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### FOOD SECURITY AND ECOLOGICAL SAFETY OF MEGALOPOLIS: A CASE STUDY ANALYSIS

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**Abstract.** In the scientific paper data on assessment of the impact of food enterprise “ALMA” on the environment of Almaty city megalopolis are provided. An approximate level of influence of the harmful substances are emitted by production of food products on the environment is calculated. Mathematical modeling of the dispersion of pollutants in the atmosphere and calculation of the values of surface concentrations were carried out using the unified program for calculation of atmospheric pollution ERA software complex, version 1.7. It is established that the propionic aldehyde emitted in the course of preparation of food products in the amount exceeding standard requirements is dissipated within maximum permissible concentration (MPC) until reaching the boundaries of nearby houses, without rendering harm on human health, and values of background concentration of carbon and nitrogen dioxides fluctuate within MPC.

**Keywords:** food production, food security, ecology, environment, pollutants, carbon monoxide, nitric oxide, propionic aldehyde, ERA software complex, maximum permissible concentration

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**JEL Classifications:** R51; R52

## 1. Introduction

One of the mechanisms for implementing environmental protection is environmental impact assessment (EIA) and environmental expertise, which are the most effective management levers of environmental management and environmental protection, which ultimately allows solving environmental problems (The Ecological Code of the Republic of Kazakhstan, 2007 No. 212 with amendments and additions of April 28, 2016; ISO 14001-2015. Environmental Management System).

Optimization of ecological safety of food products is impossible without carrying out EIA of enterprises producing food products, especially in conditions when demand in food production constantly increases in urban areas (Pavlova, Šenfelde 2017), what impacts food security, from one side, and endangers environmental security, from another side (Svetlanská et. al. 2017). EIA allows prevent environmentally harmful effects on the environment and possible social, economic and environmental consequences. In this regard, researches on the impact of food production activities on the ecological state of the environment were carried out. (The Republican Complex Program of the Ministry of Health of the Republic of Kazakhstan “Healthy Lifestyle” for 2008-2016, 2007).

Food industry in Kazakhstan, unlike metallurgy, chemical industry and other industries, does not belong to the main polluters of the environment however emissions of number of food industries containing dust, vapors, gases also adversely affect the environment. (Report on the realization of the Action Plan for the implementation of the State Program for Health Development of the Republic of Kazakhstan “Salamatty Kazakhstan” for 2011-2015).

Technological process at the enterprises of food industry, the quality of raw materials and finished goods are under constant observation of the sanitary inspection bodies, since the health of population directly depends on their sanitary condition. Essential role plays also an introduction at the enterprise of the system for safety of products recognized in the world for consumers operating control over risk factors during the full cycle of production and transportation of foodstuff (Akhmetova et al., 2017). At the food enterprises, in the framework of use of many types of raw materials and their processing, practically all types of the harmful allocations polluting the atmosphere of air (more than 15 thousand tons per year) take place. Emissions of food industry enterprises include substances such as acetic acid esters, monocarboxylic acids, lactates, formaldehyde, naphthalene, diacetyl, ammonium acetate, ethylbenzene, dimethylbenzene, anthracene, acrolein, butyric acid, phenol, toluene, benzene. (Statistical Digest of the Statistics Department for Almaty, 2015).

Many technological installations of food industry enterprises are sources of unpleasant smells which affect people, even in the case if their concentration in the air does not exceed the MPC of harmful substances in the atmosphere (Dalin, Rodríguez-Iturbe, 2016; Aydosov et al., 2017).

To the air of a number of enterprises in a large amount come water vapor (canneries, meat-processing plants, dairies plants, etc.), carbon dioxide at the enterprises which technological process is connected with fermentation (breweries, wine-making enterprises, yeast production, etc.), vapors of solvents, for example, in extraction shops of the oil and fat enterprises. (Regulations about the Ministry of EI RK. Resolution No. 1113 of the Government of the Republic of Kazakhstan of October 28, 2004).

At many food enterprises (bakeries, sugar plants, confectioneries, etc.) thermal processes, such as heating, drying, etc. which are followed by allocation of convective and radiant warmth are applied. At some productions there are shops with the explosive environment (oil and fat enterprises, sugar plants, starch-packing enterprises, etc.). For implementation of the required air exchange at the production the ventilation system which prevents danger of emergence of explosive situations is provided. At the number of productions a part of raw materials and finished goods are exposed to dispersion and lost. Thanks to use of effective dust collectors in ventilation systems these materials can be stored and returned in production. (The Rules for the Inventory of Emissions of Harmful (polluting) Substances, Harmful Physical Impacts on Atmospheric Air and Their Sources, 2005 with changes of 12/4/2015; Dzhingilbaev et al., 2015).

The combustion gases which are emitted by boiler rooms of many food industry enterprises contain products of incomplete combustion of fuel and ashes. Technological emissions contain dust, vapors of solvents, alkalis, vinegar, hydrogen and also excess heat. Ventilating emissions to the atmosphere include dust which isn't detained by dust removal devices and also vapors and gases. To many enterprises raw materials are delivered and finished goods and waste are taken out by the motor transport. The intensity of its movement in a number of branches has seasonal nature – sharply increasing during the harvest period (meat-packing enterprises, sugar refineries, tea factories, etc.); at other food productions the traffic is more evenly within a year (bakeries, tobacco factories, etc.). (Order of the Minister of Energy of the Republic of Kazakhstan “On Approval of the Methodology for Determining Emission Standards in the Environment”, 2016 No. 238”; Oat 2014).

At many food enterprises there are considerable resources of secondary heat (sugar factories, fat-and-oil enterprises, canneries, bakery enterprises, etc.). These secondary energy resources can be used for useful purposes - water heating in heating and hot water supply systems, in air ventilation systems. (Order of the Minister of Energy of the Republic of Kazakhstan “On Approval of the Methodology for Determining Emission Standards in the Environment”, 2016 No. 238; Hoolohan et al., 2016).

