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Monitoring and modelling of environmental pollution in the Southern regions of Ukraine

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SUMMARY

To model the situation with the emissions of air pollutants taking into account the identified trends of the emissions of air pollutants and the main impact factors, the approximation, smoothing dynamics and trend line of Microsoft Excel were applied to determine regression equations and check significance and accuracy of the built models. Statistical modelling of air pollution safety limits was applied as well. To determine the factors affecting emissions of air pollutants, the index of cross-correlation was used. It has been proven that the regional ecological condition impacted by the emissions of air pollutants depends on the priority types of economic activity.

Introduction

Today, environmental pollution is one of the main problems facing humanity. The world`s largest economies pay great attention to air pollution, because the atmosphere plays a major role in the global, regional and local transfer of harmful substances and environmental pollution. That is why air quality modelling and monitoring remain a priority. The problems of air pollution in the Southern regions of Ukraine have been studied. Further modelling of the emissions of harmful substances has been made.

Method

In the analysis, general-scientific methods (analysis and synthesis, induction and deduction) and special methods of phenomena and processes analysis (abstraction, econometric and econometric-mathematical modelling) have been used.

Results

Situation model for the region, and Zaporizhzhia and Energodar, which are the biggest sources of air pollution (Fig. 1) has been built based on data analysis of air pollution dynamics from the stationary sources of air pollution in Zaporizhzhia region, its cities and districts.

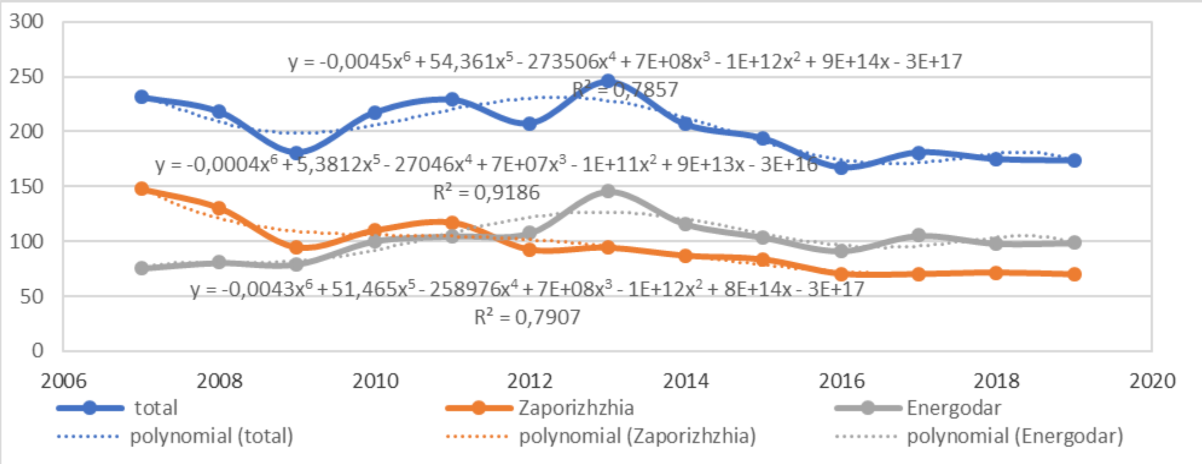

Figure 1 *Dynamics of air pollution forecasting in Zaporizhzhia region, the cities of Zaporizhzhia and Energodar (in thousands of tons)*

It has been found out that a six degree polynomial is the best tool to describe the process. The obtained values between 0,79 – 0,91 of the coefficient of determination, which is a measure of the dependence of variation in the dependent variable from the independent variables (illustrates the proportion of the variation in the dependent variable in the model) indicate that the model is correct. As one can see, the air pollution indicators` trend changes in Zaporizhzhia region is determined by the situation in Energodar, so it is the main regional "polluter", since the situation in Zaporizhzhia has improved since 2012.

