Environmental impact assessment of electromagnetic fields near to the specially protected natural areas on the example of Samara region of Russia

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Abstract. Impact of physical pollutions (electromagnetic fields, noise, vibration, ionization etc.) is increasing every year and may cause significant discomfort and health damage of inhabitants of urban territories and of specially protected natural areas. Peculiarities of negative influence of electromagnetic fields to the man's health and to environment are considered. Russian approaches to environmental impact assessment of electromagnetic fields of urban territories are discussed. It is pointed out that during environmental impact assessment it is necessary to undertake a complex of steps: identification of the most intensive sources of physical pollutions, calculations and measurements of physical pollutions propagation to the nearest living territories and of it impact to the workers of industrial enterprises, estimation of results of calculations and measurements, mapping of physical pollutions, development and implementation of measures to reduce negative impact of physical pollutions. Experience of realization of suggested approaches to environmental impact assessment of electromagnetic fields of territories are discussed on the example of Samara Region of Russia.

1. Introduction
Impact of physical pollutions (electromagnetic fields, noise, vibration, ionization etc.) is increasing every year and may cause significant discomfort and health damage of inhabitants of urban territories and of natural protective zones [1-4]. Therefore, it is necessary to carry out environmental impact assessment of physical pollutions in urban territories, especially near to the natural protective zones. Electromagnetic fields of different frequency range may cause significant negative impact both to environment and the health of population.

On the territory of Samara region of Russia there are situated the Zhigulevsky State Nature Reserve and the Samarskaya Luka National Park. Besides, on the territory of Togliatti part of the Middle Volga Integrated Biosphere Reserve is located. Near to these specially protected natural areas there are Zhigulevsk town and the Komsomolsky district of Togliatti city where there are a number of intensive sources of physical pollutions, including of electromagnetic fields.

This paper is devoted to the environmental impact assessment of electromagnetic fields in urban territories of Samara region of Russia near to the specially protected natural areas.

2. Analysis of negative impact of electromagnetic fields to the population
Electromagnetic radiation (non-ionizing) is the term generally applied to all forms of electromagnetic radiation whose primary mode of interaction with matter is other than by producing ionization.

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Therefore, non-ionizing radiation (NIR) refers to electromagnetic radiation with wavelengths exceeding 100 nm, equivalent to quantum energies below 12 eV, i.e., encompassing the spectrum which includes all radiation sources whose frequencies are equal to or less than those of the near ultraviolet.

Scientific, medical, industrial and domestic uses of devices producing non-ionizing radiation are rapidly expanding in type and number, leading to a steady increase in the amount of NIR in man's environment and causing concern about potential health hazards to workers and to the general public from uncontrolled or excessive radiation exposure.

Thus, the impact of electromagnetic fields may cause significant discomfort and health damage of inhabitants of urban territories and of the natural protective zones as well as of ecological state of territory in total.

3. Approaches to environmental impact assessment of urban territories

Environmental Impact Assessment (EIA), is now regarded as one of the principal tools in the estimation of pollutions of environment, including physical pollutions. Overall, EIA should be seen as a practical, anticipatory, decision making tool that allows the likely effects of a project upon the environment to be determined, and indicates the need for appropriate mitigating measures to reduce adverse effects and maximise positive effects.

Typical policy requirements for EIA:
- compliance with regional/national/international planning objectives and priorities;
- the assessment of alternative options that provide the same benefits;
- compliance with the requirements of emerging regulatory authorities;
- the increasingly pronounced definition of environmental protection purposes;
- awareness of the public's growing concern for environmental issues and the associated political and economical implications.

EIA began to emerge as a separate and distinct planning tool, allowing the decision makers to weigh up the potential cost and benefits of particular schemes. The basic principle is that prevention is better than cure.

EIA it is required to be undertaken prior to the project receiving authorisation (from planning authorities) to proceed. The term "project" means the execution of construction works or other interventions in natural surroundings and landscape.

For the developers of a project it is necessary to undertake an EIA that will identify, describe and assess the direct and indirect effects of a project on the following factors:
- human beings, fauna and flora;
- soil, water, air, climate and the landscape;
- the interaction between these two groups of factors;
- material assets and cultural heritage.

