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**Gubina V.G., Zaborovsky V.S., Mitsiuk N.B.**

**Gubina V.**, Senior Research Fellow, Leading Researcher, State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine", <https://orcid.org/0000-0001-7486-5451>, [gvg131619@gmail.com](mailto:gvg131619@gmail.com)

**Zaborovsky V.**, Researcher, State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine"

**Mitsiuk N.**, Research Assistant, State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine", [nmitsiuk@gmail.com](mailto:nmitsiuk@gmail.com)

## COMPARATIVE ANALYSIS OF WASTE GENERATION AND ACCUMULATION IN UKRAINE AND EU

*The volume of waste generation and accumulation in Ukraine and European countries (except for radioactive waste, which is regulated by separate legislation) has been analysed based on the waste generation statistics in these countries. The data on the annual waste generation and accumulation volumes are presented based on different classifications, i.e. by hazard waste classes, types of economic activity, composition of the waste. It has been shown that by 2013 in Ukraine more than 400 million tons of waste had been generated annually, including over 1 million tons of hazardous waste and over 12 million tons of household waste. At present about 300 million tons of different waste is produced annually, including over 0.5 million tons of hazardous and 12 million tons of household waste. The data do not include temporary occupied territories of the Crimea and parts of Donetsk and Luhansk regions. In the European Union, more than 70% of the total waste is generated in 10 countries: Germany, France, England, Poland, Romania, Italy, Sweden, the Netherlands, Spain and Finland. By type of economic activity, the largest amounts of waste in Ukraine are produced from the mineral extraction and the processing industry, the smallest – from water treatment, and the construction and demolition of buildings. In the EU countries, these values are somewhat different. For example, in Germany, the largest amounts of waste are generated from the demolition of buildings and the processing industries, the smallest – in agriculture, forestry and fishery. By classes of materials, the waste generated and accumulated both in the EU countries and in Ukraine is mineral and solid waste. In Ukraine, the largest amounts of waste are generated and accumulated in the Dnipropetrovsk, Donetsk and Zaporizhzhia regions which accommodate large enterprises for extraction and enrichment of iron and manganese ores, titanium-zirconium placers, coal, dolomite, and metallurgical limestone, as well as metallurgical and ferroalloy plants. The by-products of all these plants are slag, sludge and oil scale. Depending on the volumes of the produced waste, regions of Ukraine are classified into three groups. The first includes areas accommodating hundreds of millions of tons of waste, the second – tens of millions of tons, the third – less than 10 million tons.*

**Keywords:** waste, types of economic activity, sources of waste, waste generation and accumulation, "tails", slag, sludge

**Introduction.** Rapid global economic growth at the end of the last millennium led to excessive use of non-renewable natural resources and increase of human impact on the environment. Generation and accumulation of the production and consumption waste on the earth's surface became one of the challenges standing before the humanity in the nearest future. In accordance with the national waste management programmes, the European Union and Ukraine make inventories of the waste generated and accumulated both by enterprises and households.

The volume of waste generation in different countries varies depending on the economic activity. The waste inventories reflect the socio-economic differences and different approaches to treatment and identification of waste types. The largest amount of waste is generated in countries with developed mining and metallurgical industries. At the same time the countries where these sectors of the economy are not developed have a high level of domestic consumption, which results in significant gener-

ation of household waste as well as construction and demolition waste.

The aim of our work was to analyse the volumes of waste generation and accumulation in Ukraine by types of the economic activity, hazard classes, composition and regional distribution, and to compare waste generation and accumulation rates in Ukraine and EU countries.

**Results and Discussion.** According to the State Statistics Service of Ukraine, in recent years, over 200 million tons of waste have been generated annually including 0.6 - 1.6 million tons of hazardous waste and over 10-12 million tons of household and similar waste. In 2016, more than 12 billion tons of waste have been accumulated in Ukraine, including about 12 million tons of hazardous and over 170 million tons of household and similar wastes (except for the temporarily occupied territories of Donetsk and Luhansk regions, and the temporarily occupied Crimea). By 2013, the amount of wastes accumulated in Ukraine was 15.2 billion tons (Table 1). [1]

**Table 1.** Waste accumulation and generation in Ukraine, mln tons  
**Табл. 1.** Накопичення та утворення відходів в Україні, млн. тонн

Year	Generation of waste	Including hazardous waste	Including household and similar waste	Accumulation of waste	Including hazardous waste	Including household and similar waste
2010	419.192	1.6	12.110	13267.455	16.236	135.945
2011	447.641	1.4	10.356	14422.372	15.158	141.251
2012	450.727	1.4	13.787	14910.105	14.325	150.516
2013	448.118	0.9	14.501	15167.369	12.642	160.118
2014**	354.803	0.7	10.748	12115.241	11.951	166.112
2015	312.267	0.6	11.492	12 281.353	11.996	170.306
2016	295.870	0.6	11.563	12 451.659	12.102	174.514

As can be seen from the table the amount of waste had increased by 2013, and since 2014 it has decreased. This is explained by the fact that the enterprises located at the temporarily occupied territories of Donbass and Crimea have not been taken into account by the Ukrainian statistics.

