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EVALUATION OF THE EFFECT OF INDUSTRIAL ENTERPRISES ON THE ENVIRONMENT AND EFFICIENCY EVALUATION OF ENVIRONMENTAL PROTECTION ON THE EXAMPLE OF «TOCHPRIBOR» LLC (KHARKIV, UKRAINE)

Питання впливу забруднення довкілля на живі організми і організм людини зокрема багато в чому ще залишаються відкритими і вимагають подальшого вивчення. Тому об'єктом дослідження є вплив промислового підприємства на довкілля. У роботі проведена оцінка впливу промислового підприємства на довкілля та ефективності природоохоронних заходів на прикладі ТОВ «Точприбор» (м. Харків, Україна). Проведена оцінка дасть можливість розрахувати отриманий економічний ефект від цих заходів на підприємстві, що досліджується. Після аналізу даних щодо викидів, наданих ТОВ «Точприлад», визначено, що максимальні приземні концентрації забруднюючих речовин, що викидаються в атмосферу джерелами підприємства, малі порівняно з гранично-допустимими концентраціями (ГДК). Тому заходи щодо зниження викидів до нормативного рівня не передбачаються. Екстремальний вплив шляхом підвищеного забруднення міського стоку можливий при порушенні роботи очисних споруд, тому необхідно здійснювати періодичний контроль за вступом стічних вод на очищення і роботою споруджень очищення. В даний час рівень забруднення ґрунтів і рослин важкими металами, що містяться в техногенних викидах ТОВ «Точприлад», в цілому не перевищує гранично-допустимих значень. Враховуючи несільськогосподарський характер використання земель санітарно-захисної зони заводу повторне обстеження ґрунтів на забруднення, згідно з експертною оцінкою при існуючій технології виробництва, рекомендується проводити не раніше, ніж через 15–20 років. З метою зменшення техногенного впливу викидів на довкілля необхідно удосконалювати технологію виробництва і систему газопилових викидів ТОВ «Точприлад». При дослідженні ТОВ «Точприлад» було виявлено, що в стічних водах спостерігається перевищення по толуолу, хлоридам і залізу. Тому пропонується додаткове очищення стічних вод. Економічний ефект від запропонованого додаткового очищення стічних вод становить 5398,32 дол./рік.

Ключові слова: *викиди промислових об'єктів в навколишнє середовище, вплив забруднення довкілля на живі організми.*

1. Introduction

Manifestations of the negative impact of pollution of the components of the biosphere – atmosphere, hydrosphere, lithosphere, phonosphere – are very diverse. Along with the damage to human health, environmental pollution leads to large economic losses due to:

– a sharp decrease in the productivity of natural and artificial biosystems;
– accelerated corrosion of equipment and materials;
– direct and indirect loss of production, etc. [1, 2].

Naturally, the main concern is caused by the destructive effect of biosphere pollution on human health, the nature of which can be very different. This is, above all, the toxic effect of many chemicals, leading to acute or chronic poisoning of the body. Many aggressive substances, as well as high-intensity radiation, can cause traumatic damage to organs (skin, vision, hearing, etc.). A number of substances contained in open-air production causes changes in the body's sensitivity to external influences – allergies. Finally, some substances and radiation are carcinogenic or mutagenic, that is, they can cause cancer or genetic pathology [3–5]. A significant amount of harmful substances from wastewater enterprises enters the reservoirs, thus reducing the supply of drinking water. The problem of the influence of environmental pollution on living organisms and the human body is still largely open, therefore relevant. It is also worth noting that, knowing the composition of emissions of hazardous substances, it is possible to obtain economic profit by trapping harmful substances, which can later be used as a marketable product.

Thus, *the object of research* is the impact of industrial enterprises on the environment. *The aim of research* is evaluation of the impact of industrial enterprises on the environment and the effectiveness of environmental measures on the example of «Tochprylad» LLC (Kharkiv, Ukraine). This evaluation will provide an opportunity to calculate the resulting economic effect of these activities in the investigated enterprise.

