

Environmental assessment of emergency on hydro-technical utilities and within natural-production complexes

N A Zhilnikova^{1,3}, I A Shishkin¹, A I Shishkin² and V M Milova¹

¹ Federal state autonomous educational institution of higher education “Saint-Petersburg State University of Aerospace Instrumentation”, 67 A, Bolshaya Morskaya str., 190000, Saint-Petersburg, Russia

² Federal state budget educational institution of higher education “Saint-Petersburg State University on Industrial Technologies and Design”, 18, Bolshaya Morskaya str., 191186, Saint-Petersburg, Russia

³ E-mail: nataliazhilnikova@gmail.com

Abstract. The factors determining environmental protection activity in single natural-production complex taking into account technological specificity are identified. The most important criteria for environmental assessment applied in construction and reconstruction of hydro-technical utilities are proposed. To evaluate the impact of hydro-technical utilities in design mode and emergency conditions, the economically estimated possible changes of environmental elements and environmental risks are described. The proposed hydro-ecological assessment methodology of compound technological systems allows to make effective coordinating decisions in management of complex technical objects impact to aquatic ecosystems.

The environmental assessment of different kind of anthropogenic load including the reconstruction of hydro-technical utilities (HTU), is connected with the need to take into account changes in an aquatic ecosystem as a result of its transformation (flow regulation). Until now, the necessary scientific information about environmental aspects of hydro-technical and other water management projects is completely lacking.

The existing practice of hydro-technical utilities reconstruction on natural or artificial reservoirs and watercourses (barrages constructed during river regulation, dams, canals, sewed watercourses, closed water conduits, water intakes, etc.), to one degree or another, necessitates a hydro-ecological assessment. Water regime (its general and intra-annual balance), hydrodynamic and morphometric characteristics, thermal regime, as well as volume and composition of different incoming substances are determining.

The above mentioned factors impact to abiotic parameters and biota of aquatic ecosystems, causing hydro-physical, hydro-chemical and hydro-biological changes. The hydro-biological parameters variations significantly effect to the processes determined the water quality and bio-productivity. At the same time, kind and degree of impact of HTU in different water bodies are different.

River regulation makes an impact to their water regime, both above and below a barrage: runoff volume, its distribution over time, flow rate, and water level changed. These changes of hydro-physical and morphometric factors significantly impact to structural and functional characteristics of hydrobiont's communities, processes of biological self-purification and pollution. In result the water quality, the bio-productivity, and finally the conditions of rivers economic use changed too.



The reservoirs are characterized by specific features of slow flow, dynamic level regime, water level drawdown, vertical stratification of water mass and, sedimentation of suspended substances. Weight significantly reacts on oxygen regime, dynamics of organic, biogenic substances, and all complex of hydro-chemical parameters, as well as change of species composition and development of hydrobiocenosis.

For reservoirs, the most important consequences of impact are the changes in coastal relief, flooding and waterlogging of coastal areas.

For reservoirs-coolers of thermal power plants and nuclear power plants created on the basis of natural reservoirs and watercourses, as well as constructed specifically for these purposes, the main impact on aquatic ecosystems is the supply of heated water. These waters change the structure and functional characteristics of hydrobiocenoses, react on water quality and cause interference of operation of energy facilities.

The integrated ecosystem approach determines a need to consider the catchment basin, taking into account the characteristics of the overlying water bodies and the removal of various substances with surface and underground runoff. Only this approach allows to make an ecological assessment of the joint impact to several industrial natural-production complexes and agriculture systems with intensive water amelioration. In this case, consideration of different alternatives of technical solutions and control of scrupulous compliance with polyvariety principle is possible on the basis of simulation modelling of water ecosystems. For an objective comparison of various options, the impact indicators, criteria for their assessment, as well as methods for determining their absolute and relative values of environmental situation of considered natural-production complex should be developed. Particular attention should be paid to indirect effects that arise not as a result of direct impact of technical objects and production complexes, but as a result of factor interaction. A change of one factor may cause an unexpected change of others in another place. This requires decoding of impact mechanisms, identify the links between abiotic and biotic parameters and their quantitative characteristics and, conformity to dynamic principle of aquatic ecosystems, occurring under the influence of key environmental factors transformation studied in considered water bodies and streams.

Figure 1 shows the structure of information support for control and management of technogenic load from hydro-technical utilities and other industrial complexes to water bodies. "Water users - water object" system is considered for various emergency scenarios on hydro-technical utilities and, accordingly, the hydro-ecological assessment is required during the experimental conditions within whole natural-production complex (NPC) taking into account the flow of different wastewater, fertilizers and toxic chemicals from agricultural land. This integrated approach allows evaluate ecological status of recreation at present time and in perspective.

Before predicting the consequences of influence from hydro-technical and other production utilities during hydro-ecological assessment, development a background environmental forecast and, using a simulation model, getting an idea of possible changes in aquatic ecosystems for the nearest and distant future for various emergency situations on HTU and extreme environmental factors is required. To assess a damage risk, the determining not only nature of the changes, but also the identification of process speed and degree of its irreversibility are relevant. The forecast of technical system impact to reservoirs and watercourses should be developed for design modes of operation, as well as for various emergency regimes if the geo-information databases and the data contained in geo-information systems are available.