Modelling results using statistical indicators of relative and cumulative frequency are shown in Fig. 2. The model takes into account that the emission values were most often reached between 2007 and 2019. They are the limits of the emissions values, which did not cause environmental disaster. Let us consider the level of reliability, which equals to half of the confidence interval for the general average of the air pollution volume rate and its growth rate, as the limitation to sustainable development of the ecological system of Zaporizhzhia region (Ukraine) for today. Calculations were verified by the assessment using confidence intervals for average values.

It has been determined that the acceptable emission values vary from 167.0 to 245.96 thousands of tons. Thus, recently the situation regarding the amount of emissions of air pollutants has been improved, as the lowest threshold of 186.74 thousands of tons was passed in 2016.

The trend line of Microsoft Excel was applied to model the situation of air pollution in Odesa region.

Data analysis of air pollution dynamics from the stationary sources of air pollution in Odesa region and the city of Odesa have been used to model the situation for the region as a whole and the main source of pollution – Odesa (Fig. 3).

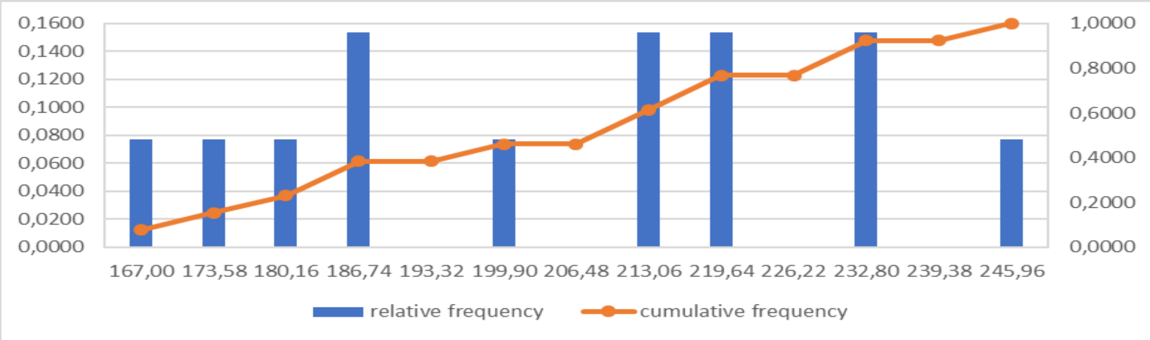

Figure 2 *Relative and cumulative frequencies of air pollution in Zaporizhzhia region from the stationary sources during 2007 – 2019s (in thousands of tons)*

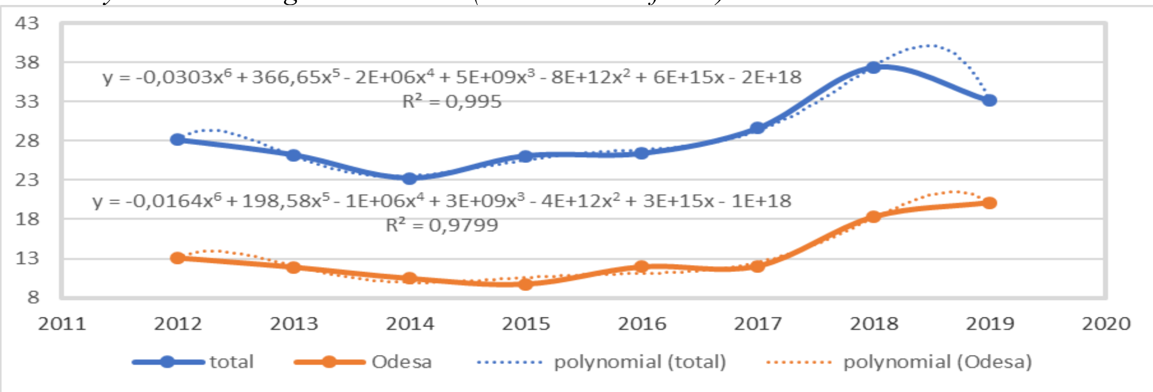

Figure 3 *Dynamics of air pollution forecasting in Odessa region and the city of Odessa (in thousands of tons)*

It has been found out that a six degree polynomial is the best tool to describe the process. The obtained values between 0,79 – 0,99 of the coefficient of determination, which is a measure of the dependence of variation in the dependent variable from the independent variables (illustrates the proportion of the variation in the dependent variable in the model) indicate that the model is correct. As one can see, the air pollution indicators` trend changes in Odesa region is determined by the situation in the city of Odesa.

