Analysing By-Products Interaction as an Industry Resource of Circular Economy in Ukraine and the World

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Abstract

The paper analyses existing and current scientific developments and literature sources, which show the advantages and disadvantages of many different influences of waste in Ukraine and other countries of Europe and the world. As a research result, stable connections have been established between the factors and criteria in assessing the by-product interaction as an industry resource. In our research, we used programs R.Studio and Power BI Desktop, and language programming R. Analysis dataset conducted by help such diagrams as Histogram, Pie Charts. Based on the analysis diagrams, we conducted our analysis, where we determined the main factors and criteria.

Keywords 1

Data analyses, by-products interaction, R.Studio, Power BI Desktop, language programming R, circular economy, analysis dataset, Ukraine

1. Introduction

The problem of implementing the circular economy [1, 2] into existing economic relations in the state is related to the need to protect the environment, to find ways to protect future generations from the negative consequences of low-tech, high-carbon production processes still used in enterprises today [3-9]. The problem is most likely exacerbated not so much by the desire of business leaders to look for a solution but by the lack of a simple tool to solve it [10-14]. The lack of information about the availability of resources on the secondary market, their volumes, prices, types of transportation, and proven recycling technologies today is the cornerstone of solving this problem. In Ukraine working, almost 5.7 thousand chemicals enterprises. Among 600 of these are objects where it is stored, or 200,000 tons of hazardous materials are used as chemical substances [15-18]. Today risks from such activity are underestimated, and the reason is the imperfection of the current legislation.

Gaps and fragmentary regulation, and more absence-free access of the public and scientists to information about dangerous properties of chemical substances, create threats to human and natural health ecosystems [19-21]. As considered by the Deputy Minister of protection environment and natural resources of Ukraine, R.Strelets [22], there are missing complex legal regulations for chemical security issues in Ukraine. We have a situation when even mercury is not de jure recognised dangerous chemical substance. In this case, inappropriate handling or illegal use of dangerous chemical materials, bringing to responsibility subject management is difficult in practice in Ukraine [22].

During the public discussion, the draft law "On chemical safety" [23-25], it was summed up that consumption of chemical products in Ukraine reached 10–12 billion dollars every year, excluding substances which are also imported and used in everyday life [23-25].

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At the same time, development technologies are accompanied by developing, synthesising, and using new chemical compounds in the industry, which are dangerously uncertain [26]. In the composition diversity, they fall into different product spheres, life activities and everyday life of a person [27-32]. So, for Ukraine, there is important to create fundamental principles for chemical safety management. Therefore, the Ministry of Environment has prepared jointly with the OSCE project framework law "On chemical safety" [19, 33]. Such a document development was included in the Program activity Cabinet Ministers of Ukraine and the Priority Plan actions of the Government for 2022 [19, 33, 34]. Bill provides [19, 33, 34]:

- the creation of systems management chemical substances (from their identification and state registration to implementation of European technical CLP and REACH regulations);
- strengthening control of dangerous chemical substances (classification of danger and marking chemical production, implementation permits on using poisonous chemical substances, restrictions production and using substances which constitute unacceptable risks to human health);
- the creation of systems for chemical security (monitoring threats, planning activities in the field management of chemical safety on levels of states, regions and specific enterprises, installation fuses for possible terrorist acts with the use of chemical substances).

After accepting the draft law, citizens will receive free access to information about chemical storage products issued on the market. Business needs clear rules that work harmonised with international and European standards. It also will simplify access to external markets.

2. Analytical review of literary and other sources

2.1. Analytical review of reference

In the works of scientists [35-37], it is substantiated that among wastes, the most dangerous for living beings and the environment are radioactive wastes, which are formed as a result of the use of various nuclear technologies in the process of their industrial production. According to researchers in [35, 38-42], such a dangerous effect of radioactive waste is caused by its radioactivity. Therefore, state bodies responsible for public safety and environmental protection regulate all production, storage and processing processes. Each state is obliged to manage waste management according to their classes. In each country, the waste classification may differ and correspond to the intensity of the hazardous content of radioactive waste [35, 40-42]. At the initial stage, radioactive waste is collected and distributed by category. Then, the waste is stored in temporary storage.

Further, the waste's volume reduction, immunisation and shielding are carried out at the processing stage. The next stage is a long-term geological burial at ground level at a depth of up to 100 m [35, 43, 44]. Highly radioactive spent fuel and reprocessing waste are stored temporarily until a long-term disposal solution is established [35].