2. Methods of research

«Tochprylad» LLC produces electrode boilers and optical-mechanical devices for various purposes [6]. The main

source of atmospheric pollution of «Tochprylad» LLC are ventilation systems that remove polluted air from the process equipment of production sites, as well as from auxiliary departments and services. Also the sources of pollution are:

1. ATS charging station (automatic telephone station), where sodium alkaline vapors are released when charging alkaline batteries through a deflector.

2. Optical workshop, where parts are processed on centering machines ЦС-10 (Belarus), working with chilled mineral oil. A couple of mineral oil is emitted in the atmosphere when machines are working.

3. Waste treatment plant. The source of pollution is the sewage accumulator, from which vapors of sulfuric acid are released into the atmosphere.

4. Machine workshop equipped with sharpening machines, which are a source of air pollution with abrasive-metal dust.

5. Galvanic area, where the source of pollution is the electrochemical degreasing baths and the electroplating bath. Into the atmosphere: sodium hydroxide and hydrochloric acid.

6. Steam power area where sources of pollution are sharpening machines.

7. Welding posts where, when performing electric welding with electrodes AHO-4, manganese and iron oxide are emitted into the atmosphere.

8. Parking garage, where the source of air pollution is internal combustion engines, during heating of which air is emitted into the atmosphere: carbon oxide, saturated hydrocarbons, nitrogen dioxide, soot, sulfur dioxide, lead, benzo(a)pyrene.

9. A painting area where, during the production of works (painting equipment, pipelines), the following is released into the atmosphere: butyl acetate, ethyl cellulose, acetone, butyl alcohol, toluene.

10. Energy-mechanical area, where the source of pollution with abrasive-metal dust is grinding machines.

According to the degree of danger substances are divided into 4 classes. With pollutants emitted by the enterprise into the atmosphere, the first class of hazard includes lead and benzo(a)pyrene. It should also be noted that in the perspective of the development of the enterprise, an increase in production capacity is not expected.

«Tochprylad» LLC refers to the IV hazard category. Emergency and salvo emissions at the enterprise are absent. There are no landfills and landfills for industrial solid waste at «Tochprylad» LLC.

The company does not have its own landfill. Removal of non-recyclable industrial waste is carried out in accordance with the permit of the city sanitary-epidemiological station.

Based on Appendix 4 to the State Sanitary Rules for the Planning and Development of Settlements, [7] a standard sanitary protection zone (SPZ) of 100 m is established for the industrial site of «Tochprylad» LLC.

The calculation of air pollution from plant sources of plant sources showed that the existing situation does not exceed the norms of maximum permissible concentrations (MPC) in residential buildings and at the SPZ border for all ingredients to be calculated [8].

Since residential development is within the boundaries of the standard SPZ, and the maximum surface concentrations of pollutants do not exceed 0.3 MPC near the residential development, it is proposed to adopt the SPZ boundary in the east and north-east direction along the boundary of the residential development. In the latter directions – within the regulatory SPZ.

Table 1 shows the data on the consumption of raw materials in the enterprise in the context of potentially hazardous substances.

Table 1

Consumption of raw materials and auxiliary materials in the whole enterprise

No.	Name of raw materials	Consumption amount for 2018	Units
1	Petrol	65	t
2	Diesel fuel	95	t
3	Motor oil	0.2	t
4	Electrodes: АНО-4 ЛКМ: НЦ-132 ЛФ-115	 0.105 0.09 0.905	t
5	Caustic soda	0.15	t
6	Hydrochloric acid	0.72	t
7	Sulfuric acid	0.07	t
8	Nitric acid	0.121	t
9	Polyethylene	1.5	t
10	Polypropylene	1.5	t
11	Polystyrene	1.5	t
12	Wood	15	m^3
13	Fluorescent lamps	250	items
14	Batteries	10	items
15	Toluene	148	kg
16	Enamel	50	kg
17	Solvent	30	kg
18	Rolled ferrous metals	100	kg
19	Rolled non-ferrous metals	129	kg
20	Tires for cars	20	items
21	Carbide	142	kg

Note: information based on materials of «Tochprylad» LLC [6]

Table 2 shows the characteristics of emissions of pollutants into the atmosphere in the whole enterprise.