Modelling of the situation in Kherson region was based on statistical indicators of relative and cumulative frequency. The results are presented in Fig. 4. The model takes into account that the emission values were most often reached between 2007 and 2019. They are the limits of the emissions values, which did not cause environmental disaster. Let us consider the level of reliability, which equals to half of the confidence interval for the general average of the air pollution volume rate and its growth rate, as the limitation to sustainable development of the ecological system of Kherson region (Ukraine) for today. Calculations were verified by the assessment using confidence intervals for average values.

It has been determined that the acceptable emission values vary from 5,30 to 25,34 thousands of tons. Thus, recently the situation regarding the amount of emissions of air pollutants has been improved, as the lowest threshold of 9,7 thousands of tons was passed in 2016.

The trend line of Microsoft Excel was applied to model the situation of air pollution in Mykolaiv region.

Data analysis of air pollution dynamics from the stationary sources of air pollution in Mykolaiv region and Vitovka district have been used to model the situation for the region as a whole and the main sources of pollution – Vitovska district and the city of Mykolaiv (Fig. 5).

It has been found out that a third degree polynomial is the best tool to describe the process. The obtained values between 0,89 – 0,98 of the coefficient of determination, which is a measure of the dependence of variation in the dependent variable from the independent variables (illustrates the proportion of the variation in the dependent variable in the model) indicate that the model is correct. A third degree polynomial was applied, because higher degree polynomials have coefficient of determination equal to 1, which is not acceptable for experimental data. As one can see, the air pollution indicators` trend changes in Mykolaiv region is determined by the situation in the city of Mykolaiv and Vitovska district (from 2016). The peculiarity of Vitovska district is its agro-industrial specialization. Number of people employed in agriculture and manufacturing is approximately the same – 2,500 people each.

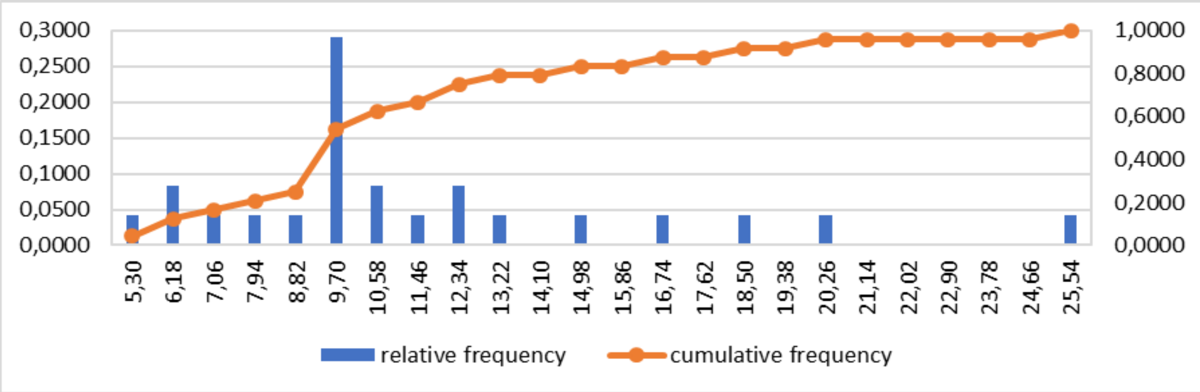

Figure 4 *Relative and cumulative frequencies of air pollution in Kherson region from the stationary sources during 2007 – 2019s (in thousands of tons)*

