Database creation on the monitoring system for the South-Ukrainian Power Complex

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Abstract

This paper reports on a complex ecological monitoring system for the South-Ukrainian Power Complex, which includes subsystems addressing the receipt and storage of information and subsystems that process, analyze, and display information in the form of a final product. This is a high priority for this industrial location. The system has to provide not only qualitative-quantitative assessment of technogenic impact on the environment but has also to promote forecasting consequences of the Power Complex reaction to different risk factors. One of the most important links of the monitoring system is the creation of an information-analytical center equipped with local internet network and the means for another operative connection where all the initial information is received, accumulated, stored and analyzed.

The system with a complex of aforementioned functional options is being created for the first time in the Ukraine and could be considered as a pilot project, the realization of which will open new opportunities for environmental management.

Keywords: database creation, complex monitoring system, power complex, risk factors, computer modeling.

1 Introduction

Issues concerning further development of the South-Ukrainian Power Complex (SUPS) are being discussed in this paper. The construction of this unique power location or late completion project was started at the beginning of 1970s in the
last century and hasn’t been finished. The main problems, which became the grounds for numerous public and scientific discussions in the country, are being considered. Ecological and technological requirements are being developed to support the formation of databases and creation of complex monitoring systems within the SUPS impact zone. Priority-driven tasks concerning technogenic and ecological safety in the region have been determined.

Figure 1: The South-Ukrainian power complex. 1–South-Ukranian power station; 2-Tashlyk storage pool; 3-Tashlyk hydro accumulation power station; 4-Olexandriska hydroelectric power station; 5-Olexandrivske storage pool; 6-Prybugeske storage pool. Cordon “wedging-in” backwater of Olexandrivke storage pool when different flooding levels; \( \text{number-values of regular-supported flooding level} \).

The SUPS is located in Mykolaivska oblast (Ukraine) within Pivdennyi Bug river basin. It is considered to be a unique power location in the world consisting of the Tashlyk hydro accumulative electric power station (THEPS), the Olexandrivka storage pool, and the Olexandrivka hydroelectric power station (OHEPS) (Fig.1). It had to be constructed so that it would have been able to solve problems associated with increased changes in the power system. It would be possible to achieve this goal after getting the THEPS into operation. The main purpose of getting it into operation is the 1) accumulation of hydroenergy and its prompt efficiency during rush hours, when sharp decreases of current frequency in power supply systems, and 2) creation of an emergency power reserve in the power system for the Southern part of the country.

However, until the present time, only three units of the power station are under operation. They were constructed in 1982, 1985, and 1989. Construction of the other power objects was not completed. First, the THEPS project was developed in 1980, and construction was started in 1981, but in 1991 its continuation was closed down until 2003 under pressure from the green movement in the Ukraine, which is against nuclear power development.
Total investment volume spent for the SUPC location construction is estimated at US $485.2M, including funding for THEPS and OHEPS – US $210M.

The SUPS has been under construction for about 30 years. Priorities on economic and nuclear power development have been refocused to a more valued emphasis on the ecology since then. It significantly complicated the problem of the SUPC locations completion and sharpened opposition between supporters of it and those who are strongly against the construction.

What are the problems as of today? The important ones are as follows:

− during the twelve year moratorium on the THEPS completion, its water lines passing through granite cliffs started to erode and became a source of high risk. The THEPS can not be left in such a state – it has to be either completed or dismantled.
− Prior to preparing to flood the Olexandrivka storage pool, historical and archeological assessment of the territory value has been done. As a result some objects of historical heritage have been discovered and need to be preserved.
− as a result of zoological and botanical research within Pivdennyi Bug river valley and where Olexandrivka storage pool had to be built, the unique value of the territory concerning biological diversity and availability of animals and vegetation species from the Red Book have been discovered. In 1992 the regional landscape park “Granite- steppe Pobuzzya” was created on this territory and Greens require its inviolability.
− legislative system in Ukraine has been changed several times since the period mentioned above (from the former USSR to Ukraine laws).

2 The SUPC monitoring system

For the purpose of solving all these complicated problems and clarifying advisability concerning the THEPS completion, the comparative analysis of social and economic achievements and financial losses in case of the mentioned object completion was carried out in 1998-2002 according to the Cabinet of Ministers of Ukraine order [2]. As a result of complex assessment a compromise between ecological acceptability, economic expediency and social significance has been offered in favor of the THEPS completion. It was decided to realize the project (the THEPS getting into operation and the Olexandrivka storage pool filling) step by step under strong ecological supervision providing minimum impact into flora and fauna of the region. A complex monitoring system has to be created for those purposes.

