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EDITORS

Prof. Dr. Ahmet DEMİR **Prof. Dr. Mehmet Sinan Bilgili**

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Waste Management in Ukraine: New Challenges and Opportunities in Wartime

Vitalii Ishchenko¹

Abstract

Although waste management system in Ukraine has been slowly transforming due to close integration to European Union, a new challenge – hostilities – has significantly impacted the system. Since the beginning of the war, many companies have suspended activities, and therefore less waste is generated comparing to peacetime. After constant increase, 2.5 times less waste was totally generated in 2022. Almost all waste categories have decreased, except spent solvents, paper and cardboard wastes, which were doubled. Analyzing the waste structure after 2022, one can admit a significant increase in the amount of construction waste, medical waste, metals (destroyed military equipment), old cars (damaged and destroyed cars used by volunteers and the military). Over 670,000 tons of demolition waste have already been generated in Ukraine since 2022. One of the main challenges is military waste collection due to safety reasons and huge area it is placed at. Military waste collection is completely different from traditional waste collection. There are also many cases of destruction of waste management infrastructure, particularly transport equipment. Also, hazardous components of demolition waste (waste electronics, medical waste, batteries, lamps, asbestos-containing slate) may be a big issue. Hostilities also affected Ukraine's fulfilment of international agreements and obligations. Despite the challenges associated with hostilities, this gives the opportunities to improve waste management and deploy a circular economy in Ukraine. When restoring destroyed and damaged plants, an environmental modernization, application of cleaner production technologies, and creation of own capacities for industrial waste processing are supposed to be implemented.

Keywords: challenge, hostilities, opportunity, war, waste management

1. INTRODUCTION

Waste management in Ukraine has traditionally been an important environmental problem unresolved for many years. Ukraine, as many other countries have no efficient waste separation and mixed waste is mostly accumulated in landfills, which could pose serious environmental risks since most landfills do not fulfil the requirements. Ukraine generates large amounts of waste but there is a lack of infrastructure for waste management.

Recently, the waste management system in Ukraine is slowly beginning to transform due to Ukraine's international agreements obligations. According to Ukraine 2050 Low Emission Development Strategy [1], the use of wood and agricultural waste for energy production and the application of other organic waste processing

¹ Corresponding author: Vinnytsia National Technical University, Department of Ecology, Chemistry and Environmental Protection Technologies, 21021, Vinnytsia, Ukraine, ischenko.v.a@vntu.edu.ua

technologies will provide the reduction of greenhouse gas emissions. This policy will reduce the waste volume from residential, commercial and administrative sectors through waste reduction programs.

The Ukraine-EU Association Agreement [2] includes the approximation of Ukrainian legislation to EU law and policies, including the field of waste management. The framework law on waste management is already in force, a number of sectoral laws (on packaging and packaging waste, on waste electrical and electronic equipment management, and others) are under discussion in the Ukrainian Parliament. This should become the basement for creating an effective waste management system. At the same time, a significant part of the Ukraine-EU Association Agreement remains unimplemented in the field of waste management.

The National Waste Management Strategy in Ukraine until 2030 [3] will establish an effective waste management system (waste prevention, preparation for reuse, recycling, disposal, energy production) on an innovative basis, ensuring comprehensive recycling of natural resources and waste recycling.

In addition to the above-mentioned issues, waste management is facing today a new challenge – hostilities. This, on the one hand, had a significant impact on waste management, and on the other hand, due to unprecedented international support, it created new opportunities for the implementation of modern waste management solutions. The impact of military actions is manifested not only in a direct change in the waste volume and structure, but also in the impact on the structure of manufacture. This, in turn, causes a change in the waste structure as well. The inability to timely and effectively dispose of military equipment leads to the fact that it accumulates in the places of hostilities, and also partially moves to landfills [4].

Actually, there is very limited research dedicated to waste management under war conditions. Filho et al. [5] examined the impact of compliance and safety processes related to medical waste management and final disposal strategies on the achievement sustainable development goals in Ukraine during the war. Marchenko et al. [4] tried to assess an amount of destroyed military equipment. Also, some papers are focused on post-war waste management, like construction waste use for buildings reconstruction [6]. Unfortunately, many regions in the world are exposed to military actions. Wasted warcraft are littered throughout the world as rubbish, left behind with little or no commemoration and unclear possibilities for reuse [7]. In the same time, recycling economy requires military waste to be evaluated as potential resource. Besides, during conflicts large quantities of new waste accumulate, including pharmaceutical wastes from humanitarian aids, and military wastes, weighing on the existing collection and disposal systems [8]. Calvo et al. [9] underlined the strategic importance of critical resources such as copper, lead, tungsten, timber, rubber, and coal for rearmament and wartime economic mobilization. While some basic structures of the existent waste economies remained valid, other conditions changed substantially such as the economic cost relations between labor, resources, and secondary resources [10].