Protection of the natural resources is also part of the protection of human life. However, there are other socio-cultural aspects which require consideration during a planning process and which are part of a comprehensive environmental impact assessment.

General EIA principles may be described as following:
1. Timing – the EIA should begin at the earliest possible stage in the planning process, integrating with engineers and economic phases of the project planning.
2. Multi-disciplinary – the EIA will require inputs from a number of experts. These should be identified and briefed at the earliest possible stage.
3. Organization – the EIA must be well managed as it will require the assimilation of inputs from various sources.
4. All findings should be based on documented evidence and supported where possible by hard data open to verification.

The EIA process will often not end with the submission of a report or environmental statement. It is necessary to provide continuous monitoring and reconsideration of issues as the project develops.
4. Analysis of sources and main principles of monitoring of electromagnetic fields in conditions of urban territories

Electromagnetic fields of ecological monitoring usually are natural, anthropogenic or natural-anthropogenic. It is important that ecological monitoring of electromagnetic fields should not only be a passive statement of facts, but also include modeling and forecasting.

Among the main principles of ecological monitoring of electromagnetic fields it is possible to emphasize the following [2, 4]:
- Identification of sources of electromagnetic fields of urban territories and of degree of its potential ecological danger;
- The most dangerous zones of urban territories from the point of impact of electromagnetic fields;
- Measurements of electromagnetic fields in conditions of urban territories;
- Processing of experimental data, issue of conclusions;
- Mathematical and calculative modeling of propagation and estimation of electromagnetic fields in conditions of urban territories;
- Development of electromagnetic fields mapping in conditions of urban territories;
- Development of measures of reduction of electromagnetic fields in the most dangerous zones of urban territories.

In dependence of place and conditions of impact of electromagnetic fields four main kinds of electromagnetic fields radiation are classified: professional, non-professional, domestic radiation and radiation for medical purposes - general and local.

Main sources of electromagnetic fields of urban territories may be the following: electric power lines, domestic electrical nets and electrical devices, contact nets of electrical transport, surfaces with electrostatic charge, radio transmitting devices, means of personal radio transmission etc.

In conditions of towns the most significant danger may be caused by impact of external sources of electromagnetic fields: high voltage power lines, radio- and TV stations, means of radio transmission, scanning antennas, open distribution devices, different energetic devises and units.

Analysis of the most intensive sources of electromagnetic fields in conditions of Samara region is showing that the most significant danger is from electric power lines, radio transmission devices, antennas, devices of TV communication.

The most intensive electromagnetic radiation of industrial frequency is generated by electric power lines near Zhigulevskaya hydro power station and abutting territories of city district Zhigulevsk and of Komsomolsky district of Togliatti city. It should be noted that level of electromagnetic radiation is not stable in time and depends on the load of electrical nets which cause seasons and even day variations.

5. Results of measurements of electromagnetic fields in the territory of Samara region of Russia situated near to the natural protective zones

Measurements of electromagnetic fields were carried out for industrial frequency range (electrical component $E$, kV m$^{-1}$, and magnetic component $H$, A m$^{-1}$, of the electromagnetic field strength) and for radio frequency range (electrical part $E$, kV m$^{-1}$; magnetic part $H$, A m$^{-1}$, of electromagnetic field strength and density of flow of energy, $\mu$W cm$^{-2}$).

On the living territory of Togliatti city in total more than 250 measurements of electromagnetic fields were carried out. Results of measurements of electromagnetic fields strength industrial frequency range in the territory of Komsomolsky district are showing that the most values of electromagnetic fields strength were near to electric power lines Exceeding of sanitary norms was determined for Esenin street situated near to the Zhigulevsky hydro power station. In point of measurements №3, Esenin street, house N16 the value of strength of electrical field $E$ was 3.950 kV m$^{-1}$ (maximal normative value according to Russian sanitary norms is 1 kV m$^{-1}$).

