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ANALYSIS OF ATMOSPHERIC AIR OF POLTAVA CITY

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Purpose. To assessment the air pollution from stationary sources of Poltava industrial emissions according to the calculations substances in surface air that carried by the program EOL - 2000(h), materials from stationary site observations and inventory reports of emission sources. *Methodology.* We have collected, processed and performed a comparative analysis of calculations by computer programs EOL - 2000 with observations of air at stationary sites "POST-2A" and calculation of pollution index. Consequently we have used materials of inventory reporting of pollutant emissions from stationary sources and substantiating documents for emission allowances; statistical reporting forms for 2013; materials which have provided by observation laboratory of air pollution of Poltava Center of Hydrometeorology; calculation results of pollutants in surface air that carried by the program EOL-2000. *Results.* We have examined 195 enterprises that represent 3686 emission sources. We have conducted assessment of air using EOL-2000, conducted a comparative analysis of data from stationary site observations. *Originality.* For the first time we have obtained cartographic materials, namely dispersal maps, of concentrations of 196 pollutants and 21 summation groups. As a result we have matter and determined area of the city where the observed excess of regulatory indicators. *Practical value.* The results of the study have allowed set number of conclusions about the state of the surface air and determine their further use in research, forecasting of air quality and improving the environmental situation of the atmospheric environment of the city, for example for modernization of enterprises, improving the technologies of these enterprises and creating additional recreation areas. *References 5, tables 2, figures 2.*
Key words: air condition, pollution, system EOL – 2000, stationary site and control station, dispersal map.

АНАЛІЗ СТАНУ АТМОСФЕРНОГО ПОВІТРЯ М. ПОЛТАВИ

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Для міста Полтави досліджено 195 підприємств, що являють 3686 джерел викидів. Загальна кількість визначених забруднюючих речовин складає 196. Методологія наукового дослідження ґрунтується на збиранні, обробці та порівняльному аналізі результатів розрахунків програми ЕОЛ – 2000 з даними спостережень за станом атмосферного повітря на стаціонарних постах «ПОСТ-2А», розрахунку індексів забруднення атмосфери. Наукова новизна отриманих результатів полягає у тому, що для міста Полтави вперше отримано картографічні матеріали концентрацій 196 забруднюючих речовин і 21 групи сумації. Визначено речовини та район міста, де відзначено перевищення нормативних показників. Результати роботи дали змогу встановити ряд висновків щодо стану приземного шару повітря, та визначити їх подальше застосування в дослідженнях, прогнозуванні стану повітря та покращенні екологічної ситуації атмосферного середовища міста.
Ключові слова: стан атмосферного повітря, забрудненість, система ЕОЛ – 2000, пости спостережень та контролю, карти розсіювань.

PROBLEM STATEMENT. The strategy of sustainable development was declared like priority area of future development of Ukraine. Ecological component is an essential part in it. Its importance in national policy lay down by law of Ukraine «On Basic Principles (strategy) of the State Environmental Policy of Ukraine till 2020» [1]. The achievement of safe condition of environment for human health (strategic goal №2) is one of the key strategic goals. This is also important for Poltava region [2].

The methods of assessment of air condition in Ukraine and some others countries were considered in this research. The condition of air pollution in Poltava city from stationary emission sources was defined. 195 enterprises that represent 3686 emission sources were studied. The total number of identified pollutants is 196 [3]. Methods to improve the state air are considered.

Presented topic is relevant because both ecological environment and human health depends on the air quality of the city.

The goal of the study is: the evaluation of the dispersion of pollutants in the surface layer of the atmosphere by using EOL-2000, materials from stationary sites, and by reports of inventory of emission sources. Also, the aim is to review possible areas of determination of scientific innovation of this paper.

EXPERIMENTAL PART AND RESULTS OBTAINED. Poltava city is one of the cleanest cities in Ukraine by expert estimates. Of course, everybody interested in the air quality in the city, which is its ecological condition of urboecosystem and whether it corresponds to the condition of sanitary and hygienic standards?

Air pollution is one of the major environmental problems of the city. Emissions have been stabilized a little in recent years.

