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ASSESSMENT OF THE IMPACT OF THE PAPER ENTERPRISE ON THE ENVIRONMENT

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Abstract. Pulp and paper enterprises are of great importance for sustainable economic and environmental development of certain regions and the economy of Ukraine. Man uses many natural resources during the lifetime, creating a burden on nature. As the world's population increases, this load increases, leading to a shortage of resources and deterioration in the environment. The main activity of Kokhavynska Paper Mill PJSC is the production of sanitary products for the domestic market and export. Rational use of secondary raw materials helps to cut the use of forest resources and reduce the amount of waste paper utilized in landfills.

15291.76 t of pollutants from the sources of the enterprise emissions enter the air each year. A total of 9 standardized and 3 non-standardized substances (greenhouse gases) are released into the atmosphere, namely nitrogen oxides, carbon monoxide, nitrogen (1) oxide (N_2O) (greenhouse gas), carbon dioxide (greenhouse gas), methane (greenhouse gas), iron and its compounds, manganese and its compounds, hexavalent chromium (expressed in terms of chromium trioxide), gaseous fluorides, hydrogen sulfide, saturated hydrocarbons C12-C19. There is no excess of the established maximum concentration limits at all emission sources at this enterprise.

To assess the impact of the enterprise on soils, the content of heavy metals Zn, Cr (VI), Co, Cu, Pb, Mn, and Fe at the border of the sanitary protection zone of the enterprise was determined and the maximum multi plicity of the excess of MPC of heavy metals was calculated. The content of heavy metals in the selected soil samples was determined using a spectrophotometer atomic absorption C-115-M1. Evaluation of soils for heavy metals showed that the soils at the border of the sanitary protection zone of the enterprise are contaminated with heavy metals. The maximum multiplicity of the excess of the MPC of heavy metals in the soil is 1.04 times for lead; 0.43 times for zinc; 0.37 times for chromium; 0.93 times for copper; 1.85 times for manganese; 0.35 times for cobalt. Maximum concentrations of heavy metals exceed their background content: 1.6 times for lead; 1.8 times for zinc; 1.16 times for chromium; 0.77 times for copper; 3.9 times for manganese; 9.7 times for iron; 1.2 times for cobalt.

Key words: environment, pulp and paper industry, pollution, atmospheric air, sanitary protection zone, heavy metals.

1. Introduction

The products of this economic activity are widely used in everyday life, as well as in such basic sectors of the national economy as the food and processing industries, trade, construction, printing, and others [1].

Previously, only low-grade products such as packaging and toilet paper were made from paper waste. The introduction of modern western technologies in domestic production has significantly expanded the scope of raw materials obtained from waste paper. Today, waste paper processing as a business is a very profitable field of activity [2, 3]. Now, recycled waste paper is used to produce the following products: personal care products, office and technical paper, different types of cardboard, printing products, craft packages, egg packing, disposable tableware, construction and insulation materials.

The range of pollutants, as well as the range of substances used for the production of pulp, paper, and cardboard, is extremely wide. It is determined by the complexity of the technological cycle and the chosen technology. Components of emissions from the pulp and paper industry are oxides of sulfur, hydrogen sulfide, chlorine (the latter is used as a bleach), numerous organic substances–wood components and intermediates, or products of numerous chemical reactions, organic solvents [4, 5, 6].

The constant inflow of heavy metals into the soil causes the formation of zones of high environmental toxicity. The main sources of heavy metals on the earth's surface are emissions of dust and gases from the mining,

metallurgical and chemical industries [7, 8, 9]. The level of soil pollution and spatial distribution of heavy metals depends on the capacity of polluting enterprises, the quality of processed raw materials, production technology, the efficiency of treatment plants. Soil pollution is mainly local. Such areas cannot be used for agriculture without their prior rehabilitation.

The study of issues related to the assessment of the impact of enterprises on the environment is of great relevance. This makes it possible to develop and improve technologies aimed at reducing the level of anthropogenic pressure on the environment, minimizing environmental hazards.

Kokhavynska Paper Mill PJSC is located on one industrial site in the western part of the urban-type settlement of Gnizdychiv, Zhydachiv district. The main activity of Kokhavynska Paper Mill PJSC is the production of sanitary products for the domestic market and export – toilet paper and paper towels [10]. The products are made of paper pulp prepared at the factory.