Data on the concentration of pollutants in the waste water of «Tochprylad» LLC and temporarily permissible values of indicators (TPV) of the quality of wastewater when discharged into the municipal sewer network are presented in Table 3.

Therefore, in order to meet the quality of wastewater with the standards for discharge into the municipal sewage system of the city of Kharkiv (Ukraine) while reducing the following pollutants:

– chlorides up to 500 mg/l;
– iron up to 4 mg/l;
– toluene to 28 mg/l.

At «Tochprylad» LLC, retail waste is generated during the production process. Their number, chemical composition and disposal routes are presented in Table 4.

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Table 2

Characteristics of emissions of pollutants into the atmosphere in the whole enterprise

No.	Pollutants	Actual emission, tons/year		Caught at the treatment plant, t/year	Emitted into the atmosphere, t/year	Temporarily agreed emission (TAE), t/year	Maximum permissible emission (MPE), t/year
	Name	Code	–				
1	Metal dust	10414	0.00891	0	0.00891	0.00891	0.0089
2	Abrasive dust	10431	0.00716	0.00591	0.00125	0.00716	0.0071
3	Aerosol varnish	11510	0.0149	0.012263	0.0026	0.0149	0.0149
4	Manganese	143	0.00011	0	0.00011	0.000111	0.0001
5	Lead	184	0.00023	0	0.00023	0.000233	0.0002
6	Nitrogen dioxide	301	0.0653	0	0.0653	0.0653	0.0653
7	Nitrogen oxide	304	0.00083	0	0.0008	0.00083	0.0008
8	Hydrogen chloride	316	0.09300	0	0.093	0.093	0.093
9	Sulfuric acid	322	0.00013	0	0.00013	0.000135	0.0001
10	Soot	328	0.01021	0	0.01021	0.01021	0.0102
11	Sulfur dioxide	330	0.01424	0	0.01424	0.01424	0.0142
12	Carbon oxide	337	0.54782	0	0.54782	0.54782	0.5478
13	Xylene	616	0.2040	0	0.204	0.204000	0.204
14	Styrene	620	0.00045	0	0.00045	0.00045	0.0004
15	Toluene	621	0.03	0	0.03	0.03	0.03
16	Butyl alcohol	1042	0.011	0	0.011	0.011	0.011
17	Ethanol	1061	0.014	0	0.014	0.014	0.014
18	Butyl acetate	1210	0.0058	0	0.0058	0.0058	0.0058
19	Acetone	1401	0.0058	0	0.0058	0.005800	0.0058
20	Acetic acid	1555	0.0029	0	0.0029	0.0029	0.0029
21	Petrol	2704	0.00142	0	0.00142	0.00142	0.00142
22	Carbohydrate	2754	0.0816	0	0.0816	0.10044	0.1004
23	Iron oxide	123	0.00217	0	0.00217	0.00217	0.0021
24	Benz(a)pyren	703	0.347	0	0.347	0.347	0.347
25	Acrid meadow	150	0.00217	0	0.00217	0.00217	0.0021
27	Kerosene	2732	0.00018	0	0.00018	0.000189	0.00018
28	Mineral oil	2735	0.00058	0.0000464	0.000012	0.00058	0.00058
29	White Spirit	2752	0.20400	0	0.204	0.204	0.204
30	Wood dust	10293	0.0033000	0	0.0033000	0.0033000	0.0033
	Total		1.386046	0.01822	1.36783	1.40489	1.40489

Note: information based on materials of «Tochprylad» LLC [6]

