

THE ASSESSMENT OF THE VISUAL POLLUTION FROM INDUSTRIAL FACILITIES IN NATURAL LANDSCAPES

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Purpose. To is to define the appropriate methods for the evaluation of visual pollution from artificial structures in natural landscapes and apply the developed technique to the sample territory. **Methodology.** The visual pollution is a violation of natural landscape with manmade structures, which degrades the quality of scenery, prevents normal visibility, irritate due to lack of natural and irregular elements and predominance of certain shapes and colors. Visual pollution has been recognized as a problem in the end of the XX century and therefore it is not provided with standard methods of analysis. The variety of assessment methods offered by the researches could be divided into subjective, conditionally objective and objective. Due to high subjectivity of aesthetic perception of experts and common residents and problematic interpretation of the data from metering equipment the efficient assessment of visual environment is possible only by combination of methods. **Results.** We have developed the list of criteria for the integral assessment of visual pollution from industrial facilities in natural landscapes. The criteria are interpreted in points providing comparable total score, which could be used to define the major eyesore objects at a study area. Using the data provided by the assessment it is possible to develop specific action plan for the mitigation of visual pollution based on the most urgent issues. The method has been applied for the evaluation of industrial facilities of the Dolyna region, Ivano-Frankivsk oblast. The major issues reducing visual environment quality at the location of these enterprises are landscape transformation and fragmentation, visual fields aggressiveness and homogeneity, light pollution and chemical pollution, which is visually perceived in the form of smoke emissions and oil spills. **Originality.** For the first time, we have carried out comprehensive assessment of the visual pollution from industrial facilities in natural landscapes outside cities with the application of original method. **Practical value.** The results of the assessment should be considered at the project and exploitation stage to mitigate the negative visual impacts of the industrial objects and infrastructure. **References 7.**

Keywords: visual pollution, visual environment, environment quality, industrial facilities, natural landscape deformation.

ОЦІНКА ВІЗУАЛЬНОГО ЗАБРУДНЕННЯ ВІД ПРОМИСЛОВИХ ОБ'ЄКТІВ В ПРИРОДНИХ ЛАНДШАФТАХ

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У статті розглядається проблема формування якості візуального середовища при поєднанні промислових підприємств та природних ландшафтів, в яких вони розташовані. Проведено порівняльний аналіз наявних методик оцінки візуального забруднення навколишнього середовища та запропоновано методіку інтегральної бальної оцінки візуального забруднення, сформованого виробничими майданчиками та відповідною інфраструктурою. Виконано аналіз якості візуального середовища в місцях розташування підприємств нафтогазового, деревообробного, будівельного та санітарного комплексу міста Долина Івано-Франківської області. Визначено основні фактори формування візуального забруднення в межах розташування даних підприємств та напрямки пом'якшення даного типу впливів на якість навколишнього середовища. Рекомендовано проводити відповідну оцінку на стадії проектування та модернізації промислових підприємств.

Ключові слова: візуальне забруднення, візуальне середовище, якість навколишнього середовища, промислові об'єкти, деформація природного ландшафту.

PROBLEM STATEMENT. The term visual pollution stands for the negative effects of artificial structures on the perception of the surrounding environment. It is valid for urban and natural environment, which are either strongly transformed, or dramatically deformed by certain man-made objects. Visual pollution is thus a negative visual impact of certain visual pollution object (VPO) on landscape, i.e. the changes of landscape physical components (relief, water bodies, vegetation, and structures and/or installations) and their visual characteristics, which diminish landscape visual quality, obstruct overview of the valuable natural complexes or objects, or make the

natural areas look non-pristine and disbalanced [1]. In general, the sources of visual pollution are such facilities and objects as commerce, industry, transports or advertising, due to their inconsistency with the other elements of the landscape, they are located in.

The problem of visual pollution has appeared and since then is mostly connected with the violation of safety of visual environment at the territory of settlements. Thus the issue is better formulated as the problem of visual fields quality degradation under urban conditions and their impacts on the human health. This approach is the basis for the research field of a special science – videoecology, introduced by V. Filin [2].