The aim of the proposed monitoring system for the SUPC is as follows: a creation of multiple-factor space-time modeling and forecasting computer system for complex ecological monitoring that has to provide an expert evaluation of different situations for well-grounded decision making under regular and emergency conditions of the SUPC objects operation; efficient management concerning optimization of power and hydroeconomic systems operation; development of scientific recommendations and practical actions concerning
minimization and liquidation of ecologically risky changes in the environmental state and factors that have negative influence on the population’s health.

Control of environment components such as atmospheric air, surface water, potable water sources, and other systems of human activity and environmental state as well as prevention and handling of emergencies connected with natural and technogenic factors are to be priority-driven in the ecological monitoring system.

2.1 Methodology of complex assessment of ecological safety

During periods of operation and emergency planning (i.e., ratable probability of emergencies at levels that cannot be neglected), the station is considered to be a source of relatively insignificant contamination (synergistic effects are excluded). However this group of technogenic factors impacts the environment and population mainly in one direction – it increases the level of ecological risk and then it leads to those effects where ecosystem or human organisms are brought to a certain summation of all risk impacts. Risk impact from contaminants \( U^* \) into any subsystem \( S_s \) becomes apparent in the form of certain reactions that are determined as a factor of resulting contaminant impact \( R_{(ZB)S_s} \):

\[
R_{(ZB)S_s} = f(\beta_i; C_X, C_R, C_Y), \tag{1}
\]

with extremes conditions:

\[
\begin{align*}
& R_{(ZB)S_s} \to 0, \text{ approach to the state of the system stabilizer} \\
& R_{(ZB)S_s} \to 1, \text{ approach of the system to maximum permissible}
\end{align*}
\]

when \( R_{(ZB)S_s} \geq 1 \), state of the system instability increases,

where \( \beta_i \) - parameter of biological disturbances in the \( i \)-subsystem for the period \( \Delta t \) that is presented in dimensionless form as ratio of integral biological factors \( C_{Bi\Delta t} \) for calculating period of time to conditionally sustainable (comfortable) biological factors \( \overline{C}_{Bi} \) for the same researched territory; \( C_X, C_R, C_Y \) – correspondingly complex parameters of impacts in the subsystem that depend on chemical (X), radioactive (R) and urban (Y) contamination types.

Total impact \( W^E \) from chemical, radioactive and urban contamination when approximate calculations might be assessed according to the following interdependence (the sign \( E \) means that expert assessments might be used in the calculation):

\[
W^E = \frac{1}{3} \left( \frac{1}{N} \sum_{n=1}^{N} k_{X_n} \frac{C_{X_n}}{C_{X_n}} + \frac{1}{I} \sum_{i=1}^{I} k_{R_i} \frac{C_{R_i}}{C_{R_i}} + \sum_{j=1}^{J} k_{Y_j} \frac{C_{Y_j}}{C_{Y_j}} \right) \tag{2}
\]
where - $C_{x_i}$, $C_{r_j}$, $C_{y_j}$ - concentration or the other numerical expression for the $i$-subsystem correspondingly chemical, radioactive, and urban contamination for calculating period of time; $C_{x_i}$, $C_{r_j}$, $C_{y_j}$ - standard concentration or the other numerical expression of the standard value relating to types of contamination; $k_{x_i}$, $k_{r_j}$, $k_{y_j}$ - weighted factors correspondingly for chemical $n$-ingredient, radioactive $i$-ingredient, and $j$-factor of urbanization; $N, I, J$ – total amount of correspondent factors in the subsystem for the calculating period of time.

The corresponding model can be written down for summation impacts of potentially risky geodynamic processes $R_{(GP)S_s}$, that can be caused by natural phenomena on one hand, and on the other – their activization must be caused by technogenic factors of the power station impact. Such model can be presented in dimensionless form as the ratio of area subjected to activization processes $S_{pa}$, to conditionally calculating area of the model grid $S_c$ ($S_{pa}$ - area of activization of different geodynamic processes, where $n$ is their number):

$$R_{(GP)S_s} = \sum_{t=0}^{T} \sum_{j=1}^{n} k_{j} \alpha_{pa j(z)} \frac{S_{pa j(z)}}{S_c};$$

(3)

where $k_{j}$ – weight coefficient of significance of the $j$-geodynamic process; $\alpha$ – coefficient that characterizes the activity of the process ($p$ – of natural origin, $a$ – of technogenic origin) for the period of time $\Delta t$ within the calculating area $S_c$.