This article aims to analyze changes in waste management in Ukraine caused by war, new challenges and opportunities appeared due to the changes in waste structure and manufacturing patterns.

2. MATERIALS AND METHODS

For the research, the statistical data on waste generation in the pre-war period and after 2022 (from the Ministry of Environmental Protection and Natural Resources of Ukraine and regional administrations) were processed. An analysis of the hostilities impact on the implementation of legislative and strategic documents and international obligations of Ukraine was also carried out.

It is worth noting that access to statistical data is problematic today. The data on waste generation do not include information from temporarily occupied territories, as well as most eastern and southern regions of Ukraine not having the opportunity to provide complete statistical data due to military actions. Since part of the Ukrainian territories were occupied for some time or still remain occupied, the data collection is impossible or very limited. Besides, during a wartime (since 2022), companies and organizations, temporarily exempted from mandatory reporting. This means that official reporting underestimates waste generation.

3. RESULTS AND DISCUSSION

3.1. Waste generation and structure during wartime

Usually, waste generation is more or less stable. But, under war conditions, it radically changes: the wastes amount exceeds the collection capacity and a change in the type of generated wastes is generally seen, since they derive from both housing and industrial facilities and the destroyed buildings [8]. Since the beginning of the war, many companies have suspended activities, and therefore less waste is generated comparing to peacetime. After constant increase during 2018–2021, 2.5 times less waste was totally generated in 2022 (Fig. 1).

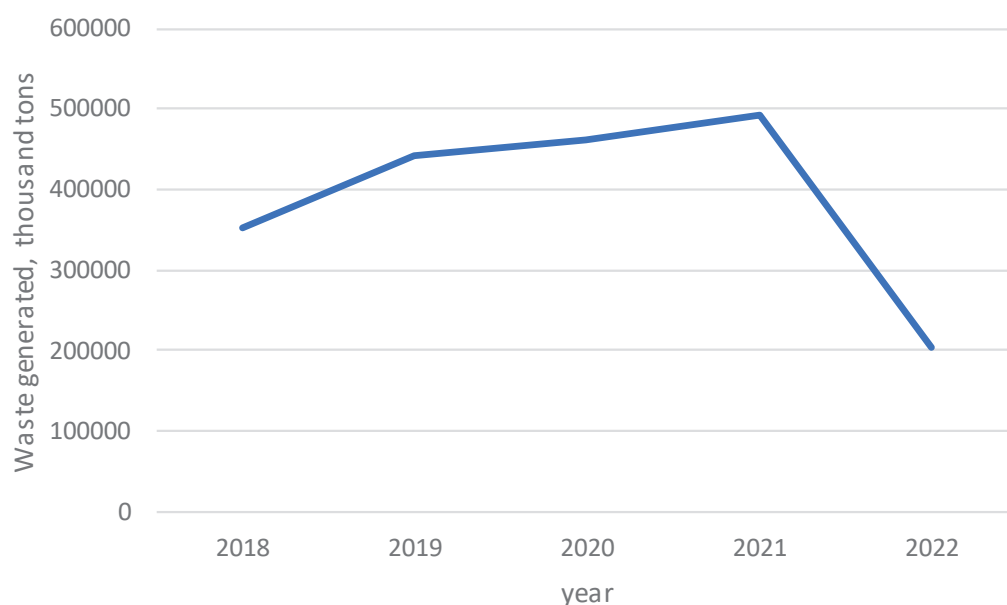


Figure 1. Waste generation in Ukraine, 2018–2022

Almost all waste categories have decreased, except spent solvents, paper and cardboard wastes, which were doubled (see Table 1). Also, slight increase was noticed for plastic and textile waste.

