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Comprehensive approach to the establishment, development, financing, stimulation, promotion, and implementation of the environmentally related activity: the EU as a case study

MONOGRAPH

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«An interdisciplinary approach to waste management study: implementing the EU practices» (621029-EPP-1-2020-1-UA-EPPJMO-MODULE)

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INTRODUCTION

In the relentless pursuit of sustainable and environmentally responsible practices, nations worldwide find themselves navigating the complex nexus of regulations, funding mechanisms, and innovative strategies essential for effective waste management. This monograph undertakes an extensive examination of the inception, evolution, financing, stimulation, promotion, and execution of environmentally related activities, with a specific emphasis on the European Union (EU). Approaching this matter with discernment, the work critically analyzes the EU's waste management policies, leveraging insights from its legal frameworks, funding mechanisms, and successful case studies. Simultaneously, it draws attention to the challenges encountered by Ukraine, a nation earnestly endeavoring to harmonize its waste management strategies with EU standards.

Conceived under the umbrella of the EU Erasmus+ Program's "Jean Monnet Module" initiative, this monograph delves into the interdisciplinary dimensions of waste management study encapsulated in the project titled "An Interdisciplinary Approach to Waste Management Study: Implementing EU Practices" (Project ID: 621029-EPP-1-2020-1-UA-EPPJMO-MODULE). This initiative embodies a commitment to fostering knowledge exchange, interdisciplinary collaboration, and the integration of EU best practices into the fabric of waste management strategies.

The content of this monograph unfolds in a structured progression, commencing with an exploration of the legal framework underpinning waste management in the EU. Consequently, this monograph serves as a comprehensive guide, shedding light on the intricate interplay of legal, financial, and strategic dimensions in pursuing sustainable waste management practices. The EU emerges as a rich source of experiences and lessons, offering a tapestry of insights for nations aspiring to navigate the path of environmental stewardship.

1. Understanding the legal framework of waste management in the European Union

1.1. European Union Regulations on Waste Management. Key Legal Frameworks and Directives

The foundation of modern global waste management approaches was initially laid during the International Conference on Sustainable Development held in Johannesburg in 2002 [1]. At this landmark event, key strategies were delineated, encompassing waste reduction, promoting maximum reuse and recycling, and adopting environmentally friendly alternative materials. Implementing these strategies holds excellent promise, minimizing the adverse impacts of waste on both human well-being and the environment and enhancing the efficient utilization of secondary resources.

Within European Union (EU) member states, pursuing effective waste management entails a concerted effort involving national measures and formulating comprehensive strategies. These strategies govern various facets of waste management, spanning its generation, monitoring, processing, and ultimate disposal. They are articulated through many documents and can be broadly categorized into two major groups: programmatic and regulatory.

Programmatic documents, often called Action Programmes, serve as foundational frameworks that outline primary objectives for EU countries over medium to long-term periods, typically spanning from 3 to 10 years or even longer. Regulatory documents, on the other hand, play a pivotal role in translating these objectives into tangible actions. They may take the form of framework directives, such as the Waste Framework Directive, providing overarching guidelines, or they may pertain to specific tasks, such as regulating emission limit values for waste incineration or landfill technology.

EU Action Programmes are distinctive within this framework as strategic documents that establish concrete targets to be achieved over extended time horizons, whether in the long or medium term. These coordinated efforts at the programmatic and regulatory levels form the backbone of the EU's waste management initiatives, driving progress towards sustainable practices and reducing environmental impact.

Expanding on these principles, the EU has made substantial strides in aligning its waste management strategies with the broader goals of sustainable development and environmental protection. These efforts are crucial for addressing the challenges posed by waste generation, fostering resource efficiency, promoting circular economy practices, and mitigating the environmental footprint of human activities. Furthermore, the EU's commitment to international sustainability agendas underscores its dedication to sharing its expertise and best practices with the global community, contributing to the worldwide pursuit of responsible waste management. As a striking illustration of proactive measures within the European Union, pursuing sustainable development strategies has led to a deliberate endeavor to sever the connection between economic production growth and waste generation. A pivotal document addressing overarching waste management concerns is the Waste Framework Directive (2006) [2]. This directive plays a crucial role by identifying substances that qualify as waste, implementing the "polluter pays principle," and establishing a hierarchical framework for preferred waste management methods. This hierarchy encompasses the following steps: prevention of waste generation or source minimization, reuse, transformation into raw materials and products, composting, incineration or burial with energy recovery, burial without energy recovery, and finally, incineration without energy recovery.

An illuminating example of the impact of such directives can be witnessed in the experiences of Poland and the Czech Republic. Over two decades, Poland managed to reduce the proportion of municipal waste disposal from an alarming

98% to a more sustainable 42%, with EU financial support playing a pivotal role in catalyzing this transformation. Similarly, the Czech Republic achieved a significant reduction, lowering its figure from 93% to 49% over the same period. The Extended Producer Responsibility (EPR) policy approach, involving financial contributions from businesses, emerged as a critical driver behind this substantial progress.

Furthermore, the Czech Republic is poised to take a significant step forward in its waste management approach by implementing a complete ban on the disposal of unsorted mixed municipal waste within the next four years. Such a prohibition, which has been in effect in numerous EU countries since the early 2000s, represents a proactive stride towards more sustainable waste management practices. Subsequent sections of this paper will delve deeper into the development and evolution of waste management systems in select countries, offering a comprehensive exploration of their strategies and achievements in this vital arena.

The European Union's Environment Action Programme for 2002-2012, jointly adopted by the European Parliament and the European Council [3], laid out a deliberate roadmap to reduce the volume of waste destined for disposal. The program set ambitious targets: a 20% reduction in waste disposal between 2000 and 2010 and a more substantial 50% reduction by 2050. As a result, waste generation was projected to grow at a rate 15% slower than the gross national product of the EU.

In furtherance of this commitment, the Waste Incineration Directive [4] was introduced to establish rigorous emission limit values for incinerators and cogeneration units. This directive also delineated specific fractions of municipal waste that must undergo separate collection and cannot be subjected to incineration. Concurrently, the Landfill Directive [5] introduced comprehensive measures designed to mitigate risks to human health. It encompassed aspects such as waste treatment before burial, separating and distinct handling of hazardous and non-hazardous waste, and rigorous oversight of landfills throughout their operational lifecycle and post-closure.

A notable initiative in the United Kingdom (UK) revolves around distributing biodegradable packaging materials. This project operates under a voluntary agreement between major supermarkets and the Waste and Resources Action Programme [6], with 35 prominent retail chains and distributors participating collectively in 92% of the nation's grocery market. Simultaneously, the UK is advancing a "halve landfills" project to reduce waste generated during construction and demolition activities.

In France, Eco-Emballages [7] are pivotal in providing training and guidance on minimizing packaging waste, primarily targeting engineering students and the wider public. Meanwhile, Belgium has launched a regional program, particularly in Flanders [8], aimed at substantially reducing household waste, with a notable portion of the processed trash being redirected toward energy production. Under Ireland's National Waste Prevention Committee umbrella, the Green Business Initiative supports businesses and organizations across three critical domains: waste management, water conservation, and energy efficiency [9].

These initiatives, whether at the EU level or within individual member states, exemplify a proactive commitment to sustainable waste management practices. They underscore the importance of collaborative efforts in addressing the intricate challenges of waste generation and disposal. Finland's "It's Smart with Less Waste" program is a pioneering initiative focusing on waste reduction and seamlessly integrating innovative digital tools and smart technologies. These advancements empower participants to monitor and fine-tune their waste management practices in real time, providing invaluable data and insights to drive continuous improvements.

In Hungary, a burgeoning market for reusing building materials has given rise to online platforms and apps facilitating the exchange of construction materials among companies and individuals. This digital marketplace curbs waste and fosters community engagement as surplus construction materials find new life in diverse projects, championing sustainability and cost-effectiveness.

Austria's Act on Waste Management (2002) stands out for its proactive approach to eco-design and consumer engagement. It encourages manufacturers to imbue products with sustainability from inception, emphasizing responsible production and distribution processes. Austria has also taken the lead in incentivizing consumers to make eco-conscious choices through initiatives and awareness campaigns.

France boasts an extensive network of recycling centers and state-of-the-art waste-to-energy facilities, underscoring its impressive recycling achievements. These facilities recover raw materials and generate renewable energy from waste, substantially contributing to the country's energy requirements while diminishing landfill waste. France's unwavering dedication to circular economy principles has nurtured the growth of numerous innovative startups specializing in waste recycling and resource recovery.

Furthermore, many European countries, including France, have recently embraced the circular economy concept. They emphasize the imperative to minimize waste and maximize resource efficiency. Circular economy practices revolve around extending product lifespans, reducing consumption, and advocating for repair, refurbishment, and recycling. These endeavors collectively diminish the environmental footprint of resource extraction and production, reinforcing France's commitment to remarkable recycling and waste recovery efforts. Since 1992, eco-packaging has emerged as a pivotal component in orchestrating specialized organizations dedicated to the selective processing specific materials. Noteworthy examples include Aliapur, specializing in rubber tire recycling; Valorplast, dedicated to plastic and household packaging; Ecopse, focused on polystyrene; Recyfilm, committed to plastic films; Ecofut, dealing with plastic containers; Motus-Véolia, managing paper and document recycling; and Adivalor, addressing agricultural waste. These entities have streamlined waste management and established standardized tariffs for repurchasing waste from collectors and purchase prices for processing facilities. This sector has garnered significant attention from international investors, drawn by its potential for sustainable growth.

England and Wales's legal framework governing hazardous waste disposal has traditionally leaned heavily on EU legislation. Among the pivotal documents shaping waste disposal regulations in the EU today, the Waste Directive 2008/98/EC holds particular prominence [12]. British legislation concerning hazardous waste disposal is built upon two regulations incorporated into EU law: The Waste (England and Wales) Regulations (2011) and the List of Wastes (England) Regulations (2005). These regulations effectively transpose the European Waste Catalog, as endorsed by the decision of the European Commission 2000/532/EC, into English law. A fundamental tenet of The Waste Regulations is the strict accountability it mandates for enterprises involved in processing and disposing of hazardous waste. This emphasis on responsibility underscores the commitment to responsible waste management practices within the region.

The paramount document within the European Union governing the intricacies of waste incineration is the Industrial Emissions Directive 2010/75/EU. This directive outlines the exacting technical requirements that waste incineration facilities must adhere to, including the nuances of electricity generation. In 2013, the United Kingdom integrated this directive into its legal framework through amendments to the Environmental Permitting Regulations 2010.

The overarching public policy framework can be distilled into six fundamental principles, initially articulated in the Strategy for Hazardous Waste Management in England 2010, a publication by the Department of Environment, Food, and Rural Affairs of Great Britain.

In the contemporary discourse, increasing attention is dedicated to the "economy of recycling." This approach recognizes the transformation of waste into invaluable resources and underscores its role in mitigating the costs associated with landfill disposal. Additionally, recycling initiatives invigorate the economy, generating numerous job opportunities. For instance, statistics reveal that disposing of 10 tons of waste in landfills creates a mere six jobs, whereas recycling the same quantity generates an impressive 361 jobs. The economic benefits are significantly magnified when locally sourced recycled materials are employed, eliminating the necessity to import similar resources from distant or foreign origins. This strategy, progressively embraced within the European Union, underscores recycling as an unrivaled avenue for conserving valuable resources. Notably, recycling delivers impressive energy savings: aluminum production saves up to 95% of energy, while recycling copper and steel achieves savings of 85% and 74%, respectively. Even lead recycling reduces energy consumption by an impressive 65% [18].

Glass, in particular, stands as a paragon of recycling, capable of being reused indefinitely without any compromise in quality or purity, masterfully crafted into an array of intricate forms. Astonishingly, recycling one ton of glass conserves an equivalent ton of precious natural raw materials.

Nonetheless, a conspicuous challenge lies in effectively managing construction waste and demolition debris, constituting a substantial proportion of all EU-regulated waste. This extensive category encompasses various materials, from concrete and bricks to wood, plastics, and various metals. The primary objective in this realm is to diligently reduce such waste by a substantial 70% through meticulously devised reuse and recycling methodologies. Presently, reuse rates fluctuate widely across EU countries, ranging from a modest 10% to an impressive 90% [19].

The rapid advancement of organic agriculture and the proliferation of alternative fuel production methods have heightened the significance of recycling biowaste. This encompassing category comprises various components:

1. Food Waste. This encompasses discarded food materials.

2. Organic Waste. Surrounding waste of vegetable or animal origin.
3. Biodegradable Waste. Comprising materials that decompose either anaerobically or aerobically, such as food, garden waste, paper, and cardboard.
4. Biowaste. Encompassing the green mass from gardens and parks and food and kitchen waste generated by households, restaurants, cafes, and food-related businesses [20].

Composting has emerged as an exemplary method for recycling organic waste from kitchens, gardens, and agriculture. Large-scale composting facilities are overseen by the European Compost Network, an organization with 72 associate members spanning all 27 EU countries, providing services to over 3,000 companies [21].

Remarkably, Italy has pioneered the establishment of a network of "eco-volunteers" entrusted with enlightening the public about the benefits of "selective" food waste collection. This grassroots movement has yielded impressive outcomes, with up to 80% of households in participating communities actively engaging in food waste separation. An astounding 90% of households have adeptly embraced home composting practices. The positive impact extends to reduced household waste removal fees, underscoring the effectiveness of such initiatives.

In the English county of Kent, a comparable project has witnessed the enthusiastic participation of 95,000 households. These endeavors underscore the potential for grassroots involvement in sustainable waste management, delivering tangible benefits to communities and the environment. Advancing the waste management hierarchy, we encounter the next level, commonly called "other uses" in EU documents, often termed "waste-to-energy." This waste management facet involves using specialized facilities to incinerate waste, harnessing its energy potential. Notably, in several EU countries, including Germany, Belgium, Sweden, the Netherlands, Austria, and Denmark, the proportion of waste destined for landfills now stands at 1-2%. A substantial 35-50% of garbage undergoes various forms of incineration, while an impressive 50-60% undergoes recycling and composting processes. Notably, all these nations have enacted laws prohibiting landfilling without prior treatment [22].

In this context, a pivotal concept passionately championed by the diligent working group of the World Energy Council is the "energy balance." This concept asserts that the energy derived from waste should effectively offset the energy expenditures incurred during waste recycling. Another promising avenue within the waste recycling realm is biogas production. Directive 2009/28/EC, widely recognized as the Renewable Energy Directive, has set ambitious objectives for Member States. They aim to achieve a substantial 20% share of renewable energy consumption across all sectors by 2020, with a specific mandate of at least 10% in the transport sector [23].

The future of renewable energy in Western Europe is undeniably promising, with biomass emerging as a pivotal player. Biomass, encompassing organic materials like wood, agricultural residues, and waste products, is poised to lead the region's renewable energy portfolio. Projections indicate that biomass holds the potential to supply up to two-thirds of Western Europe's renewable energy requirements. This remarkable shift toward biomass signifies a significant stride in reducing dependence on fossil fuels and mitigating the environmental ramifications of energy production.

One of the most noteworthy developments in this renewable energy landscape is the swift adoption of biogas as a sustainable transportation fuel. Biogas, generated through the anaerobic digestion of organic matter, including agricultural waste, sewage, and food scraps, is gaining momentum in several European countries. Germany, France, Sweden, and Switzerland are at the forefront of this movement. The increasing utilization of biogas curtails greenhouse gas emissions and diversifies the transportation sector's energy mix.

This transition to biogas-powered transportation heralds the onset of an era characterized by "green transport." Biogas-powered vehicles emit fewer pollutants and less carbon dioxide, making them an environmentally conscientious alternative to traditional gasoline or diesel vehicles. Moreover, biogas production promotes responsible waste management practices by harnessing energy from organic waste materials that might otherwise find their way into landfills.

While biomass and biogas offer promising solutions for renewable energy and transportation, addressing the less favorable option of landfilling waste remains imperative. European Union directives unequivocally categorize landfills as the "least desirable option" for waste disposal, emphasizing the importance of minimizing their use whenever feasible.

EU directives impose stringent regulations governing the types of waste permissible in landfills. Materials such as liquids, flammable substances, explosives, oxidizable materials, medical waste (due to infection risks), car tires, and specific other categories are strictly prohibited from being deposited in landfills. This rigorous prohibition is designed to forestall environmental contamination, diminish health hazards, and mitigate the potential for hazardous incidents.

Moreover, these directives mandate that only pre-treated waste, which has undergone specific processing to reduce its environmental impact, may be allowed in landfills. This rigorous approach underscores the unwavering commitment of the European Union to sustainable waste management practices. It showcases the region's dedication to safeguarding the environment and public health while advancing toward more sustainable and circular economies.

In a pivotal move in 2015, the European Commission adopted the program titled "Closing the Loop – An EU Action Plan for the Circular Economy" [24]. At its core, this program champions the concept that "everything possible should be recycled." It envisions a transition to a more circular economy, where the value of products, materials, and resources is preserved within the economic cycle for as long as possible, simultaneously minimizing waste generation. This shift is viewed as a crucial contribution to the broader objectives of the European Union, including sustainability, reduced carbon emissions, enhanced resource efficiency, and maintaining competitiveness.

Today, the idea of sustainable development is intricately interwoven with the principle of reducing resource consumption per unit of output, and the concept of a circular economy has emerged as a cornerstone within the framework of the "green economy" [18; 25]. Estimations provided by the Ellen MacArthur Foundation [26] suggest that companies in the European Union engaged in producing durable goods could realize substantial annual savings of up to $630 billion by 2025, thanks to their emphasis on the circular economy. Furthermore, when we examine sectors such as households, transportation, housing, and the food industry, costs are projected to decrease by approximately 25% by 2030. This serves as a testament to the tangible benefits of embracing circular principles.

In recent years, the financial landscape surrounding the circular economy has predominantly focused on three essential objectives:

1. Promoting Best Practices involves showcasing exemplary practices to attract potential investors and engage various stakeholders.

2. Analyzing Specific Projects. In-depth examination of individual projects and their financial requirements to ensure their successful implementation.

3. Financial Consultation. Providing expert financial guidance to facilitate the integration of circular economy principles into business operations.

Furthermore, concerted efforts have been made to coordinate activities among enterprises operating within the circular economy, promote circular projects, and facilitate their financial support. Lending initiatives have also emerged to support business organizations involved in circular endeavors, particularly for medium- and long-term projects. The European Investment Bank allocated 40 billion euros for municipal solid waste management in 2020 [25]. This financial commitment underscores the European Union's commitment to transitioning to a more circular and sustainable economic model.

1.2 Waste Management Practices in Selected EU Countries

It's worth highlighting that some of the most proactive environmental policies are successfully implemented in countries like Sweden, Denmark, Germany, and the Netherlands.

Sweden, in particular, has adopted an exemplary system for shared responsibility in waste collection and treatment. In this system, households (municipalities) are responsible for separating and disposing of waste in designated containers, often conveniently located within 300 meters of any residential area. Homeowners typically contribute an average of SEK 2,000 annually for waste collection services. The number of waste fractions (various types of waste collected on different days of the week) can vary from municipality to municipality and range from 10 to 15. Additionally, roadside garbage collection is efficiently organized.

Depending on their specific activities, Swedish manufacturers play a pivotal role in organizing waste collection systems. They also provide consumers with relevant information about proper waste disposal. Various business structures are accountable for collecting materials not handled by households or manufacturers. In practice, a manufacturer can either manage the collection and export of their packaging and containers, which can be challenging and almost impractical, or opt for a more streamlined approach. They can enter into contractual agreements with companies that are part of the "dual system." In the latter case, manufacturers who choose this route receive a "Green Dot" (der Grune Punkt). This special symbol signifies the manufacturer's commitment to covering all the waste processing costs. This commitment ensures the guaranteed collection and recycling of the labeled packaging materials. Over time, the “dual system" expanded to encompass a broader range of waste, including plastics, glass, aluminum, composite materials, and paper and cardboard packaging.

Sweden has remarkably reduced landfill usage, with less than 1% of waste now directed to landfills. The country boasts approximately 6,000 recycling stations, each functioning independently and dedicated to collecting various materials, including packaging, newspapers, and other types of waste. The overarching framework for this network operates on the principle of Extended Producer Responsibility (EPR), a model that ultimately finances these recycling efforts. The upper echelon of this waste management system comprises thermal power plants unless the waste is earmarked for biogas production. Sweden currently houses over 30 robust incinerators, collectively possessing a capacity that exceeds the available fuel supply. Interestingly, Sweden imports substantial waste, primarily from Norway, the UK, and Ireland, to more than 1.5 million tonnes annually [27]. Approximately 20% of the nation's domestic heat demand is impressively met through waste incineration.

In Sweden, the strides toward sustainable practices extend to transportation, where two-thirds of the country's bus fleet operates on renewable fuels. Transport biomethane, a crucial component in this renewable transition, is produced in several cities, including Örebro, Uppsala, Västerås, the provinces of Södermanland and Östergötland, and around Stockholm.

