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Odour emissions from agricultural industries – implications for environmental safety and local sustainability

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ABSTRACT

Environmental pollution is a critical global issue with profound impacts on human health, genetic potential, and climate change. The Lancet Commission on Global Mental Health reports that approximately 9 million premature deaths each year are attributed to environmental pollution worldwide. Ukraine ranks among the highest of 120 countries in terms of deaths per 100,000 people caused by atmospheric air pollution. Notably, elevated levels of atmospheric pollution have been recorded not only in traditionally industrial regions. These alarming statistics underscore the deteriorating state of environmental security and highlight the urgent need to mitigate climate change. One critical gap in Ukrainian environmental legislation is the absence of regulations concerning the assessment of odors as pollutants. Odor-related emissions, despite being a primary cause of public complaints regarding air quality, remain outside the scope of state management and control. This research seeks to address this gap by investigating the causes and dispersion of odorous compounds, with a specific focus on emissions from oil extraction production—an important sector of Ukraine's agricultural industry. Considering odors as a significant factor is crucial in the planning, construction, and sustainable development of human settlements. Odor perception thresholds are often lower than the maximum allowable concentrations of pollutants, emphasizing the necessity of incorporating odorous substances into environmental impact assessments. The methodology employed in this study is robust and adaptable, making it applicable for assessing air pollution levels and evaluating the harmful effects of odorous substances on both the environment and public health.

Keywords: odorous substances, air pollution, agricultural processing industries, emission, sustainable development, decision-making support.

INTRODUCTION

Atmospheric quality is a critical determinant not only for human well-being but also for the survival of the species as a whole [Vilcins D. et al., 2020]. While humans can survive for weeks without food, days without water, survival without air is limited to mere minutes, highlighting the vital importance of air quality. Numerous advanced studies emphasize the significance of maintaining air quality, both in the operation of industrial facilities and in the planning and development of settlements. These issues are integral to the sustainable development of local communities [Tibbetts JH., 2015].

Research has shown that air pollution significantly affects human health, contributing to respiratory and cardiovascular diseases, stroke, and cancer [Fuller BEng R. et al., 2022; CDC, 2024]. Additionally, air pollution plays a major role in environmental degradation, driving climate change, acid rain, and damage to ecosystems [Pyrikov

O. et al., 2022; Vandyck T. et al., 2022]. Studies on air quality have explored a variety of aspects, including pollution sources, health and environmental impacts, and policy strategies to reduce air pollution. For example, some researchers have analysed hospital admissions, mortality rates, and the prevalence of respiratory and cardiovascular diseases to understand the health impacts of air pollution [Popov O. et al., 2020; WHO, 2022]. Modelling tools have also been employed to estimate atmospheric pollutant levels and identify pollution sources [Landrigan PJ. et al., 2018].

Further research has examined the relationship between air pollution and climate change, investigating the role of air pollutants in trapping heat and contributing to global warming [Hong C. et al., 2019]. The impact of climate change on air quality has also been studied, with particular focus on changes in temperature and precipitation patterns that influence pollutant formation and dispersion [Hassan NA. et al., 2016].

Quantifying the impact of air pollution on human health typically involves epidemiological studies, modeling, and risk assessment techniques [Chumachenko S. et al., 2023]. These methods estimate the burden of disease caused by air pollution by calculating premature deaths, hospital admissions, and other health outcomes [Bahrami Asl F. et al., 2018]. This body of research underscores the importance of monitoring and improving air quality to protect both human health and the environment. By identifying pollution sources, quantifying health and environmental impacts, and developing effective mitigation strategies, researchers and policymakers can contribute to a sustainable future for communities and the planet.

Air quality regulation and control vary across countries, primarily through the establishment of maximum permissible concentrations in specific areas or emission sources [EN 13725:2022; ASTM E679-04]. An additional effect of air pollutants, such as odor formation at low concentrations, can have a significant negative impact. The threshold for human odor perception—the concentration at which an odor is detectable—depends on the nature of the substance and varies widely [Piringer M. et al., 2021; Diaz C. et al., 2019].

Odor quantification through the olfactometric method is standardized in the European Union (EU Standard EN 13725:2003), where odor concentration is measured in odor units (ou_E/m^3). However, this method has limitations due to variations in individual odor perception and the difficulty of selecting a representative study group. The human sense of smell can detect trace amounts of specific substances that may not be captured by instrumental methods.

Several studies have highlighted the challenges of odor perception and measurement. Smith et al. (2018) explored the discrepancies between subjective odor assessments and instrumental measurements, noting significant variation in odor sensitivity among individuals. Johnson et al. (2020) identified difficulties in selecting representative groups for odor assessments in industrial settings due to individual variations in perception thresholds, complicating the development of universal odor standards. Brown et al. (2019) provided a comprehensive review of odor assessment methodologies, emphasizing the limitations of instrumental measurements and the importance of accounting for individual differences in odor perception.