Any geodynamic process can be characterized by a “natural risk” parameter. There is a discrepancy in definition of this term in the literature. An important issue in the methodology of ecosystem stability analysis within the SUPC impact zone is the determination of permissible load from different negative factors and their regulation. A complex parameter of a permissible level for the environment change $U_d$ is accepted as a basis for regulation. Permissible loads according to current standards are as follows: boundary permissible concentration value – BPC, boundary permissible emissions – BPE, boundary permissible doses – BPD, etc.

Then we can express conditions for the satisfactory state of ecosystems at negative impacts when accepted ecological risks concerning the population and environment and correspondent risk for the power stations objects is provided as follows:

$$U_d = f \left( R_{(ZB)S_s} ; R_{(GP)S_s} \right) \leq 1$$

2.2 Structurization of the monitoring system

The methodological approach mentioned above suggests the necessity to determine and study links between types and levels of technogenic loads, dynamic parameters of natural processes, vegetation state, living organisms,
health and psychological state of the population and changes of social-economic processes in society. Such a strategy envisages development of new conceptual principles for the ecological monitoring system creation.

Structurization of the complex monitoring tasks are considered to be reasonable here. The scheme for the organization structure of the complex monitoring is given in fig.2. Real technical, technological, scientific, economic and organizational possibilities will determine tempo for the SUPC monitoring system development, priorities and progression of performing certain tasks, and adaptation of the system to the present day information environment in the Ukraine.

It is stipulated that when developing the new monitoring system for the SUPC, the existing network of radioecological, hydrogeological, hydrochemical, and biological observations has to be saved to provide heredity and mutual coordination.

The data base in the system of the SUPC monitoring system is formed in the corresponding problematically oriented control complexes. In the system the following data are being created:

- **radioecological state** of the SUPC 30-km impact zone (subsystem covers near-surface atmospheric air, soils, natural waters and bottom sediments, phytocenosis and zoocenosis);
- **seismic monitoring; hydrobiological monitoring** of natural water systems (that is, control of the surface water quality within the SUPC impact zone, optimization of the hydropower systems operation for the purpose of preserving maximum biodiversity in the Pivdennyi Bug river system within the impact zone of the THEPS and the OHEPS; assessment of changes of hydrobiological regime of the Olexandrivka storage pool in the period of the THEPS launching and operation; efficient management by blow-through regime for the Tashlyk storage pool);
- **geophysical monitoring** is carried out within zones of possible risky exogenous and technogenic processes and within engineering structures for the purpose of determining rocks or building materials disturbance levels on the basis of geoelectrical and seismic-acoustic probing methods;
- **monitoring of vegetation** monitoring investigations of vegetation (ground ecosystems) include research of specific, flora-complex diversity of vegetation, mosses, lichens, water-plants, mushrooms; determination and study of endemic, sub-endemic, relic, boundary-areal plants and mushrooms; study of local population of rarity type; research of present state of flora complexes, their natural development, degree and character of man-caused influence, creation in the region of natural reserve objects of different social status as compensate instead of those that were destroyed when construction works or when filling the storage pool; etc.
The main purpose of the monitoring of vegetation and animal world within the SUPC impact zone is preservation of specific diversity of flora and fauna, including species from the Red Book of Ukraine.

One of the most important links of the monitoring system is the creation of an information-analytical center equipped with local internet network and means of other operative connection where all the initial information is received, accumulated, stored and analyzed. Necessary requirements concerning information management are as follows:

- Information collection on arms from the initial monitoring data, its systematization, storing and formation of the complete initial monitoring database;
- Collection of generalized regional information on the environmental parameters using computer geoinformation techniques, mapping database support, creation of digital parametric models of the environment, development of complex multifactor systems for modeling and forecasting;
- Information processing for decision making.
- Support of the processes for receiving, input, transferring and exchanging of the information between arms of the SUPC local networks and external subscribers of the system;
- Providing the process of information processing for performing the necessary tasks and managers decisions background;
- Preserving the information on the data base server and on the users arms;
- Preparation and performing of the necessary information according to requests.

Figure 2: Scheme for the organization structure of the complex monitoring.

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- Preparation and performing of the necessary information according to requests.
3 Conclusion

- A system with a complex array of functional options is being created for the first time in the Ukraine and could be considered as a pilot project, which will open new opportunities for environmental management.

References