Table 1. Waste generation in Ukraine by categories

Waste category	Waste generation, thousand tons				
	2018	2019	2020	2021	2022
Spent solvents	1.2	1.5	2.4	2.2	4.5
Acid, alkaline or saline wastes	375.4	399.5	392.7	486.9	151.6
Used oils	14.6	14.4	19.3	17.3	13.4
Chemical wastes	806.1	620.4	663.2	533.3	168.6
Industrial effluent sludges	3630.3	3346.1	3462.1	3257.6	441.2
Sludges and liquid wastes from waste treatment	793.9	792.2	860.6	1034.8	389.7
Health care and biological wastes	0.7	0.9	1.1	1.5	1.3
Metallic wastes, ferrous	3402.2	2801.4	2491.9	2656.4	583.8
Metallic wastes, non-ferrous	40.6	27.1	24.3	25.9	19.6
Metallic wastes, mixed ferrous and non-ferrous	34.1	13.7	10.3	14.2	5.9
Glass wastes	41.9	19.8	21.0	23.4	11.5
Paper and cardboard wastes	146.4	129.5	140.8	186.8	567.5
Rubber wastes	21.9	19.5	19.9	22.3	14.3
Plastic wastes	47.2	50.3	40.8	56.6	63
Wood wastes	829.8	827.9	750.1	697.5	649.5
Textile wastes	15.9	12.4	21.9	14.2	20.8
Wastes containing polychlorinatediphenyls	0.2	0.3	0.2	0.2	0.1
Discarded equipment	9.7	5.9	5.0	6.5	2.5
Discarded vehicles	1.6	1.2	1.0	10.6	0.2
Batteries and accumulators wastes	3.8	4.5	4.2	4.9	1.9
Animal and mixed food waste	607.5	441.0	405.4	353.8	258.8
Vegetal wastes	7829.3	8068.6	6101.8	4433.7	3125.7
Animal feces, urine and manure	3233.8	3612.9	3314.7	3267.4	2821.5
Household and similar wastes	6211.2	6618.0	6672.0	6479.6	5218.3
Mixed and undifferentiated materials	9164.1	9940.3	6906.3	6742	1268.7
Sorting residues	63.6	69.2	35.1	31.4	13.6
Common sludges	643.5	563.3	334.1	438.5	261.2
Mineral waste from construction and demolition, incl. mixed construction wastes	1023.1	919.4	873.2	835.5	313.5
Combustion wastes	273157.7	286785.6	10845.7	11560.7	4900.1
Other mineral wastes	13553.5	12661.5	404649.4	437015	175377.7
Soils	451.7	1360.6	1332.8	1053.8	643.6
Dredging spoils	26126.0	101361.9	11947.5	11965.5	6211.1
Mineral waste from waste treatment and stabilized wastes	51.4	25.7	22.7	24.5	21.3
Metallic wastes, mixed ferrous and non-ferrous	34.1	13.7	10.3	14.2	5.9

Glass wastes	41.9	19.8	21.0	23.4	11.5
Paper and cardboard wastes	146.4	129.5	140.8	186.8	567.5
Rubber wastes	21.9	19.5	19.9	22.3	14.3
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In 2022, around 39 million m³ (more than 7 million tons) of household waste was generated [11], which is almost twice less than the last 5 years. If one subtracts from this number the unaccounted household waste from the territories occupied in 2022 (where over 1 million people or about 2.5% of Ukraine's population live), then there is still a significant decrease in the amount of household waste. At the same time, in some regions, landfills have a greater load due to the temporary displacement of people from the occupied territories inside the country. In 2022, about 9.9% of household waste was processed: 1.66% was incinerated, and 8.24% was sent to collection points for secondary raw materials and waste processing lines [11]. The share of incinerated household waste roughly corresponds to the pre-war level (ranged between 1.3–2%). The share of recycled household waste, despite the military actions, has increased (from 6.5% in 2021 [12] to 8.24% in 2022). This is due to the location of the main facilities for household waste processing in regions less affected by military actions (the city of Kyiv, Kirovohrad, Ternopil, and Vinnytsia regions).