To create the necessary conditions for the air environment, which are favorable for workers who provide high quality products, ventilating and conditioning systems are set up in the production premises of food industry enterprises. (Sanitary rules “Sanitary and epidemiological requirements for atmospheric air in urban and rural settlements, soils and their safety, content of urban and rural settlements, working conditions with sources of physical factors that affect people”, 2012 No. 168).

In terms of the intensity of the negative impact of food industry enterprises on the environmental objects, water resources are experiencing significantly. According to the consumption of water per unit of output, food production occupies one of the first places among other industries. (Departmental statistical reporting “Report on the activities of the Sanitary and Epidemiological Service of the Republic of Kazakhstan for 2014”. Form number 18 – annual; Amienyo et al., 2016).

A high level of water consumption causes a large volume of wastewater formation at the enterprises, while they have a high degree of contamination and pose a danger to the environment. Discharge of sewage into reservoirs quickly depletes oxygen reserves, which causes the death of the inhabitants of these reservoirs. At the enterprises of sugar, starch, culinary, canning, and wine industries, the bulk of waste water is generated by hydrotransportation and washing of raw materials. (Sanitary rules “Sanitary and epidemiological requirements for water sources, domestic and drinking water supply, places of cultural and domestic water use and safety of water bodies”, 2010 No. 554; Vigil, Kenneth, 2003).

The sewage water of these industries is characterized by a high content of suspended organic substances. This deposit for many years is collected in settlers and filtration fields that leads to overflow of maps of filtration fields and hit of sewage into open reservoirs. Wastewater of meat processing plants contain a large amount of mineral and organic impurities, characterized by high aggregative and sedimentation resistance. The purification of these drains represents a challenge for technologists. (Environmental Protection in Russia. 2010: Statistical compilation/Rosstat, 2016; <https://neosintez.com.ua/en/use-of-coagulants/industrial-wastewater-of-food-factories/>). The food industry processes multicomponent raw materials, mainly agricultural origin for the purpose of extraction from it, as a rule, one any component: sugar - from sugar beet, starch - from potatoes and grain, vegetable oil - from seeds of sunflower, cotton, etc. At the same time, for receiving of the basic products, raw materials are used only by 15-30%, other part remains in the waste. Practically all these wastes are the secondary raw material resources (SRMR) since contain vitamins, cellulose, minerals, etc. Low content of solids in SRMR (5-10%) doesn't find due application them in the food industry. At long storage of waste they lose their nutritional properties, sour, rot, pollute the environment and are carriers of many diseases. (Foster et. al., 2006; Dionysiou, 2004).

Currently low-used wastes are: the filtrational deposit (defecate) in sugar industry, yeast and alcohol bard in the alcoholic branch, potato juice in starch production, tobacco dust and also fermentation carbon dioxide and secondary fermentation gas in the alcohol and brewing branches. From 5 thousand tons of potato juice only about 20% of waste are used, fermentation carbon dioxide in alcohol branch is used by 20%, the rest is dispersed into the atmosphere, polluting it and enhancing the greenhouse effect (Ovsyany 2014).

Thus, the emissions of a number of food productions containing dust, vapors, gases, adversely affect the environment, causing air, soil and water pollution, thereby make negative impact on safety of human health. These harmful phenomena can be considerably prevented or weakened due to a competent conduct of environmental monitoring and management at the enterprises of food productions. (Development Program “Almaty – 2020”. Section 2.1.6. Ecology and Land Resources. Decision of the Administration of Almaty No. 394 of 12/10/2015).

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## 2. Research Methods and Objectives

For identification of environmental impact assessment the food enterprise “ALMA” of the megalopolis of Almaty city was chosen as an object of the study and on it the approximate level of impact of harmful substances on the environment is calculated. (Instructions on the Regulation of the Emissions of Pollutants into Atmosphere. - Astana: MEP RK. Republican normative document (further RND), 2004).

Mathematical modeling of pollutants dispersion in the atmosphere and calculation of values of surface concentrations were carried out using the unified program for calculation of atmospheric pollution of the software package “ERA”, version 1.7, the developer Logos-Plus, Novosibirsk, Russian Federation.

The software package ERA is included into the list of the programs recommended for application in the territory of the Republic of Kazakhstan. Also it can be used when developing volumes of maximum-permissible emissions (MPE) of the enterprises and summary volumes of MPE on the cities. In the software package ERA blocks of modules ERA-climate, ERA-risks and ERA-waste were used.

The main characteristics of the physico-geographical and climatic conditions of the location of the “ALMA” enterprise are determined for the purpose to assess the conditions of the dispersion of harmful emissions into the atmosphere from sources of air pollution to the level of their MPCs.

The nearest residential house is located on the west side from the industrial platform of “ALMA” food production. A relief of the industrial platform is quiet with an insignificant bias to the north ( $\eta = 1$ ). Soil on the industrial platform is presented by loams, non-subsiding and gravel pebbles. The ground waters at a depth of 6 m aren't opened. A land relief around the industrial platform is plain, the difference in altitude is less than 50 m per 1 km so the dimensionless coefficient considering a land relief is equal to 1. Seismicity of the area is 9 points. To protect the soil from pollution, the area is covered from asphalt, framed with curbstone.

Environment of Almaty and Almaty region includes five climatic zones: from deserts to eternal snow. The climate is sharply continental, the average temperature of January in the plains is  $-15^{\circ}\text{C}$ , in the foothills is  $-6-8^{\circ}\text{C}$ ; in July is  $+16^{\circ}\text{C}$  and  $+24+25^{\circ}\text{C}$  respectively. Annual amount of precipitations on plains is up to 300 mm, in the foothills and mountains are from 500-700 to 1000 mm a year. (Instructions on the Regulation of the Emissions of Pollutants into Atmosphere. - Astana: MEP RK. RND, 2004).

*Flora and fauna.* In the area of the location of the “ALMA” enterprise rare animals and plants listed in the Red Book of the RK are not established.

Meteorological characteristics and factors determining the conditions for the dispersion of pollutants into the atmosphere are presented in Table 1.