According to the Scripps Oceanographic Institute, last year, the concentration of carbon dioxide in the atmosphere for the first time in the history of mankind reached the maximum level - of 415.26 ppm [45-47]. This level of carbon dioxide concentration was observed about 3-5 million years ago when the temperature on Earth was several degrees higher than it is now. In particular, in 2018, this indicator was 405.5 ppm [13, 45, 48-50]. Normally, the amount of CO_2 fluctuates greatly depending on the season, reaching a maximum in the northern hemisphere in the spring and early summer. However, the average annual concentration of CO_2 continues to grow steadily. Scientists associate this fact [51-55] with the burning of solid fuels because 67% of greenhouse gas emissions are caused by energy and fossil fuels, which lead to an increase in the global average temperature. According to preliminary forecasts [54-57], atmospheric pollution will accelerate significantly in 2022.

As you know, carbon dioxide (CO_2) is produced as a result of burning fossil fuels, in particular, coal. According to scientific research [58-61], even a small amount of carbon dioxide can be toxic and cause biochemical changes in human blood, pain in the joints, weakness, acid-base imbalance, decreased immunity, cause diseases of the kidneys and cardiovascular system. As a result, climate policy aimed at combating climate change and decarbonising the economy began to take shape in the world, which was reflected in the "European Green Agreement" [62] and the Paris Agreement of 2015 [63].

The European Union has set a goal: by 2050, Europe will become the first continent whose economy does not destroy nature. Ukraine is ready to become integral to this success story [62]. In January 2020, the Minister of Energy and Environmental Protection of Ukraine, O. Orzhel, presented the draft Concept of the “green” energy transition of Ukraine by 2050 [45], which is due to the transformation of approaches to the development of energy in the world and special attention to the problems of combating climate change. The concept envisages the complete replacement of coal generation and the transition of Ukraine’s economy, which is based on the use of fossil fuels - coal, oil, and gas, to a climate-neutral economy in the long term. Currently, the Ministry of Energy and Environmental Protection of Ukraine is developing solutions that will be reflected in reforming the coal industry’s public sector [45]. But now it will after winning in the Russian-Ukrainian war when we will rebuild Ukraine. The Ukrainian Government plans to build a nationwide monitoring system to strengthen the urgent need for environmental control over air quality. We have foreseen the opening of the Air Emissions Control Office and 50 air quality monitoring stations as early as 2022. These measures would significantly reduce atmospheric emissions [45, 62-65].

Uranium has chemical and radiological properties that have made it useful in industry and commerce, but it is toxic at sufficiently high levels for humans and the natural environment [27-30]. Various analytical methods confirm its presence in the surrounding air, water, and soil, so the impact on humans is undeniable. At least 7 of its more than 100 mineral forms have been found in different world parts at the level necessary for extraction [32, 35, 37-44]. The main producers are Canada, Russia, Ukraine, Australia and Central Africa [22-25].

Ukraine is Europe’s leader in uranium ore reserves, and the end of a multi-year price slump brings an inevitable revival to the industry. In the metric calculation of the current wave of growth in the popularity of uranium dioxide, its current world prices have exceeded the level of $ 63 thousand / ton [23]. The state concern “Nuclear Fuel of Ukraine” sells only ore concentrate (unenriched uranium dioxide). Unlike complex dioxide, this primary semi-finished product is obtained using ion exchange resins and sulfuric acid. It is produced by the Hydrometallurgical Plant of SE “Skhidniy GZK” (SE Eastern Mining and Processing Plant) in Zhovti Vody [66]. Before the global increase in the dioxide price, the concentrate of the SE Skhidniy GZK was considered very cheap due to the ore poverty and, according to unofficial data, was sold at prices in the range of $ 50-75 per ton. [23-30].

2.2. Analysis of existing software products

In the research, we used programs R.Studio [67] and Power BI Desktop [68] and language programming R [69]. Analysis dataset was conducted with the help of such diagrams as [70-72]: Histogram, Pie Chart, which are depicted below. Based on the diagrams, we conducted our analysis and determined the main points. The only example of this work is shown in Fig. 1.