These studies demonstrate the inherent challenges in quantifying odors due to individual perception variability and the limitations of instrumental methods. Recognizing these challenges is essential for developing effective odor management strategies and regulatory frameworks.

Traditionally, olfactometric methods involving human evaluations have been used to assess odor concentrations. However, advancements in technology have introduced artificial sensors, such as electronic noses and gas chromatography systems with specialized detectors, which offer greater sensitivity and specificity [Ghasemi-Varnamkhasti M. et al., 2017; Mochalski P. et al., 2020]. These detectors are crucial for assessing the impact of specific substances on human olfactory perception, often surpassing the sensitivity of human senses. This is especially important when studying pollutant emissions from industrial facilities and their effects on human health. By accurately quantifying pollutant concentrations and comparing them to national standards and scientific data on odor thresholds, the potential risks to human health can be effectively evaluated.

Given the unique characteristics of odor perception and the specific geographic and environmental conditions of certain areas, it is essential to develop a universal approach for assessing pollution caused by chemical substances, particularly considering odor formation. In Ukraine, no practical methodology currently exists for detecting, distributing, and evaluating odor impacts, making this research highly relevant in the context of sustainable development and environmental safety. A clear example of such a situation is the long-standing complaints from residents of Mykolaiv (population: 250,000–500,000), who have reported deteriorating air quality near the study site since 2016. Residents have consistently cited unpleasant odors as the primary cause of their complaints, linking these odors to negative health effects such as poor general health, difficulty breathing, and elevated blood pressure. Despite the ongoing nature of these complaints, the issue remains unresolved.

This research focuses on the activities of a typical enterprise involved in grain and oilseed production, operated by LLC "X." Ukraine is the fourth-largest producer of sunflower seed oil globally, with an output exceeding 5 million tonnes in 2020 [FAOSTAT, 2021]. This high level of production emphasizes the need for specific research methods, regulations, and mitigation measures to protect the health and living conditions of local residents. The data obtained can serve as a basis for evaluating the acceptability of economic activity and for developing additional air protection and purification measures.

ASSESSMENT OF EMISSIONS SOURCES FROM OILSEED PROCESSING FACILITIES

The object of proposed study, LLC "X," is a facility involved in the production of grains and oilseeds, located within the industrial zone of a settlement (see Fig. 1). LLC "X" is engaged in the reception, storage, and processing of oilseeds, specifically sunflower and soybean, to produce a range of products, including vegetable oils, non-granulated and granulated meals (sunflower and soybean), granulated sunflower husks, soybean hulls, lecithin, phosphatide concentrates, oilseed sediments, and seed cleaning byproducts. The plant plays a crucial role in Ukraine's grain and sunflower oil logistics and transportation sector. With a processing capacity of 2,400 tons per day for sunflower seeds and 1,700 tons per day for soybean seeds, it should be classified as a significant industrial operation.

Pollutant emissions from LLC "X" originate from various production equipment involved in the reception, processing, storage, and transshipment of grain crops and oils, including waste