According to Eurostat data, 2.5 billion tons of waste have been generated in the EU (EC-28) by 2016 (Fig. 1). More than 70% of it is in 10 countries: Germany, France, England, Poland, Romania, Italy, Sweden, the Netherlands, Spain, and Finland. [2]

The chart shows that in 2016 the volume of waste generated in these countries was as follows (mln tons): Germany – over 400, in France – 300, in Poland, Romania – about 200, Italy – more than 160, Netherlands, Sweden – over 140, Spain, Finland – more than 120. In such EU countries as Turkey, Greece, Belgium, Austria, Serbia 60-70 million tons of waste was generated, Czech Republic, Estonia, Denmark – more than 20 million tons, Hungary, Ireland, Portugal – 14, 15, Luxembourg, Slovakia, Norway – 10-11. From 1 to 6 million tons are generated in other countries. In Ukraine, excluding the occupied Crimea and territories of the Donbas, almost 300 million tons of waste was generated in 2016, which is less than in Germany and the same level as in France and the United Kingdom.

The State Statistics Service of Ukraine keeps records of waste generation and accumulation in accordance with the National Waste Classifier, which is based at the same rules as the National Classifier of Products and Services that classifies the waste by its origin. Waste is classified according to different parameters (by hazard classes, types of economic activity and households, waste categories, required disposal operations). The same inventory strategy is used in the European Union.

Based on the State Statistics Service data [3], the chart in Figure 2 presents waste generation by types of economic activity in Ukraine in 2016.

The largest volumes of waste in Ukraine are generated by mining – 237.5 million tons (84.48%), and manufacturing industry – 34.1 million tons (12.13%) which includes metallurgical and chemical enterprises, food industry etc. Municipal waste amounts to 6 million tons (2.08%). For comparison, in advanced countries such as Germany and France, the largest volumes of waste are generated by construction and demolition of buildings – 220.5 and 224.4 million tons respectively, and the manufacturing industry – 55.9 and 22.1 million tons respectively. The household garbage volume is 37.4 mln tons in Germany and 29.2 mln tons in France (Figs. 3, 4), which is about 5 times more than in Ukraine [2].

According to the State Statistics Service of Ukraine [1], the main sources of waste generation and accumulation in Ukraine are the following branches of economics (Table 2).

Thus, the largest amount of waste in Ukraine is generated by mining operations – over 300 million tons. It makes on average 79.5% of the total waste in different years. Over 80% of this volume is waste from mining of metal ores (iron, manganese, and titanium-zirconium ones).

According to the Waste Classifier DK 005-96, the group of metal ore mining waste in Ukraine include mining waste and sludges, enrichment tails of iron ores, residues (dust, powder, etc.) of iron ore, sinter and iron flux production, non-ferrous metal ore (manganese) enrichment waste. Uranium and thorium ores belong to another classification group.

The group of hard coal, lignin and peat mining waste also includes substandard coal, sludge and tails from concentrating mills etc. Other group of waste generated at Ukrainian enterprises comprises waste from mining of granite, limestone, chalk, dolomite, refractory clay, building stone and others. The waste is in the form of powder, chips and debris.

2016, mln. tons

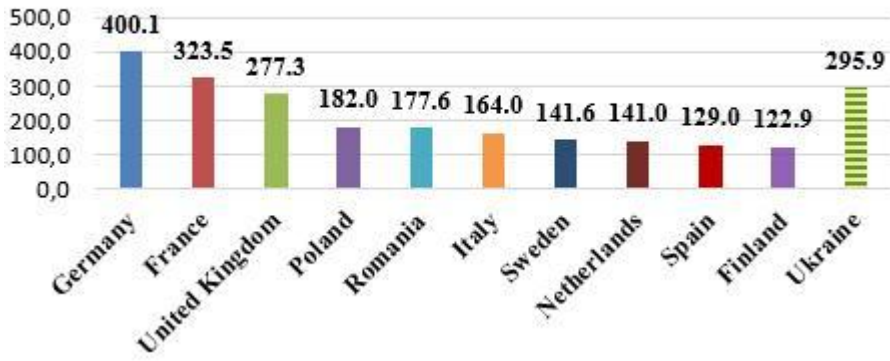


Fig. 1. Waste generation in EU countries and Ukraine, 2016, mln tons.

Рис. 1. Утворення відходів у країнах ЄС та Україні, 2016 р., млн. тонн.

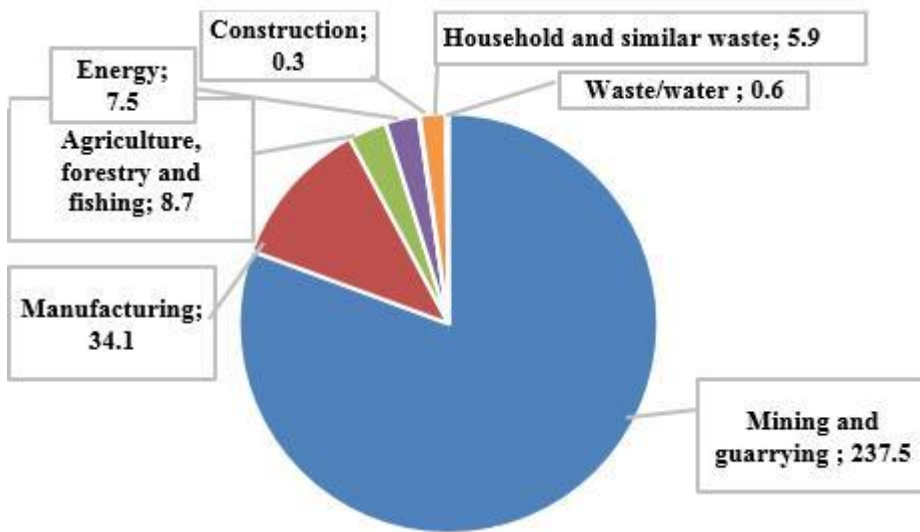


Fig. 2. Waste generation by types of economic activity in Ukraine, 2016, mln tons.