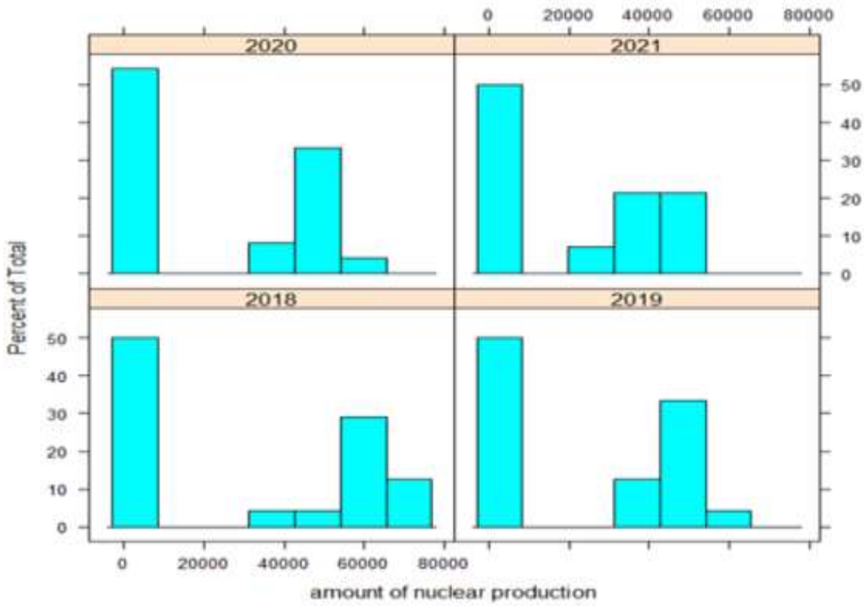

Figure 1 Histogram of the amount of nuclear production vs per cent of the total for period 2018-2021

There are more than 100 minerals that contain U. Still, the majority of U is produced from the following: authenite, carnotite, uraninite (resin blende), torbernite, thuyamunite and uranite - uranium mica, also called resin blende; aqueous uranium phosphates and uranium arsenates of alkalis, alkaline earths and copper. Another interesting mineral is cleveite, a variant of uraninite that contains rare earths and yttrium.

3. Results

3.1. Analysis of existing Dataset

We chose the dataset "Quantity produced nuclear waste from 2018 to 2021 in Ukraine" [66]. The dataset contains information about the general number of nuclear wastes for years [66]. SE Eastern Mining and Processing Plant is a state-owned enterprise, one of the 28 uranium mining centres in the world, among which it is in the top ten and is also the largest in Europe. The only enterprise in Ukraine that provides extraction of natural uranium and production of its oxide concentrate. The enterprise is located in the city of Zhovti Vody. The Data is shown in Fig. 2.

year	month	code	enterprise	activity	product	amount	cost
2018	1	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	60095	
2018	1	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	139,2	429966,4
2018	2	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	57140	
2018	2	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	162,3	504702,3
2018	3	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	61277	
2018	3	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	93,2	285267,9
2018	4	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	52262	
2018	4	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	67	201933,6
2018	5	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	40347	
2018	5	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	67	199717,6
2018	6	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	55328	
2018	6	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	72,2	215156
2018	7	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	59327	
2018	7	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	79,3	237010,5
2018	8	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	59759	
2018	8	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	66	209057,4
2018	9	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	61570	
2018	9	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	58,4	172853,3
2018	10	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	67728	
2018	10	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	64,3	188849
2018	11	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	73945	
2018	11	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	110,8	328171,6
2018	12	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	70588	
2018	12	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	199,8	616335,5
2019	1	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	44920	
2019	1	14309787	SE Eastern Mining and Processing Plant	production	Yellowcake	72,6	225617
2019	2	14309787	SE Eastern Mining and Processing Plant	mining	Uranium ore	40873	

Figure 2: Dataset and its Contents, where there is collected information about the extraction of uranium-containing materials at the SE Eastern Mining and Processing Plant

Based on the analysis diagrams as the Histogram, Pie Chart depicted below, we conducted our analysis and determined the main points

We used histogram [70, 72] for graphic representation of tabular data on the extraction of uranium-containing materials at the Eastern Mining and Processing Plant (SE Eastern Mining and Processing Plant) with the aim of approx representation distribution of numerical data. The diagram consists of rectangles without gaps between them. Quantitative correlation is some indicator presented in rectangles, areas of which are proportional. Most often, for amenities perception, width rectangles take the same; at this, their height determines the correlation displayed parameter. This one histogram depicted the dependence on nuclear fuel and waste products in 2018-2021 Ukraine.