**Table 1.** Meteorological characteristics and conditions of dispersion of harmful substances into the atmosphere of air of Almaty city megalopolis

Direction of the wind	N	NS	E	SE	S	SW	W	NW
Repeatability, %	21	9	7	23	16	9	7	8
<i>Meteorological characteristics</i>								
The coefficient, which depends on the stratification of the atmosphere, A	200	Coefficient to terrain relief						1
The average maximum outside temperature of the hottest month of the year, T °C	29.7	Calm, %						0
The average maximum outside temperature of the coldest month of the year, T °C	- 6.4	The wind speed according to the average long-term data, the repeatability of which exceeds 5%, m / s						3

When calculating the level of pollution the following criteria of quality of atmospheric air are accepted:

- maximum one-time concentrations ( $MPC_{m.o.t.}$ ), according to the “Threshold Limit Values (TLV) of Pollutants in Atmospheric Air of the Inhabited Places” list and health regulations “Sanitary and Epidemiologic Requirements to Atmospheric Air in Cities and Rural Settlements, to Soils and their Safety, the Maintenance of the Territories of Cities and Rural Settlements, Working Conditions with Sources of Physical Factors making impact on the Human” (Resolution of the Government of the Republic of Kazakhstan No. 168, 2012; UND-86. RND 211.2.01.01-97, 1997).

- temporary safe reference action level of influence, according to the “Temporary Safe Reference Action Level (TSRAL) of Pollutants in Atmospheric Air of the Inhabited Places” list and above-named sanitary and epidemiologic rules and norms.

For substances that do not have  $MPC_{m.o.t.}$  according to item 8.1. RND 211.2.01.01-97 values of Temporary Safe Reference Action Level (TSRAL) of air pollution are accepted. (All-Union normative document (further UND-86). The procedure for calculating the concentrations in the air of harmful substances contained in the emissions of enterprises. RND 211.2.01.01-97. Almaty. 1997).

In calculations the background concentration of pollutants in the atmospheric air of the region of an arrangement of the ALMA enterprise are considered: dust (suspended matter) – 0.1 mg/m<sup>3</sup>; sulfur dioxide – 0.0034 mg/m<sup>3</sup>; carbon dioxide – 0.2 mg/m<sup>3</sup>; nitrogen dioxide – 0.0029 mg/m<sup>3</sup> (“The Reference Book for the Ecologist” No. 11, 2017). Calculations are executed on all pollutants and groups of the substances possessing at joint presence the summarizing harmful effect.

### **Description of Varieties:**

The main activity of the food enterprise “ALMA” is the production of beer, baking of bakery products and sale of food products to the population.

At the territory of the enterprise “ALMA” there are: an experimental sausage workshop; dumpling shop, cooking; mini bakery; Locksmith shop; veterinary laboratory; refrigerating units; grease; parking pocket.

According to the inventory (Instructions on the Regulation of the Emissions of Pollutants into Atmosphere. MEP RK. RND, 2004) during the operation of the “ALMA” enterprise, seven sources of pollutant emissions combined into two sources of atmospheric air pollution were identified:

- organized (source of pollution № 0001 – industrial area);
- unorganized-non-normal (source of pollution № 6002 - vehicles entering the territory of the site (parking lot)).

The sources of emissions of harmful substances into the atmosphere are: experimental sausage workshop, cooking, mini bakery (source of pollution No 0001, consists of five sources of allocation) and vehicles coming to the site (source of pollution No 6002, consists of two sources of pollutants).

Emission of pollutants into the atmospheric air is blown-out by:

- when filling flour into the sifter (source of pollution No 001);
- during fermentation of the dough (source of pollution No 002);
- at the disinfection table (source of pollution No 003);
- when frying meat (source of pollution No 004);
- when the operation of refrigeration units (source of pollution No 005);
- vehicles with carburetor engines (source of pollution No 006);
- vehicles with diesel engines (source of pollution No 007).

Emission of pollutants from the industrial area of the “ALMA” enterprise is blown-out through a tube with an altitude of 5 m and a diameter of 0,4 m (The order of the Minister of Energy of the Republic of Kazakhstan “On Approval of the Technique for Determining Emission Standards in the Environment” No. 238, 2016).

In the bakery the equipment working from electricity for making bakery products, cooling and frying of meat is installed. Also the following equipment are installed: convectomat - 1 piece, electric stoves - 2 pieces, an electrofrying pan – 2 pieces, a Cook box – 1 piece, refrigerators - 6 pieces. Electric stoves are equipped with exhaust umbrellas which are attached to the general system of the exhaust ventilation which is presented by a box of 0,5x0,07 m in size. The box passes across all shop at the height of 2 m and leaves to the main vent tube (air shaft) of 20 m altitude and 0.4 m diameter. (The Order of the Minister of Energy of the Republic of Kazakhstan “Health of the People in a Health Care System” of 5/30/2015, No. 414.).

*Motor transport, coming to the territory of the site.* On the territory of the industrial area there is a parking pocket for visitors to the site for 5 auto units. The site employs 30 people including: engineering and technical worker 1 person, workers 29 people. The operating mode of the enterprise is 365 days a year, 12 hours a day, 4380 hours a year. (UND-86. UND 1987-01-01).

### **Analysis:**

*Backfill the flour in the sifter (source of pollution No 001).*

The unloading of the flour is 87.4 kg per 25 min, 87.4 kg per day, 31.9 t per year. The total excretion of the dustflour is 0.18 g/kg. The amount of dust emitted during the filling of flour is determined by the formula (1):

$$M_{\text{sec}} = B \text{ (kg)} \cdot Q / (25 \cdot 60), \text{ g/sec}; M_{\text{year}} = B \text{ (t / year)} \cdot Q / 1000, \text{ t/year (1)}$$

Where, Q is the specific excretion, g/kg; B - consumption, kg or t/year; T - the average time of backfilling, minutes, taking into account the settling in the room 50%.

*Fermentation of the dough (source of pollution No 002).*

Fermentation of the dough is carried out during the whole working day (12 hours/day), when one setting is placed into the oven, the second is put on a proofing. The amount of made bakery products are 87.4 kg /day or 7.3 kg /hour and 31.9 tons per year.