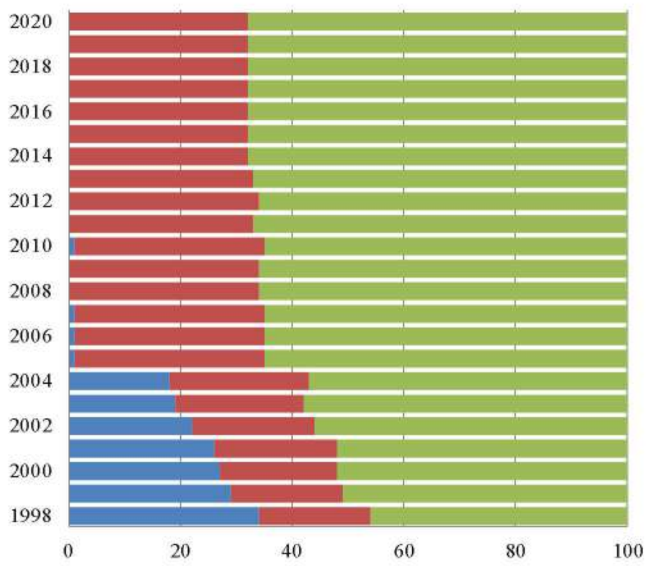
On the other hand, Denmark has developed a highly effective waste management model with a clear division of roles, responsibilities, and competencies among various stakeholders, including state, regional, and local authorities, waste generators, and waste management companies. This structured approach encompasses managing all types of waste, whether domestic, industrial, or hazardous. The local government assumes the entire responsibility, dictating the methods of waste collection and subsequent treatment, guided by rules strictly enforced for waste generators. The system is underpinned by the "polluter pays"principle, and its fundamental process revolves around the principle of separate waste collection. Aligned with Denmark's national goal outlined in the Energy Agreement, there is a concerted effort to achieve complete independence from fossil fuels by 2050, leading to a significant increase in funding for bioenergy projects.

Kalundborg, a city in Denmark, has pioneered the world's first industrial symbiosis grounded in the circular economy concept. This innovative model fosters collaboration among participating companies, where one company's production by-products become a resource for another. This symbiotic interaction has a positive environmental impact and results in substantial economic savings and a noteworthy annual reduction of €24 million in operational costs for consortium members.

At the forefront of global waste management systems, Germany has established itself as a leader with one of the most advanced and sophisticated frameworks. The technical prowess of the German waste management system far surpasses the European average, with household waste recycling exceeding 90%, a remarkable contrast to the continental average of 37%. The country boasts an overall material recycling rate exceeding 80%, including notable figures such as 70% for paper, 94% for glass, and 45% for steel, all derived from "secondary" materials [29]. To put this into perspective, the energy saved from recycling plastic bottles alone could provide heat for almost 2 million Berliners for 130 days. A comprehensive overview of Germany's waste disposal, incineration, and recycling practices is presented in Figure 2.1.

Reflecting on the 1960s, Germany once had over 50,000 landfills, lacking significant security measures. Since 1980, most have been closed, and around 150 large, well-organized dumps persist. In 2005, legislation prohibited household waste disposal at landfills without intensive pre-treatment. Today, non-recyclable household waste undergoes incineration or intensive mechanical and biological processing. This involves the removal of valuable materials, especially metals, for re-circulation and the use of elements with high heat capacity as fuel substitutes. The remaining waste undergoes biological treatment, ensuring that when humus is placed on the landfill, no gases are emitted, and there's no risk of subsidence. Efficient waste management in Germany hinges on the mandatory separate collection of recyclables, with most waste now conveniently disposed of close to households.

This waste management model has influenced practices in Ukraine, where residential areas are equipped with separate containers for residual waste (gray container), paper (blue container), packaging (yellow bag or basket), and organic waste (green or brown container). Glass is meticulously collected in separate containers, often categorized by the color of the glass (white, green, brown, or multicolored). Additionally, large waste items, including electrical equipment, can be recycled. Specific waste items like batteries and fluorescent lamps are conveniently handed over at purchase in compliance with relevant laws that mandate sales outlets to accept such waste [30].



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
waste disposal	34	29	27	26	22	19	18	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
waste incineration	20	20	21	22	22	23	25	34	34	34	34	34	34	33	34	33	32	32	32	32	32	32	32
recycling	46	51	52	52	56	58	57	65	65	65	66	66	65	67	66	67	68	68	68	68	68	68	68

Fig. 2.1. Germany's Waste Management, Incineration, and Recycling Trends. A Look at 1998-2020

In the Netherlands, the transition to a circular economy is not just a goal but a national priority endorsed at the state level. The commitment to this objective was underscored by the inception of the RACE program (The Realization of Acceleration of a Circular Economy) in 2014, followed by the government-wide Circular Netherlands until 2050 initiative in 2016. This overarching program sets a dual-phase trajectory, with the first phase targeting a 50% reduction in primary raw materials (minerals, fossils, and metals) by 2030. The five priority sectors or programs integral to expanding the circular economy are biomass, food, plastics, manufacturing, construction, and consumer goods.

Dutch experts have identified nine fundamental principles, or "9 Re," encapsulating the essence of the circular economy: refusal to overuse raw materials (Refuse); reduction of raw material use (Reduce); Reuse; maintenance and repair (Repair); refurbishment (Refurbish); remanufacturing of new products from elements of the old (Remanufacture); use of the product for other purposes (Repurpose); recycling and reuse of materials (Recycle); and energy production from materials (Recover).

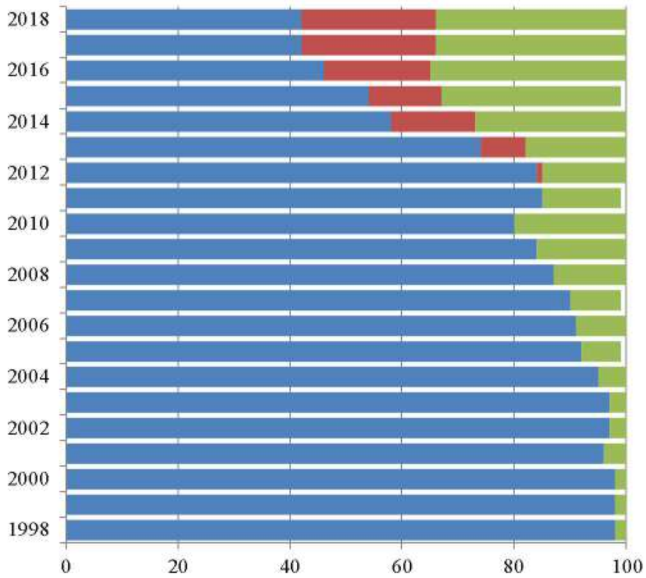
The implementation of circular methods is gaining traction in urban construction, particularly in Circular Amsterdam. Focusing on “reasonable demolition” preserves structural elements and materials that can be repurposed in new construction. The city’s housing projects are designed with a “modular and flexible” approach, allowing for remodeling without requiring extensive reconstruction [32].

In Poland, adherence to EU directives has led to the adoption key legislative acts, including the Act on Maintaining Cleanliness and Order in Municipalities (1996) and the Act on Packaging and Packaging Waste Management (2013). These laws delineate the terms and fundamental principles of waste management and processing, utilization, and disposal methods. The issuance of permits for waste generation, exclusive to enterprises, is carried out by the voivodeship (regional council) or county (district council). Notably, the legislation emphasizes the development of waste management plans at national and voivodeship levels, guided by self-sufficiency and proximity of location.

The transformation in the structure of solid waste management in Poland from 1998 to 2018 is elucidated in Figure 2.2. A pivotal shift in Poland's landfill practices commenced with its accession to the EU. During negotiations with the EU, Poland secured a transitional landfill period, marking a crucial phase in waste management reform. The turning point came with the "waste revolution" of 2012-2013, during which the state delegated the responsibility for municipal waste to local governments. Since then, local authorities in Poland have been instrumental in determining garbage removal prices for residents and ensuring compliance with EU directives, particularly in waste sorting and recycling.

Poland has banned storing flammable and explosive substances to mitigate the risk of landfill fires. Moreover, numerous Polish landfills have undergone modernization and technical upgrades facilitated by EU funds. A significant stride was made in waste incineration with the opening of six new plants in Białystok, Bydgoszcz, Kopin, Kraków, Poznań, and Szczecin in 2015-2016, followed by another in Rzeszów in 2018. The European Commission's approval of 100 million euros for constructing two new incinerators in Poland further underscores the commitment to advanced waste management practices.

Comparatively, in the early 2000s, Poland resembled Ukraine in the volume and morphology of solid waste and the state of waste management infrastructure. The subsequent years have witnessed Poland's concerted efforts and strategic investments, leading to notable advancements in waste management and environmental sustainability.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
waste disposal	98	98	98	96	97	97	95	92	91	90	87	84	80	85	84	74	58	54	46	42	42
waste incineration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	15	13	19	24	24
recycling	2	2	2	4	3	3	5	7	9	9	13	16	20	14	15	18	27	32	35	34	34

Fig. 2.2. Polish Insight. Dynamics and Evolution in Solid Household Waste Treatment Structures (1998-2018), %

Source: [33-35]

Over the past 15 years, Poland has made significant strides in waste management, reducing waste disposal from 97% to 42%. The success can be attributed to two key factors. Firstly, the recycling industry flourished, driven by extensive public engagement campaigns promoting effective sorting practices. Secondly, there was a notable surge in the construction of incinerators across the country, marking a shift from the lowest tier of waste management (disposal) to the second-to-last level (recovery). This transition has enhanced Poland's energy independence and embraced waste-to-energy technology.

Legislation plays a crucial role in shaping waste management practices in Poland. It mandates the treatment of used oils through regeneration instead of burning. Additionally, regulations govern the management of biodegradable waste, such as greens and food, necessitating separate collection and composting. There are two primary methods for managing biodegradable waste: composting, which emits methane into the atmosphere, and anaerobic fermentation, followed by combustion and electricity generation.

According to the waste management plan, municipal waste cannot be transported out of the region, except for hazardous wastes lacking recycling facilities. Monitoring and control mechanisms, led by entities like GOAP and waste collection companies, ensure the proper movement of machinery and accurate declarations. Issuing a mandatory waste transfer card by the waste-generating company, given in triplicate, places responsibility on the waste generator for the future fate of the waste.

Slovenia's waste management approach, particularly in Ljubljana, is noteworthy. Residents pay a monthly fee of up to 10 Euros per household for mixed and organic waste, with waste sorting options available in five different containers: mixed waste, organic waste, packaging, glass, and paper. The municipal company collects all types of waste, but residents are only charged for mixed and organic waste. The revenue from selling waste as a secondary raw material and the operation of Extended Producer Responsibility (EPR) systems (for packaging) covers the costs of other waste categories. Residents access public containers using an electronic resident card, while individual houses have waste containers, with charges based on container volume.

Ljubljana significantly emphasizes waste prevention, involving all stakeholders through local waste prevention programs. Initiatives such as individual composting, design alterations for specific products, access to public drinking water to minimize plastic bottle usage, the establishment of repair shops, collection points for reusable items, the introduction of green procurement systems for municipalities, and the development of a food waste management program all contribute to proactive waste prevention measures.

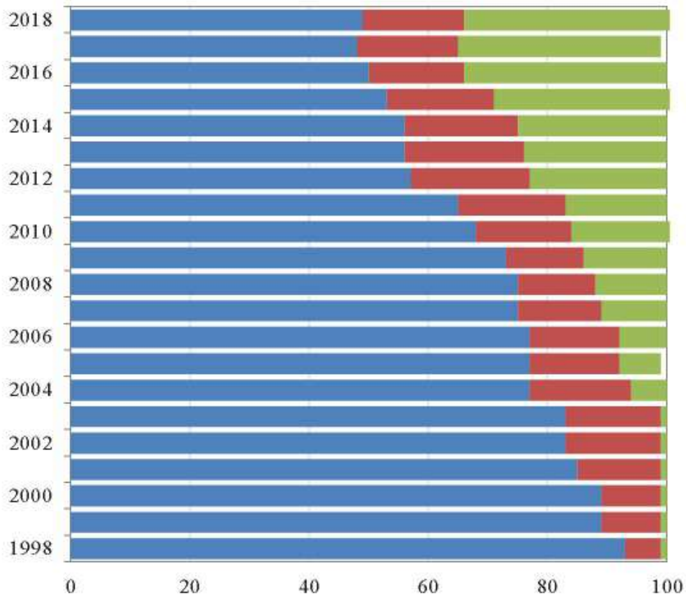
Snaga Ljubljana, a prominent Slovenian municipal waste management company, is vital to effective waste management in the region. Beyond waste management, Snaga oversees municipal public spaces, green areas, and public toilets. The company extends its support to Ljubljana's regional parks. It demonstrates its commitment as a leader in devising and implementing sustainable waste management solutions, emphasizing environmental consciousness and cost-effectiveness.

The primary thrust of Snaga's efforts is directed toward waste prevention, achieved through close collaboration with the municipality. The company actively promotes Ljubljana's transition towards a closed-cycle economy, emphasizing waste reuse and recycling. A significant milestone in this journey occurred thirteen years ago when Snaga Ljubljana initiated a separate collection of bio-waste. The company transforms this bio-waste into pure and high-quality compost through anaerobic fermentation. This compost, a byproduct of the process, is made available for purchase by residents or farmers. Notably, this compost produces biogas, which is utilized for electricity production.

In the Czech Republic, the evolution of waste management can be delineated across various stages, with crucial data on waste disposal, incineration, and recycling depicted in Fig. 2.3. The initial steps were taken between 1986 and 1989 when the aging incinerators in Brno (processing 248 thousand tons of waste annually) and Prague (handling 310 thousand tons of waste annually), constructed in 1905 and 1930, respectively, underwent significant reconstruction. Adopting the first Waste Act in 1991 was a crucial milestone in this trajectory.

In 1992, a tax on waste disposal (up to 1 euro per ton) was introduced, and the State Environmental Fund was established. In 1999, a waste incineration plant was built in Liberec (96 thousand tons of waste per year). In 2001, the waste hierarchy was determined, the foundations of EPR were laid, and tariffs for waste management, including waste disposal, were determined (Waste Act 2001). In 2002, the extended principles of the EPR of packing (Waste Act 2001) were fixed, and in 2003, the Waste Management Plan was approved until 2014

(2003-2014 Waste Management Plan). In 2004, the Czech Republic joined the EU and in 2007, 776 million euros became available to the Czech Republic under the EU Waste Management Program (2007-2014). In 2009, the landfill tax was increased to 19 euros per tonne (in 2007, it used to be 15 euros, and in 2002 – 7 euros). In 2014, a ban on the disposal of unsorted mixed municipal waste from 2024 has been introduced.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
waste disposal	93	89	89	85	83	83	77	77	77	75	75	73	68	65	57	56	56	53	50	48	49
waste incineration	6	10	10	14	16	16	17	15	15	14	13	13	16	18	20	20	19	18	16	17	17
recycling	1	1	1	1	1	1	6	7	8	11	12	14	17	17	23	24	25	30	34	34	35

Fig. 2.3. The Waste Management Landscape in the Czech Republic. Disposal, Incineration, and Recycling Trends (1998-2018), %

The next step was to approve a program to prevent waste generation by 2024 in various sectors of the economy, including dissemination of quality information among businesses and households, inclusion of lessons in schools, research, etc. (2015-2024 Waste Prevention Program). The waste management plan has also been approved until 2024, focusing on waste prevention, recycling, reuse, and transition to a circular economy (2015-2024 Waste Management Plan).

Since 2015, municipalities across the Czech Republic have adopted a mandatory program for the separate collection of biowaste. Setting the stage for 2019 and beyond, strategic priorities include an escalation in landfill taxes, a cautious approach to the incinerator and mechanical/biological plant construction, an emphasis on boosting recycling rates—especially for biowaste—and implementing the "pay-as-you-throw" principle. Propelled by the Ministry of the Environment, a new waste management law is in the works, featuring innovative elements such as redesigned waste bins. The proposed black containers are engineered to fill up slower, necessitating less frequent waste removal than their counterparts. The ministry envisions a threefold increase in waste disposal fees by 2030. A cutting-edge tracking system will empower City Hall to monitor and address unauthorized waste disposal. Textile sorting is slated for implementation by 2025, and by 2026, in alignment with EU directives, plastic tableware consumption across member states is set to undergo a reduction.

Turning our attention to Lithuania, an exploration of its waste management practices reveals a regulatory journey that commenced in 1998 with the enactment of the Law on Waste Management. A network of ten regional centers strategically oversees waste management across designated regions. Central to this landscape is the pivotal role played by local self-governments tasked with crafting effective solid waste management systems. Their responsibilities span ensuring the availability and quality of waste management services, establishing collection points for recyclables, and managing municipal waste, explicitly focusing on biodegradable waste. Since 2013, Lithuania has achieved an impressive 75% collection, recycling, or separate use of municipal waste, with only treated solid waste finding its way into landfills. The nuanced breakdown of reliable waste processing in Lithuania is artfully presented in Figure 2.4, drawing on government data.

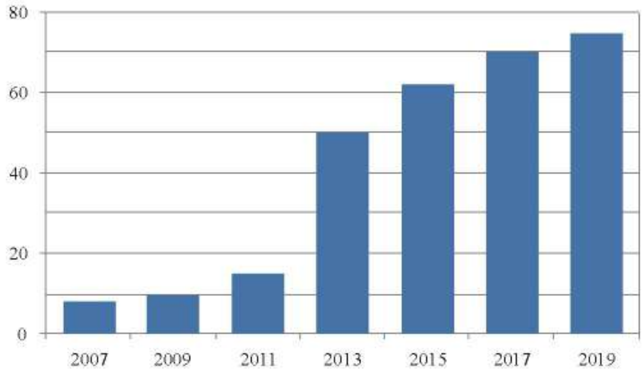


Fig. 2.4. Percentage of Solid Waste Processing in Lithuania (2007-2019)

In the vibrant tapestry of Lithuania's waste management evolution, the closing and revitalizing of over 800 antiquated landfills stand as a testament to the nation's commitment to progressive environmental practices. This transformative journey has birthed eleven contemporary regional landfills meticulously designed for the strategic disposal of solid waste. Across the Lithuanian expanse, a network of 70 sites dedicated to bulky waste and an additional 13 sites tailored for composting green waste weave, collectively boasting a capacity of approximately 34,000 tons annually.

The cityscape of Klaipeda boasts a technological marvel – a thermal power plant ingeniously fueled by pre-sorted solid waste and biomass. Lithuania's waste management landscape extends its embrace with a nationwide hazardous waste landfill near Siauliai, complemented by 32 green waste composting sites, seven specialized sites for bulky waste, and nine state-of-the-art mechanical and biological treatment plants.

Two strategic "waste-to-energy" stations in Vilnius and Kaunas contribute dynamism to Lithuania's energy infrastructure. The symphony of waste management crescendos with the orchestrated use of the high-calorie fraction of solid waste at a local cement plant. The nation's dedicated efforts in biodegradable solid waste disposal between 2007 and 2020 unfold artistically in Figure 2.5, painting a vivid portrait of Lithuania's progress in embracing sustainable waste management practices.

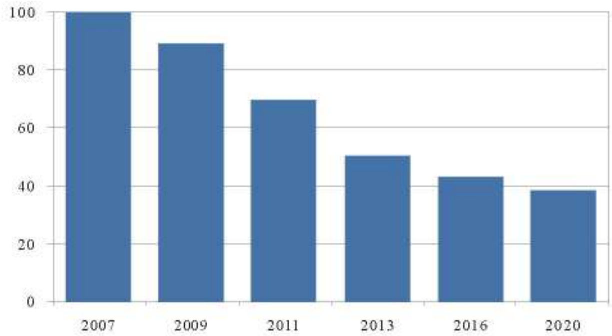


Fig. 2.5. The percentage distribution of solid household waste disposal in Lithuania from 2007 to 2020.

In the current landscape, European trends, notably "zero waste" and the "circular economy," epitomize a collective commitment to environmental stewardship. These principles prioritize environmental benefits over pollution, shaping a paradigm where waste is minimized and resources are utilized sustainably and regeneratively.

2. Ukraine's Performance in the Area of Waste Management. Challenges and comparison with EU countries

The bedrock of waste management standards enshrined in EU Directives, which Ukraine has committed to weaving into its national legislation, holds a paramount mission: safeguarding the environment from the deleterious fallout of human activities. Directive 2008/98/EC on waste stands tall among these directives, better known as the Waste Framework Directive. Its significance lies in being a comprehensive framework and setting precise standards as a guiding beacon for subsequent legislation in waste management. Within its pages, key terms like "waste," "waste treatment," and "waste disposal" are meticulously defined, delineating the fundamental tenets governing waste management.

A keystone principle embedded in this directive is the hierarchy of waste management priorities. This principle spotlights the primacy of waste prevention, reuse, and recycling while casting incineration and landfilling into a secondary role. The directive also champions the principles of "polluter pays" and "extended producer responsibility." The "polluter pays" principle, an esteemed international doctrine, mandates that those causing air, water, or soil pollution bear the onus of rectification. Concurrently, the focus on "extended producer responsibility" forges a paradigm where creators or producers of goods leading to post-consumption waste shoulder the responsibility for its subsequent management. This paradigm empowers manufacturers to intensify their focus on minimizing the environmental footprint of their products, mitigating their adverse environmental impact, and establishing a robust recycling infrastructure. To elevate the management of waste sites and proactively avert potentially catastrophic environmental calamities in locations such as landfills and spoil heaps, we must meticulously consider the following regulatory frameworks.