Оцінка та прогнозування техногенного впливу на довкілля

The following materials were used for estimation of condition of air pollution in the city:

– the reports of inventory of emission sources from stationary sources. They received on the basis of direct instrumental measurements (materials of Department of Ecology and Natural Resources of Poltava Regional State Administration);

– permits for emissions of pollutants into the atmosphere for the enterprises of the city;

– plan of arrangements of stationary sources of emissions in the industrial enterprises;

– the emissions based on reports of state statistical observations of air protection by form 2-TP (air) for the current year.

The main polluting enterprises of atmospheric air of the city are the following: refuse - fired plant PJSC «Poltava-energy» (energetics), plants: PJSC «Poltava Turbomechanical plant» (PTMP), «Poltavahimmash», PJSC «Ltava», PJSC «Electric-motor», PJSC «Motor-aggregate plant», PJSC «Diesel Locomotive» (DL), locomotive and carriage depot (Ukrainian Railways), PJSC Medical glass plant, LLC «Burat», PJSC Oil Extraction plant Karnel-group (processing industry), factory PJSC «Poltavakonditer Demitex»,

«PoltavaTransBud», Poltava house-building factory, etc.

Systematic monitoring of air pollution level according to the program was conducted at 4 stationary sites "POST-2A".

Existing network of monitoring stations has left essentially unchanged for the reporting period (2014).

Numbers and address of observation sites:

SS №1 – av. Pershotravnevyi, 20
SS №3 – Zinkovskaya street, 2
SS №6 – Kalinin street, 45
SS №7 – Zavodska street, 1
№5 – sector of meteorological observations Poltava Center of Hydrometeorology, Shvedska street, 84.

The sampling for contamination of harmful impurities produced by "full program" for 4 times a day for 10 ingredients, except dust, soluble sulfates, carbon monoxide [4].

Determination of heavy metals (SS №6) and benzopyrene on posts №3, №7 was conducted from total samples per month.

Characteristics of air pollution in the city, according to stationary sites are shown in the Table 1.

Table 1 – Characteristics of air pollution (mg/m³)

Impurities	MAC	Average concentration		Maximum concentration	
		2013	2014	2013	2014
Dust	0,15	0,2	1,3	0,9	1,8
Sulfur dioxide	0,05	0,004	0,08	0,019	0,05
Carbon dioxide	3,0	2	0,7	9	1,8
Nitrogen dioxide	0,04	0,035	0,98	0,19	1,25
Nitrogen oxide	0,06	0,025	0,46	0,11	0,3
Hydrofluoric acid	0,005	0,002	0,3	0,017	0,6
Hydrochloric acid	0,2	0,02	0,09	0,11	0,45
Hydrogen nitride	0,4	0,01	0,3	0,08	0,35
Formaldehyde	0,003	0,003	1,14	0,068	1,5

The increased content of formaldehyde – 2,5 MAC, nitrogen dioxide – 1,25 MAC, hydrogen nitride – 0,5 MAC was registered in August, and nitrogen oxide – 0,5 MAC was observed in summer. It is explained by hot weather (maximum was +33,7⁰C), and the annual average temperature was 1.9⁰C higher than normal, repeatability of wind speed was 0-1m/s (30-32%).

Regularity of seasonal changes in average monthly concentration is continued to be traced as in previous years. Contamination of sulfur dioxide and soluble sulfates increased exactly in the cold season. This is

related to higher emissions of fuel combustion products.

Average monthly concentrations of carbon monoxide – 0,7 MAC, hydrofluoric acid and hydrochloric acid are uniformly observed throughout the year and haven't exceeded MAC.

The results of observations annual average concentrations in dynamics for the period of 5 years (2010-2014) were summarized. It should be mentioned that tend to increasing of content most defining ingredients was growth (Table 2).

Table 2 – Change in the average level of air pollution (mg/m³) in the city

Impurities	2010	2011	2012	2013	2014
Dust	0,2	0,19	0,19	0,2	1,3
Sulfur dioxide	0,004	0,004	0,004	0,004	0,08
Carbon dioxide	2	2	2	2	0,7
Nitrogen dioxide	0,03	0,03	0,04	0,035	0,98
Nitrogen oxide	0,02	0,02	0,03	0,025	0,46
Hydrofluoric acid	0,002	0,002	0,002	0,002	0,3
Hydrochloric acid	0,02	0,02	0,02	0,02	0,09
Hydrogen nitride	0,01	0,01	0,01	0,01	0,3
Formaldehyde	0,004	0,004	0,004	0,003	1,14

The contamination by dust, nitrogen dioxide and nitrogen oxide a bit increased in comparison with previous years.