The amount of pollutants produced during the fermentation of the dough is determined by the formula (UND-86. UND 1987-01-01) (2), (3):

$$M_{\text{sec}} = [B \text{ (kg/day)} \cdot Q / T] / 3600, \text{ g/sec}; (2) \quad M_{\text{year}} = B \text{ (t /year)} \cdot Q/1000, \text{ t/year (3)}$$

Where, Q is the specific excretion, g/k; B - consumption, kg/day, t/year; T is the average fermentation time, hour/day.

*Experimental and sausage workshop.*

In the emissions of smoke fume in notable quantities present nitrogen oxides, carbon monoxide, sulfurous anhydride, solids (soot), ammonia, phenolic and carboxyl (propionic aldehyde) substances. Smoked sausages are cooked for seven hours a day. The operating time of the smoke generator is  $7 \cdot 270 = 1890$  hours per year. The calculation of the massive injection M (g/s) is carried out on a formula (4):

$$M = (n_1 \cdot K_1 + n_2 \cdot K_2 + \dots) \cdot 10^{-3} \text{ (4)}$$

Where,  $n_1$  and  $n_2$  are the numbers of smoke generators;  $K_1, K_2$  - specific indicators of emissions of each generator, mg/s. Specific indicators of pollutant emissions from thermal separation equipment are shown in the Table 2.

**Table 2.** Specific indicators of emissions of harmful substances in sausage production

Type of smoking equipment	Massive injection of smoke components						
	CO <sub>2</sub>	NO <sub>2</sub>	SO <sub>2</sub>	Soot	NH <sub>3</sub>	Phenol	Propionic aldehyde
Smoke generator	10.0	2.0	0.3	5.0	0.1	4.5	3.8

Disinfection of tables (source of pollution No 003)

Cleaning of tables for disinfection at the end of the working day is carried out by calcined soda. The area of rubbed tables is 1 m<sup>2</sup>. Operating time is 1 hour/day, 365 days/year. The amount of pollutants generated during the wiping of the tables is determined on the formula (UND-86. UND 1987-01-01) (5), (6):

$$M_{\text{sec}} = S \cdot Q / 3600, \text{ g/sec}; (5) \quad M_{\text{year}} = Q \cdot T \cdot 3600 / 1000000, \text{ t/year} (6)$$

Where, Q is the specific excretion, g/h • m<sup>2</sup>; S - area of the surface to be wiped, m<sup>2</sup>; T is the wiping time, hour/year.

Roasting meat (source of pollution *No 004*).

In the bakery the equipment for frying meat, powered by electricity, is installed. Emission calculations were made according to health regulations ("Sanitary and epidemiological requirements for the maintenance and operation of facilities for the production of meat and meat products, their storage and transportation. (Approved by the Order of the Minister of Health of the Republic of Kazakhstan, February 17, 2005 No. 60).

Specific emissions of acrolein when frying fat used - 0.0065 g/kg. Average fat consumption per 1 unit of equipment can be up to 30,600 kg/year and 7.0 kg/hour. The amount of emissions will be (7), (8):

$$M = 0.0065 \cdot 30600 / 1000000 = 0.0002 \text{ t / year}; (7)$$

$$M^* = 0.0065 \cdot 7.0 / 3600 = 0.00001 \text{ g/sec} (8)$$

Refrigeration installations (source of pollution *No 005*).

Six refrigerated coolers are installed in the bakery. As a result of possible efflux, an annual refilling of 5 kg per each chamber is carried out. The total number of refueling chambers of volume 10 m<sup>3</sup> each is six. When refilling Freon, a hermetically sealed device is used, excluding the evaporation of the ingredient.

The operating time of the refrigerated coolers is 24 hours/day, 365 days/year, 8760 hours/year. Specific injection of Freon during refilling of refrigeration installations is 0.03 g/s. The total amount of pollutants formed during the refilling of Freon into the atmosphere is determined on the formula (UND-86. UND 1987-01-01) (9), (10):

$$M_{\text{sec}} = V \cdot n \cdot Q / 1000; (9) \quad M_{\text{year}} = V \cdot n / 1000, \text{ t/year} (10)$$

Where, B - material consumption, kg; n - number of refrigerated coolers; Q is 0.03 g/s.

The maximum one-time emission of pollutants emitted into the atmosphere during the refilling of Freon is determined on the formula (11):

$$M_{\text{sec}} = M_{\text{year}} / 3600, \text{ g /sec} (11)$$

Motor transport, running on gasoline (source of pollution *No 006*).

The run of one car across the territory of a parking pocket taking into account maneuvering we accept 25 m. The total daily run for cars with carburetor engines will make (at the number of the coming cars in days – 50) – 1.25 km.

The total annual ran (when the number of working days per year - 365) will be 456 km/year. The consumption of gasoline per 100 km is accepted 8 kg. Consumption of combustible fuel - gasoline will be 0.36 t /year. We assume that within one hour five cars with a carburetor engine leave the site. Run for each type of cars:  $25 \cdot 5: 1000 = 0.125$  km.

The fuel consumption for cars with carburetor engines is determined on the formula (12):

$$8 \cdot 0.125 \cdot 1000 / (100 \cdot 60 \cdot 60) = 0.0028 \text{ g / sec (12)}$$

*Motor transport operating on diesel fuel* (source of pollution *No 007*)

The run of one car across the territory of a parking pocket taking into account maneuvering we accept 25 m. The total daily run for cars with diesel engines will make (at the number of the coming cars in days – 20) – 0.5 km.

The total annual ran (when the number of working days per year - 365) will be 182.5 km. The consumption of diesel fuel per 100 km is accepted 20 kg. Consumption of combustible fuel - diesel fuel will be 0.37 t /year. We assume that within five hours two cars with a diesel engine leave the site. Run for each type of cars:  $25 \cdot 2: 1000 = 0.05$  km.