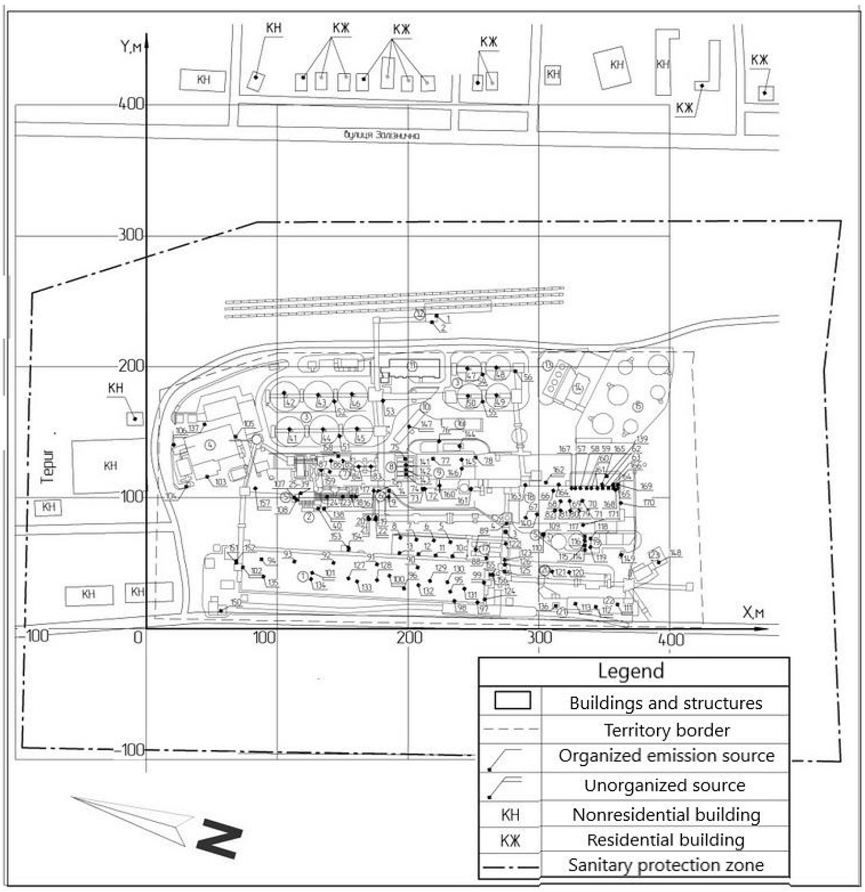

Figure 1. Map of the facility location with the designation of pollutant emission points

generated throughout the production cycle. The facility contains 171 emission sources, of which 137 are stationary and one is mobile. The primary sources of emissions include the seed elevator (comprising the raw material reception complex, seed cleaning and drying complex, and silage-type seed composition), the preparation and pressing workshop (including the shredding, fanning, and pressing sections with oil purification, and meal granulation), the extraction shop, the husk granulation shop, the phosphatide concentrate (lecithin) production line, the oil composition section, the meal and husk composition section, and the complex for the shipment of finished products. The facility's pollutant emissions were quantified through direct instrumental measurements and calculations in 2019, in accordance with national methodologies and the recommendations of the Ministry of Ecology and Natural Resources of Ukraine. These measurements and calculations followed regulatory documents such as [Governing Normative Document 211.2.3.014-95; Governing Normative Document 211.2.3.063-98], as well as state standards [State Standard of Ukraine 8725: 2017] and [State Standard of Ukraine 8726: 2017], industry guidance [Industry Guidance Document 34.02.305-2002], and the [Collection of Emission Indicators, 2004].

According to the analysis of permits and technical documentation, the activities of LLC "X" lead to the formation and emission of up to 500 tons of pollutants annually into the atmosphere. Volatile organic compounds (VOCs) account for 8.43% of total emissions under current conditions and 7.75% under planned activities. Long-term instrumental measurements have identified odor-forming substances, including acrolein (CAS No. 107-02-8), hydrogen sulfide (CAS No. 7783-06-4), and saturated hydrocarbons (C12-C19). The current air cleaning equipment at LLC "X" is primarily designed to remove particulate matter from aspirated air and is not effective at capturing VOCs (Table 1).

The proximity of the emission sources to residential areas (less than 200 meters) poses significant challenges for pollutant dispersion. Specific climatic factors, such as prevailing winds that direct emissions towards residential buildings, exacerbate the issue. The lack of natural vegetation as a protective barrier, combined with the presence of roads and railways between the facility and residential areas, increases the anthropogenic impact on residents.

METHODOLOGY OF THE RESEARCH

The research stages under which the study was conducted, are visually represented in the block diagram Fig. 2. The flow is divided into five stages, indicating the progressive structure of the study from determining objectives to identifying and prioritizing environmental safety measures. Each stage corresponds to a specific portion of the process, demonstrating the logical progression of the research. To assess the concentration of pollutants emitted from the facility and in nearby residential areas, field studies were conducted, with air samples collected from seven designated locations (Figure 2).

The following locations were selected for air sampling:
- T.1: Northeast, opposite the boiler house;
- T.2: East, between the administrative building and the railway;
- T.3: South, near treatment facilities and hexane reception site;
- T.4: Southeast, adjacent to the oil and lecithin tanks;
- T.5: Northeast, at the boundary of residential development, ~160 m from the facility;
- T.6: East, at the boundary of residential development, ~150 m from the facility;
- T.7: Southeast, at the boundary of residential development, ~150 m from the facility.

Laboratory equipment used

Proposed equipment are critical for ensuring the accuracy of air quality data at the sampling points, following the Ministry of Health of Ukraine's guidelines (2020):
- CM-2-CO-NO2-SO2 Gas Analyzer (for pollutant concentration analysis);
- digital thermometer (for temperature measurements);
- aneroid barometer (for determining atmospheric pressure);
- pumping device „Proba" (for air sampling);
- modelling of the spread of pollutants.