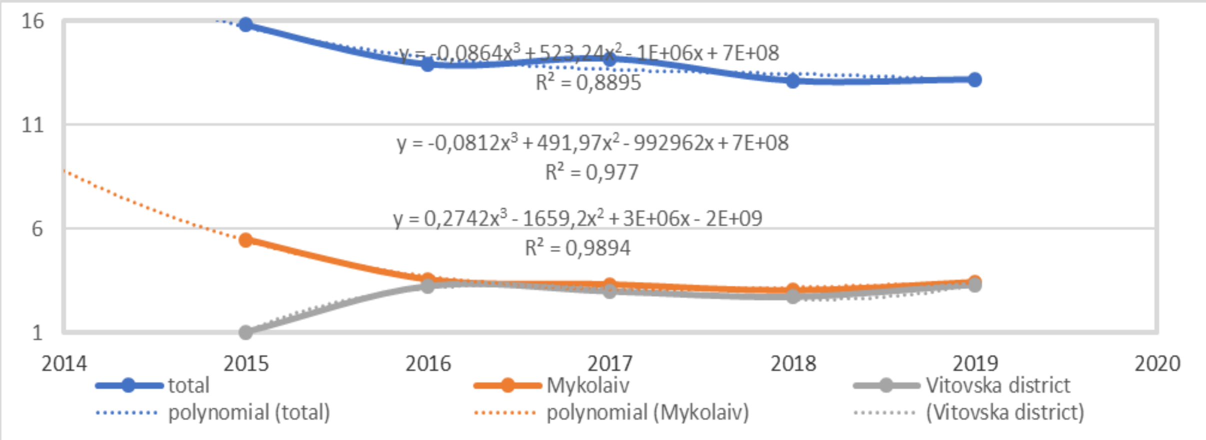

Figure 5 *Dynamics of air pollution forecasting in Mykolaiv region, Vitovska district and the city of Mykolaiv (in thousands of tons)*

There is dependence between the indicator of GDP, income per capita and emissions of air pollutants. To analyze relevant dependencies for the studied regions of Ukraine, the GRP per capita dynamics curves for Ukraine and Zaporizhzhia, Odesa, Mykolaiv and Kherson regions were built (Fig. 6).
As one could see, the index and its dynamics are just the same in Mykolaiv and Odesa regions.
A comparison of GRP per capita with emissions of air pollutants in the regions showed that the emissions` maximums correspond to 2011. Since 2015 both ecological condition and GRP per capita have significantly improved in both regions.
Zaporizhzhia and Kherson regions` situation significantly differs both in terms of emissions of air pollutants and GRP per capita rate: Zaporizhia region is at the head by both indicators, while Kherson region is behind.
A cross-correlation of emissions of air pollutants in Zaporizhzhia and Kherson regions was studied (Fig. 7)
During the studied period cross-correlation coefficient of GRP per capita and emissions of air pollutants from stationary sources in Kherson region has been growing, while in Zaporizhzhia region, after the peaks in 2014 and 2017, it almost has not been unchanged. This gives reason to assert that the nation`s well-being (GRP per capita) really affects the emissions of harmful pollutants.
Since 2014 GRP per capita has risen and emissions of air pollutants have fallen in Zaporizhzhia region. The situation is different in Kherson region: GRP per capita is much lower than in

Zaporizhzhia region; emissions of air pollutants do not have clear upward or downward trend, i.e. they fluctuate. Therefore, there is hope that higher GRP per capita in Kherson region will positively impact emissions (despite their small numbers). Thus, one can see, industrial regions (having significant emissions of harmful pollutants) affect general situation in the country.