The fuel consumption for cars with diesel engines is determined on the formula (13):

$$20 \cdot 0.05 \cdot 1000 / (100 \cdot 300 \cdot 60) = 0.0028 \text{ g/sec (14)}$$

## 2. Results and Discussions

The main pollutants of the food company “ALMA” emitted into the air atmosphere are: dustflour (code of pollutant 3721), ethyl alcohol (1061), acetic acid (1555), acetaldehyde (1115), ammonia (0333), propionic aldehyde (1314), sodium hydroxide (0150), acrolein (1301), freon-22 (0859), benzo (a) pyrene (0703), carbon black (0328), formaldehyde (1325), alkanes C12-C19 (2754), nitrogen dioxide (0331), carbon dioxide (0337) and sulfur dioxide (0330). (Codes and list of substances polluting the atmospheric air / JSC Research Institute “Atmosphere”, St. Petersburg, 2015). The total amount of pollutant emissions of the organized (No 0001) and unorganized (No 6002) pollution sources is shown in Figure 1 and Table 3.



**Table 3.** Emissions of pollutants from various sources of pollution

Pollutant code matter	Name	Emissions	
		g / sec	t / year
<b>Quantity of pollutant emissions from an organized source No 0001</b>			
<i>Emissions of pollutants from the filling of flour in the sifter (source of pollution No 001)</i>			
3721	Dustflour	0.0052	0.0057
<i>Emissions of pollutants from dough fermentation (source of pollution No 002)</i>			
1061	Ethanol	0.0135	0.035
1555	Acetic Acid	0.00121	0.0032
1115	Acetaldehyde	0.0001	0.0013
<i>Emissions of pollutants during disinfection of tables (source of pollution No 003)</i>			
0150	Sodium Hydroxide	0.0003	0.00037
<i>Emissions of contaminants during roasting (source of pollution No 004)</i>			
1301	Acrolein	0.0002	0.00001
<i>Emissions of pollutants from refrigeration coolers (source of pollution No 005)</i>			
0859	Freon-22	0.0009	0,03
<b>Total emissions of pollutants from an organized source No 0001</b>			
3721	Dustflour	0.0052	0.0057
1061	Ethanol	0.0135	0.035
1555	Acetic Acid	0.00121	0.0032
1115	Acetaldehyde	0.0001	0.0013
0337	Carbon dioxide	0.01	0.068
0331	Nitrogen dioxide	0.002	0.014
0333	Ammonia	0.0001	0.00068
0330	Sulphur dioxide	0.0003	0.002
1314	Aldehyde propionic	0.038	0.026
0150	Sodium hydroxide	0.0003	0.00037
1301	Acrolein	0.000 2	0.000 01
0859	Freon-22	0.000009	0.03
ИТОГО		0.071	0.186
<b>Quantity of pollutant emissions from unorganized source No 6002</b>			
0337	Carbon dioxide	0.0013	-
2754	Alkans C <sub>12</sub> - C <sub>19</sub>	0.00015	-
1325	Formaldehyde	0.00001	-
0328	Soot	0.00003	-
0703	Benz (a) pyrene	0.0000000007	-
0330	Sulphur dioxide	0.000036	-
0301	Sulphur dioxide	0.00017	-
1301	Acrolein	0.0000026	-

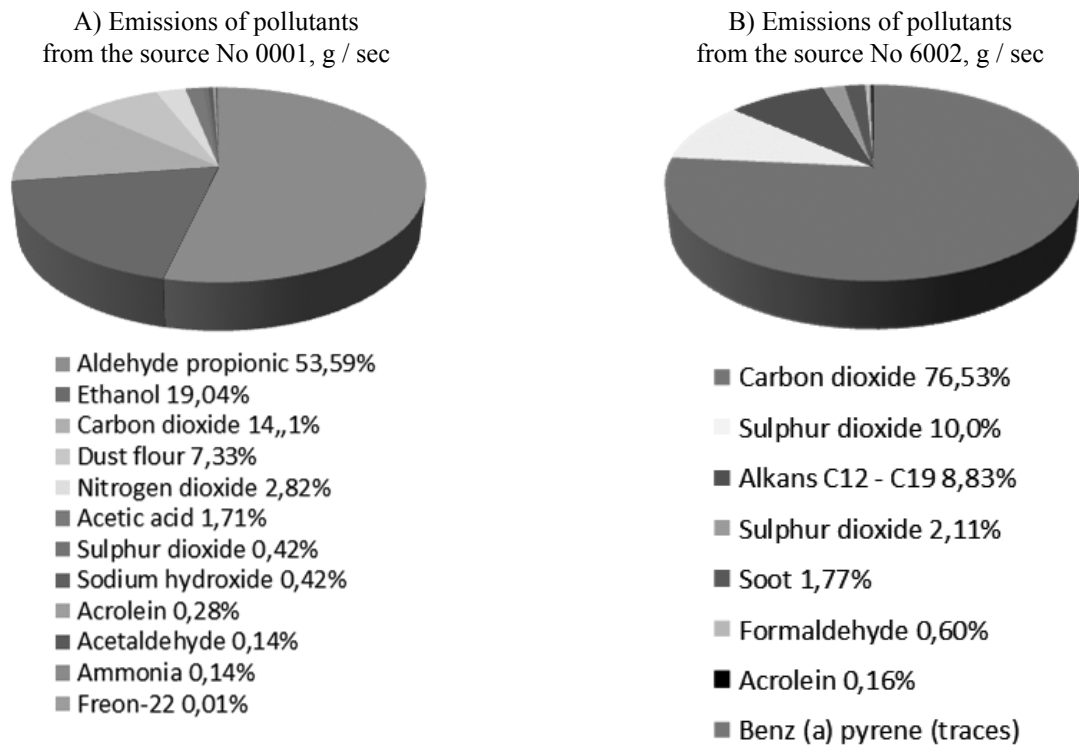
Dioxides of nitrogen, sulfur and carbon, acrolein, benz(a)pyrene, soot, formaldehyde, alkanes C<sub>12</sub>-C<sub>19</sub> belong to pollutants from vehicles entering the territory of the “ALMA” enterprise industrial platform (source of pollution No 6002, Table 4).

