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SYSTEMIC MONITORING OF CHANGES ON ENVIRONMENTAL CONDITIONS USING QUALIMETRIC METHOD

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***Abstract:** The issues of using ecological structures associated with the naturalization of urban planning as a direction for improving the urban environment are considered in the given article. The naturalization of large-scale urban development areas has become a practically large-scale direction of urban development. The goal of this direction is to connect densely populated central areas of the city with green areas, a general system of landscaping. The method of digital quantitation assessment of the impact of phytomodules on the environment was considered using the qualimetric method. Using this method, a separate “property tree” was calculated for residential areas with a typical set of phytomodules. The computational part of the method is based on using following indicators: weight coefficient, background value, measurement result, factor indicators. These indicators were determined by measurement and analysis. The improvement of the environmental situation as a result of the influence of the active part of the phytomodule is characterized by the ratio of the background to the ecological potential.*

***Keywords:** Environment, naturalization of the urban environment, eco-structures, plants, ecological potential, qualimetric method*

INTRODUCTION

The environmental problems are currently becoming more and more pressing in Shymkent and many other regions of Kazakhstan. The vegetation of the city, especially its small areas, row plantings along the street crossings, is severely damaged by a whole set of negative factors. Soil compaction, water-air, mineral (salt) and temperature regimes are disturbed. This is due to the transport load, the influence of electromagnetic radiation, the need for nutrients in the soil, pollution with lead and other substances. In a city with a continental climate, conditions approaching desert conditions are often created [1].

The increase in car parks has had a negative impact on the ecological situation, surpassing all other factors of environmental pollution.

In Shymkent, preparations are underway to implement projects on the ecological naturalization of urban planning, as well as the planting of greenery along the foundations and roofs, the creation of environmentally friendly parking lots, the installation of advertising structures in the phytoecological sphere, etc. [2].

Real opportunity is created to construct phytobiocenoses with predetermined properties and a high degree of ecological compatibility in urbanized environments. Such phytobiocenoses include open and closed phytoactive modules, which are considered in this article.

The current world experience in urban planning provides for the following structural elements of buildings and structures consisting of green space elements: roofs, foundations, walls, noise protection structures, railway tracks, road pavements adjacent to local roads and urban utility structures.

The naturalization of urban planning is harmoniously combined with the concept of “environmental space”. Each landscape is a natural resource for urban planning. Urbanized landscapes are increasing, while the land area remains stable, its value due to only human economic activity increases. It is necessary to maintain the ecological balance between the urbanized and natural environment when designing urban areas.

The current modern urban planning strategy is aimed at creating new biopositive objects (buildings and structures, villages and cities), which are perceived as truly natural objects that fully or partially restore the anthropogenic impact of nature on humans. The urban ecology of districts and cities uses the idea of “sustainable development”, which provides for the same norms of consumption of non-renewable resources for each region and for each resident of the state, the maximum norms of global pollution, the norms of use of agricultural and urban lands, forests and other natural systems. Future generations will not be harmed by the amount of natural resources we are using by adhering to these standards.

MATERIALS AND METHODS

Assessment methods are based on systematic monitoring of changes in the environmental situation. Each of the criteria is evaluated in conventional units (physical measurements and points). The assessment is carried out by laboratory analysis or expert methods.

The general quantitative indicator characterizing the ecological quality of each settlement is obtained by adding up the indicators or by a numerical value taken as a coefficient criterion. At this stage, it is of great importance to determine the zero point of the calculation, that is, the natural, real or artificially accepted quality indicator, after which it changes under the influence of anthropogenic or evolutionary factors. This quality indicator of studied environment or environment is called background.

The most economical real indicators of the ecological situation of the environment are trees, lawn grass cover, soil, snow and other elements of the urban environment biocenoses. For each territory, certain criteria (usually about 10 or more) are selected for assessment, which characterize the purity of air, land, water, vegetation composition, flora and fauna richness, soil condition (drainage), and so on.

For ecological assessment and prediction, trees have significant advantages over other simulation models, since they are a recording structure of a sufficiently long-term interaction (100 or more years). The trees are filled with information on environmental problems for specific years through the current growth in their annual cycles.