15291.76 t of pollutants from the sources of the enterprise emissions enter the air each year. A total of 9 standardized and 3 non-standardized substances (greenhouse gases) are released into the atmosphere, namely nitrogen oxides, carbon monoxide, nitrogen (1) oxide (N_2O) (greenhouse gas), carbon dioxide (greenhouse gas), methane (greenhouse gas), iron and its compounds, manganese and its compounds, hexavalent chromium (expressed in terms of chromium trioxide), gaseous fluorides, hydrogen sulfide, saturated hydrocarbons C12-C19.

The purpose of the work is to assess the impact of Kokhavynska Paper Mill PJSC on the environment.

2. Experimental part

The sanitary protection zone (SPZ) of the enterprise makes up 50 m. The nearest residential building is located at a distance of 150 m from the emission sources in the south-eastern direction. There are no objects of the nature reserve fund in the zone of influence of the enterprise, no populations or individual representatives of endangered species of fauna and flora listed in the Red Book of Ukraine.

The design capacity for the production of toilet paper and paper towels accounts for 18800 tons/year, the actual capacity is 18800 tons/year.

Waste paper is brought to the waste paper distribution site by forklifts, where it is ground and dissolved in hydraulic breakers. The dissolved waste paper is pumped through the mass cleaner into the twin pool. From the twin pool, the mass flows through sorters, where it is cleared of heavy and some other impurities, and then the pump moves it to the machine pool. From the machine pool, the finished paper mass enters the paper shop on paper machines, where the paper web is formed by the mechanical removal of moisture, compacted and dried in the drying section at a temperature of 105–110 °C. After drying, the paper is cut into the appropriate format and wound on the reel winding sleeves. During the operation of paper machines, dust–suspended solids are released into the atmosphere. Next, the rolls are fed for weighing, packaging, and marking, after which they are transported by electric cars to the warehouse of finished products or the shop of consumer goods for the production of consumer rolls or paper towels.

Carbon monoxide, hydrogen sulfide, and methane are released into the atmosphere at the water purification site from the filter press and floater.

In the consumer goods shop, rolls of paper are processed into consumer rolls of appropriate sizes, packed in a heat-shrinkable film, transport bags made of polyethylene film or boxes made of corrugated cardboard, and sent to the warehouse of finished products. In the shop, there are four rewinding machines, cutting machines, two packing machines, which are equipped with an aspiration system of air purification of the working area. Emissions of harmful substances do not enter the atmosphere.

In chilly periods, a boiler room is used to supply the required amount of steam and heat. It is equipped with two steam boilers. Natural gas is used as fuel. The boiler room has also a solid fuel boiler on biofuel. To reduce particulate emissions, the boiler is equipped with a multi-cyclone and a bag filter. When wood is burnt, nitrogen oxides (expressed in terms of nitrogen dioxide [$NO + NO_2$]), carbon monoxide, suspended solids, and greenhouse gases (methane, carbon dioxide, nitrogen (1) oxide (N_2O)) are released into the atmosphere.

The repair-mechanical section is designed to perform work related to the repair of process equipment. In a mechanical workshop, a welding station is the source of harmful substances. During the welding process, iron oxide, manganese dioxide, hexavalent chromium, and gaseous fluorides are released in the air. Likewise, the process of sharpening tools and metal billets causes the emission of suspended substances into the atmosphere. The source is equipped with a dust extraction chamber.

A gas station is used on the territory of the enterprise to provide its own motor transport with diesel fuel. During storage and filling of the diesel fuel, pollutants–saturated hydrocarbons C12-C19 are emitted into the atmosphere.

The premises of the administrative building are equipped with a water heating boiler, which runs on

solid fuel – wood. The boiler is located in a separate room–a boiler room. During the combustion of wood, nitrogen oxides (expressed in terms of nitrogen dioxide [NO + NO_2]), carbon monoxide, suspended solids, and greenhouse gases (methane, carbon dioxide, and nitrogen (1) oxide (N2O)) are released into the air.