Рис. 2. Утворення відходів за видами економічної діяльності в Україні, 2016 р., млн. тонн.

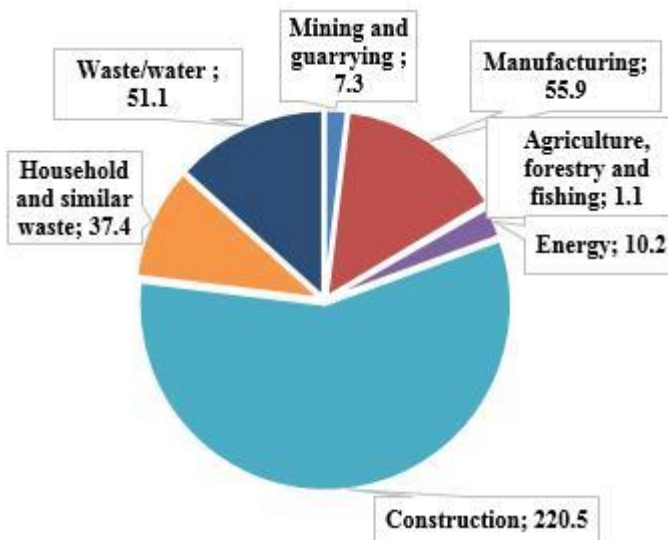
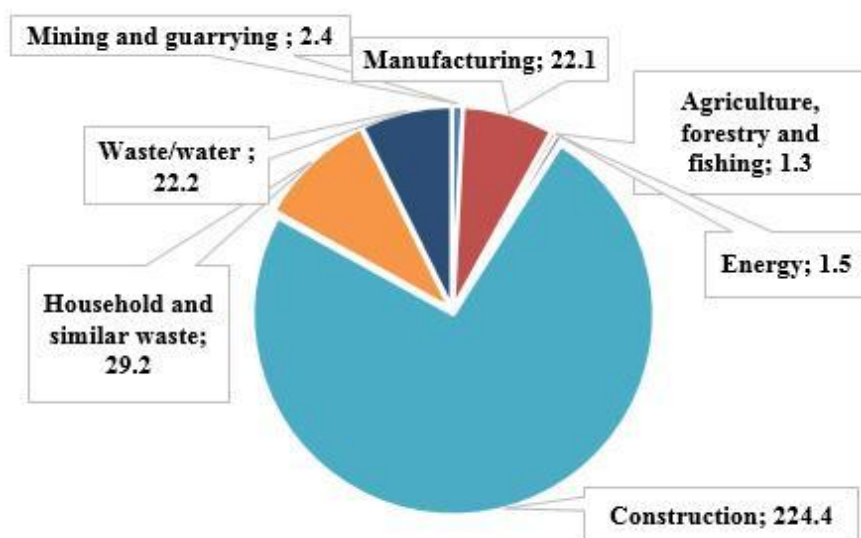


Fig.3. Waste generation by types of economic activity in Germany, 2016, mln. tons

Рис.3. Утворення відходів за видами економічної діяльності у Німеччині, 2016 р., млн. тонн



**Fig. 4.** Waste generation by type of economic activity in France, 2016, mln. tons

**Рис. 4.** Утворення відходів за видами економічної діяльності у Франції, 2016, млн. тонн

**Table 2.** Dynamics of waste generation by types of economic activity in Ukraine, mln tons

**Табл. 2.** Динаміка утворення відходів за видами економічної діяльності в Україні, млн тонн

<i>Branches of economics</i>	2012	2013	2014	2015	2016	2017	2018
<b>Total</b>	450.73	448.12	355.00	312.27	295.87	366.05	352.33
<b>Type of economic activity</b>	442.76	439.10	348.69	306.21	289.52	360.20	346.79
<b>Agriculture, hunting, and provision of related services</b>	10.2	10.3	8.4	8.7	8.7	6.2	6.0
<b>Mining (Total)</b>	335.7	341.2	297.2	252.1	237.3	313.6	301.3
Mining of metal ores	282.9	289.7	281.5	238.1	222.5	293.7	282.5
Mining of hard coal, lignin and peat	38.9	42.7	13.0	12.1	10.5	12.9	10.8
Mining of other ores	13.9	8.8	2.7	1.9	4.3	7.0	8.0
<b>Manufacturing industry (Total)</b>	69.80	66.00	29.50	25.60	28.20	29.60	28.80
Iron and steel production	59.0	60.3	23.4	20.7	22.3	22.0	21.8
Chemical industry	3.5	2.0	1.1	0.7	0.8	1.2	1.2
<b>Food industry</b>	8.7	4.3	5.8	5.1	5.7	6.8	6.2
<b>Other branches of mining industry</b>	4.9	5.4	4.5	4.5	5.3	2.2	2.3
<b>Production and distribution of energy, gas and steam, and air conditioning</b>	9.8	9.3	6.0	6.6	7.5	6.2	6.3
<b>Other types of economic activities</b>	10.9	5.8	5.0	2.2	1.8	2.0	1.6
<b>Households</b>	8.0	9.0	6.3	6.0	6.3	5.9	5.5

On average, the processing industry generates 11.76% of waste, over 75.7% of which come from the metallurgical industry (blast-furnace, steelmaking and ferroalloy slags and sludges, etc.).

An important source of metal resources is the waste generated from extraction of metal from ore and its production at metallurgical plants.