Periodic accumulation of pollutants is characterized by leaves and tree branches. These indicators are subject to laboratory analysis. The State Environmental Protection Agency establishes the maximum possible concentration of harmful substances in the air, the “MPC” [3].

Natural ecosystems have the ability to self-clean from harmful waste. This process occurs until the pollutants are completely decomposed and are not released beyond the boundaries of the ecosystem.

The rate of self-cleaning is determined by the physicochemical properties of pollutants, certain characteristics of the environment that is part of the ecosystem (plant species, soil, water, air).

The following three levels of urban planning contribute to the self-cleaning (self-regulation) of a residential area:

- macrostructure, determined by the master plan, which indicates the presence of industrial enterprises, street, park systems, and green areas outside the city

- mesostructure, the location of green plantings and squares in relation to buildings, streets, and squares within the considered areas.

- microstructure, the location of individual elements of landscaping and their effectiveness from an ecological point of view.

Studies on the self-purification of the atmosphere were determined on the basis of systematic monitoring at stationary meteorological stations (Fig. 1) [4, pp. 101-112].

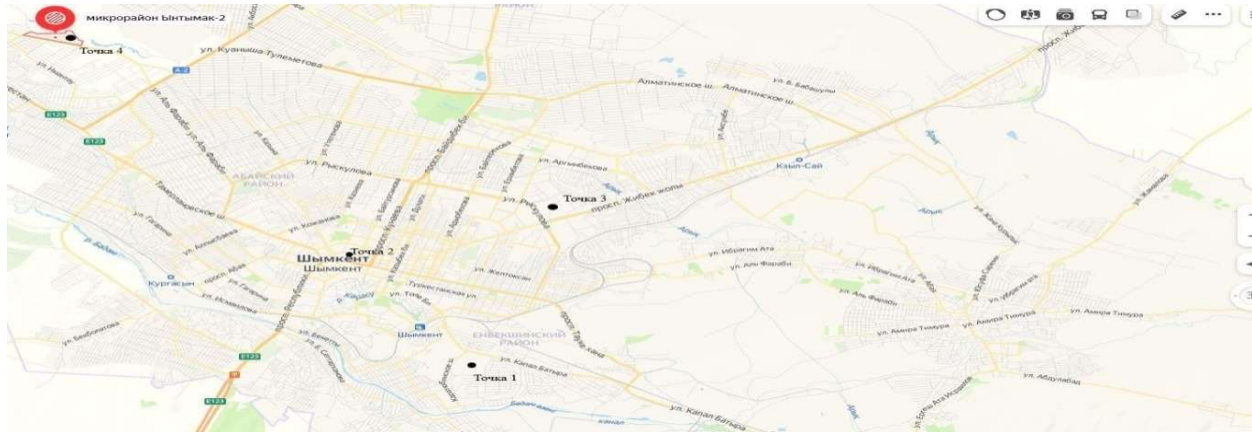


Figure 1. Location of stationary meteorological stations of Shymkent city. [4,101-112 p.]

Created by related authors

The waste of the enterprise, transport was selected as a measurement object. Separate units and methods of measurement were developed for each object.

As a unit of measurement, the average weight of given impurity (air, water, soil in the area) or the amount of impurity in a unit of volume is usually taken as the concentration of a certain impurity. In practice, this is mg/l in water, mg/m³ in air and mg/kg in soil. If pollutants emitted into the air or waste discharged into water are measured, then the unit of measurement is g per day or t per year.

As a unit of measurement of the object of study, the amount of substance consumed (released) during a certain standard process (time) can be chosen.

The variety of units of measurement of water and soil quality is greater than that of air, which is due to the greater consideration.

Each measurement is associated with errors (deviations) in the measurement process, which are regulated by standards and are characterized as measurement accuracy. Errors in the measurement process are classified into two groups: random and systematic. According to probability theory, they are mutually balanced. Systematic errors arise when using certain instruments, tools or measurement methods. These errors have the same sign and direction of accumulation. Let's consider an example of measuring the amount of one ingredient of air - nitric oxide in one m³ of air.