To model the dispersion of pollutants in the atmosphere, the OND-86 Methodology was applied, as approved by the State Hydrometeorological Committee of the USSR (1986). This methodology is designed to calculate surface-level pollutant concentrations within a two-meter layer above ground, as well as vertical distribution

Table 1. Pollutants emitted from stationary sources of LLC "X"

№	The name of the pollutant	CAS №	Danger class	Standard, mg/m3	Gross emission, t/year
1.	Iron oxide	1309-37-1	3	0.04	0.0053
2.	Manganese and its compounds	1313-13-9	2	0.001	0.0003
3.	Nickel oxide	1313-99-1	2	0.001	0.00001
4.	Chromium is hexavalent	7440-47-3	1	0.0015	0.00005
5.	Nitrogen dioxide	10102-44-0	2	0.04	64.329
6.	Ammonia	7664-41-7	4	0.04	0.024
7.	Sulfuric acid	7664-93-9	2	0.1	0.0012
8.	Silicon dioxide amorphous	-	-	0.02	0.00015
9.	Sulfuric anhydride	7446-09-5	3	0.05	148.564
10.	Hydrogen sulfide	7783-06-4	2	0.008	0.079
11.	Carbon oxide	630-08-0	4	3.0	85.754
12.	Hydrogen fluoride	7664-39-3	2	0.005	0.0001
13.	Fluorine	7681-49-4	2	0.04	0.0004
14.	Hexane	110-54-3	4	60	0.727
15.	Xylene	1330-20-7	3	0.2	0.045
16.	Ethyl alcohol	64-17-5	4	5	0.072
17.	Acrolein	107-02-8	2	0.03	0.175
18.	Acetic acid	64-19-7	3	0.06	0.008
19.	Solvent oil	-	-	0.2	0.090
20.	White spirit	-	-	1.0	0.045
21.	C12-C19	-	4	1.0	35.5258
22.	Solid substances	-	3	0.15	99.4528
23.	Emulsol	-	-	0.05	0.00002
Total (without greenhouse gases):					434.89853
24.	Methane	-	-	50.0	6.40723
25.	Carbon dioxide	-	-	-	74776.755
26.	Nitrogen (I) oxide	-	-	-	3.5528
Total (including greenhouse gases)					74786.715

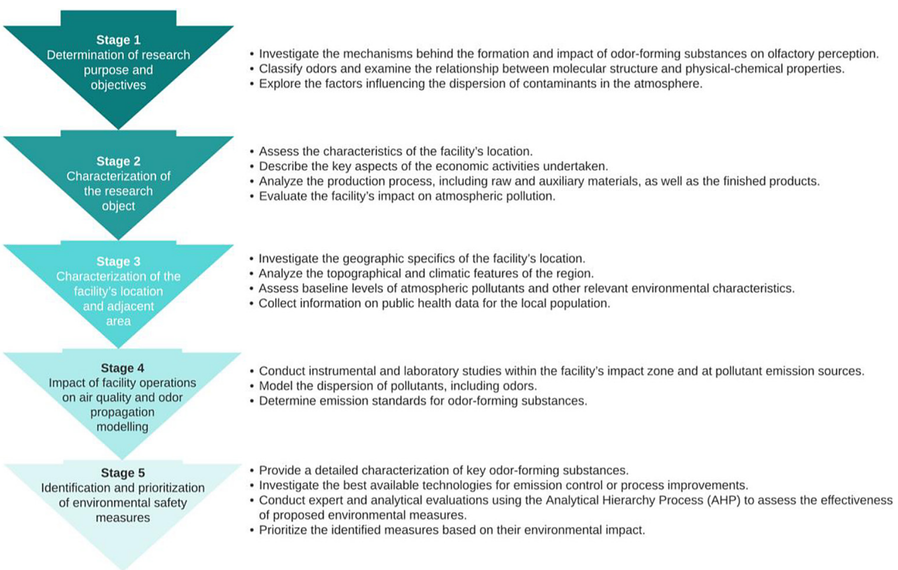

Figure 2. Block diagram for research stages

Figure 3. Situational map of the facility with sampling points

from stationary emission sources. It focuses on estimating maximum pollutant concentrations under the most unfavourable meteorological conditions, including unstable atmospheric states and critical wind speeds. A dimensionless topographic correction factor is integrated into the calculations. Despite its age, OND-86 remains the only methodology currently recognized by Ukrainian legislation for use in such analyses.

RESEARCH ON THE ENVIRONMENTAL CONDITION IN THE AREA OF THE FACILITY LOCATION

Research conducted by local environmental and sanitary-epidemiological services [Hryhorieva et al., 2018] indicates that the air quality in Mykolaiv, where the facility under study is located, exhibits exceedances of maximum permissible concentrations for several hazardous pollutants like formaldehyde, hydrogen fluoride, nitrogen dioxide, carbon dioxide, benzopyrene, and particulate matter. Exceedances are noted not only for average daily permissible concentrations but also for maximum one-time concentrations, refer to Table 2.

Notably, the simultaneous presence of formaldehyde (H_2CO) and acrolein (CH_2CHCHO) in the air can result in a synergistic effect, wherein each pollutant exacerbates the adverse effects of the other. This interaction can significantly increase the concentration of formaldehyde in the atmosphere, posing a substantial environmental risk to the city's population. Formaldehyde concentrations have been observed to exceed permissible levels by up to four times or more.

