do participate in the modernization of national and European policies, including in the field of WTP sludge utilization. However, the reverse impact of these elements of the institutional structure is highly limited because the "political process" is slow, with different priorities, and not always in the interest of overall efficiency. The same applies to the direct impact of these agents on the development of product and resource markets (fertilizers, agricultural land, etc.) and the natural environment due to lack of complete information, complexity, high uncertainty, and the need for expensive and long-term collective actions of enormous proportions and scales.

According to official statistics, by 2020 one of the goals of the National Strategic Plan for managing sludge from wastewater treatment plants in Bulgaria has been reached, as 70% of the total sludge generated from WTPs in the country has been materially utilized (EEA, 2021). At the same time, the realization of another important strategic goal "zero landfill and non-targeted temporary storage of sludge" has been significantly delayed and is unlikely to be reached in the coming years.

The impact of the institutional structure on the utilization of sludge in the country's agriculture is illustrated in Figure 2. The amount of WTP sludge generated in the country increased progressively in the period 2006-2016, after which it marked a significant decline. The share of utilized sludge in agriculture in the

country has fluctuated significantly since 2006 - from 20% (2007) to 58% (2018). Therefore, the institutional environment and governing institutions do not create favorable conditions for sustainable and growing utilization of WTP sludge in Bulgarian agriculture. Moreover, the different regions of the country do not have the same institutional efficiency, and the majority of the sludges used in agriculture are in the Sofia region (EEA, 2006-2021). The positive experience of WTP and sludge-using farmers in the Sofia region have to be thoroughly studied and replicated in other regions of the country. It is also necessary to identify the main factors and their importance, which hinder the development of this process in the other regions of the country.

**Figure 2. Evolution of the generated sludge from WTP in Bulgaria and share of utilized sludge in Bulgarian agriculture**



Source: EEA

## **Conclusion**

The utilization of sludge in general, and in agriculture in particular, is not automatic, but a complex process that depends on many institutional, production, economic, psychological, social, ecological, etc. factors. The specific institutional structure of this process largely determines its effectiveness and is to be thoroughly studied. This study is only the beginning of the necessary systematic research in this new and important field.

The present study found that over the last two decades, the institutional structure (regulatory framework, public, private, market and hybrid forms) of sludge utilization in Bulgarian agriculture has significantly improved. As a result, great progress has been observed in the agricultural use of sludge in the country. At the same time, however, uneven and unsustainable development of this process was found in the different regions of the country. Therefore, all factors limiting the behavior of the associated agents and leading to these fluctuations in sludge utilization are to be identified.

In view of their relevance, interdisciplinary studies and evaluations of the institutional structure and factors of sludge utilization in agriculture have to be expanded and enriched. However, for this, it is necessary to collect a new type of micro and macro information from all interested parties, including through the official system of agro-statistics in the country and the EU. In addition to identifying the critical factors influencing the behavior of agents along the chain, the degree of their significance is to be assessed and the existing failures in the institutional arrangement and the incentive system be identified. On this basis, detailed recommendations can be prepared for the improvement of public policies and

management strategies of WTPs and potential and sludge-using agricultural producers to improve this process.

In view of the leading role of public intervention in this area, a new national strategy for the utilization of WTP sludge is to be developed, reflecting modern conditions and social priorities, and special measures be taken to support the interested parties, including farmers with tools of CAP. An example in this regard is the inclusion of sludge in the official list of soil improvers, the use of which to replace mineral fertilization on farms is subsidized during the current program period.

Last but not least, trends in the development of the institutional structure and the utilization of sludge in other EU countries have to be studied in order to assess where Bulgaria is and where efforts are to be focused in the future. Every positive and negative experience in this regard has to be promoted in a timely manner in order to support the making of management decisions at different levels.



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