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Theoretical and applied principles of the formation of waste management system

Abstract

The objective of this article is generalization of theoretical and applied approaches to the formation of the waste management system. Based on the systems-oriented analysis of the concept of sustainable development in the context of Eurointegration strategy of Ukraine, it substantiates the need for the formation of an effective national ecological policy, one of the main tasks of which is to minimize industrial and domestic waste. Methodology. Based on the analysis of the results of leading scientists pertaining to the formation of the waste management systems, the provision is concluded that the increase in the volumes of waste closely correlates with the growth rate of the national GDP and, at the same time, even with the most advanced technologies it is impossible to prevent waste generation. However, the high level of generation is, first of all, the result of ineffective use of natural resources in the production processes. The article substantiates that under present day conditions, the theoretical and methodological foundation of the study of waste management must become the principles of sustainable development. This predetermines the need for taking into consideration not only the existing expenses for waste disposal or utilization, but also losses of the future generations resulting from the effects of waste on the environment components and human health when taking managerial decisions. Results. It has been established that the need for minimization of industrial waste is determined by the fact that the the pace of consumption of resources by human society and waste generation is not balanced; in addition, there is no necessity in using natural resources so extensively. Changes in the machinery, distribution system, legislation allow to minimize the volumes of waste essentially, thus preserving the quality of life on the planet. The article provides in-detail analysis of the EU countries' experience in the sphere of formation of waste management systems, hierarchy formed within the EU as to the priorities of the approaches to the management of the processes of minimization of industrial and domestic waste. It has been established that the strategic goals of waste management in the EU are minimization of the volumes of waste formation by way of prevention of their formation, use of waste in the production processes, reduction to the minimum the quantity of waste placed in the landfills. Practical implications. There is conducted the analysis of the features of functioning of waste management system and its goals, which allows to use experience of the developed nations in resolving the problem of waste more effectively, specify the role of state administration in the achievement of the Goals of sustainable development by 2030 in reduction of industrial and domestic waste. Value/originality. Application of system analysis permits to identify the main problems of the formation of waste management system taking into account the specific character of its functioning under modern conditions.

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Waste, development, sustainable development, goals of sustainable development, systems analysis, management

JEL: Q21, Q53, Q56, Q57

1 Introduction

Waste is one of the current problems of civilizational development that continuously becomes aggravated in the result of population growth, development of productive forces of the society, expansion of the consumption sphere. Existence of tremendous number of waste disposal resulting from human activities turns into the global problem and becomes a direct and more dangerous threat to the environment and health of population in most countries of the world.

Accumulation of waste as the “insuperable” result of any production process accompanies modern civilization at all stages of its development. Waste is the expected result of social exploitation of natural resources, which ensures appropriate conditions for functioning and development of the society. According to some data, to satisfy social needs over 30 billion tons of useful minerals are extracted annually from the earth interiors, in which process displacement of almost 150 billion tons of soil occurs. Thus, when processing gold-bearing ores with gold content

of 5 g/t, waste products exceed weight of end product by million times (Lotosh, 2007).

As Global Director for the World Bank's Urban, Disaster Risk Management, Resilience and Land Global Practice Sameh Wahba notes that inappropriate management of waste leads to the pollution of the World Ocean, contamination of sewerage networks and flooding, spreading of infectious diseases, exacerbation of respiratory diseases because of the burning processes, inflicts damage on the animals consuming waste, and has an adverse effect on economic development (World Bank, 2018).

With the development of civilization, scientific and technological progress, Earth population explosion and production volumes growth there occurs a rapid increase of volumes and types of waste, first of all, of industrial and domestic waste. Modern people consume a lot more than their ancestors, the growth and concentration of production and capital that accompany the rise of the level of consumption automatically cause the growth of the volumes of waste. It is estimated that the growth of the volumes of waste generated by the society in the processes of sustainment of its own vital activity rather closely correlates with the pace of growth of the national GDP. Should this tendency continue in the nearest future, it will be easy to foresee that this "junk civilization" will very quickly come to the natural spatial boundaries of eocumene – transport opportunities for the waste disposal, the growth of the territories and number of dumping grounds cannot grow permanently – already now in many countries these opportunities have been exhausted completely. Besides, awareness becomes more and more widespread that formation of waste means the loss of materials and energy, additional and still more aggravating environmental and economic losses for the society. In this context the problem of waste determines the need for a system approach, formation of scientific principles of elaboration of the approaches to the solution of waste minimization on the local, regional, and global levels (Kolodychuk, 2020).