Formaldehyde poses a significant environmental threat to the city due to several factors related to its physicochemical properties and external influences, including:

- formaldehyde is a volatile organic compound characterized by a pungent odor. Its relatively short atmospheric lifetime means it can dissipate more quickly than some other pollutants, rendering its concentration susceptible to fluctuations influenced by various external factors;
- as a photochemical compound, formaldehyde undergoes chemical reactions in sunlight. During sunny conditions with increased solar radiation, formaldehyde can be generated through photochemical reactions involving precursor pollutants. Elevated temperatures can also enhance formaldehyde emissions from industrial processes, vehicular exhaust, and natural sources;
- increased transit of heavy trucks during spring and autumn can contribute to elevated atmospheric formaldehyde levels. These vehicles emit pollutants, including formaldehyde, as byproducts of fuel combustion or through the degradation of other organic compounds in their exhaust. The combination of heightened

Table 2. Concentrations of pollutants in the atmosphere [Department of Ecology and Natural Resources of the Mykolayiv Regional State Administration, 2019]

Target pollutant	Indicator	Ukrainian sanitary standards, mg/m³	Monitoring data, mg/m³		
			2016	2017	2018
Dust	daily	0.15	0.1	0.1	0.1
	one-time	0.5	0.5	0.5	0.4
Sulphur dioxide	daily	0.05	0.005	0.005	0.004
	one-time	0.5	0.015	0.029	0.028
Carbon monoxide	daily	3	1.0	2.0	1.0
	one-time	5	8.0	9.0	5.0
Nitrogen dioxide	daily	0.04	0.05	0.04	0.04
	one-time	0.2	0.16	0.19	0.17
Hydrogen fluoride	daily	0.005	0.003	0.003	0.003
	one-time	0.02	0.016	0.020	0.024
Formaldehyde	daily	0.003	0.012	0.013	0.014
	one-time	0.035	0.067	0.067	0.067

truck traffic and specific air circulation patterns in the city can lead to increased formaldehyde concentrations.

The proposed study analysed various factors that affect the distribution of pollutant concentrations resulting from emissions, including the facility's location, production technology, environmental impact assessment, climatic conditions, and physical geographic features (refer to Fig. 4).

The Sankey diagram above visualizes the factors affecting pollutant dispersion. Each of the key elements, including release mode and conditions, type of source, wind direction and speed, chemical interactions, gravitational sedimentation, and terrain relief, contributes to the overall process of pollutant dispersion. The width of the flows represents the contribution of each factor, demonstrating how these variables influence the spread of pollutants in the environment. This visualization helps emphasize the complex interactions between these factors, resulting in the overall impact on air quality. It is essential to recognize that the specific ranges or values associated with each factor will depend on the particulars of the study or analysis. The findings of this research may represent an important step toward designing information and technical methodologies for the sustainable development of urban

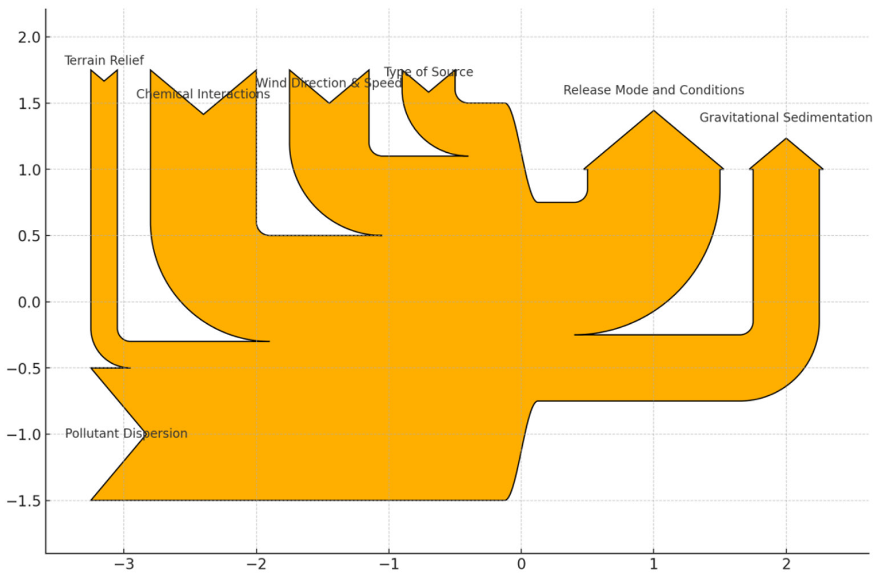

Figure 4. Visualization of factors affecting pollutant dispersion

settlements and preventing emergencies related to air pollution.