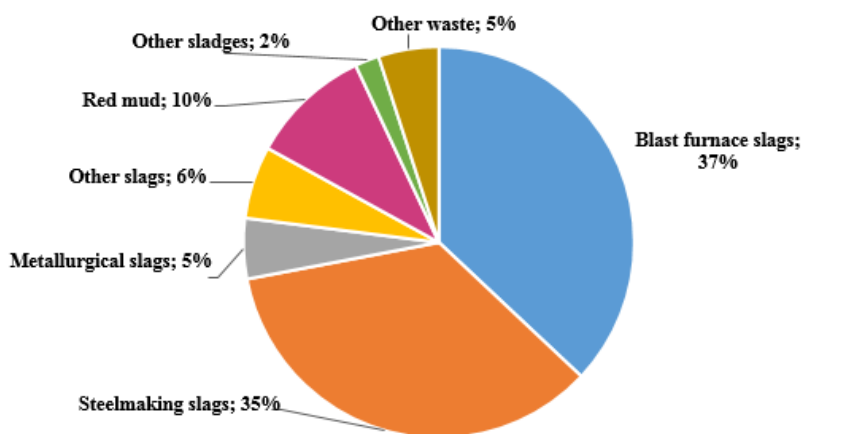
By 2011, enterprises that mine metal ores had accumulated 5.0 billion tons of sludge and tails from iron ore enrichment, 4.0 billion tons of waste from iron ore

quarry mining, and 279 million tons of sludge and tailings from non-ferrous metal ore (manganese) enrichment.

The structure of waste containing metals that has been accumulated by the mining and metallurgical industries is shown in Fig. 5,6 [4, 5].

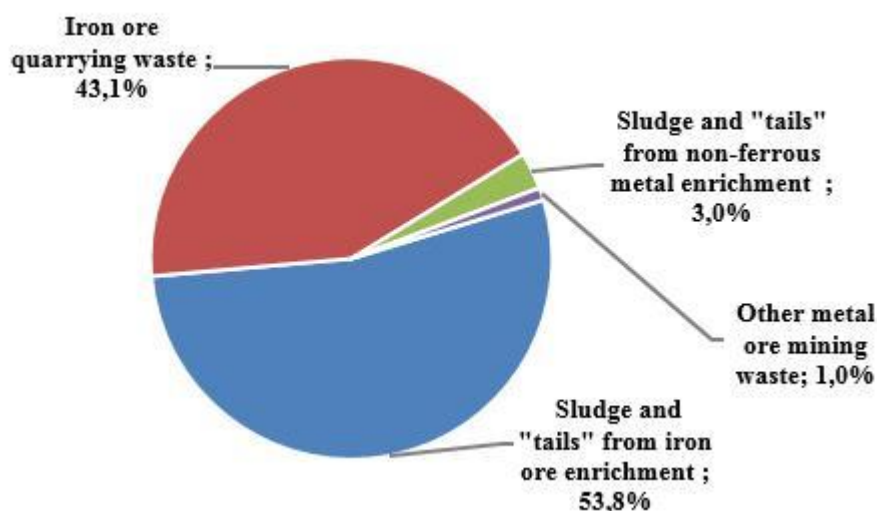
The predominant part of the waste (79%) is metallurgical and ferroalloy slags. Metallurgical sludge is the dust captured by air purifying equipment using liquid filters. It

is stored in sludge collectors. After settling, the water is discharged into the surface water bodies, while the solids, if not reused, are accumulated in sedimentation tanks. Red sludges are generated at two enterprises – Mykolaiv alumina refinery and Zaporizhzhia aluminum processing plant which produce alumina from bauxite. As can be seen from the chart, the red sludge makes 10% of the total waste from the major metal production.



**Fig. 5.** Structure of accumulated waste from production of major metals, %

**Рис. 5.** Структура накопичених відходів від виробництва основних металів, %



**Fig. 6.** Structure of metal-containing waste accumulated by the mining and metallurgical industries, %

**Рис. 6.** Структура металовмісних відходів, накопичених гірничорудною та металургійною галузями, %

One of the ways to reduce the amount of waste at the stage of extraction and enrichment of the metal ores in Ukraine is the integrated use of the mineral resources and the utilization of enrichment waste.

Thus, the annual generation of production waste from iron ore mining processing amounts to more than 80 million tons. Over 70 million tons of this amount are piled in waste heaps. The general amount of the accumulated waste is more than 4 billion tons. In the case of their selective extraction and separate storage, the following types of production can be obtained from the overburden: talcum concentrate from talc-containing shale, garnet concentrate from garnet-containing shale, muscovite concentrate from muscovite-biotite shale, muscovite quartzite and quartz-muscovite shale, pyroxene concentrate from pyroxenite, expanded clay, ceramics and pottery from kaolin clay bricks, building sand, limestone tiles, natural

pigments (ferrous oxide, ocher, seladonite etc.). The annual generation of the enrichment waste is over 130 million tons. Over 5 billion tons of such waste have been accumulated in the tailing ponds. By recycling of the enrichment tailings, ferrous concentrate and construction sand will be produced. It will also clear the place for additional 0.4 million m<sup>3</sup> of tailings.

Clay, sands and limestone-shells from the overburden can be attributed to the resource potential of manganese ore production waste in Ukraine, which can be selectively extracted and subsequently used in the national economy. In addition, more than 300 million tons of manganese-containing sludge have been accumulated in sludge storage facilities, with a mass fraction of Mn 10.5 - 17.5%. By sludge enrichment applying different schemes, it is possible to obtain manganese concentrate with a mass fraction of Mn from 35-41% (high-gradient magnetic sep-

aration with flotation) to 50% (magnetic-chemical technology) with an extraction of Mn 65-68% and 64%, respectively.