Analyzing the waste structure after 2022, one can admit a significant increase in the amount of construction waste (waste from buildings, roads, and communications destruction), medical waste, metals (destroyed military equipment), old cars (damaged and destroyed cars used by volunteers and the military). It should be noted that demolition waste is different from construction waste. They consist of the main components (parts of building structures, door and window blocks, engineering networks, sanitary and technical devices, etc.) and additional components (materials that were inside or next to the object at the time of damage / destruction or at the time of dismantling: equipment, personal belongings, household items (furniture, household appliances), organic substances). In addition, a heterogeneous waste mixture is formed under the influence of high temperatures. Metal, plastic, glass, facade decoration materials, reinforcing mesh, mineral wool, interior decoration materials, wall materials, roofing, household items, and wood scraps – all these residues can be used. But under current conditions, when these items are mixed in ruins, they need careful sorting. Usually, most of this waste is generated in or near war zones. However, the growth of construction and medical waste is observed throughout the country due to the destruction and increase of medical services to the wounded persons, which is caused by long-range missile strikes. Over 670,000 tons of demolition waste have already been generated in Ukraine since 2022. The largest amount of demolition waste is generated in Kyiv, Kherson, Kharkiv, Mykolaiv, Donetsk and Zaporizhzhia regions. In addition to the waste from the destruction of residential and transport infrastructure, more than 325,000 tons of waste was accumulated from the destroyed military machinery. More than 200,000 cars and trucks have been destroyed in Ukraine, which are now stored in specially designated places. Cleaning up the territories from demolition waste has already begun where possible. However, Ukraine currently does not have sufficient financial and technical resources to fully solve this problem.

3.2. New challenges in waste management

One of the main challenges is military waste collection due to safety reasons and huge area it is placed at. Military waste collection is completely different from traditional waste collection.

For obvious reasons, waste management is not provided in or near war zones. As a result of military actions, waste collection and transportation become very limited and dangerous. It is necessary to check the waste for

the presence of explosive and other dangerous substances, which creates additional risks, financial and time expenditures. There are also many cases of destruction of waste management infrastructure, particularly transport equipment. Even in regions far from active hostilities, waste management companies often face shortage of equipment and personnel due to the mobilization of transport and people. This is a serious challenge for the organizational provision of waste management.

A new challenge is a new category of waste – demolition waste analyzed in the previous section. In 2022, the government approved the Procedure for managing the waste generated during the destruction of buildings and structures as a result of hostilities, acts of terrorism, and sabotage. Provision of household waste management services under special conditions is impossible in case of: damage or destruction of machinery and equipment used for household waste management; damage, destruction or mining of household waste management facilities; danger of household waste transportation (roads and streets are dangerous, blocked and mined); lack or insufficient number of personnel for household waste management operations; impossibility of supplying fuel, lubricants, repair or other materials or resources. In the case of limited provision of household waste management services under special conditions, local authorities create temporary storage sites for household waste (requirements: at least 2 kilometers from water bodies, 500 meters from residential and public buildings, social infrastructure facilities, 200 meters from agricultural lands, public roads and railway tracks of the general network, 50 meters from forests, 1 kilometer from nature reserves). If there is no possibility to provide household waste management services under special conditions, sites for the temporary storage of household waste are created in the adjacent territories of multi-apartment buildings, territories of public use, territories of companies and organizations (requirements: at least 30 meters from educational and medical institutions, residential and public buildings and structures, playgrounds for children and recreation; 8 meters from home yards) [13]. Transportation of collected household waste from sites of temporary storage is carried out under safe conditions at least once every seven days.

The use of temporary storage sites for demolition waste poses significant environmental risks because it is very difficult or impossible to properly equip these sites when military actions happen. Besides, there are a large number of spontaneous waste storage sites. Due to the lack of compliance mechanisms, local communities often send demolition waste to usual landfills.

For certain industries (metallurgical, chemical, etc.), due to the use of outdated technologies and large volumes of hazardous waste generation, a sharp increase in the waste management cost (related to a significant deterioration of the economic situation) may cause significant financial and technological difficulties. Industrial waste management in Ukraine is regulated at the legislative level, but there are such shortcomings as the uncertainty of priority goals and the insufficient integration of environmental protection in the industrial strategies and programs. Not all metallurgical companies in Ukraine are technologically capable to process all types of metal scrap from military equipment disassembly. For instance, alloy steel components can be processed by only one company in Eastern Ukraine [4].

In fact, there is no developed infrastructure and advanced technologies for collection, sorting, transportation, storage, and processing complex flows of demolition waste in Ukraine. Many communities use landfilling for demolition and construction waste disposal. The current legal framework contains significant gaps in the regulation of demolition and construction waste recycling. There are no quality and safety standards for construction materials made from waste. It is necessary to pay attention not only to the cost of waste disposal (the end of the product lifecycle), but also to the cost of waste use in manufacturing (that is at the beginning of the lifecycle). Unfortunately, secondary materials currently are not competitive in Ukraine, including due to the low cost of raw materials (crushed stone, sand, etc.).