Directive 1999/31/EC on Waste Disposal, as defined by Regulation (EC) No 1882/2003, staunchly aligns with the waste management hierarchy, position-ing landfilling as a last resort and emphasizing a critical need to minimize its application. When waste disposal becomes unavoidable, adherence to the stringent requirements of Directive 1999/31/EC is imperative for exclusive disposal in landfills. The primary goal of this directive is to prevent or significantly mitigate adverse environmental impacts, particularly those affecting surface and groundwater, the atmosphere, and human health stemming from waste disposal. This formidable objective is achieved by establishing rigorous technical benchmarks governing waste treatment methodologies and the operation of landfill facilities.

Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention and Control) delineates meticulous standards governing the holistic prevention and control of environmental pollution from industrial activities. It outlines prescriptive protocols and directives to reduce emissions into the atmosphere, hydrosphere, and geosphere while fostering waste generation reduction. The central tenet of this directive lies in ensuring a high level of environmental protection in a comprehensive context. Special attention is devoted to the meticulous regulation of waste incineration procedures, encompassing the establishment of maximum permissible emission thresholds, the imposition of exacting technical prerequisites for waste incineration facilities, and the implementation of rigorous controls and comprehensive monitoring mechanisms.

Additionally, this directive introduces a groundbreaking permitting system designed to streamline the multiplicity of permits traditionally issued by various authorities. The fundamental premise behind this integrated environmental permit is the comprehensive assessment of pollutant emissions into the atmosphere, hydrosphere, and geosphere as an integrated system, thereby simplifying the regulatory apparatus. Lastly, the directive champions the principle of "Best Available Technology" (BAT), mandating the use of state-of-the-art production technologies to ensure the highest attainable levels of environmental security. By steadfastly adhering to these regulatory constructs, we can usher in a vastly improved paradigm for waste site management, reduce environmental risks, and champion the preservation of our natural ecosystems and the well-being of humankind.

Within the Association Agreement between Ukraine and the EU, the regulatory framework for waste management in Ukraine has been developed over several years. Notably, the National Waste Management Strategy until 2030, the Law of Ukraine "On Housing and Communal Services," and the draft Law of Ukraine "On Waste Management" (2207-1d), which passed the first reading in the Verkhovna Rada, aim to propel the country towards international environmental safety standards. A comparison of some waste management indicators in Ukraine and the EU is provided in Table 2.1.

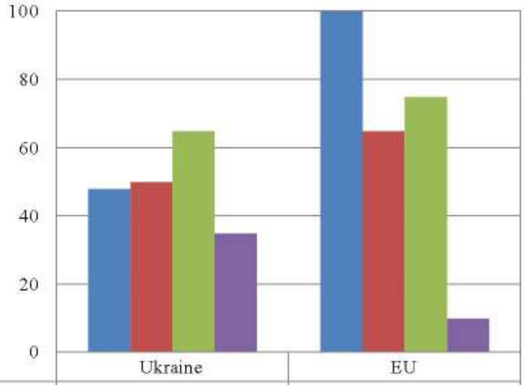
It should be noted that despite the smaller volume, waste management efficiency indicators in Ukraine, unfortunately, do not favor Ukrainians. This applies not only to areas of separate collection and processing but also to fundamental indicators. For example, 22% of Ukraine's population lacks access to household waste removal services. Even in areas with adequate infrastructure, there are other issues, such as unauthorized landfills. In 2019, about 27,000 such illegal dumps were discovered.

Table 2.1. Indicators for waste management

Indicators	Municipal recyclable waste, including composting	Municipal waste disposed in landfills	Separate waste collection	Penalty for different waste collection
EU countries	48%	23%	89%	€ 5000
Ukraine	3%	94%	5%	€45

Source: [38; 39]

The National Waste Management Strategy until 2030, ratified by the Cabinet of Ministers of Ukraine in 2017, encompasses various national objectives. A significant target involves diminishing the rate of municipal waste disposal, aiming to decrease it from the current 94% to 35% by the year 2030 (Fig. 2.6).



	Ukraine	EU
separate waste collection	48	100
waste recycling	50	65
packaging recycling	65	75
waste disposal	35	10

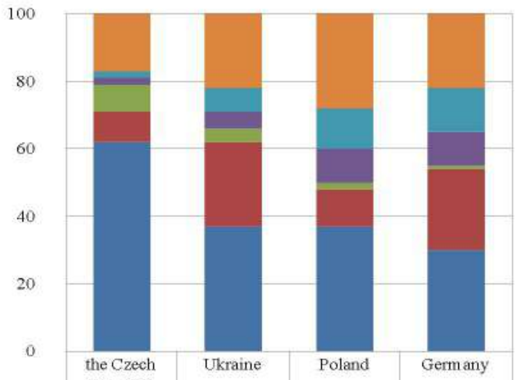
Fig. 2.6. Waste Management Indicators Until 2030 in Ukraine and the EU

Waste Management Indicators until 2030 in Ukraine and the EU showcase the ambitious goals outlined in the National Waste Management Strategy approved by the Cabinet of Ministers of Ukraine in 2017. The strategy outlines a comprehensive roadmap to transform waste management practices in Ukraine, aligning them with international environmental standards.

One of the primary objectives is a substantial reduction in the disposal of municipal waste, aiming to decrease the current rate of 94% to an impressive 35% by the year 2030 (refer to Fig. 2.6). This shift underscores a commitment to sustainable waste management, emphasizing the need for efficient waste collection, processing, and recycling initiatives. The comparison between Ukraine and the EU in waste management indicators reveals the targets for waste reduction and sheds light on areas requiring improvement. Despite the ongoing efforts, challenges persist, such as limited access to household waste removal services for 22% of Ukraine's population. Additionally, the prevalence of unauthorized landfills remains a concern, with approximately 27,000 illegal dumps discovered in 2019.

The adoption and active implementation of the National Waste Management Strategy signify Ukraine's proactive commitment to aligning its practices with global environmental standards. Ukraine aspires to elevate waste management efficiency through a united effort, curtail environmental impact, and pave the way for a sustainable and eco-friendly future.

In 13 years, Ukraine aims to cover ground other countries took almost twice as long to traverse. Achieving the ambitious benchmarks outlined in the National Waste Management Strategy and the National Waste Management Plan demands effective collaboration among diverse stakeholders: central and local authorities, businesses, the public, international partners, and volunteers. Ukraine's complexities and possibilities are dissected, drawing insightful comparisons with the finest European practices (see Fig. 2.7).



	the Czech Republic	Ukraine	Poland	Germany
other	17	22	28	22
plastic	2	7	12	13
glass	2	5	10	10
metal	8	4	2	1
paper cardboard	9	25	11	24
organic food waste	62	37	37	30

Fig. 2.7. Composition of solid waste in the Czech Republic, Ukraine, Poland and Germany, %

Source: [40]

A critical undertaking involves the enforcement of mandatory separate collection of household waste. Since organic food waste constitutes 37% of total solid waste in Ukraine, the sorting and adept management of biowaste assume paramount significance. The European Union's experience underscores that integrating biowaste into the separate collection system markedly enhances the sorting quality for dry household waste. This strategic move aligns Ukraine with proven European practices, fostering a more sustainable and efficient waste management landscape. The main fractions into which household waste can be divided are plastic, paper/cardboard, glass, metal, biowaste, clothing/footwear, and mixed waste (residual waste that does not belong to the previous fractions). Hazardous waste should also be collected separately.

Establishing waste management infrastructure remains a pivotal concern, and a closer examination of the Ukrainian scenario is warranted. In 2019, the city authorities of Kyiv embarked on a groundbreaking pilot project designed to institute a distinct solid waste collection system. Over the year, strategic placements of 3.5 thousand containers were implemented across the cityscape. Notably, the data from 2019 reveals that approximately 4.5% of the gathered waste underwent processing, marking a 1% upturn from the preceding year. However, insights from "Kyivkomunservis" underscore that, during the initial project months, only about 15-20% of separately collected waste met the stringent recycling standards, mainly due to suboptimal sorting practices among the populace.

The civic initiative "Ukraine without Garbage," in operation since 2015, has been instrumental in erecting sorting stations and elevating public awareness regarding waste sorting for heightened environmental stewardship. Ukraine currently hosts 17 enterprises dedicated to waste paper processing, 39 for polymers, 19 for PET raw materials, and 16 for cullet.

A holistic approach to this issue demands coordinated efforts across all echelons of governance. Central authorities play a pivotal role in enshrining, at the legislative forefront, mechanisms for separate waste collection, endorsing methodologies for calculating targets related to the preparation for reuse and recycling of household waste, and ratifying the procedure for setting tariffs for waste management services in alignment with the "pay-as-you-throw" principle (excluding payment for waste itself). Additionally, they should spearhead the development of universal instructions for product labeling, specifying waste subject to separate collection while also formulating general requirements for the design of containers, prioritizing user-friendly interfaces, comprehensive information support, and adherence to established color-coded norms for different waste types.

Local authorities are responsible for organizing separate collection points for household waste, establishing municipal waste collection infrastructure, and ensuring the realization of targeted indicators and quality parameters for bio-waste recycling and treating other household waste products. Business entities must adopt a straightforward approach to product labeling, indicating whether the waste requires separate collection in alignment with approved guidelines. Furthermore, businesses should seamlessly integrate different groups into their comprehensive waste management plans.

The populace must voluntarily participate in waste sorting and treatment initiatives as essential stakeholders. A harmonized and collective approach involving central and local authorities, businesses, and the public is paramount to ushering in substantive advancements in waste management practices across Ukraine. Integrating the Extended Producer Responsibility (EPR) System [41] is key to embracing the European waste management model. Over the past three decades, the proliferation of EPR systems globally has surged to 400. The legal framework sculpting EPR development at the EU level spans overarching legislation on waste and sector-specific directives governing distinct product waste categories. These directives encompass packaging, waste from electrical and electronic equipment (WEEE), end-of-life vehicles (ELV), batteries, and accumulators (B&A).

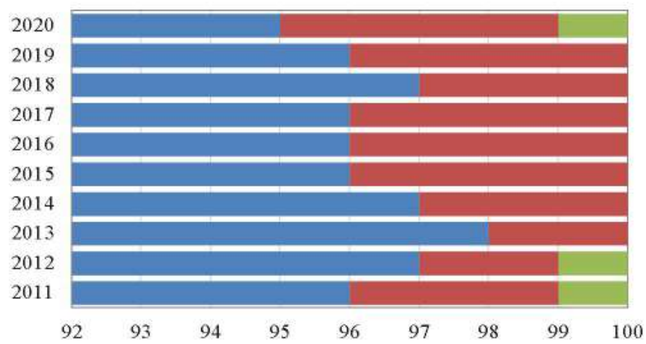
Although the EU doesn't mandate a stringent obligation to introduce EPR systems exclusively for packaging manufacturers, most EU member states (25 out of 28) have opted for the EPR approach, particularly in household waste. With the introduction of the EPR packaging system in Ukraine, a promising prospect unfolds for cultivating the domestic market of secondary raw materials. The current landscape compels processing companies to import secondary raw materials due to the exorbitant costs associated with materials domestically. Therefore, embracing the EPR system could stimulate a transformative shift, fostering self-sufficiency and diminishing reliance on foreign sources for secondary raw materials within Ukraine.

Another avenue to implement the European waste management ethos is cultivating public awareness through educational endeavors. Nations that have made substantial strides in waste management underscore the pivotal role of public attention in establishing enduring waste management systems. While the impacts of educational campaigns may take several years to materialize, practical training of the population is paramount for the sustainable operation of waste management systems.

In many countries, environmental education begins in kindergarten and primary school. Some nations initiated educational campaigns at the state level 15-20 years ago, successfully molding the nation's environmental mindset. Key initiatives include introducing waste sorting in kindergartens and schools with active children participation, integrating different collections into their comprehensive waste management plans seamlessly through mediums like cartoons, books, and toys, and engaging children in special environmental projects. Beyond educating children, conducting informational and educational activities for the adult population is imperative, fostering a sustained and nationally coordinated communication effort.

It’s worth noting that the media landscape concerning waste management is dynamic. However, the focus of discussion may only sometimes incite action or induce behavioral changes in the population. Furthermore, a reliable and transparent source of comprehensive data on the sector’s operations is necessary for interested citizens to explore and participate in solving problems or implementing public oversight where applicable.

Enhancing the infrastructure for separate collection and refining waste sorting processes in Ukraine is imperative to align with European standards. Presently, the country's waste management infrastructure comprises 34 dedicated waste sorting lines for household waste and a singular waste incineration plant, "Energy," designed for municipal waste. Furthermore, approximately 5 thousand landfills and three incinerators catering to municipal waste are designated for municipal waste. A concerning issue arises with over 27 thousand unauthorized landfills, emphasizing the urgent need to construct 384 new landfills. Fig. 2.8 presents comprehensive data on waste management in Ukraine for 2011-2020.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
waste disposal	96	97	98	97	96	96	96	97	96	95
waste incineration	3	2	2	3	4	4	4	3	4	4
recycling	1	1	0	0	0	0	0	0	0	1

Fig. 2.8. Decade-long Trends. Ukraine's Waste Management (2011-2020) in Percentage

It is imperative to underscore that Ukraine's waste disposal rate trails behind that of its European counterparts, primarily due to the inadequate organization of municipal waste collection, resulting in unregulated waste disposal. The limited technical capacities for recycling or disposing of specific waste categories further compound the issue, leading to uncontrolled emissions and disposal. The complexity adds to the need for many existing waste disposal facilities, including landfills and incinerators, to align with legal mandates and contemporary technical standards. Furthermore, challenges like the "my house is on the edge" syndrome hinder the construction of new recycling facilities, influenced by the ongoing operation of environmentally hazardous facilities. Learning from the experiences of European nations, Ukraine has outlined crucial strategic goals to be achieved by 2030 to address these pressing issues.

Implementing the EU's exemplary waste management practices holds paramount importance for Ukraine. The outlined objectives serve as a comprehensive framework, adaptable to formulate a waste management strategy in line with European standards. Core priorities encompass:

1. Mitigating early-stage risks to human health and the environment in Ukraine, steering waste management practices through hierarchical principles and established criteria.

2. Strategically optimizing waste generation opportunities while minimizing existing waste, emphasizing increased volumes of economically viable recyclable, reusable, and recoverable materials.

3. Elevating the scale and refinement of waste collection across the nation.

4. Advancing the development of waste management facilities, restoration processes, and disposal infrastructure, all aligned with the latest technical standards.

5. Mitigating risks to human health and the environment linked with landfill expansion.

6. Empowering national, regional, and local waste management institutions to play a more robust role.

7. Ensuring comprehensive and reliable waste production, management, and disposal data.

8. Catalyzing sectoral investments and widespread adoption of "extended producer responsibility" and "polluter pays" principles.

Amplifying public awareness, active participation, and heightened endeavors to confront the nation's waste management challenges are pivotal imperatives. Quantifiable tasks necessitating attention in Ukraine encompass:

- Expanding the footprint of municipal waste collection services.
- Encouraging household and analogous waste reuse and recycling, emphasizing paper, cardboard, plastic, glass, and metal.
- Propagating the reuse and recycling of construction and demolition waste.
- Enforcing specific strategies tailored for distinct waste types, including packaging waste, the proper disposal of waste electrical and electronic equipment, batteries and accumulators, end-of-life vehicles, and ensuring the judicious use of waste petroleum products.

3. Sewage Sludge Management in the EU as Elements Good Practice of Waste Management. The Situation in the Western Region of Ukraine

3.1. Best Practices in Sewage Sludge Management within the European Union Effective Waste Management Strategies

In the contemporary context, the environment is experiencing degradation owing to rapid industrial development and the proliferation of large and small industrial cities. The issue of city sewage sludge (hereafter referred to as SS) has become increasingly pressing due to its continuous growth. Despite this, its proper disposal still needs to be solved. Over the past few decades, researchers worldwide have delved into the challenge posed by the rapid escalation of SS production and accumulation following sewage biological purification.

Efficient waste management strategies intricately weave into the fabric of waste disposal practices within the European Union (EU), with sewage sludge management emerging as a pivotal aspect. Cultivating a tapestry of best practices in this domain is essential for advancing environmental sustainability and preserving the sanctity of public health. The following elucidates key components of successful sludge management within the EU.

Elevating the discourse on sewage sludge management involves seamlessly integrating with regulatory frameworks. Meticulous compliance with stringent regulations and standards is achieved through the orchestrated directives and guidelines of the EU. This synchronized approach mitigates potential hazards related to sludge treatment, disposal, and land application, presenting a sophisticated and effective sewage sludge management strategy. The cadence of efficient sludge management undergoes enrichment by infusing cutting-edge treatment technologies. The seamless integration of pioneering processes, such as anaerobic digestion, thermal treatment, and composting, transforms the narrative by reducing pollutants and pathogens. The outcome is sludge that embodies environmental virtuousness, marking a significant evolution in waste management.

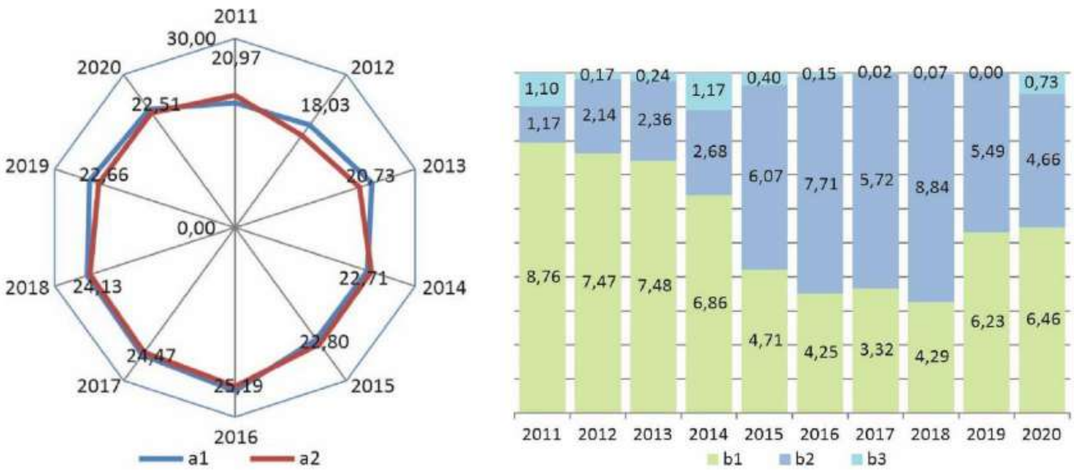
The strategic framework of resource recovery and circular economy principles takes center stage in sludge management. Delving into the core of this process involves a systematic approach that extracts valuable resources, particularly phosphorus and organic matter, embodying a meticulously coordinated sequence. This intricate movement serves as an ode to resource recovery, presenting a harmonious contribution within the larger composition dedicated to sustainable waste management. The coordination of effective communication and stakeholder engagement manifests as a carefully synchronized collaboration transcending mere participation; it evolves into an integral component of the sludge management panorama. Communities engaging in this harmonious awareness engagement are more likely to intricately participate in sustainable waste management initiatives, fostering a resonance of support that echoes through environmental responsibility.

We witness the careful coordination of risk assessment and vigilant monitoring in sludge management. Systematic evaluations of potential environmental and health risks and the consistent rhythm of robust monitoring systems create a harmonious safeguarding of the waste management process. As attention centers on the land application of sewage sludge, the commitment to best practices becomes our guiding principle. The intricate challenge involves adhering to recommended application rates, considering soil characteristics, and maintaining a steady rhythm through regular soil testing. These elements blend together in a coordinated performance, showcasing responsible land application practices. Innovation and research are also significant. Encouraging the development of new technologies and methodologies, this intellectual pursuit enriches our understanding and contributes to the continuous refinement of waste management practices.

The outcomes of biological sewage purification unveil an alarming annual release of millions of tonnes of suspended solids (SS) into the environment. Eurostat data, specifically on SS production and disposal [58], classifies these discharges into seven groups based on the volume of sludge generated.

In the initial group, characterized by a modest SS production ranging from 5.5 to 10.36 thousand tonnes annually, countries such as Cyprus (8.41 thousand tonnes per year), Luxembourg (9.47), Malta (10.36), Serbia (10), and Bosnia and Herzegovina (9.5) are identified. In Serbia and Malta, conventional approaches to SS disposal involve storage on designated sludge sites.

Moving to the second group, which produces and disposes of SS within the range of 10.36 to 30.0 thousand tonnes annually, countries like Estonia (18.99), Croatia (22.5), and Latvia (23.15) are notable contributors. Statistical insights into Latvia, including its methods of SS disposal, are visually represented in Fig. 3.1.



a) b)

Fig. 3.1. Production and disposal of sewage sludge in Latvia: a) Statistics related to the sludge produced and utilized: a_1 - Sludge production – total, thousand tonnes; a_2 - Sludge disposal – total, thousand tonnes; b) Data on the types of utilization: b_1 - Sludge disposal – agricultural use, thousand tonnes; b_2 - Sludge disposal – compost and other applications, thousand tonnes; b_3 - Sludge disposal – landfill, thousand tonnes.