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There is a wide range of research works, covering the problems of visual pressure from the man-made structures of cities and other populated areas, including works by A. Nekos, V. Miroshnichenko, S. Romanchuk, L. Zelenska, I. Bodnarchuk and V. Petruk V. However, the presence of the objects of the technosphere in any city is a “norm” to some extent, as everyone, having chosen to live at urban territory for any reason, has already given its agreement to stand some level of artificiality in his surroundings. Of course, if these objects overcome the level of citizens’ tolerance to the homogenous or aggressive visual fields, they cause negative effects on human health. However, the human activity has overreached the limits of settlements, and the traces of anthropogenic changes are seen everywhere at the territory of any country. Thus, there are lots of artificial structures in previously wild and unchanged systems. For this reason it is necessary to evaluate the impacts of technogenic objects and facilities on the quality of natural landscapes outside the urbanized territories, as the consequences of such intrusion are much more dramatic due to radical changes of the initial scene. So, the *aim* of this work is to define the appropriate methods for the evaluation of visual pollution from artificial structures in natural landscapes and apply the developed technique to the sample territory.

EXPERIMENTAL PART AND RESULTS OBTAINED. The concept of visual pollution is subjective, because it depends on one's aesthetic views, but usually includes violation of visibility, irritating contrast between natural and artificial elements, sites with absence of natural cover, too regular patterns, intrusion of alien man-made formations and predominance of certain shapes and colors [3]. Therefore, visual pollution is formed from the combination of objective and subjective factors. If to consider the objective factors these are exactly the structures and facilities constructed in the natural areas so, that they change the view of the landscape. The intensity and character of the visual pollution they create is quite different and the significance of these impacts is also varied. It is possible to differentiate them into categories by the essence of the man-made object. Most typically these are:

- Industrial facilities (plants, factories, technological equipment): their affect on landscapes has a local character, but great intensity due to deep transformation of the landscape and partial destruction of its elements. The essence of the problem is usually dramatic contrast with the natural scenery and violation of visibility.

- Mining facilities: the influence of the mining industry contributes to the creation of new elements in the landscape, including extraction points, accumulations of empty rocks and secondary landscapes formed after re-cultivation; these objects are different in area and depth of penetration into the landscape and geological environment and so the essence of the problem is the destruction of natural landscape and relief at certain area and exposing bare rocks at the place of vegetative cover, which represents sites with no natural landscape left.

- Construction impact: it affects the fundament of landscapes as it is accompanied with the reduction of positive and filling up of negative forms of relief, the complete destruction of vegetation and soil cover, and the activation of erosion and landslide processes during the slopes leveling. Even though construction undergoes any other type of human activity, the essence of its impact is of course the transformation of relief and as a result – formation of monotonous scenery with regular shapes.

- The agricultural impact is manifested in the creation of new complexes that did not exist before (reservoirs, canals, artificial lakes, etc.), changes in the hydrological, hydrochemical regimes of reservoirs, reorganization of the landscape structure of adjacent territories, introduction of man-made elements in the landscape.

- Settlement-building effects are quite diverse depending on the type of settlement and its building traditions; however, it will include a range of artificial structures of residential and service purposes, being scattered through the landscape in case of rural community or compacted and multilevel (multistory) in case of urban communities. The resulted visual field could be considered picturesque to some extent, if the traditional pastoral scenery is created, but the view of a city instead of pristine area is always an eyesore to most of viewers. The level of transformation of natural landscapes within rural settlements depends on their place and functions in regional settlement systems.

- Forest-based impact on the landscape can be very profound when it comes to logging, which defaces the natural scenery even if the minimal sections are affected. Another important issue is the exposure of the forest floor and poor understory typical for pinewoods, which are not that pleasant to view as a solid canopy cover. The signs of harvested wood transportation are also elements of visual pollution, often stretching long further from the timber site.

- Recreational influence is manifested in vegetation degeneration, soil compaction, construction of recreational facilities and infrastructure elements.

- Transport infrastructure disrupts visual environment quality with the highways and railways dissecting natural landscapes. In addition, measures for mitigating pollution (such as noise barriers) also contribute to visual pollution, as they are fabricated of artificial materials and normally shade natural landscape and form monotonous elements.