THE IMPACT ON ATMOSPHERE POLLUTION

To evaluate the presence and concentration of pollutants at the investigated site and nearby residential buildings, field studies were conducted at seven sampling points (see Figure 3) in April 2021. Analysis of the atmospheric samples revealed that pollutant levels exceeded the Ukrainian sanitary standards [Ministry of Health of Ukraine, 2024], particularly at sampling points No. 4 and 7. At these locations, the concentration of acrolein was found to be 1.23 to 3.1 times higher than the permissible standard of 0.03 mg/m³. Notable, no odour-causing pollutants, such as hydrogen sulfide (CAS No. 7783-06-4) or saturated C12-C19 hydrocarbons (CAS No. – not established), were detected in the collected samples. Additionally, to identify the primary sources of acrolein emissions, direct instrumental and laboratory measurements were performed in April 2021, based on the characteristics of the production processes and aspiration systems. The results are summarized in Table 3 below. To enhance the interpretation of the data, a statistical analysis was performed to provide a clearer understanding of the pollutant concentrations. Descriptive statistics for the acrolein concentrations measured at various emission sources were calculated:

- mean concentration across all sources – 1.23 mg/m³,
- standard deviation – 1.27 mg/m³, indicating significant variability in the concentrations between different sources,
- range – 0.20 to 3.71 mg/m³.

The results of the ANOVA ($p < 0.05$), which aim to determine whether there were statistically significant differences in acrolein concentrations between the various emission sources, indicate that there is a significant variation in concentrations between different points, particularly between the aspiration of cooler (3.71 mg/m³) and the other sources, such as the aspiration of granulation meal (2nd cyclone filter, 0.26 mg/m³).

In summary, the field studies revealed elevated concentrations of acrolein at specific sampling points, exceeding the approved standards. Statistical analyses, including descriptive statistics and hypothesis testing, further reinforce the finding that acrolein concentrations were significantly higher at certain points. However, no additional odor-forming pollutants were detected either in the atmospheric samples or in the direct measurements taken at the emission sources.

Modeling of odor spread

The OND-86 methodology was used to model pollutant dispersion in the area influenced by the facility. This method calculates surface-level concentrations within a two-meter layer and vertical dispersion from stationary sources under unfavorable meteorological conditions. Using data from pollutant sources and local climate, the model produced annual average dispersion data for acrolein (see Fig. 5). The results show that acrolein emissions from LLC "X" do not significantly threaten air quality near residential areas. However, additional pollution sources, such as nearby railways and roads, increase the risk of air pollution in these areas. The modelled acrolein concentration (0.07–0.11 mg/m³) is below the WHO human perception threshold of 0.007 mg/m³ and within permissible limits for exposure.

Table 3. Results of pollutant measurements directly on pollutant sources (in aspiration systems), based on national methodology for gas and industrial emissions measurements [Methodology No. 081/12-0571-08]

Sample number (emission sources)	Name	Concentration (max.), mg/m³
Aspiration of oil filter drying	Acrolein	3.07
Aspiration of granulation meal (1st cyclone filter)	Acrolein	0.44
Aspiration of granulation meal (2nd cyclone filter)	Acrolein	0.26
Aspiration meal granulation (ordinary cyclone)	Acrolein	0.5
Aspiration of presses and after cyclone № 1	Acrolein	0.43
Aspiration presses and presses after cyclone #2	Acrolein	0.2
Horizontal air conditioner	Acrolein	1.07
Aspiration of cooler	Acrolein	3.71
Aspiration of husk granulation	Acrolein	not specified