Table 3

Concentration of pollutants of the enterprise wastewater

No.	Name of the pollutant	Units	Concentration value	TPV
1	pH	–	7.5	6.5–8.5
2	Suspended solids	mg/l	232	232
3	BOD_5	mg/l	180	180
4	Oil and petroleum products	mg/l	5	5
5	Sulfates	mg/l	235	235
6	Chlorides	mg/l	810	500
7	Synthetic surfactants	mg/l	0.2	0.2
8	Fats	mg/l	4	4
9	Iron	mg/l	6.0	4
10	Copper	mg/l	1.0	1
11	$Chrome^{3+}$	mg/l	0.15	0.15
12	$Chrome^{6+}$	mg/l	0.15	0.15
13	Essential oil soluble substances	mg/l	9.0	9
14	Zinc	mg/l	1.0	1
15	Ammonia nitrogen	mg/l	20	20
16	Nitrite	mg/l	6.5	6.5
17	Nitrates	mg/l	10.5	10.5
18	Nickel	mg/l	1.5	1.5
19	Phosphates	mg/l	3.5	3.5
20	Sulfides	mg/l	1.0	1.0
21	Toluene	mg/l	35	28

Note: information based on materials of «Tochprylad» LLC [6]

Table 4

Characteristics of waste generated in the enterprise

Waste name	Technological process where waste is generated	Amount of waste generated t/year, and ways to their disposal				
		Chemical composition, hazard class (HC)	Total	Including		
				Transferred to other organizations	Used in the enterprise	Taken to landfill
Mercury lamps, pcs.	Production workshops	1 HC (solid, non-combustible, does not dissolve in water, those are poisonous, mercury – 0.01, glass – 60, steel – 30 phosphor – 9.99 %)	200	150	–	–
Lead plates, t	Garage	1 HC (lead, solid, non-combustible)	0.3	–	0.3	–
Oil wastes, motor oils, t	Garage	2 HC (liquid, combustible, poorly soluble in water, carbohydrates – 90 %, suspended solids)	0.5	0.5	–	–
Electrolyte, t	Garage	2 HC (liquid, non-flammable, highly soluble in water, acid – 30 %, distilled water – 70 %)	0.034	0.034	–	–
Battery electrolyte (car battery acid battery), used solvents, tons	Glass washing	3 HC (liquid, non-combustible, soluble in water, toluene – 100 %)	0.2	–	0.2	–
Scrap Al, t	Metalworking	3 HC (solid, non-flammable, insoluble in water, Al – 90 %)	1.997	1.997	–	–
Waste emulsion, t	Metalworking	3 HC (pasty, combustible, poorly soluble in water, industrial oils – 10 %, water – 90 %)	–	–	0.02	–
Ferrous scrap, t	Mechanical metal working	3 HC (solid, non-flammable, insoluble in water, Fe – 87 %)	20.16	19.06	–	–
Filters oily, t	Garage	3 HC (solid, combustible, insoluble in water, cloth – 90 %, petroleum products – 10 %)	0.03	0.03	–	–
Sediment from sedimentation tank, t	Industrial waste treatment plant	4 HC (pasty, non-flammable)	0.32	0.32	–	–
Asbestos-containing waste, t	Garage	4 HC (solid, non-flammable, insoluble in water, Fe, asbestos)	0.12	0.12	–	–
Air filters, t	Garage	4 HC (solid combustible, insoluble in water, cloth – 95 %, petroleum products – 5 %)	0.01	0.01	–	–
Wood waste, sawdust, t	Manufacturing facility	4 HC (solid combustible, insoluble in water, cellulose – 100 %)	0.4	0.1	0.4	–
Carbide silt, t	Gas welding	4 HC (pasty, water-soluble, non-flammable, calcium hydroxide)	0.06	–	0.08	–
Dust of dust and gas cleaning plants	Production workshops	4 HC (solid, non-flammable, insoluble in water, SiO_2 – 70 %, slag – 30 %)	0.029	0.029	–	–
Trash areas	Territory	4 HC (solid combustible, sand – 10 %, paper – 20 %, organic – 70 %)	4.495	4.495	–	–
Used tires	Garage	4 HC (solid, non-flammable, insoluble in water, rubber – 80 %, textiles – 20 %)	0.113	–	–	0.113
Battery case	Garage	4 HC (solid, incombustible, insoluble in water, lead – 55 %, plastic – 45 %)	0.012	0.12	–	–

Note: information based on materials of «Tochprylad» LLC [6]

Thus, it is possible to conclude that the enterprise «Tochprylad» LLC produces 28.4 t/year of industrial waste and 200 pieces of fluorescent lamps, including:

– Class I – 0.3 t/year;
– Class II – 0.54 t/year;
– Class III – 22.47 t/year;
– Class IV – 5.16 t/year; 0.4 m^3/year – wood waste; 1.5 t/year – inert.