It is necessary to accumulate 1 m³ of air in a closed space (piston cylinder). It is necessary to release the air molecule by molecule through a small hole, and compress it, separating the nitric oxide and counting them. The accuracy of the proposed method is absolute, there is no error. However, during the calculation, several molecules can be passed and mixed with other molecules, for example, 5 out of 100 molecules can be passed or 105 can be counted instead of 100. In this case, the difference between the true values of this quantity is called the measurement error or measurement false. If x is precision measure, then t_s is the measurement result, y is the measurement error $y = y_a - x$.

The relative total error of measurements of the mass concentration of detectable substances in atmospheric air should not exceed +/- 25% according to the requirements of the State Standard of Environmental Protection. Thus, single changes in the concentration of impurities in atmospheric air are not of high accuracy. Even when selecting several samples, especially in urban conditions, it is impossible to draw conclusions about the state of atmospheric air after a single measurement. The concentration of impurities changes several times during the day (Fig. 2) [5, 84-89 p.]

It is necessary to conduct calculations at least 16 measurements with absolute accuracy each time to measure the average daily concentration of impurities in the atmospheric air of Shymkent with the accuracy required by the State Standard. If the error of a single measurement is 20%, then measurements should be carried out at least 24 times every hour.

It is true that the impossibility of promptly measuring hundreds of impurities in the natural environment and analyzing and summarizing the measurement results prompted specialists to search for general quantitative methods of assessment. This accuracy issue remains problematic in practically all environmental assessment methodologies.

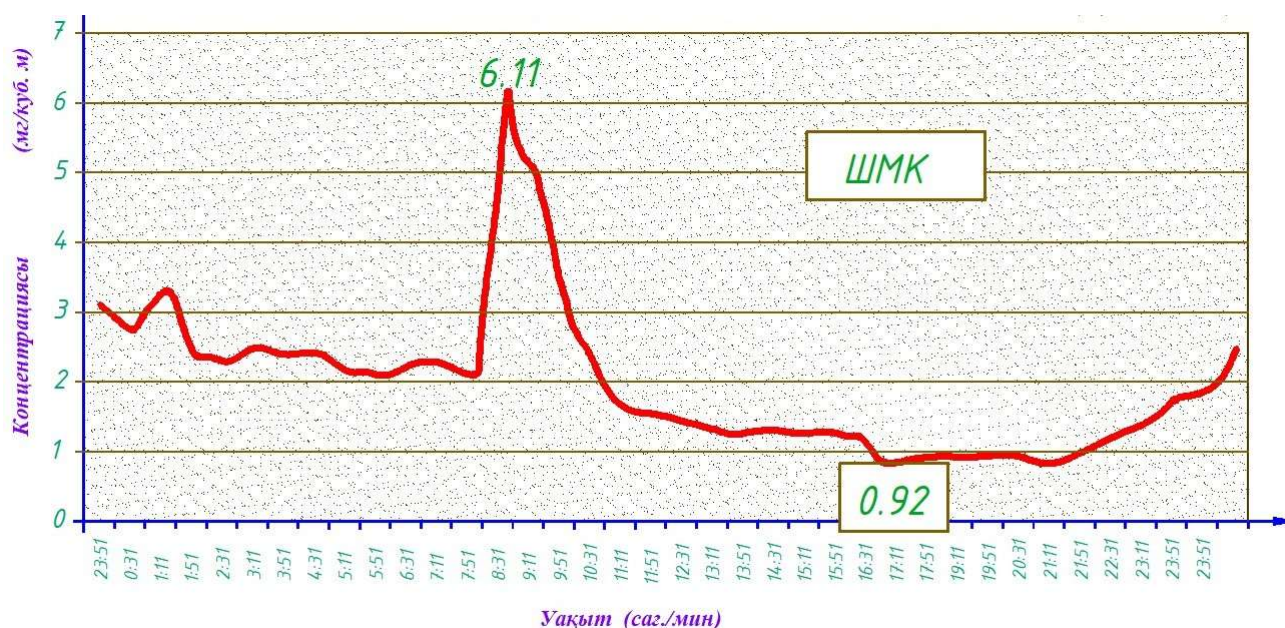


Figure 2. Dynamics of CO concentration in the atmosphere of the 6th microdistrict of Shymkent city.
Created by related authors [5, p. 84-89]

All assessments should be carried out according to a set of criteria and accepted methodology for processing the assessment results. The indicators obtained in the existing methodologies are compared with background values. This method is based on assessment monitoring.