Hazardous components of demolition waste (waste electronics, medical waste, batteries, lamps, asbestos-containing slate) may be a big issue. They must be separated from other components. The lack of technical capabilities for processing some hazardous waste categories is a prerequisite for their uncontrolled disposal.

Lack of necessary equipment and locations for collection, transportation and safe temporary storage of infectious waste on the territory of medical institutions, as well as limited possibilities to purchase high-quality equipment for medical waste processing are challenging.

The high priority must be the mapping of the demolition waste generation, which is already being provided by the UN Environment Program and partly by the European Union. Satellite data and cadasters are also used, where communities should further check the characteristics of destroyed buildings, including the time when they were built since it is usually known that asbestos was widely used in construction before a certain year.

Circular construction in Ukraine is in a “gray” zone. A laboratory conducting tests of used construction materials would not provide an official conclusion, because the term “used” does not exist in regulatory documents. That is, you can get an architect's conclusion that some material can be reused during construction, but this would not be confirmed by official tests. For instance, there are many influencing factors for brick recycling. It is important what solution was used to fix and how easily it can be separated. If the brick was in

fire, one can try to clean it from the soot. But these are additional costs for “smart” dismantling, which will take more time and require additional payment. Obviously, this is not profitable for most businesses.

Changes in manufacturing patterns to meet the needs of wartime create new waste, change their structure. First of all, this is the waste of the military-industrial complex. This creates the need to develop methods of managing new and changed waste streams, their legal basis and technical implementation.

It is worth noting that the hostilities also affected Ukraine's fulfilment of international agreements and obligations. For example, many tasks in the field of waste management (related to mining waste constituting the vast majority of total waste generation in Ukraine) required by the Ukraine-EU Association Agreement, which) have not been implemented: in particular, procedures for closing and further monitoring mining waste storage sites have not been established, a register of closed mining waste sites has not been created. Also, regional waste management plans, which should be the basis for efficient waste management, have not been implemented. It is obvious that the generation of a large amount of non-typical waste and the change in its structure will also have an impact on the low-carbon strategy of Ukraine.

The placement of military equipment at specially designated landfills is a cheaper way to manage military waste but the increase in their number and area will further aggravate the problem being already critical before the war started. This contradicts to substantial decrease of landfills number according to the Strategy of waste management. Other goals of the Strategy of waste management also remain unfulfilled: 15% recycling rate of household waste in 2023, and 50% in 2030 (current rate is about 10% and the prospects to achieve 50% in 2030 are doubtful), reuse and recycling of up to 60% of the packaging waste by the end of 2023 (current rate is below 20%), very slow and limited construction of waste sorting lines and waste processing plants, implementation of extended producer responsibility ensuring the application of the full financing mechanism in waste management system, collection points for certain types of waste have not been created (hazardous household waste, bulky waste, waste electrical and electronic equipment, spent batteries, etc.) [14].

Many waste processing companies located in Eastern and Southern Ukraine were either relocated to safer places or suspended their activities. Therefore, these territories are not provided with appropriate infrastructure. The destruction of the Kakhovka dam created significant problems for waste management in Southern Ukraine. In this process a vast amount of waste was likely to have been produced and would have piled up within the settlements. Due to the circumstances of the flood event the waste produced is expected to mainly have consisted of household interiors and building materials destroyed from being submerged. The total amount of waste expected to have been generated by the flood amounts to 1,1–2.9 million m³ [15]. Additionally to usual waste, there are public environments (such as material from parks, squares etc.), cars, boats and marine vessels in waste. Also, historical storage sites of pesticide waste are located near Kherson and pesticides may have leaked into soil either as a result of the flooding. This will also need a proper management.

Besides, military actions affect not only waste management in Ukraine. Currently, many waste sector businesses in Europe are experiencing an imbalance because of the war.

3.3. New opportunities in waste management

Despite the unprecedented challenges associated with hostilities, this opens a unique window of opportunities to “reboot” approaches to waste management and deploy a large-scale circular economy in Ukraine. The improvement of the system of demolition and construction waste collection, sorting and processing can give a powerful impetus to the domestic market of secondary materials. It also gives opportunities for launching large-scale projects to restore destroyed infrastructure based on the principles of circularity and eco-design.