2 Waste as the global environmental problem

Accumulation of the waste of human life and activities began from the emergence of *Homo sapiens* and formation of the primitive societies – about 30-40 thousand years ago. In the beginning of formation of the civilization utilization of waste was easy owing to the absorbing capacity of the environment: soil and water. The problem of waste aggravated essentially with the appearance of cities. "In the cities production and consumption flourish, it is not that simply more products are produced, it is also more products are produced per capita; it is ironic because as a rule, residences in the city are smaller than those in the villages. Under the conditions of such prosperity and over-prosperity all that is left to do is to use everything and throw it in the garbage. Throwing out garbage is the quintessential sign of city life and it does not matter whether we talk about two-hundred-years-old broken pieces of pottery or a piece of plastic thrown out today in the morning. Garbage is a familiar rhythm, a familiar pattern of accumulation. Directly or indirectly obsession of the city with garbage is widespread" (Smith, 2020).

According to the statistics there are up to 500 kilograms of waste accounted for each resident of a large modern city, residents of smaller towns leave about 150-299 kilograms of waste. The greatest amount of industrial waste falls on the USA, Norway, Spain, Sweden, and the Netherlands.

Dumping grounds and territories of organized landfills occupy tremendous areas that could be used with greater usefulness in agriculture. Regretfully, cultivation of the land on which a dumping ground existed at least several years is almost impossible because hazardous materials are accumulated within a short time, preventing growth of the plants (Real time, 2020).

The effect of industrial waste is not limited by dry land. In the end of the 20th century there appeared a huge garbage stain in the Pacific Ocean formed by the drifting plastic materials and other waste, whose quantity grows continuously. As of 2019, its area according to various estimates attains from 700 thousand to 1.5 million square kilometers, which is more than the territory of Ukraine by 20%. The problem of waste penetrated the outer space – the growing number of satellites and space junk rotating around the Earth begins to complicate for the astronomers keeping track of the celestial bodies and study of space for the scientists. According to the estimates of the European Space Agency several dozens of thousands of the large fragments of space junk rotate around the Earth, whose number attains millions, considering smaller objects with diameter up to 1 mm. According to NASA, the junk has a total mass of about 6 thousand tons (Ukrinform, 2021).

Development of man took place in parallel with the improvement of technical systems – the man created technological processes that permitted to produce new products and materials in greater quantities, draw greater volumes of natural resources into the production processes. At the same time existence of various types of the society's human waste was disregarded. In the beginning of the 21st century a strong tendency continues in the world to increase volumes of waste. Table 1 shows average regional volumes of waste generation in various regions of the planet (Real Time, 2020).

According to the data of the UN European Economic Commission in the late 20th century-early 21st century, total volume of waste in the EU countries and the European Free Trade Association grew by 2% each year. As to solid domestic waste, their generation in the world starting from 2007 exceeded 2 billion tons, while the growth rates of annual growth attained 7%. As noted in the report "Protection of the European Environment," "economic growth and consumption appeared to be a considerably stronger critical factor for waste generation than all initiatives and governmental efforts" (Dovha, 2012).

It is widely acknowledged that at present stage of civilizational development the environment acts both as the production factor and the driving force of its intensification by way of greater involvement of natural resources in the socio-economic processes. The growth of waste volumes begins from the low effectiveness of the use of natural resources, low level of ecological awareness of the population. If in the past quantitative criteria of the mankind development prevailed during millennia, under the new conditions of stabilization of population growth the main criterion of development becomes people's quality of life, one of the components of which is the effective organization of waste management. It is widely known that resource- and energy consumption per unit of GDP in the USA is by 2 times, and in Western Europe and Japan by 3-4 times lower than in the developing countries. This means that for manufacture of 1 ton of products in the developed countries the amount of involved natural resources is considerably lower, which automatically predetermines

TABLE 1 Average regional volumes of waste generation (kilogram per capita per year)

Region	Mean value	Min.	Max.
East Asia and Pacific	204.4	51.1	1357/8
Europe and Central Asia	430.7	98.55	1624.25
South Asia	189.8	62.05	525.6
North America	806.65	708.1	1657.1
Latin America and the Caribbean islands	361.35	149.65	1627.9
South Africa	167.9	40.15	573.05
Middle East and North Africa	295.65	160.6	667.95

reduction of the volumes of waste. Efficiently organized waste management will permit to optimize materials and energy flows between the production processes and the environment, ensure sustainable development of socio-economic systems.