Quantitative assessment of criteria is carried out by measuring environmental components that are subject to instrumental measurement. A number of properties can be described on the basis of formulas. Other criteria (properties) are evaluated in heuristic manner.

The expert assessment method is reliable enough for approximate assessment and is used in experimental studies to assess environmental characteristics. The assessment is carried out on a point system.

The practical application of the qualimetric assessment method begins with the construction of “property tree”, which is a set of complex and simple interconnected properties in the form of a multi-level structure.

The “property tree” is a type of grouping. The considered properties should characterize the impact of the phytomodule (phytoconstructions) on people considered at each level of the system.

The construction process of “property tree” is subject to a certain level of formalization, it cannot be programmed and carried out without human participation. The “property tree” is a continuation and deepening of the grouping of each property (criterion) to the level of quasi-simple properties that can be measured or assessed expertly. Quasi is used in complex sentences in the following meanings: nearly, approximately, close, not real.

The integral quality at the lowest level 0 is the ecological potential; at the highest-level N, simple and quasi-simple local properties are included. The accuracy of the final result is the quantitative summary assessment of the integral quality - largely depends on the correctness of the construction of the property tree. Therefore, the preparation of this stage is carried out with the greatest care.

When using expert assessment, psychophysical properties are taken into account, which make it difficult for a person to assess more than 7 groups of properties. It is advisable to assign each expert to assess the smallest number of properties - one or two. In this case, the accuracy of the assessment will be as high as possible.

The qualimetric method of property assessment allows to compare various dimensional values, which are obtained as a result of assessing the ecological conditions of residential areas. For this, the criterion weight coefficient, background and measured values, factor index and factor assessment are used according to the “property tree” [6,7,8].

The qualimetric assessment methodology and the sequence of work are considered on the example of assessing the ecological potential of phytomodule.

The qualimetric method of determining the ecological potential is considered on the example of phytoconstructive open module within the district territory with a set of phytoconstructions of following composition: vertical landscaping of individual buildings along the length, flower plantings, lawns with trees and shrubs.

Table 5. Qualimetric determination of the background value of considered photomodule

κ/ c	Name of criterium “property tree”	Assessment method	Measure- ment unit	Weight coefficient	Backgroun d value	Measure- ment results	Factor of indicator	Factor assessment
				W	B _v	R	I	F
1	Air quality improvement (O ₂)	to measure	%	0,139	21	21,09	1,004285714	0,139595714
2	Dust protection	to measure	gr/m ²	0,125	135	120	1,125	0,140625
3	Noise protection	to measure	1/dBa	0,097	40	35	1,142857143	0,110857143
4	Soil quality improvement	to analyze	point	0,089	3,5	3,5	1	0,089
5	Climate integration	Level 1 qualimeter	Conventio nal unit	0,105			1	0,105
6	Aesthetic integration	to analyze	point	0,18	3,5	3,5	1	0,18
7	Hygienic (therapeutic) air	to analyze	point	0,1	3	3	1	0,1
8	Environmental friendliness	to analyze	point	0,555	3	3	1	0,555
9	Benefits for birds	to analyze	point	0,27	3,5	3,5	1	0,027
10	Benefits for insects	to analyze	point	0,018	3	3	1	0,018
11	Social integration	to analyze	point	0,12	3,5	3,5	1	0,12
	Total			1,555				1,585077857

[9,112-125 б.] was made by related authors

The “Human friendliness” item is developed in five directions at the third level: soil quality improvement, dust protection, noise protection, climate integration, soil quality improvement. The items “dust protection” and “noise protection” are quasi-simple and are subject to physical measurements. The property - “soil quality improvement” is determined by the presence of oxygen, carbon dioxide and other impurities; the property - “climate integration” - determines wind speed, air humidity, solar radiation, temperature, ventilation (see separate qualimetric study, Table 6); the property - “soil quality improvement” determines the improvement of the mechanical and chemical composition, structure. These properties constitute the fourth level of the “property tree” and are considered quasi-simple.