Despite the recognized effects of visual pollution on human wellbeing and health, there is no standard or widely recognized method for its measurement and evaluation. The relevant researches offer a range of assessment methods, which could be roughly divided into the following groups: subjective, conditionally objective and objective methods [4, 5].

The first group includes methods of evaluation, which are based on subjective factors – the perception of the object by the experimenter (expert): expert assessment, psychosemantic and sociological methods. They are based on the pre-formulated subjective assessment of the state of the visual environment by an individual or a group of people with varying degrees of

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competence in this problem: sociological employs the assessment by the representatives of general public, while the expert method depends on the opinion of experts from various fields of knowledge [4]. The psychosemantic method is based on the construction of coloristic models of the studied territory, reflecting the correlation between various colors on the visual fields, and their further perceptive analysis by respondents or experts.

An important component in the study of the level of visual pollution is questioning. The reliable data are obtained if people of different level of education, occupation, age and gender are involved in the assessment of the visual environment. It is also important to interview both specialists in the field of architecture and urban planning, and people who are not related to the formation of the urban environment. As a result, it is possible to determine the visible elements of the urban environment, which are primarily addressed by people living in the study area or watching it outside the settlements.

The group of conditionally objective methods for assessing visual environmental pollution includes methods of structural and informational analysis, photometric method and architectural method. The essence of these methods is the technical analysis of landscape units and their numerical representation (reproduction). The system of individual indicators of landscape aesthetic appeal is based on the analysis of elements that are components of the landscape, their number (in terms of sufficiency or insufficiency) and homogeneity [6].

Photometric analysis is the most interesting and convenient method of this group, as it needs ordinary cameras to scan the visual medium. Photometric evaluation in this case can be obtained in the form of a spectrum, which is then compared to the reference spectrum, for which a set of frequencies is taken during the scanning of the natural environment. The comparison criterion is the deviation of the spectrum obtained from the reference amplitude, width, etc. Such a method is applicable when evaluating the pollution of the visible environment of the city and potentially can be used at industrial facilities as well.

The method of objective observation is a specially organized observation, which is not dependent on opinions and assessments of people. The only completely objective method, both from the point of view of collection and interpretation of data, and most used at present, is the graphoanalytic method of aggressiveness assessment [2, 7]. According to this method the grid is superimposed on the plane of the investigated object, depicted in the photograph, and the index of aggressiveness is determined as a ratio between the number of cells, in which there are more than two identical visible elements, and the total number of cells of the grid.

Another highly technological method of this group is the Eye Tracking Method [2]. This is a method that tracks and records the movement of the eyes with the special tracking device, which recognizes the movement of the eye and records the direction of vision, synchronizing it with the image that the person is

looking at. To conduct research of this type, special software for analyzing the information is also needed.

Thus, any of the above-mentioned methods can be applied in the assessment of visual environment safety, depending on the specific task of the study. While any objective method is considered the preferable one in all sciences, but it is often used in conjunction with other methods as it requires significant additions to get more accurate results.

All the presented methods are not free from certain disadvantages: subjective methods are not protected from inadequate personal opinions, and objective methods are oppositely missing the sense of human perception of the visual scene, which cannot be detected with technical equipment. In case of technogenic objects as elements of visual pollution it is possible to cover this problem with these methods only partially, as the level of aggressiveness of the visual field is obviously reduced due to presence of natural scenery and the most important problem is contrast between them. So, we believe that under such conditions it is more expedient to combine expert assessment with certain metric parameters. This way, the influence of industrial objects and their infrastructure on the distortion of the visual field could be evaluated in points (from 0 to 5 – the higher the contrast is, the higher the point is) according to the following parameters:

1. Level of contrast to the surrounding natural scenery by structure:
 - level of an object's visual aggressiveness (number of straight lines and similar structural objects);
 - level of an object's visual homogeneity (lack of irregular and curved elements, components of nature);
2. Level of contrast to the surrounding natural scenery by color.
3. Elevation above the level of natural landscape (above the top of canopy or natural hilly area).
4. Area of natural landscape transformed (leveled, flattened, etc.).
5. Level of natural vegetation destruction (cut forest, reduced grass cover, introduction of alien species).
6. Level of auxiliary infrastructure development: roads and power lines density.
7. Intensity of visual field/landscape fragmentation.
8. Intensity of an industry's environmental impacts visualization: smoked emissions, colored discharges, waste heaps and landfills, storage sites with raw materials or final products.
9. Presence of visual pollution mitigation solutions (this parameter must be ranked in an opposite manner: from 0 to -5, which corresponds to the highest intensity of pollution mitigation).
10. Light pollution

The attributes of various industrial objects could be clearly evaluated according to the given criteria and the obtained results are comparable in total or by individual parameters.