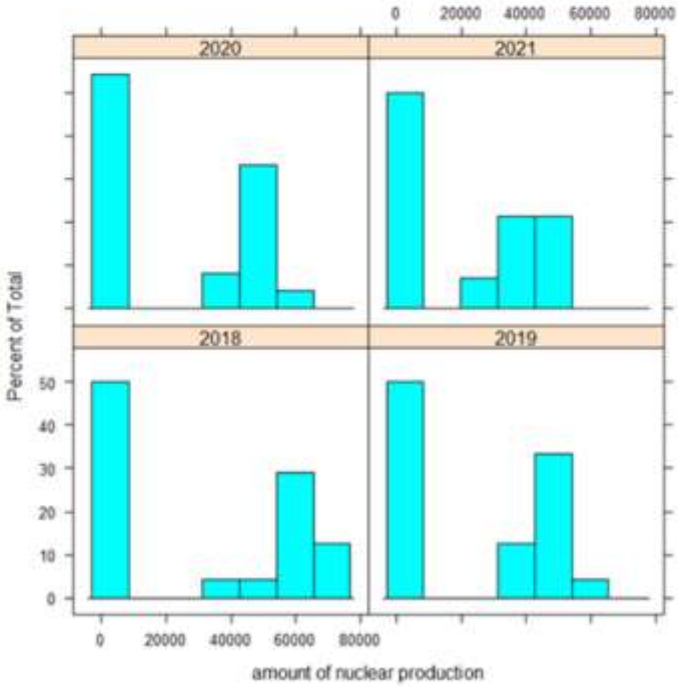

Figure 3: Histogram of the amount of nuclear production vs per cent of the total at SE Eastern Mining and Processing Plant for the period 2018-2021

3.2. Treemap

This Treemap graphics depicted a number of nuclear fuel and waste production in various countries of Europe [73]. Analysing this graph, we can observe a significant amount of waste in Romania, Germany and Great Britain [75-78].

Figure 4: Treemap number production of nuclear fuel and waste in various countries of Europe

As a result of the treemap visualisation, we got acquainted with the number of production of nuclear fuel and waste in detail in Ukraine and various countries of Europe [79-82]. The detailed analysis of the chosen dataset demonstrated that most formed households and waste enterprises are in Romania, France, Germany, and the United Kingdom. Ukraine is one of the ten top nuclear fuel and waste producers but does not have enough plants to reuse hazardous, radioactive waste content.

3.3. Diagram density of factors

The graphics below display the density distribution production of nuclear fuel and waste during 2018-2021 (Fig. 5). A diagram of the density of the amount of nuclear production for 2018-2021 is shown in Fig. 5. The SE Eastern Mining and Processing Plant produces nuclear production by the plan.