The “property tree” of the phytomodule can be presented in the form of a table, which displays the results of building the “property tree”. Tables 5, 6, 7 show the following indicators of qualimetry: criterion name, evaluation method, unit of measurement, weight coefficient, background value, measurement result, factor indicator, factor evaluation according to the “property tree”.

In tables 5 and 7, the integral quality of the phytomodule is assessed according to the following 11 criteria:

Air quality improvement (on oxygen)– % importance according to consistent measurements; dust protection (measurement data are used); noise protection (by consistent measurements of noise levels); soil improvement (experts’ data in the scoring are used); climatological interaction: wind speed, air humidity, solar radiation, ventilation, temperature, (separate qualimetric analysis data are used, see Table 6), aesthetic interaction (by expert scoring); hygienic (therapeutic) interaction – by expert assessment; environmental friendliness (by expert assessment); benefits for birds (by expert assessment); benefits for insects (by expert assessment); social interaction (by expert assessment);

Table 6 - Qualimetric assessment of measured quasi-simple properties “Climate interaction”

κ/c	The criterion name “Property tree”	Assessment method	Measure- ment unit	Weight coefficient	Background value	Measure- ment results	Factor of indicator	Factor assessment
				W	B _v	R	I	F
1	Wind speed	to measure	%	0,2	100	75	1,3333	1,266666
2	Air humidity	to measure	%	0,2	100	126	0,793650794	0,158730159
3	Solar radiation (voltage)	to measure	kW/cm ²	0,2	0,99	0,12	8,25	1,65
4	Ventilation	to analyze	point	0,2	3	5	0,6	0,12
5	Summer temperature	to measure	degree change	0,2	25	20	1,25	0,25
	Total			1				2,445396825

[10,125-135 б.] was made by related authors

Table 7. Assessment of the environmental impact of a photovoltaic module using the qualimetric method

κ/c	The criterion name “Property tree”	Assessment method	Measure- ment unit	Weight coefficient	Background value	Measure- ment results	Factor of indicator	Factor assessment
				W	B _v	R	I	F
1	Air quality improvement (O ₂)	to measure	%	0,139	21	21,09	1,004285714	0,139595714
2	Dust protection	to measure	gr/m ²	0,125	135	80	1,6875	0,2109375
3	Noise protection	to measure	1/dBA	0,097	40	29	1,379310345	0,133793103
4	Soil quality improvement	to analyze	point	0,089	3,5	4	1,142857143	0,101714286
5	Climate integration	qualimeter	convention al unit	0,105			2,445	0,256725
6	Aesthetic integration	to analyze	point	0,18	3,5	5	1,428571429	0,257142857
7	Hygienic (therapeutic) air	to analyze	point	0,1	3	4	1,333333333	0,333333333
8	Environmental friendliness	to analyze	point	0,555	3	4,5	1,5	0,8325
9	Benefits for birds	to analyze	point	0,27	3,5	4	1,142857143	0,030857143
10	Benefits for insects	to analyze	point	0,018	3	4	1,333333333	0,024
11	Social integration	to analyze	point	0,12	3,5	5	1,428571429	0,171428571
	Total							2,292027508

[11,201-211 б.] was made by related authors

The calculation section of the table is presented in the form of columns: weight coefficient, background value, measurement results, factor indicator, factor assessment. These indicators are determined using qualimetric method[12].

M weight coefficient characterizes the significance (importance) of each criterion among other criteria. The assessment of weight coefficient is carried out expertly at each level of the “property tree”. The value of the MJ– coefficient is determined at each level (branch) of the qualimetric study, while it is based on the conditions of the set for all criteria at each level of MJ= 1:

$$M_1+M_2+M_3+....+M_n= MJ=1 \quad (1)$$

In the considered model, the weight coefficient is determined for three levels of the “property tree”, which is indexed by the dashes at the top of the accepted designation. The estimated weight coefficient

entered in the table is determined as a result of systematic multiplication of the weight coefficients at the lower levels (hierarchically interconnected “property tree”)

$$M = M_1 * M_2 * M_3 = 0,6 * 0,925 * 0,25 = 0,139 \text{ (air quality improvement)}$$

Background value B_v characterizes the consistent ecological situation of the area considered for carrying out improvement measures. The absolute background value is less than the measured value after the introduction of phytomodule. Expert assessment is used on a five-point scale: 5 and 4 - high, 3 - medium, 2 - low; 1 - very low to determine the background value.