For Central and Avtozavodsky districts the main problem is impact of electromagnetic fields of radio frequency range near to the TV mast / towers. Exceeding of sanitary norms were fixed for Mira street (Central district) and Sverdlov street (Avtozavodsky district).
Also, on the territory of city district Togliatti measurements of electromagnetic fields strength radio frequency range and of density of flow of energy. Exceeding of normative hygienic requirements of strength of radio frequency range was observed in Avtozavodsky district, Moscowsky avenue, house N 21, where transmitting antenna is situated. On the frequency 100 MHz the value of strength of electric part of radio frequency range \(E\) is 3.23 V m\(^{-1}\), on the frequency 200 MHz \(E = 3.01\) V m\(^{-1}\) (normative value is 3 V m\(^{-1}\)). Near to transmitting antenna there is also significant exceeding of background values of electromagnetic fields of radio frequency range.

In other points of measurements of density of flow of energy there is no any exceeding of sanitary norms requirements.

On the territory of city district Zhigulevsk in total more than 100 measurements of electromagnetic fields were carried out in more than 25 points.

Analysis of results of measurements of electromagnetic fields strength of electric part of industrial frequency range on the territory of city district Zhigulevsk is showing that exceeding of normative values is observed for the different points of measurements in zone of dam of Zhigulevsk hydro power station, \(E = 1,150\) kV m\(^{-1}\), \(E = 1,275\) kV m\(^{-1}\), \(E = 1,275\) kV m\(^{-1}\).

Analysis of results of measurements of strengths of magnetic field of industrial frequency on the selected territory of city district Zhigulevsk is showing that there is no any exceeding of sanitary norms requirements in all points of measurements.

Also, on the territory of city district Zhigulevsk measurements of strengths of electrical and magnetic field of radio frequency range and of density of flow of energy have been carried out. In total more than 80 measurements of electromagnetic fields were carried out in more than 20 points. Analysis of results of measurements is showing that there is no any exceeding of sanitary norms requirements in all points of measurements.

On the basis of results of measurements, it is possible to conclude that there is no any exceeding of sanitary norms requirements for strengths of electrical and magnetic parts of radio frequency range and density of flow of energy on the investigated territory of city district Zhigulevsk. Exceeding of normative values of electrical part of electromagnetic fields strength industrial frequency range was observed in a number of points in zone of Zhigulevsk hydro power station.

6. Examples of mapping of electromagnetic fields of urban territories

By using of developed software \([2]\) maps of electromagnetic fields of urban territory of Samara region were developed.

Map of electromagnetic fields of industrial frequency range of the territory of Shluzovoy micro district is shown in figure 1. Map of electromagnetic fields industrial frequency range of the territory of Komsomolsky district is shown in figure 2. In green color values of electromagnetic fields are shown which are not exceeding of sanitary norms requirements, in red color - values of electromagnetic fields exceeding of sanitary norms requirements.

7. Conclusions

It was shown that physical pollutions influence may cause significant negative impact to the health of population and to environment, especially near to natural protective zones, therefore in is necessary to carry out environmental impact assessment (EIA).

Methods and results of EIA of electromagnetic fields of urban territories of Samara region of Russia have been described. Some results of monitoring of electromagnetic fields of urban territories of Samara region of Russia are described. Analysis of measurement results are showing that there are dangerous zones of dwelling territory on electromagnetic fields negative impact. Using software «Physic City Test», electromagnetic fields map of the territory of the Komsomolsky district of Togliatti city have been developed.

Results of research allows to conclude that in number of points of living territory of Samara region there is exceeding of existing sanitary-hygienic requirements on the impact of electromagnetic fields. It is especially dangerous for the protected natural areas and for the biosphere reserves. Therefore it is
necessary to carry out further monitoring of electromagnetic fields, to develop and implement measures on reduction of impact of electromagnetic fields in zones of urban territories with increased levels of electromagnetic fields.

**Figure 1.** Map of electromagnetic fields of industrial frequency range of the territory of Shluzovoy micro district of Togliatti city
Figure 2. Map of electromagnetic fields of industrial frequency range of the territory of Komsomolsky district of Togliatti city

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