When restoring destroyed and damaged plants, there is a chance to receive financial aid (loans, grants, etc.) for environmental modernization, application of cleaner production technologies, creation of own capacities for industrial waste processing.

A large amount of waste generating from military actions will require management decisions. In the context of the reconstruction needs, this will force the authorities to use potential resources directly for reconstruction instead of spending costs for waste disposal. For instance, this will provide the conditions for the development of recycled construction waste market, and for increased use of secondary metals. Some components of construction and demolition waste have a high resource value, while others may have a lower value, but could still be easily reprocessed into new products or materials. In general, construction and demolition waste mineral fraction is very heterogeneous (mortar, ceramics, concrete, rocks, natural gravel, masonry, sand, soil, etc.) and depends on the characteristics of each construction. Technology for the separation and the recovery of construction and demolition waste is well established, readily accessible and generally inexpensive. Materials that end up in construction and demolition waste are concrete, wood, steel, glass, etc. [16]. The role and potential of construction and demolition waste will be significant in post-war Ukraine, and technologies of their recycling will be highly demanded.

Currently, in the Kyiv region, 62 temporary sites for the demolition waste storage have been set up, of which 48 are used. 144,000 tons of demolition waste have already been placed there. Communities deliver demolition waste to temporary storage sites, where they are further sorted: hazardous, construction waste, etc. are separated. Construction waste is shredded for reuse. There are pilot projects being implemented in Ukraine supported by international partners. For instance, Japan International Cooperation Agency (JICA) has provided equipment for crushing and separating construction waste in the Kyiv region. Additionally, this region plans to launch one stationary and two mobile lines for construction waste processing in other settlements. Another example is Kharkiv city where concrete fragments, after crushing, are used to produce special crumb for repairing roads and pavements. In Gostomel, Kyiv region, mainly sand, filler for construction, and secondary crushed stones of various fractions were extracted from 20,000 tons of demolition waste.

Possibilities of demolition waste use are as follows:

- crushed metal can be recycled by remelting;
- stone residues are suitable for the production of various types of construction materials: fillings for roads, holes from by shell bursts;
- ruins of buildings are suitable as construction materials;
- felled trees are crushed and used in the woodworking industry as raw material;
- rubble from recycled concrete is used to fill swamps and pits, as well as to create temporary roads;
- asphalt is reused in road construction, but first it is thermally treated at a very high temperature;
- armature is reused in construction and in many other areas;
- waste mixtures can be used to produce low grade concrete; there are plants in Ukraine for such concrete manufacturing.

4. CONCLUSIONS

The military actions have generated many new challenges for waste management in Ukraine: from organizational (difficulties and danger of waste collection) to technical (for example, management of new waste categories). The amount of waste generation and waste structure has changed. Solving the problem of effective waste management is a key to solving the issues of energy and resource independence of any country, saving natural and energy resources, and is an urgent strategic task (priority) of state policy. It is necessary to develop national standards of quality and safety of construction materials produced from waste. These changes will make it possible to create an efficient system for demolition waste processing in Ukraine, which will help to reduce environmental degradation and to use resources more efficiently. Unique opportunities for creating an effective waste recycling system are appearing due to intensive work for joining the EU, as well as due to the substantial financial support from international partners. Despite the tremendous volumes of accumulated demolition waste, their successful recycling and use based on progressive global approaches creates unique opportunities for the rapid reform of the Ukrainian model of waste

management and the formation of a powerful circular economy with high added value. The implementation of such an ambitious task requires the consolidation of international expert support and investment, balanced state policy, active participation of business and a new environmental culture of society.

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BIOGRAPHY



Vitalii ISHCENKO works as Head of the Department of Ecology, Chemistry and Environmental Protection Technologies in Vinnytsia National Technical University.

V. Ishchenko received his BSc and in Environmental Engineering in 2004 and his PhD in Devices and Methods of Control and Definition of Substances in 2009 from Vinnytsia National Technical University, Ukraine. Author of scientific publications in the field of waste management and control of contaminants concentration in the air. Reviewer in many peer-reviewed journals. Vice-president of non-governmental ecological youth organization “Ecotopia Podillya”.

He may be contacted at ischenko.v.a@vntu.edu.ua