**Table 4.** Emissions of pollutants from vehicles with different types of engines

Substance name	<i>A) Emissions of harmful substances from cars with carburetor engines (source of pollution No 006)</i>		
	The consumption of gasoline is 0.0028 g/s		
	Specific emissions, t / y	Specific emissions, t / y	Maximum one-time emissions, g/s
Carbon dioxide	0.4200	0.4200	0.0012
Alkans C <sub>12</sub> - C <sub>19</sub>	0.046	0.046	0.0001
Formaldehyde	0.001	0.001	0.000003
Soot	0.0011	0.0011	0.000003
Benz(a)pyrene	0.0000001	0.0000001	0.000000003
Sulphur dioxide	0.0020	0.0020	0.000006
Nitrogen dioxide	0.0270	0.0270	0.00008
Acrolein	0.0002	0.0002	0.0000006
TOTAL			0.0014
Substance name	<i>B) Emissions of harmful substances from cars with diesel engines (source of pollution No 007)</i>		
	The consumption of diesel fuel is 0.0028 g/s		
	Specific emissions, t / year	Specific emissions, t / year	Gross Emissions, g / sec
Carbon dioxide	0.0470	0.0470	0.0001
AlkansC <sub>12</sub> - C <sub>19</sub>	0.0190	0.0190	0.00005
Formaldehyde	0.0027	0.0027	0.000008
Soot	0.0097	0.0097	0.00003
Benz (a) pyrene	0.00000014	0.00000014	0.000000004
Sulphur dioxide	0.0100	0.0100	0.00003
Nitrogen dioxide	0.0330	0.0330	0.00009
Acrolein	0.0007	0.0007	0.000002
TOTAL		0.1221	0.00031

Assessment of the impact of pollutant emissions from the enterprise sources on the residential area. The impact of pollutant emissions on the environment is estimated by the values of the maximum surface concentrations in the nearest residential area adjacent to the enterprise.

Parameters of emissions of pollutants and their characteristic on the current situation, and the perspective obtained as a result of inventory of the enterprise emissions sources are accepted to initial data for calculation of the maximum surface concentrations (Figure 1).



**Figure 1.** Emissions of pollutants from different sources of pollution

When conducting any economic activity, accompanied by the emission of pollutants, it is necessary to analyze their content in the air atmosphere of the residential area. This is necessary to take measures in a case of exceeding the concentration of pollutants above the MPC.

The volume of air emissions into the atmosphere, and the assessment of their effects on the air in a residential area, allows to assess the influence of pollutants on the environment and human health. (The Order of the Minister of Energy of the Republic of Kazakhstan № 414 “Health of the People in the Health Care System”, May 30, 2015).

When calculating the concentrations of harmful substances in the ground layer of the atmosphere, according to the requirements of the UND-86, those emitted harmful substances for which the maximum surface concentrations of harmful substances reach or exceed their MPCs are considered. Calculations were carried out using meteorological data of Almaty city (Table 5).

**Table 5.** Meteorological indicators of Almaty city

Direction of the wind	N	NE	E	SE	S	SW	W	NW
The average annual frequency of wind directions (P,%)	21	9	7	23	16	9	7	8
Repeatability of wind directions of one rhumb along a circular rose of winds (Po, %)	At eight’s rhumb wind rose Po = 100/8= 12,5							
Ratio P / Po	1.68	0.72	0.56	1.84	1.28	0.72	0.56	0.64
Distance to the nearest residential area from the outermost emission source	80	150	135	145	130	60	45	125

Borders of dispersion of harmful substances in the conditions of the boundaries of the arrangement of business entity “ALMA” and weather conditions of Almaty city megalopolis are defined. It is established that the propionic aldehyde emitted in the course of preparation of food products in quantity exceeds standard requirements for  $C_m$  0.0114 mg/m<sup>3</sup> (MPC 0.01 mg/m<sup>3</sup>), and values of background concentration  $C_m$  0.03 mg/m<sup>3</sup> of carbon

dioxide (MPC is 0.07 mg/m<sup>3</sup>) and nitrogen dioxide – C<sub>m</sub> 0.0069 mg/m<sup>3</sup> (MPC is 0.0085 mg/m<sup>3</sup>) fluctuate within maximum permissible concentration.

The boundary of dispersion of propionic aldehyde to the value of MPC, and the character of dispersion of carbon dioxide taking into account its background value is determined by the calculation method by imposing the maximum concentration of propionic aldehyde at a distance of X<sub>m</sub> on the graph for determining the dimensionless coefficient S<sub>1</sub> (Figure 2).