Source: Eurostat, 2022

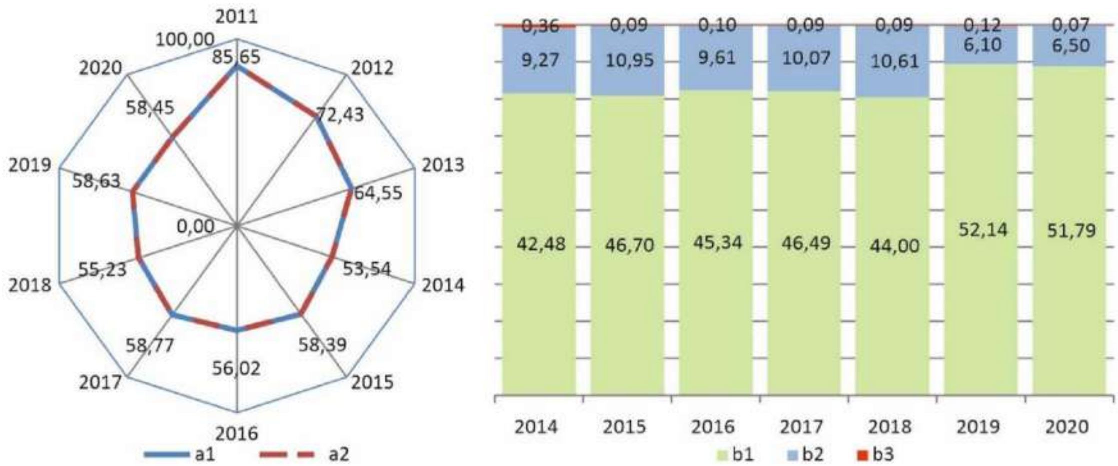
Notably, almost 100% of the overwhelming majority of sewage sludge (SS) is effectively utilized, underlining a commendable effort in managing this waste stream. Prevailing practices predominantly involve transforming sludge into valuable resources, with dried sludge being repurposed as fertilizers and utilized in composting. The extent of sludge being consigned to landfill sites is minimal, reflecting a commitment to sustainable and eco-friendly disposal methods. This approach aligns with global efforts to address environmental concerns and optimize the use of resources in waste management.

Moving on to the third group, characterized by SS production and disposal ranging from 31.0 to 58.0 thousand tonnes per year, notable countries like Lithuania and Slovenia stand out. These nations have implemented innovative strategies to efficiently handle sewage sludge, contributing to the overall success of waste management practices. For instance, Lithuania has invested in advanced technologies for sludge treatment, ensuring a significant portion is repurposed rather than ending up in landfills. Slovenia, too, showcases a model of sustainable disposal methods, emphasizing the importance of environmental responsibility.

Ireland, situated within this group, exhibits intriguing statistics regarding SS disposal methods, depicted in Fig. 3.2. The data reveals a comprehensive approach to sewage sludge management, focusing on reducing environmental impact. Ireland's efforts encompass the reduction of sludge consigned to landfills and exploring alternative, eco-friendly applications for this waste product. The country's commitment to sustainable practices positions it as a noteworthy example in the global landscape of sewage sludge management.

In summary, the effective utilization of sewage sludge and the commitment to sustainable disposal methods, as exemplified by countries like Lithuania, Slovenia, and Ireland, showcase a positive trend in addressing environmental challenges associated with wastewater treatment. These practices contribute to a more responsible and eco-conscious approach to managing sewage sludge, aligning with broader environmental sustainability goals.

As of 2020, a considerable part of the sludge is used in agriculture, accounting for 51,490 out of 58,450 thousand tonnes per year, showcasing the pivotal role of sewage sludge in enhancing soil fertility and supporting agricultural productivity. In parallel, only a small amount, approximately 6,500 tonnes per year, is dedicated to composting, indicating potential areas for further exploration of sustainable waste management practices.



a) b)

Fig. 3.2. Sewage sludge production and disposal in Ireland: a) statistics concerning the sludge produced and utilized: a_1- sludge production – total, thousand tonnes; a_2-sludge disposal – total, thousand tonnes; b) data on the kinds of utilization: b_1-sludge disposal – agricultural use, thousand tonnes; b_2-sludge disposal – compost and other applications, thousand tonnes; b_3- sludge disposal – landfill, thousand tonnes

Source: Eurostat, 2022

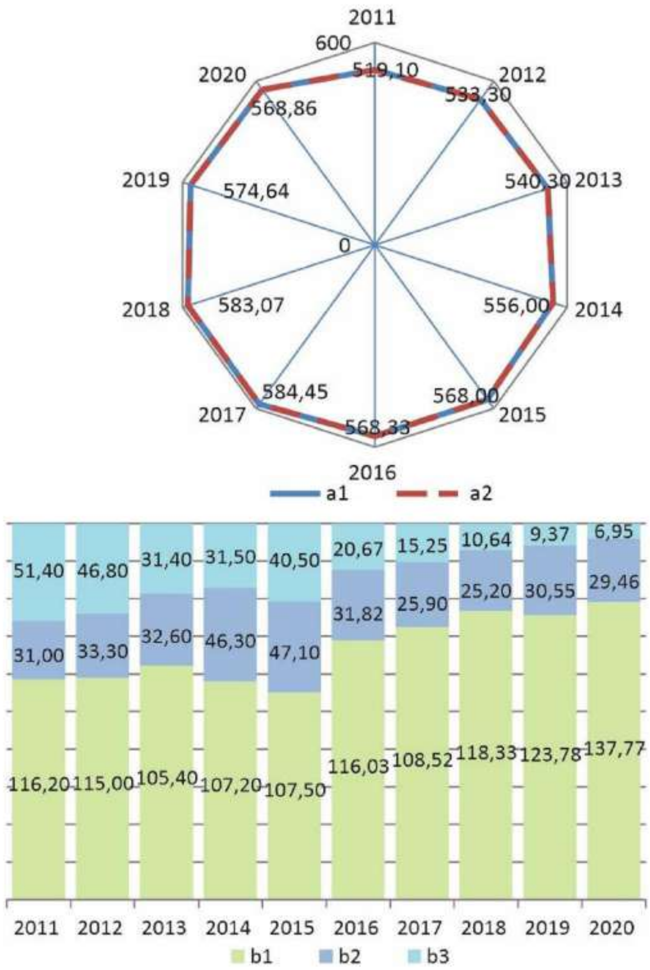
The data specific to Belgium, a member of the group of countries producing 58,000 to 155,000 thousand tonnes of sludge per year, is illustrated in Figure 3. Belgium's approach to sewage sludge management is noteworthy, with approximately 10% of the sewage sludge repurposed as fertilizers. The percentage varies depending on the method of processing employed, whether regular or advanced treatment methods are utilized. This nuanced approach demonstrates

Belgium's commitment to optimizing the value derived from sewage sludge, considering the environmental implications and the potential benefits to agriculture.

Belgium’s strategy aligns with the broader trend observed in countries within this production range, emphasizing the importance of adopting advanced treatment technologies to enhance the utilization of sewage sludge. By incorporating innovative methods, these nations aim to maximize the beneficial applications of sludge in agriculture while minimizing environmental impact.

The data from 2020 highlights the predominant use of sewage sludge in agriculture, with Belgium exemplifying a nuanced approach where approximately 10% of the sludge is utilized as fertilizers based on the processing method. These insights underscore the ongoing efforts to refine sewage sludge management practices, ensuring a balance between agricultural benefits and sustainable waste disposal methods.

The updated Regulations on fertilizers, implemented in 2019, directly address the matter of sludge disposal, marking a significant milestone in the European Union's approach to sustainable waste management. These Regulations are designed to promote large-scale fertilizer production, considering the internal resources of EU countries. Notably, the amendments were deemed necessary due to the absence of statements in previous regulatory documents regarding including sludge processing by-products as potential fertilizer constituents. This oversight had previously limited the market potential of these products.



a) b)

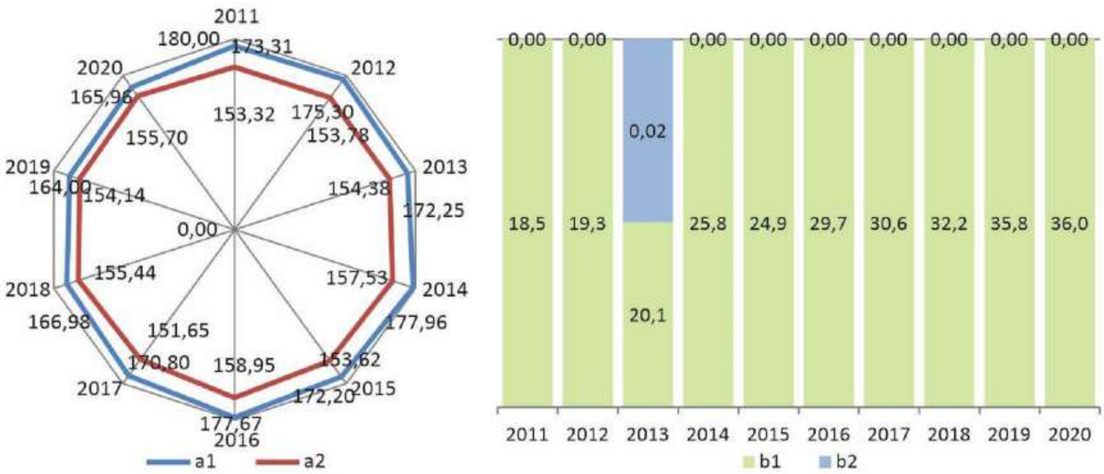
Fig. 3.3. Sewage sludge production and disposal in Belgium: a) statistics concerning the sludge produced and utilized: a_1- sludge production – total, thousand tonnes; a_2-sludge disposal – total, thousand tonnes; b) data on the kinds of utilization: b_1-sludge disposal – agricultural use, thousand tonnes; b_2-sludge disposal – compost and other applications, thousand tonnes.

Source: Eurostat, 2022

In a pivotal move in 2020, the EU decided to include sewage sludge (SS) in the materials permitted for use as fertilizer constituents. This progressive amendment officially came into force in 2022, enabling the sale of fertilizers derived from sewage sludge on the entire territory of the European single market. This strategic shift enhances the market potential of sludge-derived products and aligns with broader sustainability goals by promoting the recycling and beneficial use of waste materials.

Despite sewage sludge disposal (by putting it into the soil) being considered a sustainable practice and generally approved by the EU, the practical implementation of this approach varies across countries. While some nations continue to incorporate sewage sludge into the soil, others are primarily oriented towards burning as a disposal method [42, 44, 45, 48]. This divergence in practices underscores the complexity of waste management strategies and reflects the diverse approaches taken by EU member states.

The data specific to Poland is provided in Fig. 3.4, offering a comprehensive overview of critical metrics that contribute to understanding the country's approach to sewage sludge management.



a) b)

Fig. 3.4. sewage sludge production and disposal in Poland, providing comprehensive statistics on the quantity of sludge generated and its various utilization methods: a) Statistics concerning the sludge produced and utilized: a_1 - Sludge production – total, thousand tonnes; a_2 - Sludge disposal – total, thousand tonnes; b) Data on the kinds of utilization: b_1 - Sludge disposal – agricultural use, thousand tonnes; b_2 - Sludge disposal – compost and other applications, thousand tonnes; b_3 - Sludge disposal – landfill, thousand tonnes.

Source: Eurostat, 2022

This figure includes data on total production, disposal methods, and specific utilization strategies Poland employs. This information is crucial for evaluating the effectiveness and sustainability of Poland's sewage sludge management practices in the context of evolving EU regulations and the broader landscape of waste management strategies

The high level of sewage sludge (SS) utilization observed underscores a positive trend, emphasizing the significance of adopting efficient waste management practices to derive value from what was once considered a challenging waste product. Against the backdrop of global efforts toward sustainability, these examples serve as beacons of successful strategies, showcasing the ability to minimize environmental impact and maximize resource recovery from sewage sludge.

In 2017, Europe exhibited a diverse approach to sewage sludge management, reflecting the dynamic evolution in waste disposal practices. Approximately 51% of the total sewage sludge volume was repurposed as organic fertilizers, with 35% attributed to processed sludge and an additional 16% incorporated into compost (refer to Fig. 3.5). In contrast, 44% of the sewage sludge underwent incineration. Notably, countries that joined the European Union after 2004, including Malta, Croatia, Romania, and others, predominantly relied on landfill burial as the dominant method for sewage sludge disposal.

The period from 2010 to 2015 witnessed a significant trend, revealing increased incineration volumes and a simultaneous reduction in sludge application to soil. This trend shift suggests a complex interplay of factors influencing sewage sludge management practices across European nations. As a prominent European player, Germany faced a unique situation with substantial sewage sludge production. Before implementing new state regulatory acts in October 2017, Germany favored incineration over other disposal methods.

This diverse landscape in sewage sludge management practices across European countries reflects the adaptability and responsiveness of waste management strategies. It underscores the need for further exploration and optimization of these practices. It prompts a critical evaluation of the evolving dynamics in sewage sludge management, emphasizing the importance of aligning strategies with sustainability goals and considering the broader environmental implications of each approach.

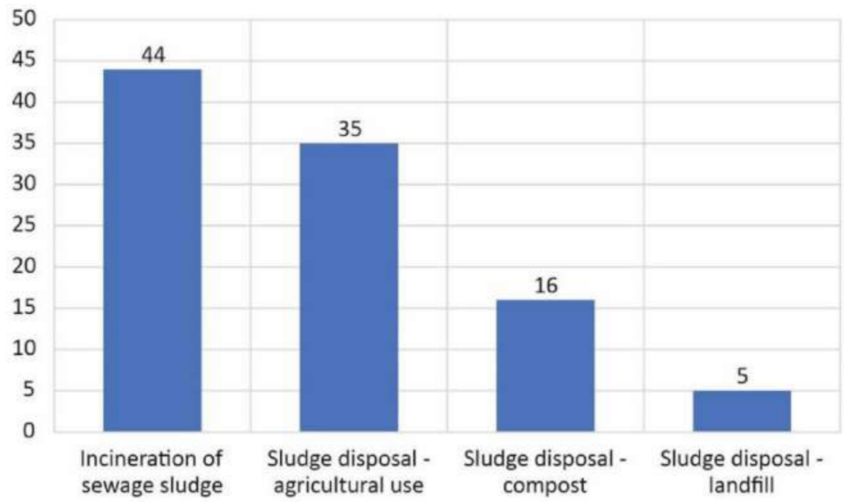


Fig. 3.5. Methods of Sewage Sludge Disposal in Europe

Source: Eurostat, 2022

Great Britain and France stand out as leaders in sewage sludge (SS) disposal in agriculture, both in terms of volume. However, sludge's agricultural utilization is more prevalent in Portugal, Ireland, Bulgaria, and Norway. In Great Britain, the predominant scheme for sludge disposal involves anaerobic fermentation, coupled with the subsequent utilization of biogas energy. This process yields a product from sludge processing that is then employed in agriculture. Notably, sludge incineration plants are currently limited to London and Belfast. In contrast, other major cities, including Manchester, have moved away from using incinerators in recent years. Many existing incineration plants, constructed over two decades ago, have nearly exhausted their operational capacities, demanding substantial investments for restoration. Surprisingly, sewage treatment companies have discovered that processed sludge is in high demand among farmers. This utilization method has proven to be more efficient than the recovery and operation of aging incineration plants. With the decommissioning of these plants, the share of agricultural placement for processed sludge has surged from 78% in 2012 to almost 90% in 2020. This shift underscores the growing preference for sustainable and environmentally friendly solutions in sludge management.

A large-scale information campaign for farmer businesses and the consumers of their products (food shops and food industry enterprises) took place in the drainage sector. They aimed to clarify the safety and benefits of sludge product usage. Such wastes are in great demand in the agriculture of Great Britain. Treatment plant operators in Great Britain are responsible for the quality of the sludge processing products and their safe usage in agriculture.

Drainage enterprises have some specialized groups in their structure that are responsible for sludge product sales to farmers, and, in most cases, companies and farmers put them into the soil to provide effective (the proper dose per hectare of agricultural lands) and safe disposal of the product. Enterprises collect the records of solid household waste use objects and then transfer them to the state body of environmental regulation for monitoring.

For the last 15 years, in Great Britain, some significant investments have been put into new technologies and the construction of plants to produce energy from waste. Some schemes were introduced to provide comprehensive quality control during sludge processing (as well as strict control of industrial sewage discharge into the drainage systems). These investments contributed to high sludge quality standards after its processing (plants produce deep processing products), encouraging farmers to apply fertilizers and soil additives from the sewage sludge in agriculture.

The necessary increase in vegetable and animal production is closely connected with soil fertility due to manure and fertilizers introduced. However, their production and usage capacity aren't enough to satisfy agricultural needs. The problem can be solved by SS disposal. The above-mentioned sludge is rich in important plant food compounds and many organic substances, making it a proper organic-mineral fertilizer and determining its agricultural value. SS disposal as agricultural fertilizer is one of the most serious, as it is closely connected with environmental protection, soil fertility rise, and crop species yield improvement.

SS (or the mixture of compost and sludge) applied in the fields to grow agricultural crops is an efficient way of organics (carbon) and biogenic elements content increasing in the soil, nitrogen and phosphorus, in particular. In this case, soil's physical characteristics, such as retaining moisture, texture, water infiltration, bulk density, and porosity, are improved. In many cases, agricultural disposal of the treated SS suggests a more efficient and environmentally safe alternative to chemical fertilizers [49, 56, 59, 60]. After its treatment, the SS can be applied to the soil in fields (liquid sludge, dehydrated sludge, dried sludge). One should consider certain technical, environmental, and financial aspects dealing with the material storage, transportation, and application to soil, as well as the control of quality standards compliance while using sludge.

The land areas for sludge applying to soil, as well as the demand for material that farmers have, depend on many factors, and the most important of them are listed below:

1. Restrictions regarding sludge application on the fields where berries and vegetables are grown (it is usually required to apply sludge to the soil 10 months before harvesting). Sludge can be used for all field crops grown, including those produced for biofuel or biomass production.

2. Requirements for the quality of sludge and soil, including the restrictions on biogenic elements content (for example, phosphorus).

3. Water resources protection – avoiding territories located in the protective zones with sensitive water resources or near them is necessary.

4. The earth's surface slope – the steeper the slope, the higher the risk of the material being washed away by the surface flow. It is also more difficult to apply sludge to spoil physically.

5. Soil texture – applying to heavy or light soil is undesirable.

6. Chemical characteristics of soil – normative restrictions by hydrogen index value and heavy metals content.

7. Benefits for farmers – farmers might save money by using solid biological substances, for example, by purchasing chemical fertilizers.

Because of the high costs of chemical fertilizers, solid biological substances can become an economically efficient source of nutrients for farm businesses. The Western European experience has proved that, in most cases, sludge utilization (by its application to soil) has been efficient even if the practical usage of the sludge is possible in only 5-10% of potentially available land. In this case, it should be considered that all farmers won't apply that sludge and not every year. Moreover, sludge application to soil is impossible everywhere (for example, on surfaces with steep slopes, near water, residential areas, etc.). In many European countries, there is a policy promoting the disposal of biological substances on agricultural lands, providing that sanitary and environmental safety standards are kept. Sludge disposal in agriculture is acceptable only when organic substances and biogenic elements application can improve the quality of soil and crops.

The viability of using sewage sludge as fertilizers in agriculture is contingent upon various factors. These include the quality of the sludge, its ease of transportation and application to soil, reduced levels of heavy metals, and biological availability for plants. Additionally, it hinges on the sludge's ability to prevent contamination of the crops grown and the associated risks to human and animal health due to the potential presence of pathogenic microorganisms. Other crucial considerations involve the agronomic value of the sludge, including the content of organics and biogenic elements in a readily accessible form for plants and factors such as the hydrogen index.

To mitigate potential risks to human health, sludge not promptly applied to the soil using methods like jet application must undergo preliminary biological, chemical, or thermal treatment during long-term storage. This treatment, or any other technology aimed at reducing the sludge's fermentability and, consequently, the production of unpleasant odors, is essential to ensure the safety and efficacy of its use in agricultural settings. One of the necessary conditions for SS usage as a fertilizer is its sanitary-bacteriological cleanliness provided by its decontamination. One more severe restriction of sludge usage in agriculture is heavy metals, but their content in different SS is different. Sludge is also differentiated according to its agrochemical properties and the range of plant essential food compounds. Hence, in every specific case, we should have the complete characteristics of sludge to determine the way of SS disposal. So, the study of the main attributes of Ternopil City and Ternopil region (Ukraine) SS treatment and its possible usage as fertilizer in agriculture is conducted in the paper.

It is worth noting that the research results on the suitability of sewage sludge as a fertilizer vary greatly depending on the region because different climatic, geological, and geographical characteristics affect sediment composition and properties. For example, sewage sludge usually contains large amounts of nitrates and other nutrients, which are beneficial for plant growth in regions where high humidity and rainfall are observed, and vice versa - in areas with low humidity and rain, sediment contains fewer nutrients.

In addition, there are different approaches to wastewater treatment methods used in other regions, which also affect sediment composition and properties. For example, sediment usually contains chemicals harmful to plants and soil in areas where chemical methods of wastewater treatment are used. At the same time, sediment contains biologically active substances, beneficial for plant growth if biological wastewater treatment methods are used in the region. Therefore, research on the suitability of sewage sludge as a fertilizer must consider regional characteristics to determine their usage efficiency and safety.

The chemical composition of SS dramatically depends on the sludge-making technique and storage time. Sludge fermentation and accumulation in sludge digesters lead to a percent rise of food components, whereas its storage on sludge banks –drops. For example, whereas raw sludge contains 3,22% of general and 0,07% of migrating nitrogen per dry substance, the fermented sludge is 3,97 i 0,27% correspondingly, dried on sludge banks – 2,26 and 0,50%, and thermally dried – 1,68 and 0,84%. A significant amount of macro- and microelements in the sludge makes it an additional feeding source for plants and allows them to cut the need for organic and expensive mineral fertilizers. Considering that, as a rule, SS is characterized by a high nitrogen and phosphorus content. Still, it's poor in potassium, so it becomes necessary to balance its composition by additional Potassium-fertilization.