Ukraine is characterized with a high concentration of industrial enterprises, which are most often located in the vicinity of large cities. Therefore, the state of natural landscapes at these territories is exposed to significant negative impacts and the consequences are much more

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dramatic as it ruins the aesthetic quality of recreational facilities for city dwellers.

The visual environment is the most damaged and loses its natural characteristics during mining, construction and functioning of power generation, metal and chemicals production, etc. All these anthropogenic processes cause negative changes not only in the structure of the landscape environment, but also have a significant impact on the visual component of nature. So, it was decided to conduct the sample assessment on the example of the industrial complex of Dolyna region, Ivano-Frankivsk oblast. This is the region with well preserved natural landscapes and at the same time it is the area with well-developed heavy industry.

The main branches of industry in the area include:

1. Oil and gas industry: Oil and Gas Production Company "Dolyna Naftogaz", "Dolyna gas processing plant". The main specialization is the extraction of oil, gas (natural and associated), and production of petroleum products.

2. The forestry and woodworking industry is represented by the following companies: State Company "Wood Processing Plant" of the OJSC "Vygodsky forestry complex", LLC "Uniplyt", and OJSC "Dolynsky wood processing plant". The main products of these enterprises are window and yard blocks, fiberboard, and parquet.

3. Industry of building materials, which includes such enterprise as OJSC "Dolyna factory of reinforced concrete products". It produces prefabricated concrete, concrete blocks, commercial concrete.

4. Treatment facilities for municipal and industrial wastewaters.

Thus, the analysis included a wide range of industrial facilities with a variety of visual pollution patterns typical for the given industries.

The major industrial facility of Oil and Gas Production Company "Dolyna Naftogaz" incorporates a number of drilling sites, where there the following elements of visual pollution: drilling rigs, sludge pits, reception capacities and power generators. On average wells and their infrastructure occupy 1.5 ha.

The assessment according to the presented criteria gives the total value of 21 for each drilling site with the highest contribution from the intensity of environmental impacts visualization, especially oil spills, sludge accumulation, emissions from storage reservoirs, etc. Level of light pollution and removal of natural vegetation at the area of 1.5 are noticeable as well. The level of actual disturbance and habitat fragmentation are not very high if a single site is considered, but there are dozens of them located close to each other, which raises the intensity of visual pollution considerably and creates aggressive visual field, ranking the problem to the top at the area.

The local department of the Major Pipelines Administration "Prykarpattansgaz", the Dolynsky linear production management of main gas pipelines is also evaluated as an object with moderate level of visual pollution with total score of 30 points. The given object is not elevated high above the ground and needs moderate level of landscape transformation and forms noticeable contrast with natural scenery. The most

serious elements of visual impact are complex network of infrastructure, which is the essence of its activity, and thus it contributes to intensive fragmentation of habitats and visual fields. The overall visual field of the enterprise is characterized with high level of aggressiveness due to abundance of straight lines.

Refinery, in particular, gas processing plant is among the top polluters of the environment both in terms of chemical and visual pollution. The assessment method has given its score of 42, with 4 points by most of parameters. The issues of the highest concern are of course the visual environmental impacts and light pollution. Similarly, the plant is high enough to be visible above the forest level and form the noticeable landmark on the territory. The auxiliary infrastructure is strongly developed and includes access road, railway, internal linear structures (pipelines), storage reservoirs, etc. the only parameter, which is on average level is visual homogeneity, due to the absence of very broad blank surfaces of technological objects. The GPP has also residuals and newly planted green islands around and inside the facility, for which it has been given -1 point for visual pollution mitigation.