0.06 t/year of waste II class are neutralized at the enterprise. Wasted for recycling – 51.3 t/year.

3. Research results and discussion

To reduce dust emissions at «Tochprylad» LLC there are 6 gas cleaning plants. The gas cleaning unit at sources 2 and 3 is an aerosol filter that purifies air polluted with mineral oil vapors, the cleaning efficiency is 80 %. The spray booth of the source 6 is equipped with a gravel filter for cleaning from aerosol, paints and varnishes with an efficiency of 82.3 %. Source 7 grinding machines are equipped with non-standard cyclone type ЦН-11 (Russia), the cleaning efficiency of abrasive metal dust is 75.2 %. Emissions of dust from the abrasive-metal source of the grinding machine source 12 are sent for cleaning into a dust-collecting unit of the ПА-212 type (Ukraine) with a bag filter, the cleaning efficiency is 85.7 %. The source 17 grinding machines are equipped with ЗИЛ-900 (Ukraine), the abrasive-metal dust cleaning efficiency is 86.8 %.

Table 5 shows the characteristics of gas treatment units (GTU).

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Table 5

Characteristics of gas treatment units (GTU)

GTU name	Contaminants		Treatment level number	Concentration at the GTU inlet (max), mg/m^3	Treatment efficiency	Concentration at the GTU outlet (max), mg/m^3
	Code	Name				
Aerosol filter	2735	mineral oil	1	3.54	80.2	0.7
Aerosol filter	2735	mineral oil	1	3.5	80	0.7
Gravel filter	11510	aerosol	1	42.4	82.3	7.5
Cyclone non-standard ЦН-11	10431	dust	1	56.5	75.2	14
Unit dust removal ПА-212М bag filter	10431	dust	1	62.9	85.7	9
ЗИЛ-900	10431	dust	1	73.9	86.8	9.75

Note: information based on materials of «Tochprylad» LLC [6]

As a result, it can be concluded that gas treatment units work very well, treatment efficiency averages 82 %. Although, in general, «Tochprylad» LLC is not sufficiently provided with a dust and gas treatment unit, since they are from 6 sources from 20.

In general, the main sources of pollution affect the environment as follows:

Atmosphere. The main source of exposure to atmospheric air is carbon monoxide. The calculation of dispersion is carried out according to the technique [9]. This method allows to calculate the dispersion of impurities emitted into the atmosphere as a single, point and linear, as well as a group of sources, taking into account the influence of the terrain.

The maximum value of the surface concentration of a harmful substance (C_m) when a gas-air mixture is ejected from a single point source with a round pipe is reached under adverse meteorological conditions at a distance (X_m) and is calculated by the formula:

$$C_m = \frac{A \cdot M \cdot F \cdot m' \cdot \eta}{H^{7/3}}, \quad (1)$$

where A – coefficient depending on the temperature stratification of the atmosphere; M – mass of the harmful substance emitted into the atmosphere per unit of time, g/s; F – coefficient taking into account the sedimentation rate of harmful substances in the air; m' – coefficient taking into account the conditions of exit of the gas-air mixture from the mouth of the emission source; H – height of emission source above ground level, m; η – coefficient taking into account the influence of the terrain.

Because $\Delta T = T_T - T_B$, $\Delta T = 0$ °C, the release source is cold.