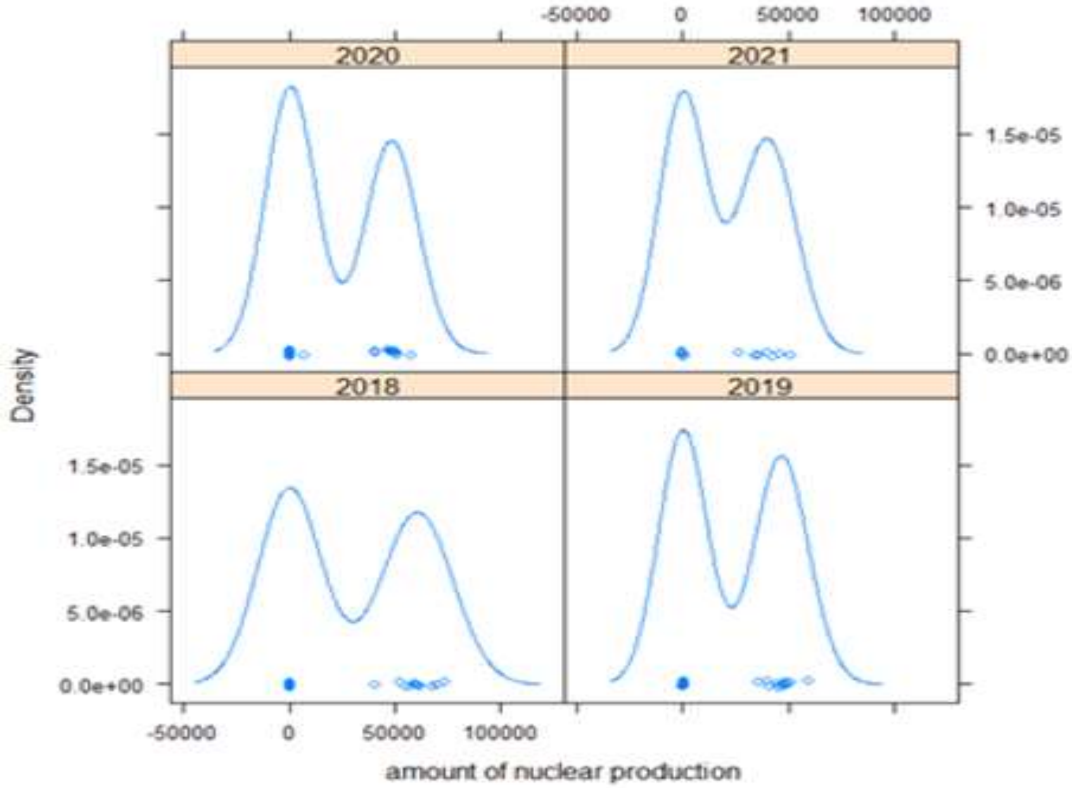

Figure 5: Diagram of the density of amount of nuclear production for the period 2018-2021 at SE Eastern Mining and Processing Plant

4. Discussion

By-products result from economic or daily activities and accumulate in various institutions such as enterprises, companies, government agencies, households, etc., as waste, emissions and discharges [83-88]. The problem of the deterioration of the quality of life of the population due to the achievement of critical levels of pollution by emissions, discharges and wastes of the environment in the system “nature - production - society” causes a critical need to find solutions that would ensure an established and effective interaction of by-products [89-110]. In most cases, by-products are also a cheaper type of resource and sometimes even a free type of resource. Certain volumes of emissions, discharges and waste for enterprises are associated with the costs of their storage, transportation, disposal, and significant amounts of environmental taxes.

In our case, some enterprises generate by-products and enterprises that need raw materials. A search is done for a match between them. Also, in the absence of the existence of appropriate technologies (methods) for the subsequent use of by-products (that is, their aggregation, delivery, processing and transformation), a special place in the system belongs to the formation of requests for the development and implementation of such technologies. In this case, the leading role in the proposed system is assigned to research and educational institutions that create innovative technologies for aggregation, delivery, processing and transformation of by-products missing in this waste transformation chain. The key role in the system is assigned to the transfer of technologies from educational institutions to businesses, the formation of open requests for the development of missing technologies for aggregation, delivery, processing and transformation of various types of waste, emissions and discharges.

Authors [1, 2, 9-14, 49, 50] have significant scientific experience in managing and implementing projects, the content of which is related to the management of by-products, with the development of models and mechanisms for the formation of a circular economy.

The world is already working on the creation of mechanisms for managing the damage caused by the economic activity of enterprises, i.e. man-made waste management (emissions, discharges, pollution, business waste and consumption waste) [3-8, 17, 19, 20, 29, 33-38, 82, 83]. The essence of the mechanism for managing all types of waste (man-made, business, household, etc.) is primarily related to the optimisation (cost, time, information, etc.) of man-made waste flows at all stages of waste management (planning, management, processing, i.e. collection, sorting, storage, transportation, processing, reuse, recycling, environmentally friendly storage, etc.). Modern waste management covers five main processes related to waste management: 1) waste prevention, in particular ways to rationalise production and consumption; 2) generation of waste, as well as the development of products from used materials and recycled raw materials; 3) separate waste collection directly at the source; 4) recovery of matter and energy contained in waste, or processing of waste in whole or in part, or utilisation of waste substances, materials or energy and their application; 5) disposal, processing of substances or materials from waste during production to obtain new substances or materials for other purposes; 6) placement of waste in specialised places for carrying out processes of their biological, physical or chemical treatment to achieve a state that does not pose a danger to human life or health or the environment. The best way to deal with waste is to prevent it at the production stage (innovative waste-free production technologies) and consumption (reduction or rationalisation). Still, the most common is the placement (destruction) of waste, among which in works [27-32] allocate household waste, industrial waste of electrical and electronic equipment, decommissioned cars, hazardous waste and other waste, including sewage sludge (pollution), construction waste, medical and veterinary waste.

5. Conclusions

The article analyses existing and modern scientific developments and literary sources that show the advantages and disadvantages of various impacts of hazardous waste in Ukraine and other European countries. It was established that among the by-wastes, the most dangerous for living beings and the environment are radioactive wastes, which are formed as a result of the use of various nuclear technologies in the process of their industrial production. The hazard class of radioactive waste is determined by its radioactivity. All production, storage and processing processes are regulated by state bodies responsible for public safety and environmental protection. Each state is obliged to manage waste management according to their classes. In each country, the waste classification may differ and correspond to the intensity of the hazardous content of radioactive waste. The research used R.Studio, Power BI Desktop, and R programming language. The data set analysis was carried out using histograms and Pie charts.

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