Sludge nutrients are both in mineral and organic forms, which determine their effect on plants: the positive impact is observed not only during the first year after fertilization but also in the future as long as organic substances keep degrading. Numerous experiments prove that using this valuable mineral-organic fertilizer in different soil-climate zones for other crop species significantly improves soil quality and yields. While being put into the soil, the mud gets rich in humus, available for plants nitrogen and phosphorus, functional elements absorption; saturation increases while acidity decreases. The positive effect is particularly noticed in the case of low soil fertility. There is significant data about sewage sludge's impact on soil biological activity. The sludge causes an increase in the total number of microorganisms, catalyst activity rating, and cellulose-fermenting bacteria and reduces the amount of fungus. Heat-processed mud increases soil biological activity, making it rich in moving forms of nitrogen and phosphorus, and its effect on corn and winter wheat yield is as good as on barnyard manure or even better.

However, it should be emphasized that disinfection of sludge usage as a fertilizer is a strict requirement because any agents of human and animal diseases (bacteria, viruses, helminth eggs) can be present in wastewater and, therefore, in the mud. SS disposal as fertilizer without pre-processing doesn't guarantee agricultural products' safety. Pre-processing and processing technology for their usage in agriculture must meet sanitary hygiene requirements.

Sludge disinfection can be done by various methods: thermal, biothermal, chemical, biological, and physical. In particular, primary and excess sludge aerobic and anaerobic treatments are widely used in Ukraine. The sludge is trampled and dried in two stages: on sludge beds – up to 70-60 % humidity, and after that – in storing bunkers for not less than two years with moisture up to 60%. Such preparation must provide complete sludge disinfection.

Other commonly used methods are heat treatment, disinfection reagents usage, and biological disinfection. The most efficient and technologically significant method is the sludge biothermal treatment, based on composting with different organic fillers: chaff, peat, sawdust, wood scraps, rind, etc. Like any other organic waste, Sludge composting means organic mass treatment by aerobic bacteria, generating significant heat. The composting mass here is heated up to 55-65 ^{0}C, and as a result, it's being disinfected. Besides that, the combustion of the most unstable part of organics stabilizes the rest of the fertilizer. Therefore, in several months, a very nutritional fertilizer-compost, sanitary safe, rich in organic matter and other valuable plants' food components will be obtained.

The disadvantage of any sludge is its heavy metals content, which significantly varies depending on production waste flow composition. According to some data, raw sludge may contain up to 30 metals, although the presence of heavy metals doesn't exclude sludge application as a fertilizer but requires proper control. It makes the development of allowable concentrations (further – AC) of heavy metals in sludge, soil, plants, and different products very urgent.

Many countries have their own criteria for toxicants AC in sludge (presented in Table 1). Some authors believe that significant attention must be paid to cadmium content. The agricultural research service of the US Ministry of Agriculture developed contemporary criteria to prevent soil contamination by heavy metal salts. They include cadmium and zinc salts, in particular. The sludge containing cadmium of more than 1% of zinc cannot be used for agricultural crops. In Great Britain, zinc-equivalent (calculated parameter) determines the sludge dose. The most harmful metals are nickel, copper, and zinc. AC of these elements in soil according to zinc-equivalent is 250 mg/kg of soil. The application rate of cadmium cannot be over 0.2-5 kg/ha.

Table 3.1. Requirements on heavy metals content in sewage sludge used as fertilizer (mg/kg of dry substance)

Country	Ag	Co	Ni	As	Cu	Zn	Pb	Cr	Cd	Hg	Mn
France	–	20	100	–	1500	3000	300	200	15	8	–
Germany	–	–	200	–	1200	3000	1200	1200	20	20	–
Austria	–	–	100	–	500	2000	100	–	–	10	–
Netherlands	–	–	50	–	500	2000	500	500	10	10	–
Switzerland	–	100	200	–	100	3000	1000	1000	30	10	–
Finland	85	100	500	–	3000	5000	1200	1000	30	–	3000

Source: "EU Sludge Directive 86/278/EEC"

Certain scholars posit that fermented sludge can be deemed safe when heavy metal concentrations do not exceed specific thresholds (mg/kg of dry substance). These limits are defined as follows: zinc – 1500, copper – 750, lead – 500, chromium – 500, nickel – 150, and cadmium – 50. Notably, these parameters are often utilized by the Council for Mutual Economic Assistance member countries, serving as a framework for establishing standards for heavy metal content in sludge – a common practice in Ukraine for evaluating sludge characteristics and its potential agricultural application.

3.2 Challenges in Ukraine's Sewage Sludge Management. Example of Sustainable Sewage Sludge Treatment in the Western Region of Ukraine

In line with these considerations, the Ministry of Healthcare of Ukraine has formally endorsed permissible concentrations of heavy metals in soil, further refining the criteria for environmental safety. Presently, the accepted limits for heavy metal concentrations in soil are as follows (mg/kg): lead – 20, cadmium – 9, arsenic – 2, nickel – 50, chromium – 100, mercury – 2.1, manganese – 1500, and vanadium – 150. This regulatory framework signifies a concerted effort to safeguard environmental health. It underscores the importance of meticulous monitoring in waste management practices, particularly in sludge application in agriculture. By aligning with these established standards, Ukraine aims to balance utilizing organic waste for agricultural benefits and protecting ecosystems from potential adverse effects of heavy metal contamination.

Research across various countries has provided evidence of potential toxicity accumulation in soil when sludge is utilized as fertilizer over an extended period. Heavy metals from the sludge are notably concentrated in the upper layers of the soil. Despite the widespread use of sludge in agricultural practices, there is a prevailing belief that the risk of soil water contamination with heavy metals is minimal, as these contaminants tend to remain confined to the areas of sludge application. However, the localized accumulation of heavy metals, notably lead, in specific soil layers can inhibit numerous microorganisms, including essential microbial flora crucial for soil health.

Upon reviewing international information sources, it was discerned that an excess of zinc and copper in the soil may be a contributing factor to its deficiency in certain instances. Research conducted by the Kyiv Institute of Common and Communal Hygiene in Ukraine further substantiates that the accumulation of various metals in the soil significantly hampers its natural self-cleaning processes. Additionally, a correlation was observed between the concentration of metals in the soil and their subsequent accumulation in plants. For instance, experimentation with grass growth using sludge as a fertilizer revealed that at cadmium concentrations in the soil ranging from 15 to 145 mkg/g, the cadmium content in plant tissues exhibited a corresponding increase from 9 to 43 mkg/g. However, intriguingly, at a cadmium concentration of 3 mg/kg, the height of wheat plants reached an impressive 76 cm. Furthermore, long-term experiments involving sludge application to various crop species demonstrated elevated levels of manganese, zinc, and cadmium in leaves. Notably, while the concentrations were higher, they remained non-toxic. Notably, the grain's heavy metal content was lower than in the leaves, suggesting a nuanced relationship between sludge application, metal accumulation, and potential toxicity in plant tissues.

Notably, different plant species exhibit varying degrees of sensitivity to metals. For instance, lettuce, beets, and carrots demonstrate a higher propensity to absorb metals, while corn, cabbage, berries, tomatoes, melon crops, and fruit trees exhibit a comparatively lower absorption rate. Additionally, the age of plants is a pertinent factor; older plants tend to contain a higher concentration of heavy metals. The timing of sludge application also plays a crucial role, with plants accumulating fewer metals when sewage is used in autumn compared to spring.

Observations have indicated the adverse impact of heavy metals on soil, particularly in soils that are light or deficient in humus. A more pronounced inhibition of plant growth was noted when sludge was applied to acidic soil compared to soil with a neutral pH. This discrepancy can be attributed to metals in compounds with lower pH becoming more soluble, rendering them available to plants. Conversely, soil enriched with liming material impedes the absorption of metals by plants. Interestingly, despite heavy metals in sludge, applying sludge as a fertilizer generally does not result in the accumulation of toxicants in agricultural crops at levels that could threaten humans and animals.

Various research data, both domestic and international, consistently advocate for the potential and promising utilization of decontaminated sewage sludge as a fertilizer, mainly when it contains acceptable concentrations of heavy metals. However, alternative disposal methods come into play for sludge with elevated levels of these elements. A practical approach involves thermal treatment through high-temperature heating in an anaerobic environment, known as pyrolysis. This method proves efficient, particularly for sludge with a high content of heavy metals. Due to the scarcity of carbon raw materials, the resulting carbon-containing products from pyrolysis are gaining increasing importance. Resolving the complexities associated with sewage sludge disposal necessitates a comprehensive study tailored to each specific case. During our research on Ternopil city sewage sludge (Western part of Ukraine), six samples were thoroughly examined, encompassing leading sanitary-biological, physical-chemical, and agrochemical indices. The detailed findings from this investigation are presented in Tables 3.2-3.4.

Table 3.2. Sanitary-biological indices of sewage sludge in Ternopil city

№ of lot	Time of sample obtaining	№ of sample	Area of sample obtaining	Number of bacteria	Titre coliform bacteria	Helmints eggs	Titre Cl.perfringes
1	March 2021	1	Storage platform (old)	94100	<0.00001	none	0,1
		2	Storage platform (new)	52000	0,001	none	0,1
		3	Sludge lagoon №21 – 2 years	77200	<0,00001	none	0,1
2	May 2021	4	Storage platform (new)	119200	0,0001	none	>0.1
		5	Sludge lagoon №1– V. Myshkovychi	6520	0,01	none	>0.1
		6	Sludge lagoon № 25 – 4 years	79200	0,01	none	>0.1

Source: Own research

A shared characteristic among all six sludge samples is their bacterial contamination, with coliform bacteria titers consistently measuring less than 0.1. It's worth noting that the extent of bacterial contamination does vary across these samples. Of particular concern from a sanitary standpoint is the sludge acquired from both old and new storage platforms, notably Sludge Lagoon No. 21, which has undergone a storage period of 2 years. In terms of sanitary considerations, this sample presents a heightened level of risk.

Table 3.3. Sludge agrochemical characteristics city

№ of lot	Time of samples obtaining	№ of sample	Samples obtaining area	Ph	Humidity %	% of dry substance				Ash content %
						N	P_2O_5	K_2O	C	
1	March 2021	1	Storage platform (old)	7,1	68,6	1,13	2,1	0,48	10,66	72,34
		2	Storage platform (new)	7,6	84,8	1,41	2,11	0,49	15,96	61,12
		3	Sludge lagoon №21	7,2	77,6	1,10	2,41	0,46	16,91	54,32
2	May 2021	4	Storage platform (new)	7,1	32,3	1,39	2,62	0,45	10,94	58,68
		5	Sludge lagoon №1 – V.Myshkovychi	7,3	85,4	1,42	2,35	0,58	13,26	64,35
		6	Sludge lagoon № 25	6,7	20,9	1,66	2,21	0,29	11,2	64,01

Source: Own research

Nevertheless, they are also rich in heavy metals such as cadmium, nickel, and strontium.

Table 3.4. Heavy metals content in the Ternopil city sewage sludge, mg/kg of dry substance

№ of lot	Samples obtaining time	№ of sample	Samples obtaining area	Sr	Cr^{3+}	Ni	Co	Cd	Mn	Pb	Cu	Fe	Zn
1	March 2021	1	Storage platform (old)	214	196	25	26	47	476	248	249	12670	1562
		2	Storage platform (new)	123	106	188	25	26	487	118	101	13220	888
		3	Sludge lagoon №21	356	226	26	35	47	486	520	448	13430	1568
2	May 2021	4	Storage platform (old)	368	307	526	0	54	468	489	418	14540	1327
		5	Sludge lagoon №1 – V. Myshkovychi	326	24	327	0	36	487	450	316	13800	1218
		6	Sludge lagoon № 25	287	326	563	0	64	435	377	346	14440	1364

Source: Own research

A notable abundance of phosphorus and potassium is observed across the Ternopil city sewage sludge spectrum. However, in comparison, these sludge samples exhibit a relatively lower richness in nitrogen. This nutrient composition is crucial in evaluating these sludge samples' potential applications and limitations in agricultural or environmental contexts.

The research findings unequivocally indicate the presence of heavy metals in sediments within the Ternopil region. Among the primary sources of heavy metal pollution identified in the area are landfills and water systems comprising aging metal pipes. Landfills have been identified as potential reservoirs for heavy metals, including lead and mercury, which gradually infiltrate groundwater and surface water sources, contaminating wastewater.

Furthermore, the intensive practices of agriculture and the application of mineral fertilizers, pesticides, and other chemical agents also contribute to heavy metal pollution in both soil and wastewater within the region. Considering the aforementioned indicators and the existing standards that govern the acceptable concentrations of heavy metal anthropogenic contaminants (ACs), it is evident that all identified sludge samples in Ternopil City fall within the fourth group classification [50]. This classification implies that these sludge samples are suitable solely for composting purposes, emphasizing the importance of responsible waste management practices in the region.

Two recommended composting methods are pile composting, a natural approach involving bio-oxidation, and composting in bio-convectors, which utilize forced aeration. Particularly intriguing technologies are those that establish conditions fostering the rapid proliferation of microorganisms, leading to the secretion of biogenic substances, specifically phytoliths. Simultaneously, these technologies effectively inhibit the development of competing microorganisms [46, 47].

The process of bio-fermentation of peat-mud mixtures into fertilizers initiates with the swift development of mesophilic microorganisms (with a temperature range of 10-15 °C for t_{min}, 35-47 °C for t_{max}, and an optimum range of 30-45 °C). Subsequently, the progression transitions to thermophilic microorganisms (tmin = 40-45 °C, tmax = 80 °C, topt = 55-75 °C). In composting under forced aeration conditions, curating an environment conducive to the predominant development of actinomycetes becomes possible. These microorganisms excrete antibiotics, including Actinomyces Streptomycin, which effectively inhibits a broad spectrum of bacteria, encompassing putrefactive and miscellaneous bacteria.

Temperature elevation within the compost pile serves a dual purpose: thwarting the germination of weed seeds in the mixture and effectively eradicating pathogenic microflora, larvae, helminth eggs, and pupa flies. This temperature-controlled environment proves instrumental in ensuring the hygiene and quality of the composting process, rendering it an effective method for producing fertile and sanitary soil amendments. The composting phase typically spans 5 to 8 months, allowing for the comprehensive breakdown of organic matter.

For those seeking to expedite the composting process, the integration of selective cultures of microorganisms proves advantageous. As an illustrative example, a culture of thermophilic actinomycetes can be cultivated under controlled laboratory conditions. The composition for this culture, per liter of running water (g), includes KNO_3 – 1; (NH4)2SO_4 – 1; Na_2HPO_4 – 1; $MgSO_4$ – 0.5; $FeSO_4$ – 1; chalk – 4; starch – 20; agar – 20. Maintaining an optimal pH range of 7.2-7.5, this culture is then applied to a compost pile with a height of 2.5-3.0 m and a minimum width of 4.0 m. The compost pile's length is arbitrary, with the minimal mass set at 200 tons. Within the compost pile, strategically positioned perforated pipes facilitate the aeration process, ensuring a constant flow of air blown by a compressor or ventilator. This meticulous approach not only accelerates composting but also enhances the quality of the final product.

Optimal biothermal processes necessitate meticulous adherence to specific conditions: the dry substance content should ideally range between 30-40%, while humidity must not exceed 70%. Achieving the right balance in the C: N ratio, ideally between 20:1 to 30:1, is paramount, as is maintaining a pH environment within the range of 6.0-8.0. Under these carefully met criteria, the temperature inside the compost pile naturally elevates to 55-60 °C and can even surpass 70 °C. It is imperative to ensure uniformity in the composting process throughout all layers of the mixture, prompting the need to turn over the compost pile every two weeks.

Peat-based compost, precisely the peat-mud mixture, encompasses crucial specifications:

- Moisture content comprises 70%.
- Phosphorus share per atmospheric sewage should not fall below 0.5%.
- The natural slope angle of the compost pile ranges from 36-43°.

To safeguard the composted mass from freezing during the winter months, each stack undergoes a brief preparation period, typically lasting 1-2 days. This process involves shielding the stack with a protective layer of peat, measuring a substantial 30 cm thick. Elevating the temperature within the compost pile is skillfully orchestrated by strategically incorporating straw. This meticulous approach is a testament to the resilience and efficiency of the composting process, demonstrating its adaptability across a spectrum of environmental conditions.

In our specific case, where the sediments exhibit an elevated concentration of heavy metals, it becomes imperative to undertake additional material preparation. This may encompass employing chemical reagents or other purification methods to diminish the heavy metal content, thereby ensuring the safety of the composting process. A feasible protocol for preparing heavy metal-laden sediments for composting in bio-convectors can be delineated through several pivotal steps.

1. Commence with a preliminary analysis to ascertain the heavy metal content, enabling a comprehensive assessment of contamination levels and formulating requisite preparatory measures.

2. Implement a meticulous sorting process to segregate heavy metals and other unwanted impurities from the material.

3. Undertake chemical treatment of the sediments employing chelating agents. These agents facilitate the binding of heavy metals, subsequently facilitating their removal from the material.

4. Initiate the composting of the treated sediments in bio-convectors, all while meticulously monitoring and maintaining optimal conditions in terms of temperature, humidity, and ventilation. These parameters are essential to ensure the effective decomposition of organic substances and the eventual formation of finished compost.

5. Conclude the process with a comprehensive analysis of heavy metal content within the finished compost, thereby substantiating its safety for utilization [51, 53, 54, 57].

A compelling illustration of the preparation of heavy metal sediments for composting in bio-convectors can be found in Liverpool, Great Britain. The city employs specialized bio-convectors designed to compost heavy metal sludge from sewage treatment plants, containing potentially harmful heavy metals such as lead and cadmium. Recognizing the environmental risks associated with these metals, Liverpool adopts a meticulous approach to ensure the safety and effectiveness of the composting process.

Before the sludge undergoes composting in the bio-convectors, it undergoes a thorough treatment system. This system encompasses cleaning out impurities and adjusting the pH by introducing calcium. Subsequently, the treated sediments are introduced into the bio-convectors, where they undergo a composting period lasting 21 days. This process occurs at an optimal temperature of 60 degrees Celsius, meticulously maintained to provide the necessary ventilation and humidity for effective decomposition.

Upon completing the composting process, the finished compost undergoes certification to validate its safety in agriculture and horticulture. This comprehensive certification ensures that the resulting compost meets stringent standards and poses no threat to the environment or public health. The city of Liverpool plans to continue researching this direction, underlining a commitment to evolving sustainable waste management practices.

Today, harmonizing Ukrainian legislation with EU standards holds exceptional significance, particularly in environmental policies. This integration is driven by a collective ambition to promote the transformation of waste into valuable raw materials. Within the EU member states, a structured protocol governs the disposal of sewage sludge as organic fertilizers in agriculture, as outlined in EU Directive No. 86/278/EEC.

Given the presence of organic matter, sewage sludge can serve as a potential source of fertilizers under conditions conducive to organic availability. Research findings reveal that the dry substance of newly formed sludge consists of approximately 70% organic matter, alongside significant proportions of nitrogen (up to 6-7%), phosphorus (almost equivalent amounts), and potassium (up to 0.5%). Furthermore, these sludge deposits contain essential microelements vital for the robust growth of plants. These inherent characteristics position sludge deposits as valuable sources of organic mineral fertilizers, rich in nitrogen and phosphorus, fully compliant with Ukrainian national standards, and environmentally sustainable sewage sludge treatment practices.

Importantly, this fertilizer production remains resilient, regardless of the prevailing economic conditions in the country, as it is based on waste resources, ensuring the utilization of inexhaustible raw materials. A notable advantage of this approach lies in its potential to reduce the area allocated for sludge sites, contributing to environmental conservation. However, it is noteworthy that sludge utilization as fertilizers remains relatively modest, especially in the western regions of Ukraine. This has led to a delay in the reduction of sludge site areas. Particularly concerning are chlorine-containing, sulfurous compounds, and metal-organic components, which often constitute super-toxic substances, imposing restrictions on using sludge as fertilizers. As a result, it becomes imperative to employ technologies to minimize the presence of toxic substances in dried sludge. In this context, sewage sludge composting emerges as a promising and sustainable method for effectively managing and utilizing this resource.

Referencesto chapters 1, 2 and 3

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4. Doing business activity by keeping balance between economic, social and environmental dimensions of sustainable development: EU realities and their applications in Ukraine

Small and medium enterprises (SMEs) in Ukraine are a powerful socio-economic driver, which provide jobs and more than half of production. SMEs dominate the economy of Ukraine in terms of quantity, employment (generate about 80 % of employment) and value added. According to the State Statistics Service of Ukraine, before the pandemics the country had 446 large enterprises and 1,839,147 SMEs [10]. Eighty per cent of all SMEs were selfemployed individuals in a situation where 75 % of women participating in labour force are self-employed and the sector generated around 20 % of GDP. Currently Ukrainian enterprises work under various conditions which are of great importance to analyze in terms of country's economic growth to be achieved: war in the Eastern part of Ukraine, European integration, COVID-19 pandemics and sustainability constrain. Each of the above mentioned has a significant impact on business activities and all together they create a very challenging environment for its development.