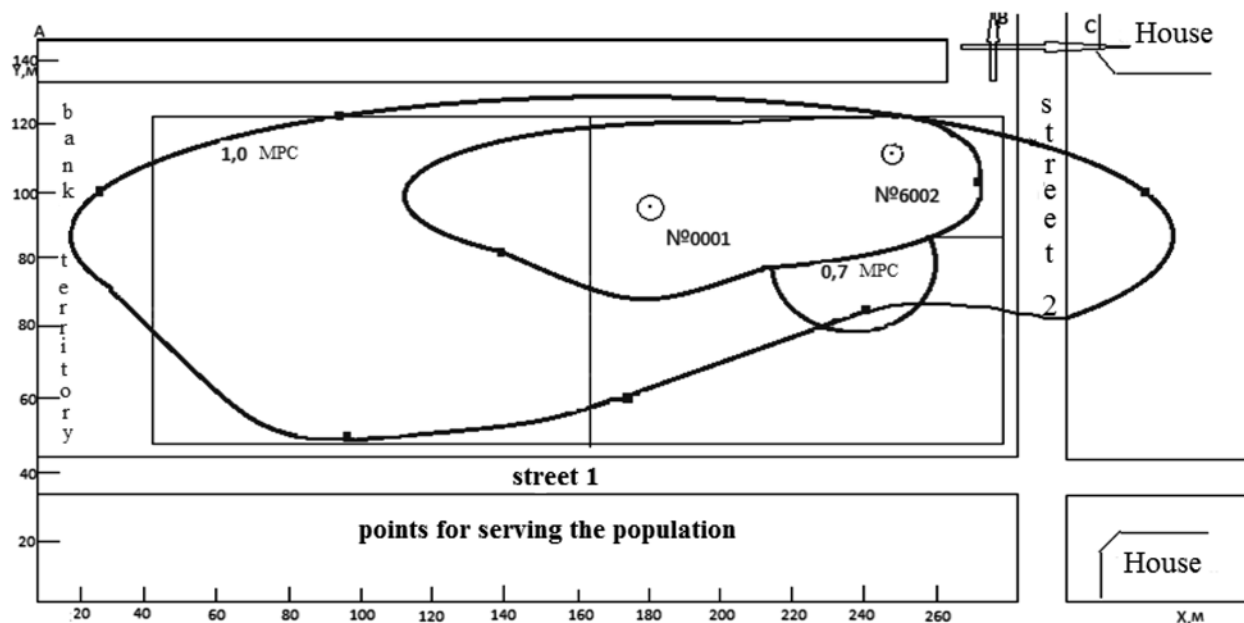


Figure 2. Situational plan for the location of the enterprise “ALMA”

(1- organized source of pollution, 2 - unorganized source of pollution; 3 - territory of the enterprise location;  
 4 - concentration field of MPC of propionic aldehyde; 5 - concentration field of carbon monoxide)

In order to carry out studies on the determination of the propene aldehyde dispersion limits, we determined the maximum surface concentration of propionic aldehyde S<sub>m</sub>. For the occurrence of unfavorable meteorological conditions, the maximum distance to the nearest residential building, X<sub>m</sub>, at which the maximum concentration of the investigated ingredient is determined as a result of the economic activity of the investigated object is defined.

The maximum concentration of propionic aldehyde C<sub>m</sub> was determined on the formula:

$$C_m = \frac{A \cdot M \cdot F \cdot m \cdot n \cdot \eta}{H^2 \cdot \sqrt[3]{V} \cdot \Delta T}$$

Where, C<sub>m</sub> is the maximum surface concentration of harmful substances, mg/m<sup>3</sup>; A is a coefficient that depends on temperature stratification; M - the amount of harmful substance emitted into the atmosphere, g/s; F - coefficient, taking into account the rate of sedimentation of harmful substances; H - height of the source of emission above ground level, m; V is the volume of the gas-air mixture m<sup>3</sup>/s, emitted into the atmosphere, determined on the formula (15):

$$V = \frac{\pi \cdot D^2}{4} \cdot \dot{\omega}_0 \tag{15}$$

Where, D is the diameter of the outlet of the emission source, m;  $\dot{\omega}_0$  - average velocity of gas-air mixture output from the source, m/s;  $\Delta T$  is the difference between the temperature of the air-gas mixture and ambient air, °C.

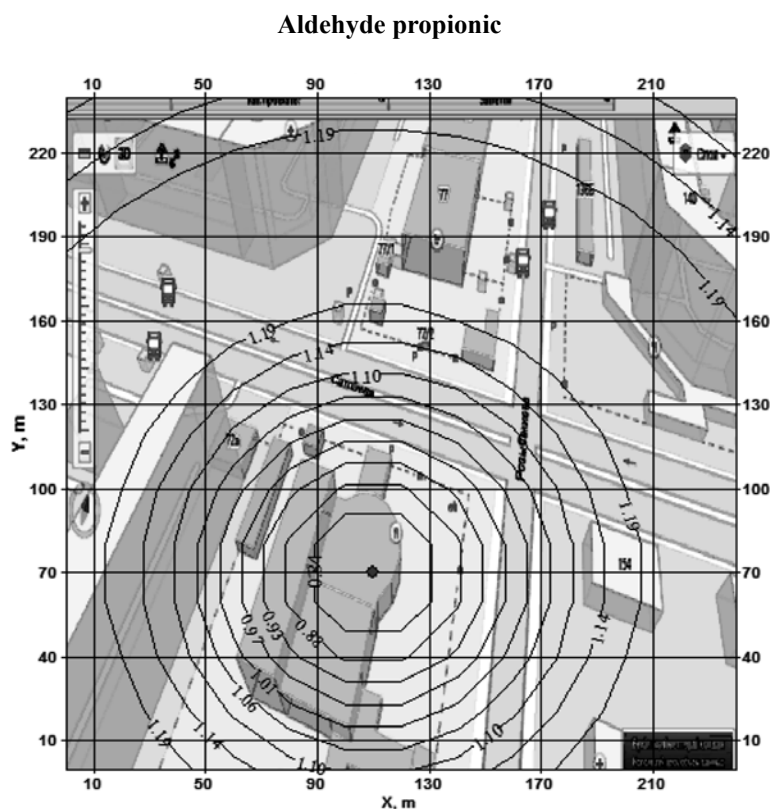
To calculate the fields of concentrations of propionic aldehyde in the atmosphere without taking into account an

influence of the development of the “ALMA” enterprise (according to UND-86), the characteristics of the area, the parameters of the calculated rectangle and the source of pollution are used (Table 6).

**Table 6.** Characteristics of the district, parameters of the calculated rectangle and the source of pollution

<i>1) Characteristics of the area</i>							
Parameter		Value					
Stratification coefficient of the atmosphere		200					
Coefficient of terrain influence		1.0					
Average maximum temperature of outside air, °C							
The warmest month		29.7					
The coldest month		-6.4					
The wind speed V* the repeatability of which is 5%, m / s		3.0					
<i>2) Calculation Rectangle Parameters</i>							
Length, m		Width, m		Step in X, m		Step by Y, m	
240		240		20		20	
<i>3) Parameters of the source of pollution</i>							
No пп	Name of the source	Height, m	Diameter, m	Volume flow of gases, m <sup>3</sup> / s	Temperature of gases, ° C	Coordinate X, m	Coordinate Y, m
1	0001 Organized	5.0	0.40	3.61000	140.0	120	70

The results of calculations for the dispersion of the concentration in air of propionic aldehyde (1314) are shown in Figure 3.