OJSC "Dolyna factory of reinforced concrete products" is also a major eyesore (38) due to high level of visual field homogeneity and aggressiveness, elevation above the natural green plantations level and light pollution from the territory. The relief transformation and natural vegetation removal is also considerable for the needs of major structures location. Storage and transportation of raw materials and ready-made goods have caused the need for wide communication infrastructure, which create additional technogenic elements of the landscape and its fragmentation.

Both wood processing plants form the visual disturbance (35 points) due to bare land plots cluttered with timber and its products. The road infrastructure is of moderate impact and is involved into the general road pattern of the territory. The height of the objects is also moderate, but the plants' structures are clearly visible due to lack of any natural vegetation at the territory.

The LLC "Uniplyt" working within the same branch of industry is characterized with lower level of visual nuisance as it is more compact and most of its technological elements is located inside the industrial premises. However, its environmental impacts are more noticeable and visual: smoke emissions from the boiling plant, which is also a dominant visual factor due to the height of its pipe. The view on the territory of the plant is rich if homogenous and aggressive fields, well-developed infrastructure and noticeable storage facilities. The overall score is 33 with almost no pollution mitigation solutions.

The treatment facilities are of lower importance from the point of visual pollution (26 points), but there are still disturbing elements as environmental impacts, transformation of relief and landscape for the creation of reservoirs above all.

The overall visual pollution from industrial objects located within natural landscapes is quite noticeable and should be addresses in the plans of negative environmental impacts mitigation for these facilities. It

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is important to note, that the intensity of the visual fields deformation is of changeable character, as it strongly depends on the season. The period of the year affects the level of contrast between artificial and natural elements: it is more severe during vegetation period, but at the same time trees and bushes are able to mask them partially, while the leaves are still on. In winter silver color of industrial equipment is also partially hidden.

CONCLUSIONS. Even though there is already considerable amount of materials and recommendations accumulated about the structure of visual environment and its role in human health and comfort, it is not very well introduced into the official projects and plans of industrial facilities construction and modernization. As the analysis of eight industrial facilities showed the visual pollution mitigation is absent everywhere. Furthermore, the issues of natural landscape transformation and fragmentation are among the top for this objects showing the fact that they are neglected by the developers and constructors. The level of contrast between natural and artificial scenery is also considerable in terms of visual fields aggressiveness and homogeneity, as well as contrast by color. The latter one is easy to manipulate, so it is possible to hide the technogenic spots with special painting and decorative materials. This will not only reduce the level of visual quality degradation, but also improve the image of corresponding companies.

It is also worth mentioning that an important contribution to the aggressiveness of visual fields is made by infrastructure of the studied objects – their role is almost equal to the influence of the technological sites themselves.

Light pollution from the industrial facilities is also an important factor especially in case of their 24-hours work in the natural surroundings. Chemical pollution, which is visually perceived in the form of smoke emissions and oil spills, is also a very profound factor in the final vision of any industrial facility.

Thus, we have developed a list of criteria for the evaluation of visual pollution from industrial facilities in natural landscapes outside cities and consider it is an important element in the assessment of enterprises environmental safety at the project and exploitation stage.

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ОЦЕНКА ВИЗУАЛЬНОГО ЗАГРЯЗНЕНИЯ ОТ ПРОМЫШЛЕННЫХ ОБЪЕКТОВ В ПРИРОДНЫХ ЛАНДШАФТАХ

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В статье рассматривается проблема формирования качества визуальной среды при сочетании промышленных предприятий и природных ландшафтов, в которых они расположены. Проведен сравнительный анализ имеющихся методик оценки визуального загрязнения окружающей среды и предложена методика интегральной балльной оценки визуального загрязнения, сформированного производственными площадками и соответствующей инфраструктурой. Выполнен анализ качества визуальной среды в местах расположения предприятий нефтегазового, деревообрабатывающего, строительного и санитарного комплекта города Долина Ивано-Франковской области. Определены основные факторы формирования визуального загрязнения в пределах расположения данных предприятий и направления смягчения данного типа воздействий на качество окружающей среды. Рекомендуется проводить соответствующую оценку на стадии проектирования и модернизации промышленных предприятий.

Ключевые слова: визуальное загрязнение, визуальная среда, качество окружающей среды, промышленные объекты, деформация природного ландшафта.