The enrichment waste prevail in the total amount of wastes from extraction and enrichment of heavy mineral titanium-zirconium sands. The overburden from the development of titanium-zirconium placer deposits in Ukraine (clay, loam, sand) is acceptable to be used for reclamation works.

Ore minerals in the technogenic sands of the Malyshevskiy deposit (the Volnogorsk MMC) are represented by zircon, rutile, leucosen and ilmenite. Mostly they are concentrated in the fraction – 0.16 + 0.06 mm. Disten, sillimanite, staurolite and tourmaline have relatively significant contents.

Studies of the material composition of the waste from the Irshan group of deposits have revealed that 60 wt.% of sands are represented by 0.5 + 0.125 mm grains; 5-15 wt.% is the metallic fraction, 85-95 wt.% – the non-metallic one.

The ore minerals are mainly ilmenite, rutile, ilmenorutil and zircon. The presence of zircon as the main mineral carrier of zirconium. We consider that these technogenic sands can be used to produce titanium and zirconium as well as quartz sand.

Eurostat and the State Statistics Committee of Ukraine keep records of waste generation by material as

well. Subdivision of wastes by material based on EU and Ukrainian data (2016) is presented in Table 3 [2, 3].

As indicated in table 3, over 2 billion tons of waste is generated annually in EU countries. In 2016, the total volume of waste generated in all 28 EU countries was 2.45 billion tons. 78.87% (1935.97 million tons) of this amount was generated in 9 countries: Germany, France, England, Poland, Romania, Italy, Sweden, the Netherlands and Spain. 295.85 million tons were generated in Ukraine, which is comparable to the volumes generated in France and Great Britain. Mineral and solidified waste constitutes the largest part of the total waste generated in all countries – from 39.91% in Italy to 80.92% in France. In Ukraine, this percentage is 76.4, which is less than in France, Germany and Romania. Thus, the amount of mineral and solid waste in Ukraine is equal to that in Germany and France, and the volume of animal and plant waste is similar to that in Germany and Netherlands.

In the EU countries, a considerable percentage of waste is generated from waste recycling – from 5.95% in Netherlands to 15.55% in the United Kingdom. In Ukraine, this category of waste amounts to 0.07%. The category “Equipment”, in contrast to the EU countries, is not registered in our statistics. This suggests that waste recycling legislation is not effective in Ukraine. The Waste Act states that waste is any substance, material and object generated during production or consumption; products that have completely or partially lost their consumer properties and cannot be used at the place of their production or detection, and which the owner has an intention or should recover or dispose. More than 50% of industrial waste generated from the production process in Ukraine has been accumulated at special sites for decades.

Fig.7 shows waste accumulation in different regions in Ukraine is very non-uniform [3].

The chart shows the volume of waste accumulated in different regions as of 2016. In accordance with the volume of accumulated waste, the regions were divided into 3 groups. The first includes areas accommodating hundreds of millions of tons of waste, the second – tens of millions of tons, the third – less than 10 million tons.

Having the well-developed industry Dnipropetrovsk region accommodates the largest volumes of waste. The plants extract and enrich iron, manganese, titanium-zirconium ores, and coal. There are also metallurgical and ferroalloy plants.

As can be seen from the chart, Dnipropetrovsk region accumulated 10 billion tons of waste at the disposal sites.

According to our estimates, more than 90% of them is waste from extraction, enrichment and processing of iron and manganese ores (Kryvbas mining and processing integrated plant, Nikopol manganese ore field and metallurgical plants).

In Donetsk region, at the territory controlled by the Ukraine authorities, most of the waste is accumulated at the coal mining and enrichment plants, coke plants and metallurgical plants. Dokuchaiv flux-dolomite plant, which accumulated huge amounts of waste by 2013, is

located at the temporarily occupied territories and the data are not available.

In Kirovohrad region, 99.9% of waste is accumulated at three enterprises: Petrivskiy quarry of the Central mining and processing complex, gulch “Shcherbakivska” and mine “Inhul’ska” of the Eastern mining and processing plant. Waste at the disposal sites of the Eastern mining and processing plant. Petrivskiy quarry’s disposal sites accommodate almost 80% of the waste accumulated in Kirovohrad region.

In Lviv region over 96% of waste is accumulated at four enterprises: JSC “Lviv Coal Company”, 6 mines of SE “Lvivuhillia”, Novoiavorivske SE “Ekotransenergo” and Dobrotvir’ska TPP.

In Zaporizhzhia region, almost 90% of waste was accumulated at 5 enterprises, i.e. JSC “Zaporizhstal (metallurgical (iron) slag and sludge), Zaporizhzhia TPP (coal ash), LLC “Remondis Zaporizhzhia” (household waste), JSC “Zaporizhzhia Ferroalloy Plant” (ferroalloy slag and dust from gas purification plants) and JSC “Zaporizhzhia Aluminum Production Plant” (over 10 million tons of red sludge).

In Luhansk region, at the territory controlled by the Ukrainian authorities, there are coal enterprises which generate coal mining and enrichment waste.

The second group comprises the Ukrainian regions which accommodate the most powerful TPPs (Trypilska, Zmiiv’ska, Ladyzhyn’ska, and Burshtyn’ska). These TPPs produce 60-70% of the total waste generated in a region.