The degree of contamination of the air was set by the multiplicity of exceeding the actual concentration of pollutants of relevant MAC considering class of hazard.

Calculated index – it is relative values which characterize association between the actual concentrations of pollutants in the atmosphere, duration of their actions and hygienic standards of air quality. They also characterize the total value of air pollution.

In practice, their dimensionless concentration should not exceed 1, while at presence of several pollutants that have summation effect (adaptive action):

$$X = \sum_{i=1}^{n} \frac{C_i}{MAC_i} \qquad (1)$$

For several pollutants this index is calculated as follows:

$$X = \left(\sum_{i=1}^{n} I_i \right) = \sum_{i=1}^{n} \left(\frac{C_i}{MAC_{ш}} \right)^{\kappa_i} \leq 1 \qquad (2)$$

Ranking ecological air condition for classes is done by calculating the complex air pollution index.

Thus the class of ecological air condition is determined as follows:

Norm – <5;

Risk – 5-8;

Crisis – 8-15;

Disaster – >15.

Air pollution indexes (I_i) for separate polluters for the districts of Poltava city were calculated as part of this research [5].

For this the actual pollutant concentrations were normalized to the concentration of sulfur dioxide by using the coefficient taking into account hazard class of the ingredient.

Based on these data, the complex air pollution index for urban districts of Poltava city was found. It was done by adding the five major local indices values:

For Kyyivs'kyy district:

$I_A = 0.837 + 0.134 + 0.032 + 0.25 + 0.05 = 1.3$

For Oktyabrs'kyy district:

$I_A = 0.411 + 0.042 + 2.03 + 0.084 + 0.0489 = 2.61$

For Lenins'kyy district:

$I_A = 0.925 + 0.134 + 1.018 + 0.048 + 0.138 = 2.26$

The average air pollution index of Poltava city:

1. Nitrogen dioxide = $(0,0657/0,085)^{1,3} = 0,715$;
2. Sulfur dioxide = $(0,0188/0,5)^{1,0} = 0,0376$;
3. Carbon dioxide = $(0,408/5)^{0,9} = 0,104$;
4. Dust = $(0,803/0,5)^{1,0} = 1,606$;
5. Benzopyrene = $(0,38/5)^{0,9} = 0,098$.

The complex air pollution index of Poltava city:

$I_A = 0.715 + 0.0376 + 0.104 + 1.606 + 0.098 = 2.56$

So the atmosphere air each district and city as a whole can be called relatively clean, as the complex index of air pollution range from 1.3 to 2.61, well below the 5. The class of ecological air condition is determined as normal, this is a low level of pollution that has little effect on overall air pollution of the city and as a result,

does not cause a significant impact on public health and its performance.

Analysis of pollution conducted according to the calculations of dispersion of pollutants in the air under the program EOL-2000[h]. It is agreed upon by letter from 22.05.2003 № 5185/18-10 from the Ministry of Ecology and Natural Resources.

For the first time data for 3686 emissions sources were included for the calculation under the program. The total number of pollutants is 196 that form 21 groups of summation.

Calculation of the dispersion of pollutants in surface air showed that the excess observed in some areas of the city for dust not differentiated composition in 1,2 times; inorganic dust containing silicon dioxide 70-20% (fireclay, cement etc.) - in 5,2 times; inorganic dust containing silicon dioxide less than 20 % (dolomite etc.) in 7 times.

Data from the calculation of the system EOL-2000 were compared with data from monitoring the air pollution at stationary sites "POST-2A". This comparison showed that indeed according to both the calculations by EOL program and data from stationary sites, there is excess of dust in the air.

The program compiled dispersion maps of pollutants in surface air separately for administrative districts of the city based on the calculation results (Fig. 1).