Sustainability issues has become a widely discussed question around the globe before, during and after COVID-19 pandemics arose. Its spread in different areas of our lives has been tremendous and as the time goes, it is getting bigger and bigger. Talking from business perspectives, sustainability patterns have caused changes in consumer behavior and if one might think that COVID-19 made people care more about their spendings (which is for sure also true), not environment, responsible consumption alongside with sustainability paradigm has become a real trend in developed countries.

Sustainable development goals (SDGs) are crucial components of practical implementation of Ukraine's new model of inclusive growth and an integral part of European integration [7]. Taking into account that the EU is becoming Ukraine's main trade partner (almost 42% of Ukraine trade volume), business sustainable practices may become those tools which enhance the process of European integration and positively impact on market expansion, investment climate, job creation, better social and environmental standards [9]. Although how does it work now, in the time of economies recovery from COVID-19? What are the main challenges business faces due to that? And is it possible to keep the balance between economic, social and environmental dimensions of sustainable development today for Ukrainian business entities on its way to European Integration? These are the main questions the paper aims to answer.

It is well known that time of crisis sets both – challenges and opportunities. It depends on certain actions to be taken to face the first and meet the latter ones. The findings of the EBA survey conducted in late March 2020 highlight that the main concerns for Ukrainian SMEs were: lack of cash flow for rent, utilities, salary and supplies; failure to meet deadlines for the supply of raw materials and components under contracts; debts owed to banks; administrative burdens; penalties for late payments [4]. At the same time field surveys showed that about 30% of business owners [1] claimed a 90% drop in revenue since the adoption of the lockdown measures; about 50% reported a 20–50% loss of income; 25% planned to reduce employees wages and 20% planned to reduce staff. Such challenges that businesses had to face caused urgent necessity of the analysis of possible measures to be taken in order to overcome crisis times which both depends on and impact on the overall economic situation of the country.

Analysis of the above mentioned in the regard of sustainability shows that market expansion and economic growth to be achieved in a country will at the same time boost the consumption of natural resources and result in waste generation which puts more pressure on the environment. That is the time when "green economy" plays a vital role.

Transition to green economy is a long and complicated process. "Green business" can be defined as a business that follows the principles of environmental sustainability in its operations, strives to use renewable resources and tries to minimize the negative impact on the environment [6]. It is difficult (if possible at all) to find a company in the world which can be called as fully "green" not having any negative environmental impacts. However, many companies (small, medium, and large) have taken the path to become "greener". Some of them have achieved "zero waste" or\and "closed-loop water use" or\and use only recycled materials in the production process. Some business owners take such strategy as a tool to be more profitable by reducing costs or increasing sales; some – have taken it as a long-term social responsibility action. The level of which the company aims to "go greener" differs greatly but in each case certain decisions and actions have reduced their impact on the environment.

Current business policies, models and strategies used in Ukraine depend greatly on Ukraine-EU Association Agreement on a Deep and Comprehensive Free Trade Area with the EU together with the action plan of its implementation (in particular, the Economic and Sectoral Cooperation section) and regulations related to energy, environment and technical guidelines, which are considered as the core ones in Ukraine's transition to the European green development model [3]. To better understand possibilities how to keep balance between economic, social and environmental dimensions of sustainable development based on the above mentioned it is important to analyze its measuring system.

In 2016 it was adopted "The Measuring the green transformation of the economy. Guide for EU Eastern Partnership countries" (by OECD), where there were made efforts to establish a common system for economic, social and environmental evaluation of country's green transformation progress. According to this Guide, Economy Green Transformation [8] should be measured by the following:

1. OECD indicators and statistical database (member and partner countries):

1.1. Economic performance, national accounts, productivity.

1.2. Environmental performance, resource productivity.

1.3. Science and technology innovation, entrepreneurship.

1.4. Energy, agriculture, transport.

1.5. Employment, education.

1.6. Development aid, investments, trade.

2. Measuring well-being and progress towards Green Growth (UNEP, WB, UNECE, EU, national indicators):

2.1. Socio-economic and growth characteristics.

2.2. Environmental and resource productivity.

2.3. Natural asset base.

2.4. Environmental quality of life.

2.5. Economic opportunities and policies.

3. Measuring the progress of societies - GDP and beyond (UN SDGs).

Of more than 100 indicators proposed by OECD in 2011 and 2014, 80 were examined and 60 adapted to be used in Ukraine [3]. It was researched that the indicators data varies greatly from each other which makes it hard to evaluate the exact situation with the Ukraine green growth.

Meanwhile the importance of greening the economy is seen in the following: it creates less resource-intensive economy sectors along with new jobs; introduces efficient technologies and boosts innovation activities in the sector of energy efficiency; increases enterprises' competitiveness and labour productivity; minimizes waste. Green economy role becomes at a fore front in the COVID-19 pandemics as more pressure has been put on business.

It was found that the most affected by COVID-19 were micro and small businesses in such areas as beauty, hospitality, tourism and leisure (often operate in the informal economy) where mainly women work; the largest decrease in the number of female employees occurred in wholesale and retail trade [11].

There were defined the following mechanisms of SMEs to cope with COVID-19 [5]:

– purchase of protective equipment;

– decrease in purchases;

– reduction of costs of rented premises and equipment;

– part-time employment, salary cuts;

– change of logistics and transportation of goods;

– cessation of work of production lines and outlets; payment deferral;

– search for new suppliers;

– introduction of flexible schedule, telecommuting, etc; dismissal of employees;

– reduction of the costs of paying interest, debt deferral;

– applying for assistance from the state;

– reduction of the cultivated land area.

The extent of the economic shock as well as how well businesses are able to cope with COVID-19 largely depends on how much the policy response is able to deal with it. The Europe 2020 Strategy outlines the EU's priorities for becoming a "sustainable economy". Governments within the EU have identified the development of SMEs and the transition to a green economy as core objectives of their economic development policy. In EU countries the "green" goods and services sector employs around 3.4 million persons [5] and green business sector has been one of the fastest growing business sectors over the past decade. As part of the Europe 2020 Strategy the EU has developed a Green

Action Plan, which aims at helping SMEs to exploit business opportunities that green economy offers.

Also the EU is leading the "Greening Economies in the Eastern Neighbourhood" (EaP Green) project in six countries, including Ukraine. The project is working at government and private sector levels (including SMEs) to: (1) mainstream sustainable consumption and production into national development plans, and legislation; (2) promote the use of strategic environmental assessment and environmental impact assessment as essential planning tools for environmentally sustainable economic development; (3) facilitate the greening of selected economic sectors [6]. On its way to European integration, Ukraine should focus its recovery policies on puting the economy on a more sustainable path. The private sector has great potential to drive green growth. Fostering entrepreneurship, supporting startups, and creating a stable environment for business to grow using green growth principles are important.

Based on the above mentioned we consider that the following measures and policy options enable to keep balance between economic, social and environmental dimensions of sustaianable development for businesses after COVID-19 recovery (Fig. 4.1).

Measures mentioned on the picture 1 show that approach to business sustainable recovery after COVID-19 should be complex. A common strategic planning for Ukrainian Green Economy defines the main areas of sustainable economic growth, environment and employment. As elements of sustainability are economic, social and environmental, business sustainable practices can be seen in social responsible companies, ecologically clean production facilities, “green” investments, eco-friendly products and services, labour protection policies at work, decent work provided in urban and rural areas etc. Each of the above mentioned is an example of “green business” as a part of “green economy”, which provides solutions to some of society’s greatest environmental challenges.

Measures that enable to keep balance between economic, social and environmental dimensions of sustainable development for Ukrainian business after COVID-19 recovery

1. Employment retention and generation:

- development of a comprehensive employment policy, linking policy decisions to support trade, foreign direct investments, industrial policy, infrastructure development and skills development to increase in the quantity and quality of jobs, especially for vulnerable groups;
- strengthening of institutions that bear direct responsibility for the efficient governance of the labour market;
- promotion of a decentralized implementation of the employment policy through local employment partnership initiatives;
- employment retention schemes aimed at preserving employment at crisis times
- adoption of international labour standards

2. Safe work environments

(scientific, health, humanitarian and development communities should collaborate with state and interested private actors towards enhanced understanding of transmission through waste management)

3. Greening the small and medium-sized enterprises

- strengthen SMEs' contribution to the lowcarbon transition;
- policies to support the greening of SMEs (financial support measures; incentives for better environmental performance; provision of clear and simple procedures to apply to business support mechanisms and business incubators that could encourage more enterprising SMEs to transition from the informal to the formal sector)

4. Digitalizing of SMEs

5. Circular migration

- safeguard decent work for Ukrainian labour migrants;
- support the safe return and reintegration of Ukrainian migrant workers;
- develop a framework that enables investments and incentivizes the return of qualified nationals;
- establish economic support measures that benefit migrants and remittance service providers

6. Digital infrastructure

7. E-Government

(to reduce administrative barriers by accelerating the implementation of e-government initiatives)

8. Food and agriculture

- develop a crop insurance system with state support;
- develop legislation and infrastructure along food value chains;
- support digital connectivity in agriculture;
- facilitate foreign trade and investment

Fig. 4.1. Measures that enable to keep balance between economic, social and environmental dimensions of sustainable development for Ukrainian business after COVID-19 recovery

Source: [2]

Ukraine has substantial national resources, in particular land and minerals. Ideas for green businesses are driven by increased environmental awareness in the community, which in turn creates a demand for green products and services. As levels of environmental awareness increase over time, demand for green goods and services also increases, together with opportunities for business development. It is therefore necessary to create conditions that enable a transition by SMEs to a greener performance. The introduction of sustainable practices with a people-centred approach is a helpful tool for meeting challenges business faces today and application of complex measures enables to keep the balance between the three core elements of sustainability.

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5. Financial aspects of the environmental taxation in the EU and Ukraine

5.1. Environmental taxation basic principles, functions and features: an overview

Tax system instruments are one of the methods to be used for solving and removing the problem of negative environmental processes taking place nowadays. In recent years, tax policy has become a central pillar of government measures to boost the economy and tackle social and environmental issues[1]. Environmental taxation has not developed in a significant way so far, but there is potential for it to become a major source of revenue in a world where climate change and other environmental threats are taken more seriously[2]. The aim of these taxes is both to encourage companies to change behaviours so that they operate in a way which benefits the environment, and to achieve specific environmental objectives and targets set by government and international bodies[3].

In Ukraine environmental tax has been imposed on enterprises polluting in 2011 but most of the environmental problems still are to be resolved as the system of environmental taxation in Ukraine is not optimal. A large part of its elements do not cause a multiplicative effect aimed at reduction of the negative impact on the environment. So, an adequate assessment of the efficiency of the environmental taxation system in Ukraine functioning is urgent.

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[3] *Paying Taxes 2009:* The global picture, World Bank Group and PwC [online], https://www.pwc.com/gx/en/paying-taxes/assets/paying-taxes-2009.pdf, p. 60 [accessed: 13.01.2019]

The analysis of indicators for comparision and concluding is carried out for the period of the environmental tax existence in Ukraine (2011–2018). For the European Union (EU) data are available till 2017 (including).

The aim of the article is to analyze the current situation in environmental taxation in Ukraine in terms of identifying main problems existing in this area, compare Ukraine's performance with the EU countries for studying best practice within the issues discussed and provide recommendations for the environmental taxation improvement and efficiency increase in Ukraine.

In "Environmental taxes – a statistical guide" issued by European Commission (2013)[4] the environmental tax is defined as "a tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment". The same definition is used in the European system of accounts[5] and Regulation (EU) No 691/2011 on European environmental economic accounts[6].

Basic subgroups within environmental taxes are as follows[6]:

1. Energy taxes (including fuel for transport, in which CO2 taxes).

2. Transport taxes (excluding fuel for transport).

3. Pollution taxes. This group includes taxes on measured or estimated emission to air (except CO2 taxes) and water, on the management of waste and noise.

4. Resource taxes covers taxes on extraction of raw materials, with the exception of oil and gas.

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[4] *Environmental taxes – a statistical guide* [online], http://ec.europa.eu/eurostat/documents/3859598/5936129/KS-GQ-13-005-EN.PDF, p. 9, p. 13

[5] *Glossary: European system of national and regional accounts (ESA 2010)* [online], http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_system_of_national_and_regional_accounts_(ESA_2010)

[6] *Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts* [online], http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:02011R0691-20140616

In Ukraine, the environmental tax was enacted in 2011 with the adoption of the Tax Code [4, article 240] and charge the taxpayers engaged in the following[7]:

1) emissions of pollutants into the air from stationary sources of pollution;

2) discharges of pollutants directly into water bodies;

3) waste disposal (except for placement of certain types (classes) of waste as secondary raw material to be placed on its own territory of economic entities);

4) the generation of radioactive waste (including already accrued);

5) temporary storage of radioactive waste over the deadline.

In addition, there are environmental taxes regulating the use of natural resources, which are not a component of the environmental tax. These include rental fee for the following:

1) use of mineral resources and the radio frequency resource of Ukraine;

2) special use of water and forest resources, as well as land tax.

Ukrainian legislation, unlike foreign ones, already defines the types of activities that are the basis of environmental taxation in the definition of environmental taxes, and specifies which radioactive waste is taxed, that is, the definition of environmental tax by the Tax Code of Ukraine is excessively detailed. In Ukraine there are taxes/fees that regulate the use of natural resources, electricity and the use of vehicles, however, they are not part of the environmental tax. But this aspect of the national taxation system should not be taken critical, as many countries have the experience of gradually transforming some national taxes into environmental ones, e.g. United Kingdom[8].

Various types of environmental taxes that can be levied in the EU countries partially coincide with the components of the environmental tax in Ukraine: for example, pollution taxes and, partially, energy taxes in the EU, and such com-

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[7] *Tax Code of Ukraine* [online], https://zakon.rada.gov.ua/laws/show/2755-17?lang=en

[8] Kozmenko S.M., Volkovets T.V. Features of environmental taxation in foreign countries, *Bulletin of Sumy State University*, 2012, No. 1, pp. 11–18, p. 12.

ponents of the environmental tax in Ukraine as emissions of pollutants into the atmospheric air, discharges of pollutants to water bodies, waste disposal, taxes on volumes of electric energy produced by operating organizations of nuclear installations (nuclear power plants).

Also, EU environmental taxes include taxes that are distinct from environmental in Ukraine: for example, transport taxes and taxes on EU resources and rental fees for special use of forest resources, water, use of minerals, etc. in Ukraine.

It should also be taken into account that during their comparisons the total correspondance of the EU environmental taxes and environmental taxes in Ukraine is not ensured as environmental payments are considered only as revenues from the environmental tax by the State Statistics Service of Ukraine.

Environmental taxes have many important advantages, such as environmental effectiveness, economic efficiency, the ability to raise public revenue, and transparency. Also, environmental taxes have been successfully used to address a wide range of issues including waste disposal, water pollution and air emissions.

In the Organisation for Economic Co-operation and Development (OECD) countries effective environmental taxes are designed on the following principles:

1. Environmental tax bases should be targeted to the pollutant or polluting behavior.

2. The scope of an environmental tax should ideally be as broad as the scope of the environmental damage.

3. Environmental taxes should apply uniformly with few (if any) exceptions.

4. The tax rate should be commensurate with the environmental damage.

5. The tax must be credible and its rate predictable in order to motivate environmental improvements[9].

But according to[10] the environmental tax has a non-tax nature, since the compensation is a feature of non-tax payments.

Environmental taxes have three key roles and functions: internalization of external costs (i.e. optimal tax rate should correspond to overall social marginal costs of pollution, the so-called Pareto efficiency of environmental use), educational (serve to encourage potential pollutants, i.e. emitters of harmful substances to reach a decision about whether to pay an additional tax unit or to give up emission of additional unit of pollution, an end result being levelled marginal costs of pollution of all emitters), and financial (all taxes are usually financially generous, and collected funds could serve in environment protection). In addition to these functions, environmental taxes have the function of improving environmental quality[11].

Environmental taxation functions are also identified as: fiscal (is realized through raising budget revenue), environmental protection (is achieved by financing environmental programs aimed at solving environmental quality problems) and incentive (such taxes are intended to stimulate the environmental behavior of taxpayers, which should reduce the burden on the environment and ensure its protection). In order to reduce environmental payments to the budget, an entity should reduce the level of environmental pollution caused by its economic activity, which is impossible without investing in resource-saving, wasteless technologies etc.[12].

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[9] *Environmental Taxation. A Guide for Policy Makers* [online], https://www.oecd.org/env/tools-evaluation/48164926.pdf

[10] Shulha T.M. Formation and development of environmental taxation in Ukraine. *Scientific Bulletin of the International Humanitarian University. series: Jurisprudence*, 2013, No. 6-3, Vol. 2, pp. 68–70, p. 69.

[11] Sabina Hodžić, Vjekoslav Bratić. Comparative analysis of environmental taxes in EU and Croatia. *Ekon. Misao i Praksa DBK*. GOD XXIV, 2015, BR. 2, pp. 555-578., p. 560-561.

[12] Yakusha Ya. Problems of the European experience of environmental taxation adaptation to Ukrainian conditions, *Economy of the Crimea*, 2011, No.3 (36), pp. 73–77.

Trade-offs between fiscal (revenue raising) and environmental objectives should be addressed. In the long-term, if environmental taxes are effective, revenues will decline as a result of behavioural change. This is a natural consequence of the application of an environmental tax. To stabilise revenues in the short-term, governments might find it useful to index the tax rate to inflation or gross domestic product (GDP) growth or to foresee regular tax increases.

The criteria used for the impact of environmental taxes on environmental degradation, social equity and the economy are: environmental effectiveness (analysing whether the tax is capable of leading to an overall reduction in pollution and/or result in reduced consumption of energy or other scarce resources); social impacts (including indirect impacts, resulting from changing relative prices, and the potential for regressive impact of the tax); economic and fiscal impacts, including impacts on GDP, international competitiveness, employment, and government revenues[13].

One of the criteria for the effectiveness of the taxation system is also the degree of integration, coherence and a combination of environmental and tax interests of the state, taxpayers and citizens[14].

Due to many developing countries' capacity constraints, it might be advisable to first target a tax base for which existing effective collection mechanisms exist. Revenues can subsequently be used to improve fiscal capacity. In developing countries, fiscal space is limited and environmental policies tend not to be prioritised. In this context, loose symbolic earmarking, or even legal earmarking of a proportion of revenues, can be an important tool to raise awareness of the implementation of the tax, gain popular support, and to ring fence funds for a specific environmental cause[15].

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[13] Jacqueline Cottrell, Tatiana Falcão. *A Climate of Fairness. Environmental Taxation and Tax Justice in Developing Countries* [online], 2018, p. 9, https://www.globaltaxjustice.org/sites/default/files/A_Climate_of_Fairness.pdf

[14] Bets M.T., Bezpalova O.V. Environmental taxation in Ukraine and its prospects. *Scientific Bulletin*, Iss. 14.7, 2004, Lviv: UkrSFTU, pp. 154-158, p. 155

5.2. Ukraine's performance: key features and findings in environmental taxation issues

At the macro level, an important aspect in the field of environmental taxation is the distribution of funds between the levels of the budget system and the directions of their spending. Throughout the period of the environmental tax existence and the previous fees and charges for pollution of the environment, the proportions of distribution of tax revenues in Ukraine between the budgets and the regulatory legal base that determines them have constantly changed. This fact makes it impossible to formulate consistent policy of environmental activities and the implementation of multi-year programs in this area[15].

The distribution of the amounts of environmental tax is carried out in the following proportions[16]:

– 45% of the tax – to the general fund of the State Budget of Ukraine (except for the tax, which is charged for carbon dioxide emissions from stationary sources of pollution, which is transfered to the general fund of the state budget in full; the tax that is charged for the generation of radioactive waste (including already accrued) and / or temporary storage of radioactive wastes by their producers above the established by the license term, which is transfered to the special fund of the state budget in full);

– 55% – to the special fund of local budgets (except for the tax that is charged for the generation of radioactive waste), including:

– to rural, city budgets, budgets of united territorial communities, created in accordance with the law and a prospective plan for the formation of community territories – 25%;

– regional budgets and the budget of the Autonomous Republic of Crimea – 30%;

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[15] Kanonishena-Kovalenko K. *Environmental Tax from A to Z*. Kyiv: Foundation «Vidkryte Suspilstvo», 2017, 108 p., pp. 6-7.

[16] http://sfs.gov.ua/zakonodavstvo/podatkove-zakonodavstvo/listi-dps/73141.html [online]

– budgets of the cities of Kyiv and Sevastopol – 55%.

It is important to identify the budget funds that were earmarked for environmental taxation, where significant changes took place: from the formation of extra-budgetary funds, from which revenues could be spent only on environmental protection measures (until 1998) to transfer of these revenues to the budget. Since 2012, the proportions of the distribution of revenues from the environmental tax and its funds have changed every year (table 5.1). As a result, the environmental tax could not perform its functions in full due to misplaced revenues from it, and budget planning on environmental tax revenues and environmental protection expenditures could not be effectively realized in the medium and long term. Revenues tranfered to the special budget fund can be spent only on specific goals, whereas transfer of environmental tax revenues to the general fund of budgets contradicts the nature of this tax – such funds are not directed towards compensation for the damage to the environment done, and are distributed to the budget without further targeted use[17].