To assess the impact of the enterprise on soils, the content of heavy metals Zn, Cr (VI), Co, Cu, Pb, Mn, and Fe at the border of the sanitary protection zone of the enterprise was determined and the maximum multi-plicity of the excess of the MPC of heavy metals was calculated. According to the degree of the negative impact of heavy metals–soil contaminants, they are divided into three classes: highly dangerous (arsenic, cadmium, mercury, selenium, lead, zinc, fluorine); dangerous (boron, cobalt, nickel, molybdenum, antimony, chromium); low-risk (barium, vanadium, manganese, strontium) [7].

Soil sampling was carried out following the requirements of GOST 17.4.3.-83, GOST 17.4.4.02-84 [11, 12]. The content of heavy metals in the selected soil samples was determined using a spectrophotometer atomic absorption C-115-M1.

3. Results and Discussions

Characteristics of gas purification plants, their technical condition, and average efficiency, parameters of gas-dust flow are given in Table 1. The efficiency of gas purification equipment in the plant shops is as follows: multi-cyclone–85 %; bag filter–98 %; dust collection chamber–82.6 % (Table 1).

Information on the state of air pollution by this enterprise is given in Table 2. The analysis of the data in Table 2 shows that there is no excess of the established maximum concentration limits for all emission sources at this enterprise [13].

Calculations of pollutant dispersion in the surface layer of atmospheric air, taking into account background pollution, showed that the maximum surface concentrations generated by emissions from the sources of Kokhavynska Paper Mill PJSC do not exceed the maximum concentration of pollutants in the air of settlements. The MPC of nitrogen oxides (expressed in terms of nitrogen dioxide [NO + NO_2]) in the northern direction at a distance of 75 m from emission sources equals 0.69; the MPC of carbon monoxide in the north-western direction at a distance of 75 m from the emission source is 0.41; the MPC of substances in the form of suspended solids in the western direction at a distance of 55 m from emission sources is 0.43; the number for hydrogen sulfide in the western direction at a distance of 110 m from emission sources makes up 0.49.

Excess of maximum onetime MPC was not found for any of the ingredients, so the company does not create the air pollution zone, and therefore there is no threat to human life.

The most common and dangerous pollutants, the emissions of which into the air are subject to regulation, the list of pollutants and threshold values of potential emissions, which are subject to a public record, the list of other pollutants and their volumes emitted into the air by stationary sources of Kokhavynska Paper Mill PJSC are presented in Table 3.

Table 1

Characteristics of the gas purification equipment

No.	Name of the gas treatment plant	Pollutants, name	Consumption of gas and dust flow at the entrance to the gas treatment plant, m^3/s	The maximum mass concentration at the entrance to the gas treatment plant, mg/m^3	The efficiency of the gas treatment plant, %	Consumption of gas and dust flow at the outlet of the gas treatment plant, m^3/s	Maximum mass concentration at the outlet of the gas treatment plant, mg/m^3
1	2	3	4	5	6	7	8
1.	Multicyclone	Substances in the form of suspended solids, undifferentiated in composition	2.616	6666.7	85	2.616	1000.0
2.	Hose filter	-«-	2.616	1000	98	2.616	20.0
3.	Dusting chamber	-«-	0.063	81.84	82.5	0.063	14.24

Table 2

Background concentrations of pollutants in the atmosphere

No.	Pollutants, name	Hygienic standards		Background concentration, mg/m^3
		MPC, mg/m^3	Approximate safe levels of action, mg/m^3	
1	2	3	4	5
1.	Nitrogen oxides (in terms of nitrogen dioxide [NO + NO_2])	0.2	–	0.08
2.	Carbon monoxide	5.0	–	2.0
3.	Methane	–	50.0	20.0
4.	Iron and its compounds (in terms of iron)	0.04	–	0.016
5.	Manganese and its compounds (in terms of manganese dioxide)	0.01	–	0.004
6.	Chromium and its compounds (in terms of chromium trioxide)	0.0015	–	0.0008
7.	Fluorine gaseous compounds	0.02	–	0.008
8.	Substances in the form of suspended solids particles	0.5	–	0.2
9.	Hydrogen sulfide	0.008	–	0.0032
10.	Hydrocarbons saturated C_{12}-C_{19}	1	–	0.48
11.	Nitrogen (1) oxide (N_2O)	–	–	–
12.	Carbon dioxide	–	–	–