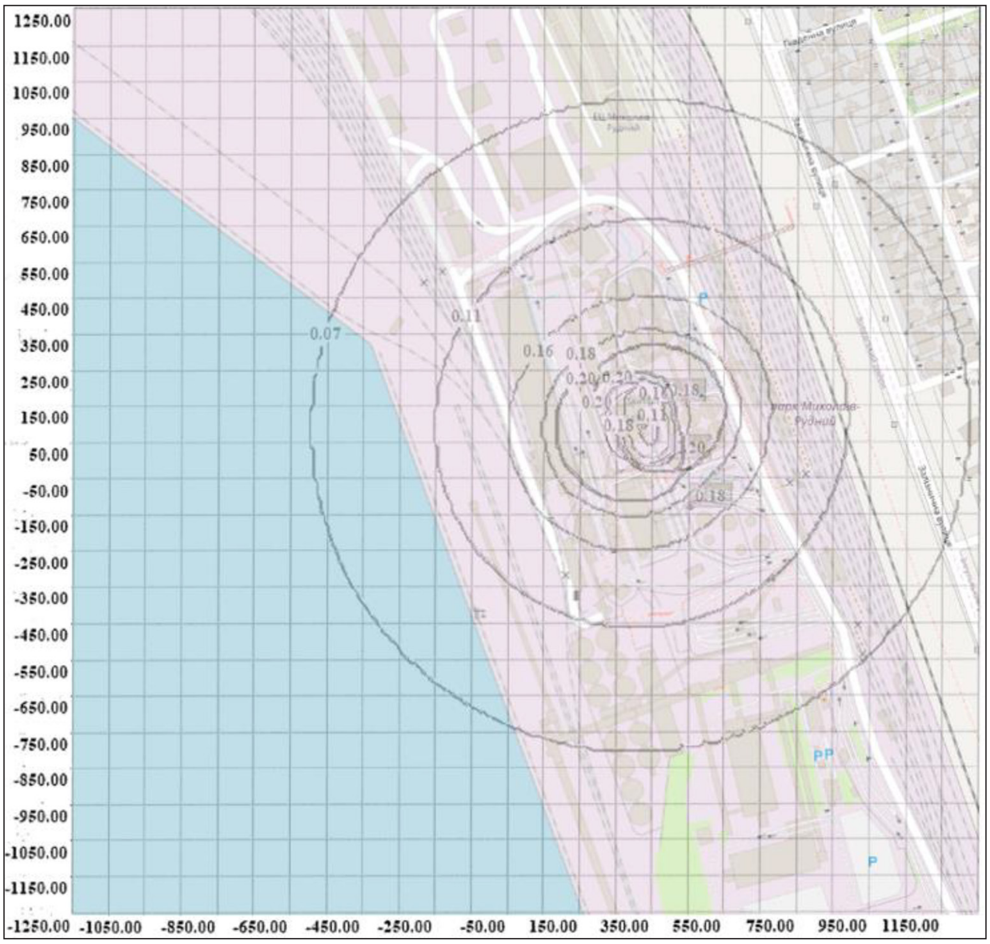

Figure 5. Dissemination of acrolein from LLC "X"

Further analysis confirmed the model's reliability, even under variable meteorological conditions, ensuring accurate predictions of pollutant levels.

DETERMINING THE PRIORITY OF IMPLEMENTATION OF ENVIRONMENTAL PROTECTION MEASURES

Environmental protection measures are essential for preventing and mitigating negative human-induced impacts on the environment. To safeguard the atmosphere from pollution caused by emissions from the technological equipment of LLC "X," several measures have been proposed to ensure compliance with maximum permissible concentrations and minimize emissions. These measures include:

- compliance with technical regulations and fire safety requirements,
- ensuring equipment tightness,
- increasing the height of air ducts in aspiration systems to enhance the dispersion of pollutant emissions below permissible concentrations,
- implementing systematic control of pollutant emissions,
- utilizing modern, efficient, and environmentally friendly equipment, as well as dust and gas cleaning devices in production processes,
- conducting regular preventive inspections of the equipment's technical condition,
- landscaping the enterprise's territory and adjacent areas.

The challenge of determining the priority of these environmental protection measures can be analyzed using a structured set of criteria. The Analytic Hierarchy Process (AHP) method, which decomposes the problem into simpler components and facilitates pairwise comparisons, was employed for criteria identification and evaluation. Previous works by the authors [Honcharenko I., et al. 2020; Honcharenko I., et al. 2021] have demonstrated the application of AHP in multi-criteria assessment and environmental safety management.

Due to the extensive calculations involved, this research will present only the finalized part of the analysis. The hierarchical representation of the studied issues is illustrated in Figure 6, showcasing the components of environmental safety in the atmosphere and the prioritization of environmental protection measures.

According to the results of the expert analytical research, the highest priority among the proposed measures to enhance environmental safety for LLC "X" is assigned to C1 "Purification of Aspiration Air," with a weight of 48% among all proposed measures. The next most significant measures are C3 "Creation of Forest Protection Plantations" and C6 "Monitoring and Control," with priorities of 25% and 18%, respectively. C5 "Economic (Compensatory) Measures" is identified as the least significant, with a priority of 1%.

This prioritization aligns with both national and global environmental standards, as monetary payments alone cannot effectively address environmental pollution issues and do not incentivize the adoption of the best available technologies.

REGULATION OF EMISSIONS OF ODOR-FORMING SUBSTANCES

When developing a system for regulating odors, it is logical to adopt an approach similar to that used for regulating pollutants. However, it is crucial to note that while permissible pollutant concentrations are typically measured in milligrams per cubic meter (mg/m³), odor standards are quantified in odor units per cubic meter (ouE/m³). The unit "ouE" denotes the odor concentration detectable by 50% of volunteers in a given study. Testing the aforementioned method for establishing allowable concentrations of odor-forming substances and determining odor standards in the atmosphere (ouE/m³) has revealed that using the ouE16 value, which corresponds to a 16% detection threshold, results in extremely low normative values for odor concentration (less than 1 ouE/m³). Such low odor standards are rarely utilized in other countries due to the challenges in achieving and monitoring them.