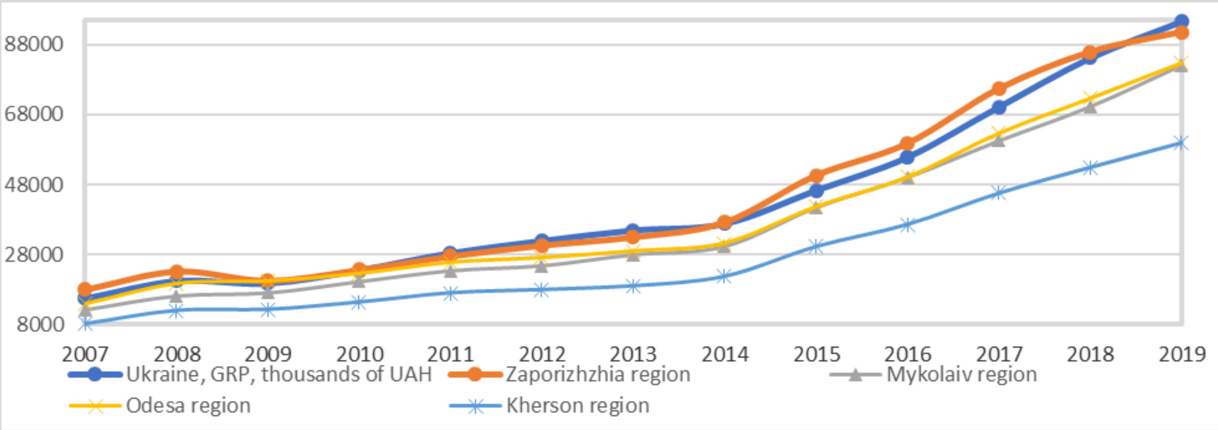

Figure 6 *GRP per capita dynamics curves for Ukraine and Zaporizhzhia, Odesa, Mykolaiv and Kherson regions during 2007 – 2019s*

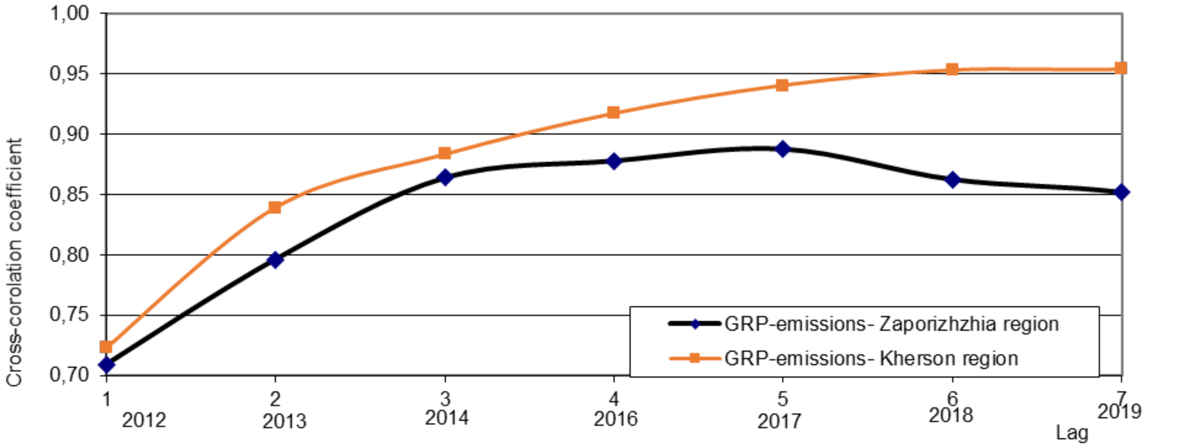

Figure 7 *Dynamics of cross-correlation coefficient (correlogram) of emissions of air pollutants and GRP per capita in Zaporizhzhia and Kherson regions*

Conclusions

Regional performance efficiency and income level are important impact factors too. That is why a number of Southern regions of Ukraine, which have different specialization, were studied: Zaporizhzhia and Odesa regions are industrial; Kherson and Mykolaiv regions are agrarian. The specialization causes different level of income (GRP per capita). Therefore, governance of the national economy structure and support of the appropriate level of income are considered to be key impact factors on the ecological condition in the regions and the country in general.

The studies of the magnetic properties of soils in Ukraine are promising for pollution assessment (Menshov et al., 2012) and Modeling of Recreation Systems (Arhipova et al., 2022).

Reference

Arhipova L., Vivichenko I., Kinash I., Horoshkova L., Khlobystov Ie. (2022). Theoretical Substitutional of Modeling of Recreation Systems. *Ecological Engineering & Enviromental Technology,* 23(5), 99-108.

Menshov, O., Sukhorada, A., Homenko, R., Kruglov, O. (2012). Ultradetailed Environmental Magnetic Investigations in Ukraine. *Near Surface Geoscience 2012-18th European Meeting of Environmental and Engineering Geophysics, European Association of Geoscientists & Engineers*, 306.