3 Waste in the system of goals of sustainable development till 2030

The trendsetter of functioning of socio-economic systems under present day conditions is transfer of human vital activity to the principles of sustainable development. Analysis of the sustainable development goals till 2030 shows that the problem of waste somehow deals with almost every goal. This is why, in our opinion, theoretical and methodological foundation for elaboration of organizational and economic mechanisms of industrial and domestic waste management must be the concept of ensure sustainable development, which requires taking into consideration not only the present day costs of waste disposal or utilization, but also losses of the future generations resulting from the adverse effects of waste on the environment components when taking managerial decisions.

As it is well-known, the main problem, that is in the prime focus of the concept of sustainable development is the uncontrolled growth of population and growth of the scale of use of natural resources, which in its turn automatically predetermines the increase of waste. System studies of modern socio-economic processes shows, that the main trend in ensuring sustainable development is dematerialization. This means that reasonable needs of humankind must be satisfied with the minimal costs of natural resources by way of improvement of effectiveness of the use of natural resources and changing the style of human consumption (Bilorus, Matseyko, 2005). In the program documents of sustainable development the problem of waste is identified as one of the main factors preventing transition of global economy to the principles of sustainable development. Production of various types of waste makes open-ended anthropogenic circulation of resources and leads to disruption of biosphere durability in the result of depletion of natural resources and an adverse effect on natural ecosystem. Each year about 1 billion tons of gaseous waste is emitted into the atmosphere (170 kg per 1 human), into the hydrosphere – about 15 billion liquid waste (2.5 tons per 1 human), about 85 billion tons of solid waste pollutes soil (14 tons per 1 human or 567 tons per 1 square kilometer) (Action Agenda, 2000).

In our opinion, the cornerstone of strategy for reduction of industrial and domestic waste must include the results

obtained from the analysis of modern use of natural resources (Meadows, Meadows, Randers, (1994):

1. Modern rates of consumption by human society of resources and production of waste are not balanced.

2. Excessive rates of the use of natural resources are not necessary. Changes in the machinery, distribution system, legislation could essentially cut them down, preserving the quality of life on the planet.

3. Simultaneously, even with most effective novations, capability of the planet to support the growth of population and capital has been almost exhausted.

With the up-to-date environmentally imperfect technologies, the rate of depletion of natural resources and a massive pollution of the environment still continues. This is why in the search for the ways of averting the global ecological crisis, the problem of developing technological processes based on the waste-free technologies, purification systems, etc. comes into the picture. In this context, the important aspect of sustainable development is environmentally safe waste management of various hazard classes and reclamation of the waste dumping grounds. Within the framework of sustainable development concept to achieve the goals of sustainable development, the problem of a safe reduction and utilization of solid or domestic waste includes as the well-defined tasks many of the 17 sustainable development goals, which represent the 2030 Agenda, deal not only with the earth surface, but with the surface of the world ocean and the atmosphere. This adds further credence to the importance of solution of the problem of waste management for all countries and the planet in general.

4 Modern approaches to the development of waste management systems

Formation of methodology for the study of management processes connected with problem of waste requires elaboration of a quality discourse, reconciliation of basic concepts that would permit to apply up-to-date scientific tools for resolving the tasks of waste minimization. We can admit that as of today the system of defining principles, methods and ways of their implementation in the sphere of waste handling in the context of the sustainable development concept has not been formed completely. In this context the notion «waste» is basic. It is generally acknowledged that waste is the “insuperable” element of anthropogenic activity that takes place as per flowchart: matter+energy → planned product → consumption → industrial and consumer (Shanina, et al., 2012).

As I. Kolodiychuk notes, the waste is an objective consequential product of civilizational development that

generates quite a few problems and requires decisive actions of environment-oriented character. However, on the other hand, waste represents resources that, as it is well-known, are limited under the conditions of the market economy. Such economy defines their indications as follows:

as a general category:

- attribution to substances, materials and objects, residual raw materials, materials, semi-product, etc. or to the goods with relevant physical properties;
- objective formation in the process of production/consumption, technogenic and natural action;
- loss of consumptive qualities (complete or partial);
- impossibility of further use of waste in the location of their generation or detection;
- existence of intention/obligation of the owner to get rid of it by way of disposal or utilization;

as an economic category:

- potential possibility of its use for recycling and/or a new production process;
- restricted volumes and composition for the use at the specified level of socio-economic development and scientific-technological progress;

as a socio-ecological category:

- ability to produce an essential effect on the environment and human health (Kolodiychuk, 2020).