In European countries, odor standards are not fixed at the national level but are instead established based on the source and nature of the odor, taking into account factors such as the volume of complaints from the public and the characteristics of specific areas. Generally, in developed nations, atmospheric odor standards based on dispersion modeling typically range from 2 to 15 ouE/m³. Local odor standards should be established for areas adjacent to enterprises that emit odorous substances negatively impacting the population. In setting these normative values, it is essential to consider factors such as population density, the significance of the enterprise to the region, public complaints regarding unpleasant odors, meteorological conditions, and the results of odor dispersion calculations.

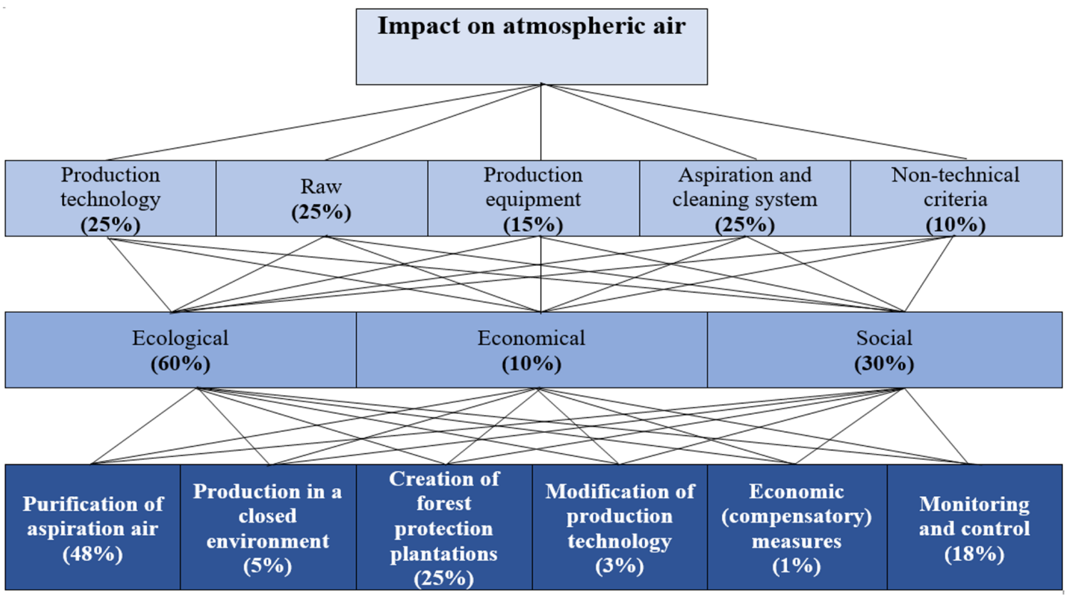

Figure 6. Hierarchy of atmosphere safety components with protection measures priority

By comparing these results with the locations of residences from which the majority of complaints originate, it is possible to delineate the influence zone of odor emissions and adjust the calculated odor standard to mitigate the volume of complaints from residents outside the regulatory concentration isoline.

CONCLUSIONS

The findings of this research yield several important conclusions regarding odor emissions from agricultural industries, particularly in the context of environmental safety and local sustainability. The average annual concentration of acrolein, an odorant emitted from stationary sources, ranges from 0.07 to 0.11 times the acceptable concentration, corresponding to 0.0021 to 0.0033 mg/m³. These values remain below the average threshold of human perception, set at 0.007 mg/m³. However, atmospheric samples collected near residential buildings indicate that acrolein concentrations exceed approved limits at specific sampling points (No. 4 and 7), with values ranging from 1.23 to 3.1 times higher than the permissible norm of 0.03 mg/m³. This discrepancy raises significant concerns about air quality in those areas.

Furthermore, the analysis reveals elevated levels of formaldehyde, a carbonyl compound with similar physicochemical properties to acrolein, which may contribute to cumulative impacts on air quality. While the data suggest that acrolein emissions from production sources alone do not pose an immediate threat to air quality near residential buildings, external factors – such as proximity to railways and roads – introduce a documented risk of atmospheric pollution affecting local populations.

It is essential to note the limitations of this study. The research was conducted within a specific geographical context and timeframe, which may limit the generalizability of the findings to other regions or longer-term trends. Additionally, the sample size may not fully represent the diverse conditions across different agricultural sectors in Ukraine. Methodological constraints, including the reliance on specific analytical techniques, could introduce variability in the data. Moreover, the analysis primarily focuses on acrolein and formaldehyde, potentially overlooking other significant odorants that may also impact air quality.

Using the Analytic Hierarchy Process "purification of aspiration air" was identified as the highest priority measure for enhancing environmental safety in the target oilseed production facility. Other significant measures include the creation of forest protection plantations and monitoring and control efforts, while economic (compensatory) measures were ranked as the least significant, with a priority of 1%.

Legislative regulation and practical research on the impact of odors are essential for the effective planning and development of settlements, as odors significantly influence the quality of life for local populations. These findings emphasize the need to address odor pollution and implement measures to mitigate its impact on the environment and public health.

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