Table 5. 1. Environmental tax revenues distribution between general and special funds in state, local and consolidated budgets of Ukraine, 2011–2018, (mln UAH)

Environmental tax revenues	2011	2012	2013	2014	2015	2016	2017	2018
State budget	**1085, 3**	**1263, 6**	**2364,9**	**3614,5**	**1105,4**	**1619,1**	**1720, 7**	**2779, 6**
General fund	–	–	–	2585,9	1105,4	1619,1	1720, 7	2266, 0
Special fund	1085, 3	1263, 5	2364,9	1028,6	–	–	–	513, 5
Local budgets	**1190, 5**	**1552, 4**	**1534,5**	**1216,4**	**1585,6**	**3368, 2**	**2977, 6**	**2141, 8**
General fund	–	–	–	–	1585,6		–	–
Special fund	1190, 5	1552, 4	1534,5	1216,4	–	3368, 2	2977, 6	2141, 8
Consolidated budget	**2275, 8**	**2816, 0**	**3899,5**	**4830,9**	**2691,0**	**4987, 4**	**4 698, 4**	**4921, 5**
General fund	–	–	–	2585,9	2691,0	1619, 1	1720, 7	2266, 0
Special fund	2275, 8	2816, 0	3899,5	2245,0	–	3368, 2	2977, 6	2655, 4

Source: Reports on the state budget execution, https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu

The structure of the distribution of environmental taxes is tied to the territory of its formation, which prompts local budgets to receive their own revenues. A positive fact is that the increase in revenues of local budgets and the distribution of the share of environmental taxes between the levels of budgets are vertical, which makes it possible to adhere to the polluter pays principle[17].

Environmental tax revenues (table 5.2) from the time of its introduction until 2014 increased, but a significant decrease has been recorded in 2015. A considerable increase again took place in 2016. As a whole, the amount of the environmental tax paid in Ukraine in the period analyzed has doubled.

Table 5.2. Dynamics of the environmental tax revenues to the consolidated budget of Ukraine for 2011-2018

Indicator	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total budget revenue (excluding inter-budget transfer payments), mln UAH	398 5,5	445 5,2	4427,8	4560,6	6520,3	7828,5	1016, 9	1184, 2
% to GDP	29,8	29,7	28,2	28,0	32,8	32,8	34,1	33,7
Total tax revenue, mln UAH	3346,9	3605,6	3539,6	3675,1	5076,3	6507,8	8281,5	9863,4
% to GDP	28,1	23,8	22,4	22,4	25,5	27,3	27,8	27,8
% to total budget revenue	84,0	80,9	79,9	80,6	77,9	83,1	81,4	83,3
Environmental tax, mln UAH	2275, 8	2816, 0	3899,4	4830,9	2691,0	4987, 4	4698, 4	4921,5
% to GDP	0,2	0,2	0,3	0,3	0,1	0,1	0,16	0,14
% to total budget revenue	0,6	0,6	0,9	1,1	0,4	0,4	0,5	0,4
% to total tax revenue	0,7	0,8	1,1	1,3	0,5	0,5	0,6	0,5

[17] Chala O.A. Modern aspects of the environmental tax distribution in the context of ensuring the ecologization of the national economy, *Effective economy*, *No.* 3, 2015 [online], http://www.economy.nayka.com.ua/?op=1&z=3908

Source: Reports on the state budget execution, https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu

One of the reasons for the constant increase in environmental taxes revenues may be due to the increase in environmental tax rates, continuously being increased throughout the environmental tax existence period. Commencing 1 January 2018, the payers of environmental tax had to apply the respective tax rates increased by 11.2 percent. From January 1, 2019, the rate of carbon dioxide tax rate by stationary sources increased by 24.4 times (from 0,41 UAH per tonne till 10 UAH per tonne) with the aim of stimulating polluting enterprises to reduce environmental pollution, as well as approximating greenhouse gas emission rates to the EU countries' ones**;** rent for oil extraction increased by 2%; the rate for iron ore mining increased by 0.8%; the rent for the special use of forest resources, for the purchase of wood of main and minor forest species increased by 50%[18].

When analyzing the fiscal role of an environmental tax, its share in total budget revenues and tax revenues is important. Data given in Table 5.2 testify that the share of environmental tax revenues in the total tax revenues in consolidated budget varies in the range of only 0,5 - 1,3%. In general (table 5.3, figure 5.1), environmental tax revenues account for a very small portion in the consolidated budget revenues – from 0.41% to 1.06%.

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[18]http://sfs.gov.ua/zakonodavstvo/podatkove-zakonodavstvo/listi-dps/73141.html, http://www.visnuk.com.ua/uk/news/100011175-u-2019-rotsi-zastosovuyutsya-novi-stavki-rentnoyi-plati

Table 5.3. Environmental tax revenues and environmental protection expenditures in local, state and consolidated budgets of Ukraine in 2011–2018, (mln UAH)

Budget	2011		2012		2013		2014		2015		2016		2017		2018	
	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures	Revenues	Expenditures
Consolidated budget	2 275,8	3891,0	2 816, 0	5298,0	3 899, 4	5594,0	4 830, 9	3482,0	2 691, 0	5530,0	4 987, 4	6255,0	4 698, 4	7349,0	4921,5	8242,0
State budget	1085, 3	3008,3	1263, 5	4135,0	2 364, 9	4595,0	3614, 4	2597,0	1105, 4	4053,0	1619, 1	4772,0	1720, 7	4740,0	2266,0	5241,0
Local budgets	1190, 5	882,0	1552, 4	1163,0	1534, 5	999,0	1216, 4	885,0	1585, 6	1477,0	3368, 2	1484,0	2 977, 6	2609,0	2655,4	3001,0

Source: Reports on the state budget execution, https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu

In the state budget's revenues, the share of environmental tax ranges from 0.21% to 1.02%, and in total revenues of local budgets – up to 2%.

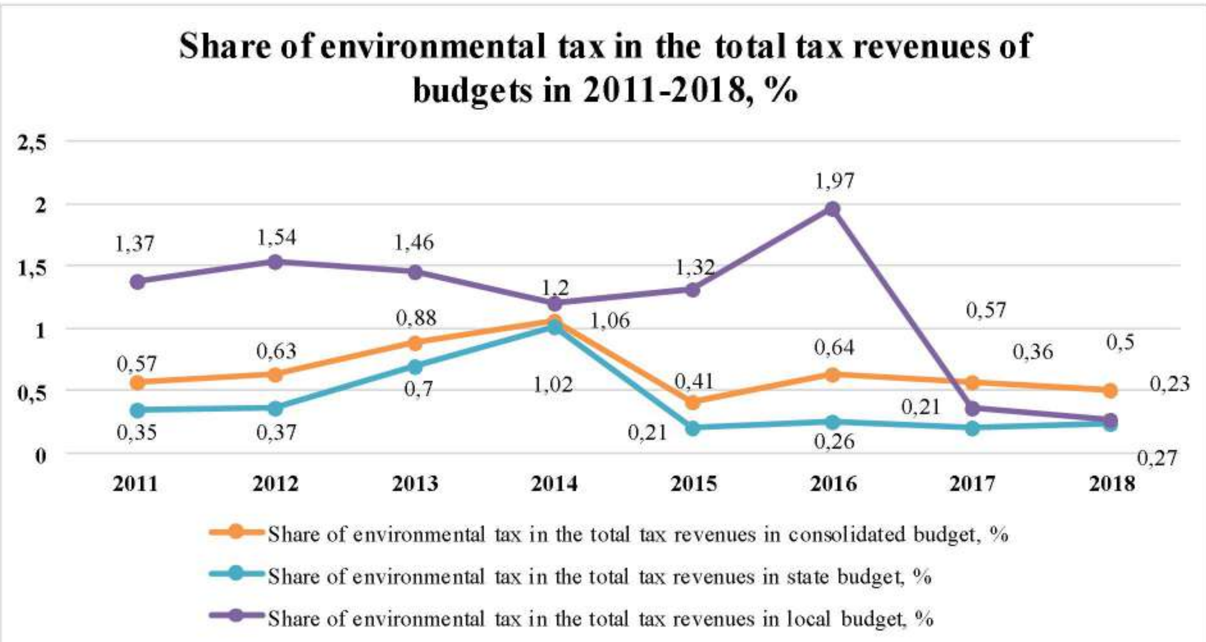

Fig. 5.1. Share of environmental tax revenues in the total tax revenues of local, state and consolidated budgets of Ukraine in 2011-2018, %

Source: Reports on the state budget execution, https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu

The fiscal role of the environmental tax for local budgets in general and for the state and consolidated budgets is insignificant.

5.3. Environmental taxation in the EU: lessons for Ukraine

Since the environmental tax is currently not performing its functions in Ukraine, the environmental tax system needs to be improved. In addition, the international obligations undertaken by Ukraine (Association Agreement between Ukraine and the EU signed in 2014) are challenged by the need to modernize the system of environmental taxation. Therefore, it is useful to study the European experience in managing environmental taxation.

The main feature of the environmental policy of the EU countries is that it aims at preventing the occurrence of environmental pollution by conducting an environmental assessment through Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA)[19]. As to the Ukraine, without an effective EIA it would steadily move towards a resource-dependent country, where the quality of life of the population will grow much more slowly than the GDP. Unlike environmental monitoring, EIA is carried out at a stage where the pollution is not yet taking place and there is the possibility of minimizing or even eliminating it. EIA are a key element in preventing environmental damage when planning and granting permissions for industrial (production) activities[20].

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[19] Naidenko O.Ye. Problems of environmental taxation and ways of their solution [online], *Economy and Society*, Iss. 8, 2017, pp. 627–633, http://www.economyandsociety.in.ua/journal/8_ukr/105.pdf

[20] Andrusevych A. Live like in Europe: an assessment of the environmental impact and quality of life [online], https://dt.ua/ECOLOGY/zhiti-po-yevropeyski-ocinka-vplivu-na-dovkillya-ta-yakist-zhittya-_.html

The Unified Register of Environmental Impact Assessment is operating as of January 2018[21].

Implementation of the system of environmental payments in Europe was taking place at the end of the past century within the so-called green tax reforms –restructuring of tax systems by the introduction of environmental payments and simultaneous reduction of the tax burden on labor remuneration. These resulted in a "win-win situation": economic incentives for environmental protection and environmental management through the introduction of environmental taxes while reducing the tax burden on other taxation objects[22] [23]. In order to avoid comparision of Ukraine's and the EU performance in monetary units because of the effect of exchange rate, it is worth considering the share (percentage of total revenues from taxes and social contributions) of environmental tax in tax revenues of the budgets of countries (table 5.2, table 5.4).

The share of environmental tax in tax revenues in Ukraine (0.5 - 1.3% throughout the analyzed period) is almost 10 times lower compared the European countries where it ranges from 4 to 12%. For example, Bulgaria, Greece, Croatia, Latvia, Malta, Netherlands, Romania and Slovenia stand out among EU countries with the share of 9-11%, 8-10%, 7-9%, 10-12%, 8-9%, 9-10%, 7-9%, 10-11% correspondingly; data provided for Serbia tesify about the share of 8-12%. The share in Estonia, Cyprus, Italy, Poland accounts for around 8%, in the UK is more or less than 7%, in Germany and France – around 4-5%, overally in the EU (28 countries) – around 6% (table 5.4).

[21] Myron B. Rabij, Igor Davydenko, and Anzhelika Livitska. Ukraine: Kyiv Environment Newsletter [online], http://www.mondaq.com/x/666250/Clean+Air+Pollution/Kyiv+Environment+Newsletter

[22] Yatsyshin Yevhenii. Ecological taxation: Ukrainian realities and European practice, No. 23 (625) [online], http://yur-gazeta.com/publications/practice/ekologichne-pravo-turistichne-pravo/ekologichne-opodatkuvannya-ukrayinski-realiyi-ta-evropeyska-praktika.html

[23] Shevchenko I.V. Ecological taxation: foreign experience and Ukraine, *Strategic priorities*, No. 2 (31), 2014, pp. 55–60.

Table 5.4. Environmental tax revenues in the EU in 2011–2017, (EUR million and % of GDP)

Year	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**	
Country	**Total, milon euro**	**% of total reven.**[24]	**Total, million euro**	**% of total reven.**	**Total, million euro**	**% of total reven.**	**Total, million euro**	**% of total reven.**	**Total, million euro**	**% of total reven.**	**Total, million euro**	**% of total reven.**	**Total, million euro**	**% of total reven.**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
EU[25] (current composition)	317 172,46	6,18	327 510,87	6,16	332 668,05	6,13	344 118,88	6,14	360 145,98	6,13	364 780,16	6,11	368 796,24	5,97
Euro area (19 countries)	229 595,52	5,89	235 135,02	5,86	240 129,61	5,84	245 751,28	5,84	251 161,16	5,79	259 857,91	5,83	265 578,91	5,72
Belgium	8 529,3	4,87	8 313,7	4,54	8 129	4,3	8 337,3	4,33	8 659,4	4,43	9 374,9	4,73	9 826,7	4,74
Bulgaria	1 107,66	10,59	1 119,38	10	1 174,6	9,9	1 167,82	9,61	1 315,89	10	1 334,32	9,57	1 383,89	9,07
Czechia	3 846,08	6,94	3 606,43	6,52	3 359,89	6,11	3 281,3	6,18	3 490,56	6,08	3 725,42	6,07	3 974,74	5,86
Denmark	9 957,41	8,68	10 098,54	8,46	10 712,52	8,76	10 621,61	8,02	10 847,43	8,4	11 065,4	8,38	10 878,28	7,98
Germany	58 691	5,61	58 274	5,38	57 947	5,17	58 292	5,02	58 063	4,79	58 449	4,6	59 259	4,46
Estonia	454,26	8,59	489,06	8,56	484,64	8,04	533,07	8,22	562,83	8,14	645,19	8,81	680,76	8,73
Ireland	4 206,32	8,5	4 168,74	8,16	4 425,35	8,32	4 629,43	8,02	4 927,07	7,88	5 059,07	7,71	5 148,92	7,46
Greece	6 017	8,05	6 265	8,45	6 585	9,45	6 628	9,49	6 749	9,57	6 656	9,01	7 162	9,5
Spain	16 885	4,92	16 339	4,75	19 622	5,63	19 382	5,41	20 857	5,59	20 754	5,44	21 382	5,32
France	39 614	4,24	40 946	4,21	42 897	4,26	43 716	4,26	47 493	4,53	50 128	4,71	52 925	4,77
Croatia	1 200,72	7,62	1 124,97	7,13	1 248,92	7,86	1 379,96	8,66	1 502,95	9,04	1 625,71	9,21	1 679,78	9,08
Italy	49 980	7,31	56 315	7,98	55 320	7,88	58 175	8,26	56 067	7,85	58 705	8,17	57 384	7,85
Cyprus	545,5	8,68	502,5	8,15	494	8,62	536,8	9,13	525,3	8,9	536,6	8,81	572,9	8,62
Latvia	604,8	10,5	660,4	10,21	723,46	10,71	790,25	11,16	859,36	11,63	907,89	11,54	941,53	11,11
Lithuania	527,68	6,12	548,13	6,02	587,27	6,16	633,88	6,24	691,52	6,33	747,92	6,41	807,4	6,42
Luxembourg	1 018,61	6,13	1 038,78	5,9	1 003,92	5,44	975,26	5,03	948,5	4,74	928,95	4,42	946,69	4,25
Hungary	2 656,42	7,15	2 594,59	6,79	2 554,75	6,6	2 621,76	6,51	2 823,5	6,55	2 986,41	6,67	3 141,88	6,6
Malta	211,27	9,24	205,49	8,52	205,67	7,97	239,77	8,42	269,9	8,84	277,14	8,34	303,05	8,16
Netherlands	22 224	9,46	21 178	8,98	21 564	8,91	22 216	8,8	22 925	8,86	23 754	8,62	24 563	8,49
Austria	7 508,22	5,76	7 663,47	5,65	7 724,33	5,49	7 973,44	5,51	8 201,85	5,43	8 382,56	5,53	8 841,99	5,64
Poland	10 018,44	8,04	10 072,65	7,83	9 521,62	7,32	10 581,94	7,83	11 423,25	7,97	11 579,8	7,87	12 536,76	7,65
Portugal	4 078,24	6,53	3 637,59	6,27	3 761,42	5,94	3 933,9	6,13	4 341,62	6,52	4 811,43	7,04	5 041,16	7,02
Romania	2 573,54	6,89	2 632,32	7,12	2 890,02	7,36	3 493,06	8,45	3 888,33	8,66	3 962,9	8,77	3 577,68	7,39
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Continuation of Table 5.4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Slovakia	1 278,5	6,3	1 252	6,07	1 274,35	5,67	1 349,44	5,68	1 392,45	5,47	1 467,39	5,58	1 497,53	5,32
Finland	5 945	7,16	5 949	6,95	5 953	6,69	5 957	6,6	6 118	6,63	6 709	7,03	6 693	6,88
Sweden	9 740,19	5,58	10 216,22	5,6	10 257,76	5,42	9 547,29	5,11	9 929,55	5,07	10 376,07	5	10 258,22	4,8
United Kingdom	46 476,47	6,94	50 910,75	7,06	50 818,36	7,13	55 672,85	7,17	63 763,36	7,11	58 266,22	6,94	55 786,1	6,75
Liechtenstein	39,24	:	38,7	:	37,13	:	41,78	:	46,95	:	46,27	:	:	:
Norway	9 015,06	5,98	9 360,81	5,68	9 279,08	5,9	8 817,51	6,03	8 234,67	6,15	8 135,1	6,26	8 202,85	5,95
Switzerland	8 639,62	6,36	8 910,38	6,35	8 684,76	6,19	8 918,76	6,19	10 299,66	6,09	10 438,18	6,21	10 542,15	6,15
Serbia	1 106,24	8,85	982,48	8,36	1 147,04	9,15	1 303,15	10,46	1 384,87	11,09	1 516,05	11,41	:	:
Turkey	21 403,55	:	23 148,97	:	26 024,24	:	23 839,13	:	26 459,7	:	26 534,3	:	24 392,9	:

Source: Eurostat. Environmental tax revenues, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_tax&lang=en

Despite doubled environmental tax revenues in Ukraine in 2016-2018 compared to previous periods (table 5.2), environmental pollution rates remain steady, and environmental studies testify about a permanent environmental crisis.

The volume of environmental protection expenditures (expenditures for radioactive safety are not taken into account) increases as a whole (table 5.3) but it is important to compare them with the environmental tax revenues: during the whole period of the environmental tax existence (except for 2014), expenditures exceeded the amount of environmental tax revenues. From 50 to 80% (139% in 2014) of environmental protection measures could be financed by the environmental tax revenues (figure 5.2).

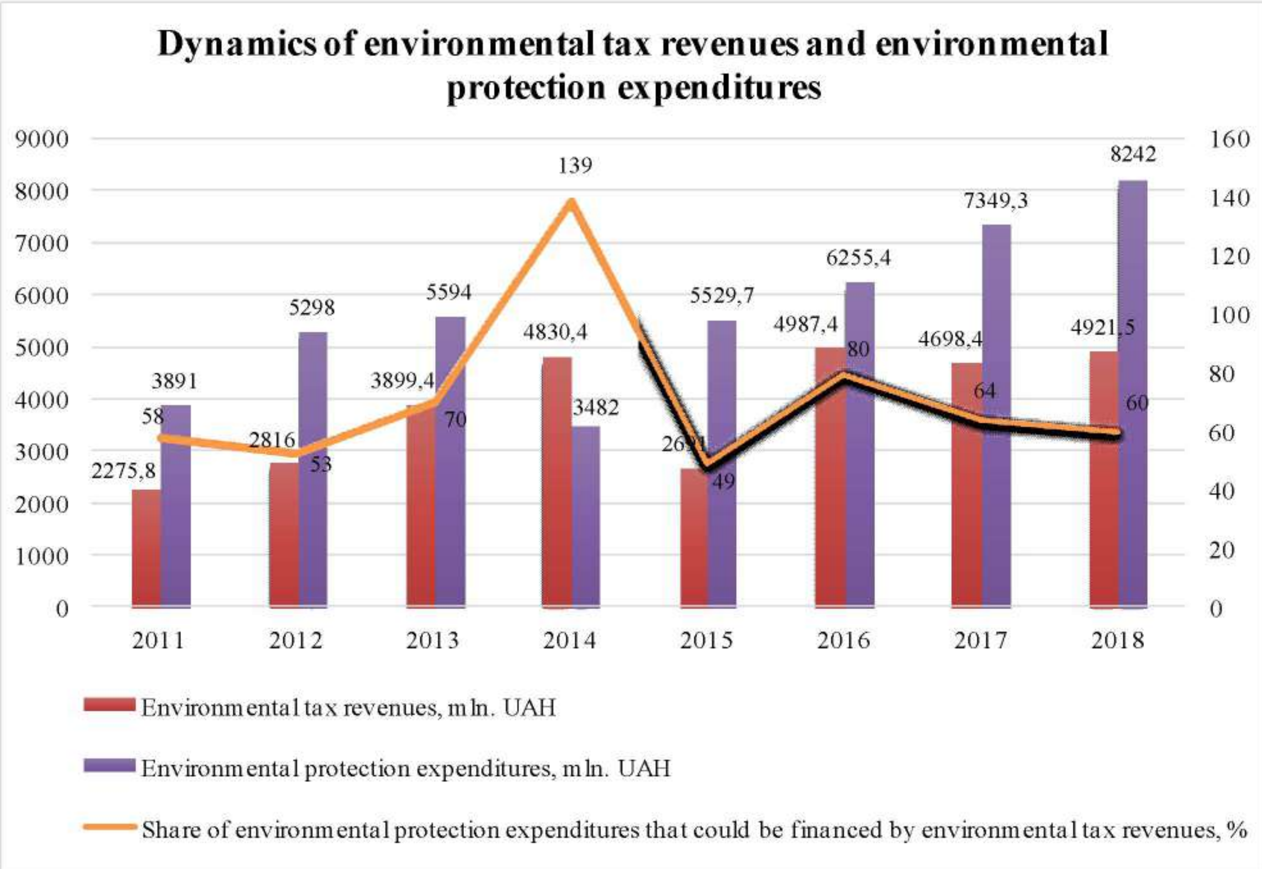

Fig. 5.2. Dynamics of environmental tax revenues and environmental protection expenditures (consolidated budget) for Ukraine in 2011–2018, (mln UAH)

Source: Reports on the state budget execution, https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu

But the distribution of environmental tax revenues between special and general funds is changed constantly which doesn't make it possible to use them fully for financing environment protection measures as stated above.