Table 3

List of species and pollutants emitted into the atmosphere by stationary sources

No.	Pollutants, name	Actual emissions, t/year	Potential emissions, t/year	Threshold values of potential emissions, t/year
1	2	3	4	5
	Total for the company*	43.85101	43.85101	
1.	Carbon monoxide	23.57121	23.57121	1.5
2.	Carbon dioxide	15247.909	15247.909	500
3.	Methane	0.6923	0.6923	10
	Metals and their compounds, including:	0.0082	0.0082	
4.	Iron oxide (in terms of iron)	0.007	0.007	0.1
5.	Chromium and its compounds (in terms of chromium trioxide)	0.0006	0.0006	0.02
6.	Manganese and its compounds (in terms of manganese dioxide)	0.0006	0.0006	0.005
	Substances in the form of suspended solids particles, including:	0.7462	0.7462	3
7.	Substances in the form of suspended solids particles undifferentiated by composition	0.7462	0.7462	3
	Nitrogen compounds, including: :	18.812	18.812	
8.	Nitrogen oxides (oxide and nitrogen dioxide) in terms of nitrogen dioxide	18.331	18.331	1
9.	Nitrogen (1) oxide (N_2O)	0.481	0.481	0.1
	Dioxide and other sulfur compounds, including:	0.0144	0.0144	2
10.	Hydrogen sulfide	0.0144	0.0144	0.3
	Non-methane volatile organic compounds, including:	0.0062	0.0062	1.5
11.	Saturated hydrocarbons C_{12}-C_{19}	0.0062	0.0062	1.5
	Fluorine and its compounds (in terms of fluorine), including:	0.0005	0.0005	0.05
12.	Fluorine and its vapor and gaseous compounds in terms of hydrogen fluoride	0.0005	0.0005	0.05
Total		15291.76001	15291.76001	

* Carbon dioxide in the final line total for the company is not included.

Characteristics of emission parameters over the year in the actual operating conditions of the enterprise. 13 stationary organized sources and 2 unorganized stationary sources of air pollution were investigated at the site of the enterprise. A total of 9 standardized and 3 non-standardized substances (greenhouse gases) are emitted into the atmosphere. The company has no sources of emissions that divert pollutants from several sources of generation. There are no volley emissions on the industrial site of the enterprise. There are unorganized sources of emissions into the atmosphere from the section of mechanical metal-working and sharpening machines.

Table 3 shows that the actual emissions of pollutants such as nitrogen oxides (expressed in terms of nitrogen dioxide [NO + NO_2]), carbon monoxide, nitrogen (1) oxide (N_2O) exceed the emission thresholds, therefore it is necessary to keep a public record of the site.

For the general characteristic of the condition of soils and their potential danger, gross maintenance of heavy metals in soil and the maintenance of mobile forms that specifies the level of their toxicity are used. The maximum concentration limit of heavy metals in the soil is obtained from [14].

Evaluation of soils for heavy metals showed that the soils at the border of the sanitary protection zone of the enterprise are contaminated with heavy metals (Table 4).

The maximum multiplicity of the excess of the maximum concentration limit of heavy metals in the soil at the boundary of the sanitary protection zone of the enterprise is 1.04 times for lead; 0.43 times for zinc; 0.37 times for chromium; 0.93 times for copper; 1.85 times for manganese; 0.35 times for cobalt. Maximum concentrations of heavy metals exceed their background content (1.6 times for lead; 1.8 times for zinc; 1.16 times for chromium; 0.77 times for copper; 3.9 times for manganese; 9.7 times for iron; 1.2 times for cobalt). The MPC for the gross iron content and its mobile forms in the soil is not regulated.

Table 4

The main parameters of the content of heavy metals in the soil at the border of the sanitary protection zone of the enterprise

The name of the chemical element	Background content, mobile forms, mg/kg	MPC, mobile forms, mg/kg	Actual gross content, mobile forms, mg/kg	The maximum multiplicity of exceeding the MPC
1	2	3	4	5
Pb	3.91	6.0	3.52* – 6.21**	1.04
Zn	5.54	23.0	6.75* – 9.91**	0.43
Cr	1.91	6.0	1.56* – 2.21**	0.37
Cu	3.65	3.0	2.23* – 2.80**	0.93
Mn	47.62	100	154.90* –185.32**	1.85
Fe	20.76	–	180.48* –201.40**	–
Co	1.48	5.0	1.53* – 1.74**	0.35

*; ** Minimum and maximum content of the element.