RESULTS AND DISCUSSION OF THE RESEARCH

P measurement results are given in physical units or points (during expert assessment) for each criterion of the “property tree”. The absolute measurement value may be less or more than the background value. In some cases, when assessing factors, the results of successive measurements may decrease due to the positive influence of the factor [13,14,15].

For example, dust protection has a background value of 135 g/m^2 , after the creation of the phytomodule the value is equal to 80 g/m^2 , the values of noise protection are 40 dBA and 29 dBA (see Table 7).

The K factor indicator is obtained by dividing the “measurement results” R by the “background value” B_v .

$$K = P/BV \quad (2)$$

The conditional indicator of this factor is necessary for comparing different units of the “property tree”. Due to the fact that the activities have a positive impact on the environment, the factor indicator is always higher than 1. In this case, the assessment is carried out according to the reciprocal of the measurement results.

For example, when calculating the indicator of the factor of dust protection, the reciprocal is taken: $1/135$ and $1/80$. Similarly, the values of the noise protection values are determined: $1/40$ and $1/29$ (see Table 7).

The assessment of the factor F is determined according to the criterion of the “property tree”:

$$\Phi_i = M_i k_i \quad (3)$$

The overall assessment of the ecological potential of a phytomodule is determined by a simple summation:

$$EP = F_1 + F_2 + F_3 + \dots + F_n \quad (4)$$

The given assessment can be used to determine the potential of open and closed phytomodules, as well as to determine the environmental impact of phytoconstructions, obtained on the basis of monitoring.

In Table 5, the qualimetric assessment of the background value of the phytomodule under consideration is carried out, based on the results of the study, which is equal to $E_p = 1.59$ [16,17,18,19].

Using the elements of qualimetrics, the assessment of the impact of the phytomodule on the environment characterizes the integral quality of the environment, which means a conditional improvement in the general condition of the area under consideration by the corresponding E_p value.

As shown in Table 7, the assessment of the impact of the phytomodule on the environment is described as $E_p = 2.29$. The given value characterizes the environmental potential of the considered open phytomodule with a typical set of phytoconstructions (greening along the walls, lawn, flower planting, trees and shrubs) [20,21].

As a result of the action of the active part of the phytomodule, the improvement of the environmental situation is characterized by the ratio of the phytomodule's ecological potential $E_p = 2.29$ to the background value of the phytomodule's ecological potential $E_p = 1.59$. The result of the comparison: $2.29/1.59 = 1.44$ times.

$$K_e = E_p / E_{pf} = 2,29 / 1,59 = 1,44 \text{ (144\%)} \quad (5)$$

In the considered option, the implementation of measures to create and use a phytomodule improves the condition of the urban environment by 1.44 times.

This method can be used to assess the environmental friendliness of the environment in various options. In the case of deterioration of the environmental situation, the value of the coefficient is less than unity, and in the case of improvement of K_e , a value of more than 1 is taken. All calculations are performed using the Microsoft Excel 98 computer program.

CONCLUSION

It is recommended to use the qualimetric method of comparison in various dimensions (properties) to assess the ecological potential of phytomodules characterized by spatial parameters, as well as complex phytoconstructive modules. The qualimetric method allows for a quantitative assessment of the environment according to selected criteria: half of the criteria are characterized by measurement indicators, and half are assessed by expert assessment. Based on the comparison of criteria in various dimensions and personalized “property tree”, final assessment of the impact of phytoconstructive modules on the environment is carried out based on the coefficients calculated for a specific phytoconstructive module and background value.

In the considered model, the qualimetric method allowed for a quantitative assessment of the environment after carrying out phytoecological measures by the ratio of the calculated values of ecological value of the phytomodule ($E_p = 2.29$) to the background value of the ecological potential of the environment ($E_{pf} = 1.59$). The implementation result of the considered option is: $E_{pf} 1.59$.

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