The inefficiency of the local authorities decision-making concerning the use of the environmental tax revenues is testified by the fact that only 32% of them were adequately used in 2016 from local budgets, none of the region (oblast) has used the environmental tax in full[26].

In the study[27] it is stated that the highest level of comfort of life is found out in the regions, in which the share of expenditures for environment protection exceeds the share of the environmental tax revenues. In this regard, a conclusion on the casual nature of the environmental tax, environmental activities of pollutants and the level of comfort of life in the region is drawn.

Most Ukrainian enterprises are not able to implement measures for the rational use of natural resources and environmental protection by themselves, to use low-cost, resource-saving and energy-saving technologies under current economic situation in the country. Entities require government support in the form of introducing tax privileges on environmental taxes, thus funds received as a result of preferential regime of paying environmental tax could be directed by enterprises on environmental measures, in particular, for complying with international environmental commitments by Ukraine[28].

Therefore, the compensatory and fiscal functions of the environmental tax are not realized.

At the same time, in European countries environmental tax performs both compensatory (tax revenues are several times higher than government expenditures on environmental measures) and fiscal (environmental tax accounts for up to 10% of all tax revenues) functions (table 5.4, figure 5.3). Significant volumes of environmental

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[26] Local authorities managed to disburse only one third of the funds from the environmental tax, the Ministry of Environment and Natural Resources of Ukraine [online], https://menr.gov.ua/news/31607.html

[27] Shako Olena. Efficiency of environmental taxation in Ukraine, *Finance, accounting and audit*, 2015. Issue 1 (25), pp. 156–169.

[28] Environmental tax-2019 in Ukraine: "hot" changes as a step towards a European model of development or an element of increasing pressure on business? *Ecobusiness. Ecology of the enterprise*, No.1, 2019 [online], http://ecolog-ua.com/articles/ekologichnyy-podatok-2019-v-ukrayini-garyachi-zminy-yak-krok-do-yevropeyskoyi-modeli

tax revenues in the EU countries determine the possibility for financing necessary environmental protection measures by governments.

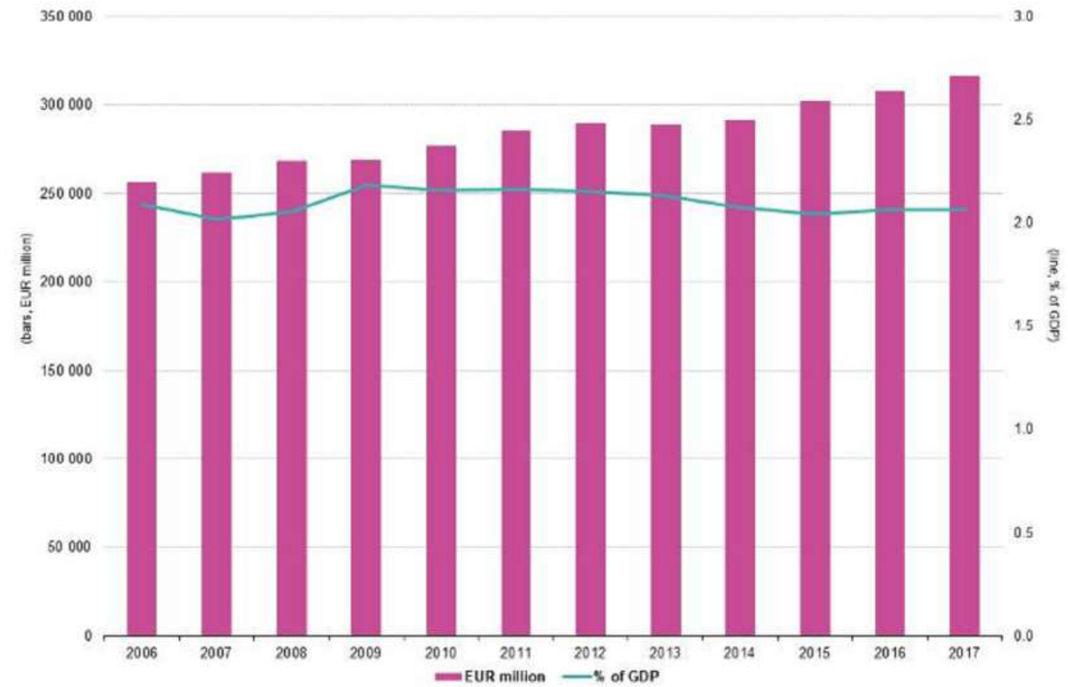

Fig. 5.3. National expenditure on environmental protection, EU-28, 2006–2017, (EUR million and % of GDP)

Source: Eurostat. National expenditure on environmental protection, EU-28, (env_ac_pepsgg), (env_ac_pepssp),(env_ac_pepsnsp) and (nama_10_gdp), https://ec.europa.eu/eurostat/statistics-ex-plained/index.php?title=File:National_expenditure_on_environmental_protection,_EU-28,_2006–2017_(EUR_million_and_%25_of_GDP).png

Ukraine has introduced a program of preferential financing of environmental programs for the modernization of enterprises of the largest polluters of the environment, but the interest of the business sector in using such programs and carrying out modernization is low. The amount of environmental tax paid by enterprises is insignificant and does not stimulate a high-value modernization[29].

Only one company in 2016 took advantage of such opportunity. The Ministry of Ecology and Natural Resources, together with PJSC CB "Ukrgasbank" and international partners, offered preferential eco-loans to enterprises from the list of "TOP-100 largest pollutants". PJSC "Zaporizhstal" (Metinvest Group) used such a

[29] Kanonishena-Kovalenko K. *Environmental Tax from A to Z*. Kyiv: Foundation «Vidkryte Suspilstvo», 2017, 108 p.

loan to replace the furnace filter, another 16 enterprises were negotiating for such a loan[30]. Therefore, the stimulating function of environmental taxation in Ukraine is also not realized.

In addition to the stated above, administration and control over the environmentalal tax in Ukraine is characterized by inconsistency as the interaction between the fiscal services and the environmental expertise is not regulated, the functions of different agencies are not clearly defined. Around 300 legal acts are accounted in the field of environmental legislation in Ukraine, many of which are not coordinated with each other.

The experience of countries with developed market economy convinces that the main purpose of environmental taxes (fees) is not the budget revenue raising, but provision of incentives to the taxpayer for a positive and responsible attitude towards environment. Money received can be used as incentives for environmental protection by pollutants, developing and implementing wasteless technologies, waste utilization, etc.[31].

As to one of the most drastic environmental problems in Ukraine – waste management, at the first meeting of the Coordinating Council on the implementation of the National Waste Management Plan in Ukraine until 2030, which was adopted by the Cabinet of Ministers of Ukraine on February 20, 2019[32], Deputy Prime Minister of Ukraine, Minister of Regional Development, Construction, Housing and Communal Services of Ukraine Hennadii Zubko said that today, 2,7% of waste is burned in Ukraine, and in the EU as an example, this figure goes up to 26%. If we talk about recycling, the situation is much worse: 43% of waste in the EU is recycled and returned to consumption, while in Ukraine this figure accounts only 3%. According to H. Zubko, the implementation of the National Plan is very important for the development of the regions. Key points within it are as follows: a package of tasks for each type of waste (from the adoption of the necessary legal framework to specific measures for the collection, processing and recycling); development of regional waste

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[30] Semerak Ostap. During the year, only one company took advantage of an eco-loan for the modernization of production, the Ministry of Environment and Natural Resources of Ukraine [online], https://menr.gov.ua/news/31608.html

[31] Serebrianskyi D.M., Yushchenko Yu.V. European experience in the introduction and functioning of the environmental taxation system: lessons for Ukraine, *Bulletin of the Tax Service of Ukraine*, 2009, No. 41, pp. 41–45.

[32] https://www.kmu.gov.ua/ua/npas/pro-zatverdzhennya-nacionalnogo-planu-upravlinnya-vidhodami-do-2030-roku [online].

management plans; construction of non-hazardous waste landfills; construction of regional complexes for the restoration of domestic waste; adoption of the bill on "municipal waste" development of new state building standards for landfills. The program is aimed at constructing a waste management system in Ukraine based on EU standards and a closed loop economy[33].

It takes a year or two to build a waste recycling plant, but this is not possible at present due to the imperfection of national legislation. Waste is a resource that can and must be recycled to produce secondary raw materials or energy, but its processing is more expensive than the output received. So, for creating waste recycling industry in the country, it is necessary to impose a tariff for waste processing, which will be an unpopular decision for any authorities[34].

Based on the study of scientific findings of [35 et al.] and having made own conclusions upon the research conducted, for improvement of the environmental taxation in Ukraine it is recommended to:

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[33] http://www.minregion.gov.ua/press/news/uryad-shvaliv-natsplan-upravlinnya-vidhodami-do-2030-roku-zubko/ [online]

[34] Mamaieva Mariia. The emergence of waste processing plants in Ukraine takes several years [online], https://www.unn.com.ua/uk/exclusive/1791584-na-poyavu-v-ukrayini-smittyepererobnikh-zavodiv-potribno-kilka-rokiv

[35] Budko O.V. Improvement of environmental taxation as a component of sustainable development of the enterprise, *Investments: practice and experience,* 2015, No. 22, pp. 46–50.

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Rybachok N.P. Modern Theoretical and Legislative Basis of Environmental Taxation in Ukraine, *Financial Law*, No. 4 (26), 2013, pp. 15–18.

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Naidenko O.Ye. Problems of environmental taxation and ways of their solution [online], *Economy and Society*, Iss. 8, 2017, pp. 627–633, http://www.economyandsociety.in.ua/journal/8_ukr/105.pdf

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Ministry of Ecology and Natural Resources of Ukraine [online] https://menr.gov.ua/en/

Boyko, L.I., Mazievich T.A. 2018. Changes in the tax regulation of environmental processes. *Young Scientist*, No. 3 (55), pp. 316–321.

– intensify the transfer of the tax burden from labor and capital to environmental taxes and resource payments by increasing the share of such taxes while maintaining the total amount of taxes (fiscal neutrality), stimulating so the modernization of production, reduction of unemployment, etc.;

– change the Tax Code of Ukraine in the context of putting limits on emission, pollutants discharges and waste disposal due to the fact that environmental tax in terms of all its components does not foresee such limits, which, in turn, does not stimulate companies to the pollution reduction by introducing new resource-saving technologies and equipment. Excessive volumes should be taxed at higher rates, thus, rates scale for the volumes of excess emissions of pollutants and waste disposal should be developed. Special accounts at enterprises for accumulating some share of funds from environmental taxes are to be opened;

– exempt from taxation the enterprises for the period of their reconstruction and modernization aimed at increasing the environmental sustainability of production;

– introduce taxation of hazardous products that harm environment (e.g., packaging materials, fertilizers, electrical and electronic equipment, etc.).

– impose penalties for environmental offenses;

– expand the scope of transport taxes by introducing railway taxes, taxes on traffic and taxes on the used (decommissioned) cars, etc.;

– expand the range of tax agents paying the environmental tax;

– use stimulating prices and allowances for eco-friendly products;

– transfer the environmental tax revenues only to the special fund of the state and local budgets and to abolish rules of the Budget Code that allow local authorities to spend environmental tax revenues on financing activities that are not related to the environment protection;

– differentiate environmental tax rates by increasing it in more "polluted" regions, which will make it possible to improve the environmental situation in these territories faster and stimulate business entities to purchase advanced technologies and modern equipment being safe for environment;

– implement quarterly indexation of environmental tax rates taking into account the inflation rate at the end of the reporting quarter;

– introduce the EU experience in fertilizer and pesticide taxation as Ukraine is an agrarian country;

– use an accelerated depreciation, which will make it possible to update fixed assets faster;

– introduce preferential rates or value-added tax exemptions for the sale of eco-friendly technologies;

– introduce a preferential taxation regime of real estate used as environmental protection facilities;

– reduce environmental tax payments by the amount of expenditures faced by enterprises for environmental protection measures;

– unify approaches to the main groups of environmental taxes determination and attribution of each tax to one of the groups – energy, transport, resource or pollution ones in accordance with the practice of foreign countries;

– improve fiscal and tax legislation in terms of increasing financial discipline;

– put into action the environmental tax for mobile sources of pollution again etc.

In foreign practice it is determined that environmental taxes include payments according to the "polluter pay principle" – the polluting economic agent should aim at increasing the natural resources use efficiency and improvement of the environment, and only then fiscal function of environmental tax comes into force. But in Ukraine revenue generation is sill prioritised.

Environmental policy in the EU is based on the market signals to the private sector – creating conditions under which businesses become more profitable by reducing environment pollution.

The use of taxes, payments and fees of environmental nature in European countries testifies that they include all of them related to the environment. In Ukraine, other taxes, payments and fees (which, similar to foreign experience, could be considered as environmental ones) alongside with the environmental tax are levied, however, neither legally nor statistically, they are not recognized as such.

In order to achieve environmental goals, it is necessary to ensure the targeted and efficient disbursement of environmental tax funds and to stimulate the modernization of polluting enterprises. Despite the fact that a significant part of environmental protection expenditures can be financed by the environmental tax revenues received, an important question about how the envisaged measures can eliminate the negative environmental impacts of pollutants arised.

As to the increase of the environmental tax rates to the level of foreign countries, it should be done carefully and gradually, taking into account the level of economic development of Ukraine and all subsequent consequences for industrial enterprises, as the increase in environmental tax rates will seriously concern taxpayers in terms of how to maintain the profitability and implement environmentally safe technologies.

Analysis of the environmental taxation in Ukraine makes it possible to state that environmental taxes, in contrast to the EU countries, do not perform neither fiscal, nor compensatory or incentive functions. The current system of environmental taxation in Ukraine needs to be improved, as enterprises are not interested in solving ecological and economic problems, including environmental protection. Only some enterprises try to implement rational environmental management.

The inconsistency of legislative acts also puts forward the necessity to further develop domestic system of environmental management.

Improvement of the environmental taxation system will result in Ukraine's compliance with the terms of the Ukraine – EU Association Agreement, enhancing Ukraine's competitiveness and bringing the system of environmental management at local and national levels closer to the best international practice.

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6. Impact of the war on sustainable development

A brief outlook of some of the global war threats is presented in this chapter.

The war itself is the biggest threat to sustainability, principles of humanity and has changed the whole paradigm of life and society for all: people, companies, and the state as a whole. The first United Nations Sustainable Development Goals (UN SDG) to be mentioned is Goal 16 "Peace, Justice and Strong Institutions" [1]. The situation in Ukraine has shown how fragile the world is and the level of international organizations' efficiency in solving disputes, conflicts and wars. What became clear is the necessity in unity and partnership to meet the global challenges of humanity and to ensure sustainable development goals realization. Although "peace, justice and strong institutions" are defined as goal 16 in Agenda 2030, it should be the first one, because if peace and defense are not secured, its' impossible to talk about other SDGs.

One of the UN SDGs facing war threats is Goal 8 "Decent Work and Economic Growth" [2]. According to the International Monetary Fund (IMF) economic damage from the war in Ukraine will contribute to a significant slowdown in global growth in 2022 and add to inflation. Fuel and food prices have increased rapidly, hitting vulnerable populations in low-income countries hardest [3]. The war adds to the supply chain problems in the global economy because of the pandemic and creates more shortages. Through integrated global supply chains, production disruptions in one country goes global and affects all. As an example, some companies in russia and Ukraine supply specialized inputs, and their deficit already has impact on car manufacturers. This is just one of the examples that explains why this war is not only Ukraine's deal but the whole world's.

Another aspect in terms of decent work and economic growth is the displacement of more than 4 million Ukrainians which has an impact both on Ukraine and neighboring countries, especially Poland, Romania, Moldova and others. This creates economic pressures in the whole region. That is why Government initiatives and incentives for business play an essential role in economic recovery in Ukraine. Currently, there are adopted laws to facilitate business activities that give certain tax privileges to some business entities and those who employ internally moved people etc.

Talking about business, it is considered that the above-mentioned Goal 16 should be at the forefront of every company's lives, otherwise, there is no sense in doing any business activity. Principles of doing business and living a prosperous life have been influenced by the tragedy of war and those disasters it brought. The war has triggered a costly humanitarian crisis that demands a peaceful resolution. Today it is a challenge for companies to decide which path they should take – a path of making money or a path of keeping business moral. Therefore the sustainability concept of business management – ESG (environmental, social and governance) has faced significant difficulties in times of war, as ESG criteria define a clear business strategy regarding the prevention of war, conflicts and human rights violations [4].

It should be noted that since February, 24th, 2022 hundreds of world companies have left russian market. This happened not only because of sanctions imposed on russia, but also because of the volunteering wish of those companies and as a result, foreign investors stop investments and leave the current projects in russian market no matter the stage of their realization.

It is of huge importance for Ukraine to create such projects which will attract investments, especially in terms of the fact that Ukraine became a center for world financial aid. The European investment bank (EIB) has approved the financial aid of 668 mln Euro for critical infrastructure and social infrastructure renewal [5]. The bank has increased the requirements towards social and ecological standards for all its projects since January 2022.

At the same time The European Bank for Reconstruction and Development (EBRD), a world leader in climate financing, has released 2 billion euros in response to the war in Ukraine. Since the bank's inception in Ukraine, lending has reached 16 billion euros and 511 projects. All investment activities are done in accordance with the EBRD's socio-environmental policy and standards. It plans to become the major green bank by 2025 [5].

Another UN SDG that faces one of the most difficult and serious threats nowadays is Goal 7 "Affordable and Clean Energy". The importance of fulfilling this

SDG also falls in the following – "..energy services are key to preventing disease and fighting pandemics – from powering healthcare facilities and supplying clean water for essential hygiene, to enabling communications and IT services that connect people while maintaining social distancing" [6]. That is why access to energy is essential for sustainable well-being. The war has shown all countries the level of their dependence on russian energy sector and how negative it is.

That is why the direction of particular importance in terms of sustainable investments is the energy sector, not only in Ukraine but in Europe and US as well. Therefore many experts state that one of the best ways to decrease the dependence on russian energy sector is the transition to renewable energy sources and the creation of tax stimulus for business that works in this field; production of electro cars and increase of energy efficiency. The IMF also states that carbon pricing and fossil fuel subsidy reform might also help with the transition to a cleaner mode of production, less exposed to fossil fuel prices which is more important than ever in light of the war impact on the global energy market [3].

The next UN SDG which is in danger due to the war is UN SDG 2 – "Zero Hunger". Nearly 690 mln people or 8.9% of the world population are hungry [7]. Currently, due to the war in Ukraine, which is known as the world breadbasket, Ukrainian ports are blocked, agriproducts can't be exported, logistic is destroyed, therefore the above-mentioned numbers increase every day. Such a situation requires attention to investments in the food sector and agricultural business. There should be created projects and funds to support established businesses in this sector, as sustainable development of the world is possible to be achieved only with the combination of different tools to be used in all areas of human lives, whilst agriculture and food sector play a crucial role [8].

The next one to be mentioned is SDG 9 "Industries, Innovation and Infrastructure" [9]. Inclusive and sustainable industrialization, together with innovation and infrastructure, unleash dynamic economic forces that generate employment and income. According to the Kyiv School of Economics [10] direct damage caused to Ukraine's infrastructure during the war has reached $88 billion as of April, 26, 2022. Rebuilding Ukraine's infrastructure, homes and businesses will cost up to $1trn. International organizations and investors will play a leading role in this [11]. It points out the perspectives to be opened after Ukraine's victory in the war in the sector of engineering, in particular civil engineering. There are already announced different projects, competitions etc for sustainable cities and buildings recovery. This is another interesting and well-recognized sector that will require sustainable investments.

As a result, it can be summed some of the war outcomes and threats to sustainable development, which require attention from the Government, corporate and personal sides: threats to humanity as a whole; humanitarian crisis; shortage of certain consumer goods and basic necessities, reduction of exports and imports; energy crisis; food crisis; pessimism, which leads to reduced investments; the collapse of exchange rules, leading to greater uncertainty, lower confidence; decreased personal incomes; reduction of tax revenues and budget deficit increase; suspension of economic activity; destruction of supply chains; manipulative pricing; industrial inflation due to geopolitical changes (energy crisis) and the destruction of infrastructure. It is clear today that it can be possible to overcome the difficulties, meet the challenges and face the threats if only there will be cooperation between the above-mentioned agents and global community in searhing for innovative, effective and inclusive solutions.

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