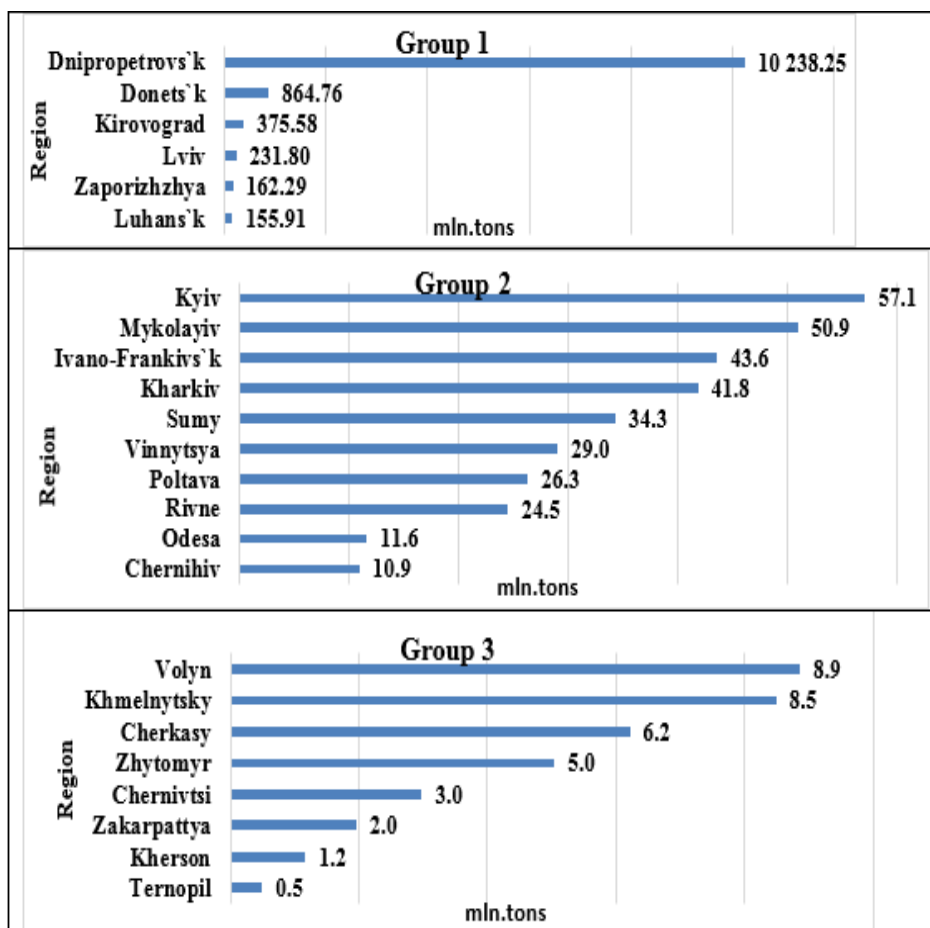
The third group includes regions in which 70-99% of the total waste is municipal waste.

It should be noted that the volume of accumulated waste in Ukraine is much higher than the mentioned above. This is because the State Statistics Service receives information only from operating enterprises. Large volumes of waste are stored at enterprises abandoned after disintegration of the Soviet Union.

**Table 3.** Waste generation of materials in Ukraine and EU countries

**Табл 3.** Утворення відходів матеріалів в Україні та країнах ЄС

Country	Total volume in a country, mln tons	%	Mineral and solid waste, mln tons	%	Chemical and medical waste, mln tons	%	Animal and plant waste, mln tons	%	Sludges, mln tons	%	Reprocessing waste, mln tons	%	Equipment, mln tons	%
<b>Total EU, million tons</b>	<b>2454,72</b>	<b>100,00</b>	<b>1796,60</b>	<b>73,19</b>	<b>54,15</b>	<b>2,21</b>	<b>95,28</b>	<b>3,88</b>	<b>20,71</b>	<b>0,84</b>	<b>246,13</b>	<b>10,03</b>	<b>17,83</b>	<b>0,73</b>
Germany	400,07	16,30	261,39	65,33	8,92	2,23	15,62	3,91	1,49	0,37	39,38	9,84	2,43	0,61
France	323,47	13,18	261,76	80,92	4,96	1,53	11,81	3,65	1,21	0,37	34,90	10,79	2,44	0,75
England	277,26	11,29	141,64	51,09	4,80	1,73	10,29	3,71	4,17	1,50	43,11	15,55	3,80	1,37
Poland	182,01	7,41	122,71	67,42	2,99	1,64	3,19	1,75	0,66	0,36	13,56	7,45	0,70	0,39
Romania	177,56	7,23	163,36	92,00	0,95	0,54	0,86	0,49	0,20	0,11	5,82	3,28	0,13	0,08
Italy	164,00	6,68	65,46	39,91	14,29	8,71	7,85	4,79	6,08	3,70	28,10	17,14	3,03	1,85
Sweden	141,62	5,77	101,83	71,90	1,29	0,91	2,38	1,68	0,40	0,28	6,31	4,45	0,85	0,60
Netherlands	141,02	5,75	104,04	73,77	2,40	1,70	15,20	10,78	0,66	0,47	8,39	5,95	0,54	0,39
Spain	128,96	5,25	67,03	51,98	2,66	2,06	9,14	7,08	1,46	1,13	12,56	9,74	1,21	0,93
Amount	1935,97	78,87	1289,21		43,26		76,35		16,32		192,14		15,13	
Other countries	518,75	21,13	507,39	26,81	10,89	97,79	18,93	96,12	4,39	99,16	53,99	89,97	2,70	99,27
<b>Ukraine</b>	<b>295,87</b>		<b>226,20</b>	<b>76,4</b>	<b>1,44</b>	<b>0,49</b>	<b>13,89</b>	<b>4,69</b>	<b>3,90</b>	<b>1,32</b>	<b>...</b>		<b>...</b>	



**Fig. 7** Regional distribution of waste in Ukraine, 2016

**Рис. 7.** Регіональний розподіл відходів в Україні, 2016 рік

According to the Ministry of Energy and Environmental Protection data, 35 billion tons of waste have been accumulated in the country. 14 of the largest waste generators are located in Dnipropetrovsk region, 9 - in Donetsk, 3 - in Poltava, 2 in Kirovohrad and Zaporizhia, and 1 in Ivano-Frankivsk, Mykolaiv, Ternopil and Lviv regions. 6 out of 35 largest waste generators in 2018 are Kryvbas mining and processing enterprises which exploit iron ore deposits (Table 4) [6].