To obtain the value of the coefficient m', let's determine the following intermediate coefficients:

$$\omega'_m = 1.3 \cdot \frac{\omega_G \cdot D}{H}, \quad (2)$$

where ω_G – rate of release of the gas-air mixture from the pipe, m/s; D – diameter of the chimney pipe, m.

$$f_e = 800\left(\omega'_m\right)^3, \ \omega'_m = 1.107,$$

$$f_e = 1086.46, \ m' = 0.9.$$

Since $\omega'_m \geq 0.5$ and $f_e \geq 100$, then let's use the formula (1) and obtain the values:

$$C_m = 0.0029 \text{ mg/m}^3.$$

Since the maximum concentration limit is lower than MPC$_{a.d.}$ (3 mg/m^3), it is impractical to calculate carbon oxide dispersion.

Hydrosphere. «Tochprylad» LLC does not provide direct influence on nearby hydrological objects due to the fact that the industrial site is equipped with drain and production sewerage networks. The discharge of wastewater is carried out in the sewage system, and the collection of surface runoff into a storm sewer.

The collector is a stormwater, covering approximately 3,039 hectares of the site. To determine the flow of storm water, the climatic characteristics of the city of Kharkiv (Ukraine), the condition of the territory, the roofs of the enterprise were studied. The annual discharge of surface runoff is 7570 m^3/year.

The mode of discharge of stormwater depends on the duration of the rains. The maximum possible flow of storm water in the existing collector is 70.3 l/s. The average rainfall in the city is 700 mm/year.

Due to the fact that there is no capacity for collecting storm water at the plant, the quality of stormwater can only be predicted. When forecasting the quality of storm water, data from the draft MPD standard was used.

Groundwater. Possible sources of negative impact on groundwater can be:

– sewage leakage from sewer pipes;
– flow of petroleum products from vehicles at the enterprise;
– hit on the soil of the used raw materials with subsequent infiltration;
– aerosol emissions of the enterprise, washed out by precipitation.

Soils. The growing volumes of industrial production cause pollution of the soil, plants and water sources by chemical substances and compounds in terms of air emissions, solid waste and wastewater of cities and individual industrial facilities. The accumulation of these substances and compounds in natural environments becomes dangerous to human health.

Particularly toxic pollutants with carcinogenic properties are heavy metals, nitrates, fluorine, benzo(a)pyrene, etc.

During the research work on the survey of soil and vegetation in the area of activity of «Tochprylad» LLC on the pollution with their toxic elements, the following conclusions were obtained:

1. In the soils of the sanitary protection zone of the «Tochprylad» LLC, the content of heavy metals generally does not exceed the maximum permissible concentrations, although it is slightly higher compared to their content in an unpolluted (reference) environment.

2. A lower content of heavy metals in the layer is 30–40 cm, compared with the number of them in a layer of 0–15 cm, which indicates the absence of movement of

metals in the soil profile with precipitation and, thus, ingress into the groundwater from the soil is excluded.

3. Technogenic emissions of a plant into the atmosphere contribute to an increase in the content of copper, nickel and zinc in the soil.

4. A significant «contribution» to the pollution of the atmosphere and soil on the western side of the plant with lead, cadmium and zinc is made by road transport (lead content is higher than the MPC).

In the study of «Tochprylad» LLC it was found that in wastewater there is an excess of MPC for toluene, chlorides and iron. Therefore, additional wastewater treatment is proposed.

As a result, water intake and discharge will be reduced, and the charge for excess discharge will be reduced.

The economic effect is determined by the formulas [10]:

$$E = \text{Results} - \text{Cost}, \quad (3)$$

$$\text{Result} = \Delta P_1 + \Delta P_2 + \Delta P_3 + P_T, \quad (4)$$

$$\text{Cost} = k \cdot E_H + C, \quad (5)$$

where k – capital investments; $E_H = 0.12$ (Year)$^{-1}$ – the normative capital investment efficiency ratio; C – operational work on the implementation of environmental measures;

$\Delta P_1 =$ Existing water consumption – – Project water consumption;

$\Delta P_2 =$ Existing drainage – Project drainage;

ΔP_3 – reduction of payment for pollution by toluene; P_T – the cost of mined toluene.