Kyyivs'kyy district of the city is the most polluted. There is exceeding the MAC for 2 groups of summation and 7 pollutants, such as: nitrogen dioxide, formaldehyde, inorganic dust containing silicon dioxide 70-20%, feed mill dust, wood dust, grain dust, dust sunflower seeds. Exceeded by 3-contaminants is observed in the Leninsky district: inorganic dust containing silicon dioxide less than 20 %, feed mill dust and wood dust. Exceeded is not observed in Oktyabrs'kyy district. It is caused by not a significant industrial load on the territory of the district.
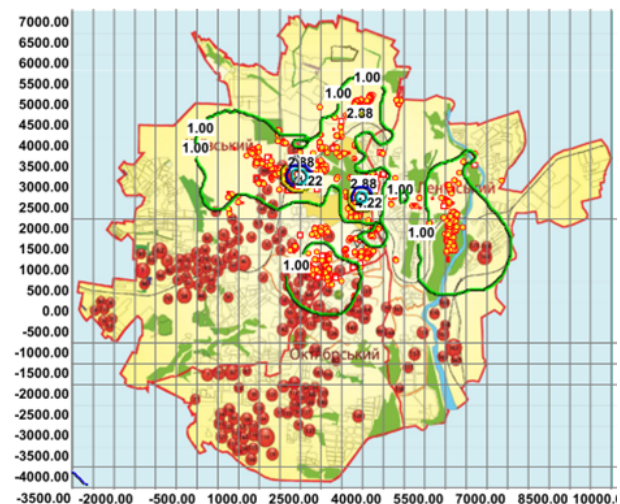

Figure 1 – Dispersion map of nitrogen dioxide

Using and establishment of modern dust and gas-purifying equipment at air pollution objects is one of the solutions. It is really an effective solution because currently only 18% of city emissions sources that are running with dust and gas-purifying equipment (Fig. 2).
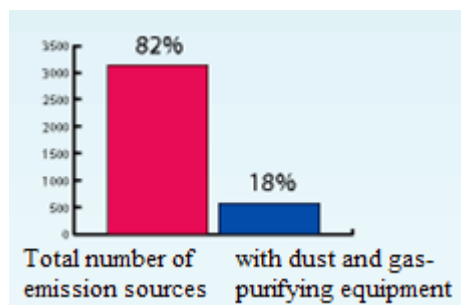
Figure 2 – Number dust and gas-purifying
equipment in Poltava city

CONCLUSIONS. Comparative analysis of the calculation by program EOL-2000 and data from observation stationary sites made to set:

- coincidence of results;
- the most excess of maximum allowable norms observed by inorganic dust containing silicon dioxide less than 20 %;
- Kyyivs'kyy district of the city is the most polluted (by nitrogen dioxide, formaldehyde and dust), as the district with the highest number of industrial enterprises;
- it should be mentioned that tend to increasing of content most defining ingredients was growth. The contamination by dust, nitrogen dioxide and nitrogen oxide a bit increased in comparison with previous years.

This enables to:

1) development of scientific methods for complex estimation and predicting of techno genic pollution impact on the environment and human;

2) use of models of environmental monitoring of regions, cities and individual ecosystems taking into account the available results;

3) determination of the main polluting enterprises, review each enterprise technology and design measures to reduce the impact on the atmosphere of the city;

4) use results in terms of industrial development. This means that the results make it possible to get a picture of the most profitable location for enterprises of any sphere of activity, to prevent excessive load on the air;

5) dispersion maps of pollutants determine the areas which most effectively for installing additional recreation areas (parks, etc.);

6) identify areas for additional monitoring of air pollution, for a more complete determines the specific emissions in the most contaminated areas (definition of time, quantity of the air at the maximum emission, etc.);

7) use the results to the research of correlation between pollutant emissions and morbidity of people.

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АНАЛИЗ СОСТОЯНИЯ АТМОСФЕРНОГО ВОЗДУХА Г. ПОЛТАВЫ

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Для города Полтавы исследовано 195 предприятий, представляющих 3686 источников выбросов. Общее количество определяемых загрязняющих веществ составляет 196. Методология научного исследования основывается на сборе, обработке и сравнительном анализе результатов расчетов программы ЕОЛ - 2000 с данными наблюдений за состоянием атмосферного воздуха на стационарных постах «ПОСТ-2А», расчета индексов загрязнения атмосферы. Научная новизна полученных результатов заключается в том, что для города Полтавы впервые получено картографические материалы концентраций 196 загрязняющих веществ и 21 группы суммации. Определены вещества и район города, где отмечено превышение нормативных показателей. Результаты работы позволили установить ряд выводов относительно состояния приземного слоя воздуха, и определить их дальнейшее применение в исследованиях, прогнозировании состояния воздуха и улучшении экологической ситуации атмосферной среды города.

Ключевые слова: состояние атмосферного воздуха, загрязненность, система ЭОЛ - 2000, посты наблюдений и контроля, карты рассеиваний.