Interpretation of this concept is given in various legal documents of Ukraine and, depending on the scope of its application, is characterized by its specificity. In this context, the Law of Ukraine “On Waste” is basic, according to which waste is any substance, material and object produced in the process of manufacture or consumption, as well as the goods (products) that have lost their consumer properties completely or partially and cannot be used further at the location of their generation or detection and from which their owner gets rid of, intends or must get rid of by way of their utilization or disposal.

The most general interpretation of the term “waste” is contained in the EU Framework Directive: waste is any substance or object that the owner throws away, intends to throw away, or must throw away. The EU Waste Framework Directive gives the most general interpretation of the term “waste”, which subsequently leads to considerable differences in waste classification. It should be noted that the EU Waste Framework Directive (Directive 2008/98/EC dated November 19, 2008) is the EU basic document in the sphere of waste management (Directive, 2008). It applies to all types of waste (with the exception of nuclear waste and some other specific types of waste) and establishes the rules of the waste hierarchy, rules for planning waste management, collection and recycling, and compliance with the obligatory authorization-based procedures in waste processing.

Depending on the sources of generation, waste is generally divided into industrial and consumption waste. Industrial waste, which means “residual raw materials, materials, semi-products that have been formed during manufacture of the production or execution of the works and lost completely or partially their end consumer properties” and/or a part of “primary or auxiliary resources that are not used or produced in the technological process, are removed from the process for dispersal, landfilling in the environment, recovery or disposal” (State Classifier, 1996). Consumption waste is the residue of substances, materials, objects, products, goods (products or articles of merchandise) that have lost their primary consumer properties partially or completely for use in direct or indirect purpose as a result of physical wear and

obsolescence in the processes of public or personal use (vital activities), use or operation (Borisovska, 2017).

In a broader sense industrial and consumption wastes are:

1) substandard residues of raw materials, materials, semi-products generated in the process production and consumption of marketable products, or

2) marketable products, that have lost their consumer properties completely or partially in the process of use or storage, or

3) untargeted products of manufacture produced as a side line of marketable products, that under certain socio-ecological-economic conditions can be used as raw materials, semi-products (Lotosh, 2007).

In general, there is a fairly full range of conceptual and categorial frameworks for the study of waste problems. At the same time, there is also a certain ambiguity in the interpretation of some or other notions that may complicate the formation of uniform approaches to the development of waste management mechanisms.

5 Conclusions

The study has shown that industrial and domestic waste is a systemic component of the global environmental problem that has a significant effect on the socio-economic development of any country – waste is concentrated both in densely populated territories and in the uninhabited areas of our planet, including outer space. Waste is an integral part of production and the result of interaction of the society with the environment. In this context, the problem of developing scientific principles for elaboration of the approaches to solving the problem of waste reduction on the local and regional levels and on the global scale is growing more urgent. There is no doubt that it is the explosion of waste that hinders transition of the global economy to the principles of sustainable development. Despite the fact that it is practically impossible to ensure waste-free production, waste reduction can be achieved by way of reduction or optimization of the use of natural resources. The conceptual basis for resolving the problem of waste is a systematic approach that must be based on the principles of sustainable development.

The problem of solid domestic waste management covers a wide range of issues, including collection, transportation, utilization, and recycling. The issue of forming an effectively functioning waste management system must be addressed within the concept of the national environmental policy, which ensures the active participation of the state, whose main goal is formation of a transparent mechanism for legal regulation of the state and society in this sphere.

Methodological basis for the waste management system must be a systems analysis of the principles and methods of organization and construction of theoretical and practical activities in the sphere of waste management, based on appropriate environmental and economic forms of management, social behavior and transformation of natural and human-made systems, that will ensure durability, feasibility, manageability of waste handling processes.

The important factor in the formation of waste management is taking into consideration the sustainable development goals by 2030, aiming at minimization of the adverse effect of industrial and consumption waste on the environment and human health with the aid of introduction and use of engineering, technological and other means of protection of the environment

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