The enterprises listed in the table, except for PJSC “Ilyich Iron and Steel Works”, are the mining and processing plants that predominantly accumulate overburden, iron and manganese ore enrichment waste. Mineralogy and chemical composition of some mineral resources have been studied and described in detail. Enrichment technologies have been developed under laboratory conditions. Therefore, the problem of complex use of the deposits in order to reduce technogenic impact is predominantly the economic and political one. Extraction of iron ore concentrate from the enrichment waste at the Central mining and processing complex (Kryvyi Rih) has shown that its cost is 40% lower than the concentrate extracted from the quarried ore; its quality is only slightly lower.

We believe that it is possible to reduce the technogenic impact on the environment in the areas of intensive use of mineral resources by integrated use of mineral deposits. It depends on the legislation and the willingness of business to invest in diversification of production.

**Table 4.** Largest waste generators and polluters of the environment

**Табл 4.** Найбільші генератори відходів та забруднювачі навколишнього середовища

№	Company name	Generated waste, mln. tons, 2018
1.	Northern Mining and Processing Plant	81.34
2.	Inhulets Mining and Processing Plant	63.48
3.	Central Mining and Processing Plant	61.56
4.	ArcelorMittalKryvyiRih	27.65
5.	Southern Mining and Processing Plant	26.92
6.	Yerystivskyi Mining and Processing Plant“	14.95
7.	Novotroitske Ore Mining Company	6.74
8.	Ilyich Iron and Steel Works	6.23
9.	“Ukrmechanobr” Ore Mining and Processing Integrated Plant	3.86
10.	Pokrovskyi Mining and Processing Plant	3.26
11.	Total	<b>295.99</b>



## Conclusions

According to the State Statistics Service more than 12 billion tons of waste have been accumulated in Ukraine by 2016. It includes 12 million tons of household waste and 0.6 million tons of hazardous waste. The annual generation of waste is over 200 million tons including more than 11 million tons of household waste and 0.6 million tons of hazardous waste.

2.5 billion tons of waste are generated annually in the EU countries. Over 70% of it is produced in 10 countries: Germany, France, England, Poland, Romania, Italy, Sweden, Netherlands, Spain, and Finland.

In Ukraine, the annual generation of waste from economic activity and households is less than in Germany and is at the same level as in France and the United Kingdom. In other EU countries these values are smaller.

The largest volumes of waste in Ukraine are generated from the extraction of minerals – 237.5 million tons (84.48%) and the manufacturing industry (metallurgical and chemical enterprises and food industry) – 34.1 million tons (12.13%). Households produce only about 6 million tons (2.08%).

In EU countries such as Germany and the United Kingdom, the construction and demolition of buildings and the processing industry produce the largest volumes of waste.

By major classes of materials, the largest amount of waste both in Ukraine and in the EU countries is mineral waste [5], as well as waste rock derived from dredging. In Ukraine, it is mainly soil-forming materials and other sedimentary rock that occur at the top of the geologic cross-section, in Germany and France – construction and demolition waste.

In Ukraine, combustion waste (slag and TPP sludge) makes up over 6%, animal and plant waste – about 3%, industrial water sediments, household and similar waste,

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metallic waste, mixed and non-differentiated materials and other wastes make less than 2%.

In the EU, a considerable percentage of waste is generated from waste recycling – from 5.95% in Netherlands to 15.55% in the United Kingdom. In Ukraine, this category of waste amounts to 0.07%. The category

“Equipment”, in contrast to the EU countries, is not registered in our statistics.

In accordance with the volume of accumulated waste, the regions were divided into 3 groups. The first includes areas accommodating hundreds of millions of tons of waste, the second – tens of millions of tons, the third – less than 10 million tons.

Having well-developed industry Dnipropetrovsk region accumulated the largest volumes of waste. This region accommodates huge plants that extract and enrich iron, manganese, titanium-zirconium ores and coal as well as metallurgical and ferroalloy plants.

The volume of waste accumulated in Dnipropetrovsk region is 14 times larger and in Donetsk region almost 1.5 times larger than the national average in

Ukraine. In all other regions the figures are below the national average.

The impact of industrial waste on the environment can be reduced by application of innovative technologies in ore extraction and enrichment, and in metallurgical industry. It will increase the degree of extraction of useful components from the mineral resources, improve the monitoring of waste disposal sites, i.e. the chemical and mineralogical composition of the waste, and its physical properties for their further industrial use.