**Figure 3.** Propionic aldehyde dispersion in the atmosphere without taking into account the influence of the building up to the MPC value

The total number of sources that emit one matter ("ALMA" enterprise). The contaminant is propionic aldehyde. MPC - 0.0100, mg/m<sup>3</sup>. The coefficient of subsidence is 1.0. The total emission for all sources of pollution is 0.038000, g/s. The sum of C<sub>m</sub> for all sources, units of MPC: 1.2312. Weighted average dangerous wind speed, m/s: 6.6. X<sub>m</sub> -138.3 m. U<sub>m</sub> - 6.6 m/s. Summation group: none.

Besides, for accounting of the wind rose, influencing reduction of concentration of the harmful substances in atmospheric air, the method of calculation is used for determination of a sanitary gap L (m) corresponding to the distance C (m), specified in the settlement directions depending on the rose of Almaty city on a formula (16):

$$L = x \cdot \frac{P_0}{P} \quad (16)$$

Where, P is the wind speed in calculated directions, %; P<sub>0</sub> is the repeatability index for a circular wind rose; x - distance to the calculated point, m.

To exclude the excess of air pollution standards at the territory adjacent to any enterprise, it is necessary to define a sanitary protection zone (SPZ). Due to the fact that at the territory of the industrial platform "ALMA" the maximum surface concentrations do not exceed 0.1 MPC according to the Ecological Code of the Republic of Kazakhstan of January 9, 2007 No. 212 with amendments and additions of April 28, 2016, Article 41., for the territory of the enterprise "ALMA" the SPZ is not set.

The category of danger of the enterprise (CDE), depending on the mass and species composition, pollutants discharged into the atmosphere, was determined on the formula (17):

$$CDE = \sum_{i=1}^n (M_i / \text{MPC}_i)^\alpha \quad (17)$$

Where, n is the amount of pollutants emitted by the enterprise; M is the mass of the ejection of the i-th substance, t/year; MPC - average daily MPC of the i-th substance, mg/m<sup>3</sup>; α - dimensionless coefficient, which allows to bring the degree of harmfulness of the i-th substance to the harmfulness of sulfur dioxide.

The CDE values are calculated under the condition that M<sub>i</sub>/MPC<sub>i</sub> > 10<sup>3</sup>. According to Ecological Code of the Republic of Kazakhstan of January 9, 2007 No. 212 with amendments and additions of April 28, 2016, Article 40 the food enterprise object "ALMA" refers to the enterprises of the IV hazard category.

## Conclusions

The development of EIA for food enterprise "ALMA" is being carried out for the first time. The main activity of the enterprise is cooking food, making bakery products for realization to the public. According to the inventory, during the operation of "ALMA" enterprise, seven sources of pollutants were identified, combined into two sources of ambient air pollution: organized - 1 (source of contamination No 0001 - cooking) and unorganized - non-normalized - 1 (source of pollution No 6002 - vehicles, coming to the territory of the industrial platform).

When operating the food company ALMA, the main pollutants emitted into the air atmosphere are: dustflour (code of pollutant 3721), ethyl alcohol (1061), acetic acid (1555), acetaldehyde (1115), ammonia (0333), propionic aldehyde (1314), sodium hydroxide (0150), acrolein (1301), freon-22 (0859), benzo (a) pyrene (0703), carbon black (0328), formaldehyde (1325), alkanes C12-C19 (2754), nitrogen dioxide (0331), carbon dioxide (0337) and sulfur dioxide (0330).

The boundaries of the dispersion of harmful substances in the conditions of the location of the business entity "ALMA" and the meteorological conditions of Almaty city megalopolis are determined. It was shown that propionic aldehyde, emitted during the preparation of food products in an amount exceeding the regulatory requirements (0.0114 mg/m<sup>3</sup>), is dispersed within the MPC limits (0.01 mg/m<sup>3</sup>) until reaching the boundaries of nearby residential buildings without harming people's health. The background concentration of carbon dioxide

$C_m$  0.03 mg/m<sup>3</sup> (MPC - 0.07 mg/m<sup>3</sup>) and nitrogen dioxide -  $C_m$  0.0069 mg/m<sup>3</sup> (MPC 0.0085 mg/m<sup>3</sup>) fluctuate within the limits of MPC. According to the Article 40 of the Ecological Code of the Republic of Kazakhstan the object food enterprise "ALMA" treats to the food enterprises of the IV category of danger.

For the ALMA enterprise it is recommended to carry out planned control over emissions in the atmosphere directly on sources. Control is made once a year at the maximum load of the equipment specialized laboratory. The organization of control service over emissions of pollutants at the enterprise is assigned to the director.

Also it is recommended to hold a planed control over sources of atmospheric air pollution, which should include:

- initial accounting of the types and quantities of pollutants emitted into the atmosphere;
- reporting on harmful effects on atmospheric air by forms and in accordance with instructions approved by the State Statistics Committee of the Republic of Kazakhstan.

The production control over sources of pollution of atmospheric air is carried out by service of the enterprise.

When monitoring a compliance with the maximum permissible emission (MPE) standards, the main ones should be direct methods that use measurements of the concentration of harmful substances and the volume of the gas-air mixture after gas treatment plants or in the areas of direct release of harmful substances into the atmosphere. At the "ALMA" industrial platforms, the proposed emission standards for pollutants can be normalized as MPE.

Under unfavorable meteorological conditions (UMC), that is, during periods of strong inversion of temperature, calm, fog, the enterprise is obliged to implement temporary measures to reduce emissions into the atmosphere. Activities are carried out after receiving a warning from Kazhydromet subdivisions, which indicate: the expected duration of UMC, the multiplicity of increase in surface concentrations relative to actual conditions.

In view of the insignificance of the emission values at this enterprise, it is proposed to implement (if necessary) a set of measures for the first regime. Activities under the 1st regime are organizational, technical and preventive, they can be implemented without reducing the amount of work, and they do not require special expenses.

The main events for the 1st mode for the purpose of emissions reduction in the period of UMC for this enterprise are:

- maintenance of the technological equipment in a proper condition and regular carrying out scheduled preventive works;
- carrying out damp cleaning of the territory and production rooms;
- continuous control over observance of requirements of safety measures and labor protection;
- strict observance of fire safety regulations.

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