Water intake fee – 0.33 USD/m^3.

Water discharge fee – 0.31 USD/m^3.

Actual water consumption of the optical workshop – 25.2 m^3/day.

Project water consumption of the optical workshop – 15 m^3/day.

Actual water disposal of the workshop – 23.94 m^3/day.

Drainage of the optical workshop – 8.9 m^3/day.

The cost of toluene – 1.42 USD/kg.

The cost of the metal – 9.62 USD/m^2.

The fee for increasing the concentration of toluene in wastewater – 0.69 USD/m^3.

Excess in toluene is 7 mg/l. Multiplying by the actual drainage and the number of working days let's obtain the amount of toluene, which can be removed from the waste water and sold. If multiply this by the cost of toluene, let's obtain mined toluene:

$$P_t = 7000 \frac{\text{mg}}{\text{m}^3} \cdot 23.94 \frac{\text{m}^3}{\text{day}} \cdot 251 \text{ day} \times \times 1.42 \frac{\text{USD}}{\text{kg}} = 59.85 \frac{\text{USD}}{\text{year}};$$

$$\Delta P_1 = \left(25.2 \frac{\text{m}^3}{\text{day}} - 15 \frac{\text{m}^3}{\text{day}}\right) \cdot 251 \text{ day} = = 2560.2 \frac{\text{m}^3}{\text{year}} \cdot 0.33 \frac{\text{USD}}{\text{m}^3} = 856.68 \frac{\text{USD}}{\text{year}};$$

$$\Delta P_2 = (23.9 - 8.9) \cdot 251 = 3765 \frac{\text{m}^3}{\text{year}} \times \times 0.31 \frac{\text{USD}}{\text{m}^3} = 1175.84 \frac{\text{USD}}{\text{year}};$$

$$\Delta P_3 = \left(23.94 \frac{\text{m}^3}{\text{day}} \cdot 0.69 \frac{\text{USD}}{\text{m}^3} - 8.9 \frac{\text{m}^3}{\text{day}} \cdot 0.31 \frac{\text{USD}}{\text{m}^3}\right) \times \times 251 \text{ day} = 3462.37 \frac{\text{USD}}{\text{year}}.$$

Capital investments (k) include the cost of unit and the cost of the element (distiller):

$$k = 6.5 \text{ m}^2 \cdot 1.5 \cdot 9.62 \frac{\text{USD}}{\text{m}^2} = 93.8 \text{ USD};$$

$$C = 62.5 \frac{\text{USD}}{\text{year}} \text{ (data from BIT-1 unit, Ukraine).}$$

$$E = (856.68 + 1175.84 + 3462.37 + 59.85) - - (93.8 \cdot 0.12 + 62.5) = 5398.32 \frac{\text{USD}}{\text{year}}.$$

As can be seen, the calculations confirm the economic efficiency of the proposed event.

It is also possible to consider the possibility of purification of storm sewage from the territory of the enterprise, which will reduce the discharge of pollution with storm water.

4. Conclusions

It is shown that the maximum surface concentrations of pollutants emitted into the atmosphere by the sources of the enterprise are small compared with the MPC, therefore, measures to reduce emissions to the standard level are not provided. Extreme impact by increased pollution of urban drainage is possible in the case of disruption to the operation of sewage treatment units; therefore, it is necessary to exercise periodic control over the flow of sewage into treatment and the operation of treatment facilities. Currently, the contamination level of soil and plants with heavy metals contained in industrial emissions of «Tochprylad» LLC as a whole does not exceed the maximum permissible values. Taking into account the non-agricultural nature of the use of the land of the sanitary protection zone of the plant, the re-examination of the soil for pollution, according to expert judgment with the existing production technology, is recommended not earlier than 15–20 years later. In order to reduce the anthropogenic impact of emissions on the environment, it is necessary to improve the production technology and the system of gas and dust emissions at «Tochprylad» LLC. The economic effect of the proposed additional wastewater treatment is 5398.32 USD/year.

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