Conclusions

1. Kokhavynska Paper Mill PJSC manufactures sanitary products for the domestic market and export.

2. There is no excess of the established maximum concentration limits at all emission sources at this enterprise. Excess of maximum onetime MPC was not found for any of the ingredients, so the company does not create the air pollution zone, and therefore there is no threat to human life.

3. During the year, 9 standardized substances and 3 non-standardized substances (greenhouse gases) are emitted into the atmosphere by the sources of Kokhavynska Paper Mill PJSC, namely nitrogen oxides (18,331 t/year), carbon monoxide (23.57 t/year), nitrogen (1) oxide (N_2O) (greenhouse gas) (0.481 t/year), carbon dioxide (greenhouse gas) (15247.909 t/year), methane (greenhouse gas) (0.692 t/year), iron and its compounds (0.0007 t/year), manganese and its compounds (0.0006 t/year), hexavalent chromium (expressed in terms of chromium trioxide) (0.0006 t/year), gaseous fluorides (0.0005 t/year), hydrogen sulfide (0.0144 t/year), saturated hydrocarbons C12-C19 (0.0062 t/year).

4. Evaluation of soils for the content of heavy metals Zn, Cr (VI), Cu, Pb, Mn, Fe, and Co showed that the soils at the border of the sanitary protection zone of the enterprise are contaminated with heavy metals. The maximum multiplicity of the excess of the maximum concentration limit of heavy metals in the soil at the boundary of the sanitary protection zone of the

enterprise is 1.04 times for lead; 0.43 times for zinc; 0.37 times for chromium; 0.93 times for copper; 1.85 times for manganese; 0.35 times for cobalt. Maximum concentrations of heavy metals exceed their background content (1.6 times for lead; 1.8 times for zinc; 1.16 times for chromium; 0.77 times for copper; 3.9 times for manganese; 9.7 times for iron; 1.2 times for cobalt).

References

[1] http://www.ukrpapir.org/news.php

[2] Putinceva S. V.: Visnyk KhNTU, 2016, 1, 126. (in Ukrainian)

[3] Kolotylo P. V., Kharchuk O. H: Vcheni zapysky TNU imeni V. I. Vernads′koho. Seriya: Ekonomika i upravlinnya, 2020, 31, 29. (in Ukrainian) https://doi.org/10.32838/2523-4803/70-1-5

[4] Bilyavskiy H. O., Butchenko L. I., Navrotskiy V. M.: Osnovy ekolohiyi: teoriya i praktikum. Libra, Kyiv, 2002. (in Ukrainian)

[5] Zapolskiy A. K., Salyuk A. I.: Osnovy ekolohiyi. Vyshcha shk., Kyiv, 2001. (in Ukrainian).

[6] Barbash V. A, Mykytyuk T. S., Meskiv R. V., Trembus I. V: Vostochno-Yevropeyskiy zhurnal peredovykh tekhnolohiy, 2013, 6, 52. (in Ukrainian)

[7] Smagliy O. F., Kardashov A. T., Lytvak P. V.: Ahroekolohiya. Vyshcha osvita, Kyiv, 2006. (in Ukrainian).

[8] Bobylov Yu. P., Bryhadyrenko V. V.: Ekolohiya. “Folio”, Kharkiv, 2014. (in Ukrainian)

[9] Kurayeva I. V., Roha I. V., Sorokina L. Yu., Holubtsov A. H.: Ukrayins′kyy heohrafichnyy zhurnal, 2012,3, 25. (in Ukrainian)

[10] http://www.http://kpf.ua

[11] GOST 17.4.3.01–83. (in Ukrainian)

[12] GOST 17.4.4.02–84. (in Ukrainian)

[13] Order of the Ministry of Health of Ukraine dated 14.01.2020, No. 52. (in Ukrainian)

[14] Order of the Ministry of Health of Ukraine dated 14.07.2020, No. 1595. (in Ukrainian)