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## ПОРІВНЯЛЬНИЙ АНАЛІЗ УТВОРЕННЯ І НАКОПИЧЕННЯ ВІДХОДІВ В УКРАЇНІ ТА КРАЇНАХ ЄС

Губіна В.Г., канд. геол.-мін. н., ст. н. с., пр. наук. сп., ДУ «Інститут геохімії навколишнього середовища НАН України», gvg131619@gmail.com

Заборовський В.С., н.с., ДУ «Інститут геохімії навколишнього середовища НАН України»

Мицюк Н.Б., м.н.с., ДУ «Інститут геохімії навколишнього середовища НАН України», porov\_67@voliacable.com

Губін Г.Г., к.т.н, доцент, Криворізький національний університет

*У статті проаналізовано об'єм утворення та накопичення відходів в Україні та європейських країнах на підставі аналізу статистичних даних щодо утворення відходів в країнах ЄС (ЄС-28) і Україні. Наведено обсяги щорічного утворення та накопичення відходів за різною класифікацією, в т. ч. за класами небезпеки, видами економічної діяльності, матеріалами, з яких вони складаються. Показано, що в Україні до 2013 р. щорічно утворювалось понад 400 млн. т відходів, у тому числі понад 1 млн. т небезпечних відходів та понад 12 млн. т побутових. Останніми роками, після окупації частини Донбасу і Криму, утворюється близько 300 млн. т, у т. ч. понад 0,5 млн. т – небезпечних та 12 млн. т – побутових. В країнах ЄС понад 70% відходів утворюється в 10 країнах: Німеччині, Франції, Англії, Польщі, Румунії, Італії, Швеції, Нідерландах, Іспанії та Фінляндії. В Україні за видами економічної діяльності найбільші обсяги відходів утворюються при видобуванні мінеральної сировини та в переробній промисловості, найменші – в процесі очищення води та при будівництві та знесенні будівель. В країнах ЄС-28 ці показники мають децю інший характер. Наприклад, у Німеччині найбільше відходів утворюється при знесенні будівель і в переробних галузях економіки, найменше – в сільськогосподарському, лісовому та рибному господарствах. За категоріями матеріалів, з яких вони складаються, в країнах ЄС і в Україні найбільше утворюється і накопичується мінеральних і затверділих відходів. В Україні найбільші обсяги відходів утворюються і накопичуються у Дніпропетровській, Донецькій, Запорізькій областях, де розташовані підприємства з видобування та збагачення залізних та марганцевих руд, титано-цирконієвих розсипів, вугілля, доломіту, металургійного ванняку, а також металургійні комбінати і феросплавні заводи, у виробничих циклах яких утворюються шлаки, шлами та промаслена окалина. Залежно від кількості відходів регіони України класифіковано на три групи. До першої віднесено регіони з обсягами накопичених відходів – мільярди-сотні мільйонів т накопичених відходів, до другої – десятки мільйонів тонн, до третьої – менше 10 млн. т.*

**Ключові слова:** відходи, види економічної діяльності, джерела утворення відходів, накопичення відходів, «хвости», шлаки, шлами

## СРАВНИТЕЛЬНЫЙ АНАЛИЗ ОБРАЗОВАНИЯ И НАКОПЛЕНИЯ ОТХОДОВ В УКРАИНЕ И СТРАНАХ ЕС

Губина В.Г., канд. геол.-мин. н., ст. н. с., вед. н. с., ГУ «Институт геохимии окружающей среды НАН Украины», gvg131619@gmail.com

Заборовский В.С., н.с., ГУ «Институт геохимии окружающей среды НАН Украины»

Мицюк Н.Б., м. н. с., ГУ " Институт геохимии окружающей среды НАН Украины»

Губин Г.Г., к.т.н, доцент, Криворожский национальный университет

*В статье проанализированы объемы образования и накопления отходов в Украине и европейских странах на основании анализа статистических данных по образованию отходов в Украине и странах ЕС (ЕС-28). Приведены объемы ежегодного образования и накопления отходов по разным классификациям: по классам опасности, видам экономической деятельности, материалам, из которых они состоят. Показано, что в Украине до 2013 г. ежегодно образовывалось свыше 400 млн. т отходов, в том числе более 1 млн. т опасных отходов и более 12 млн. т ТБО. В последние годы, после оккупации части Донбасса и Крыма, образовывается около 300 млн. т, в т. ч. более 0,5 млн. т – опасных и 12 млн. т – бытовых. В ЕС более 70% отходов приходится на 10 стран (Германия, Франция, Англия, Польша, Румыния, Италия, Швеция, Нидерланды, Испания и Финляндия). В Украине по видам экономической деятельности наибольшие объемы отходов образуются при добыче минерального сырья и в перерабатывающей промышленности, наименьшие – в процессе очистки воды и при строительстве и носе зданий и сооружений. В странах ЕС-28 эти показатели имеют несколько иной характер. Например, в Германии больше всего отходов образуется в строительной отрасли и в перерабатывающих отраслях экономики, меньше всего – в сельскохозяйственной, лесной и рыбной отраслях. По категориям материалов, из которых они состоят, в странах ЕС и в Украине наибольшие объемы отходов – это минеральные и твердые отходы. В Украине наибольшие объемы отходов образуются и накапливаются в Днепропетровской, Донецкой, Запорожской областях, где расположены предприятия по добыче и обогащению железных и марганцевых руд, титано-циркониевых россыпей, угля, доломита, металлургического известняка, а также металлургические комбинаты и ферросплавные заводы, в производственных циклах которых в отходы попадают шлаки, шламы и промасленная окалина. В зависимости от количества отходов регионы Украины классифицированы на три группы. К первой отнесены регионы с объемами накопленных отходов – миллиарды - сотни миллионов тон, ко второй – десятки миллионов тонн, к третьей – менее 10 млн. т.*

**Ключевые слова.** отходы, виды экономической деятельности, источники образования отходов, накопление отходов, хвосты, шлаки, шламы.