The initial data obtained in accordance with the given structure of information support (figure 1) (risk analysis, design and executive documentation, graphic materials, regulatory documents) allows to calculate the damage caused by the accident on hydro-technical utilities by combined use of damage assessment methods: detailed assessment method, flat evaluation method and, method of aggregate indicators [5]. The hydro-ecological assessment methodology is implemented in accordance with figure 1 if the main factors causing accidents and emergencies on HTU and water bodies are there. In general case, potential damage from an accident on HTU and a water body is determined by summing up all types of damages, including agriculture, environmental and social damage.

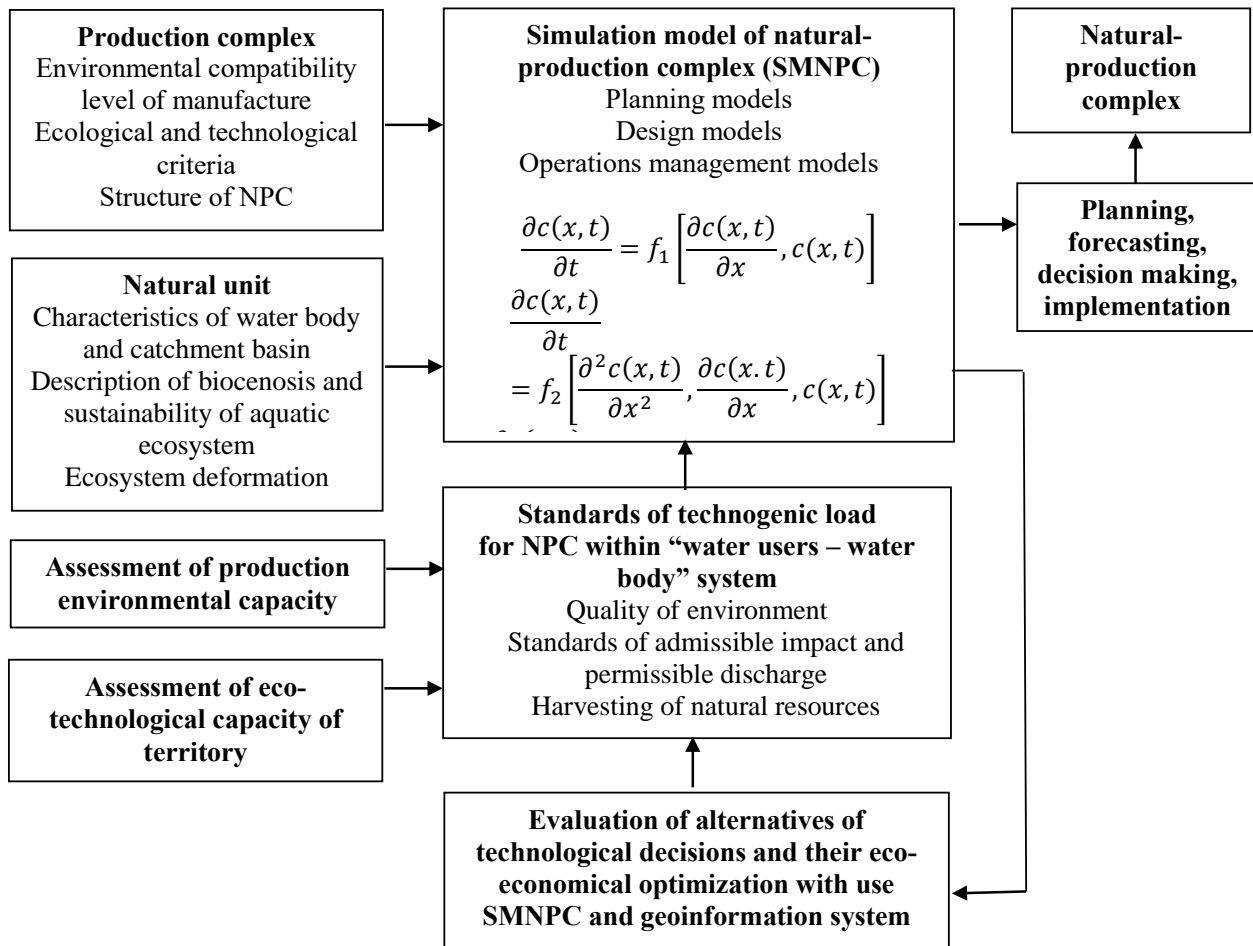


Figure 1. Structure of information support for control and management of technogenic load to water bodies from hydro-technical utilities and other production complexes.

Methodological tasks that need to be solve during hydro-ecological assessment of technical systems impact determine depending on its composition and accord to successive stages of development (figure 2). These tasks are overall for different categories of water bodies and various aspects of environmental assessment, although in each case there is a certain specificity that needs to be taken into account.

NPC safety evaluates for whole complex taking into account the current status of each utility. Possible scenarios of emergency occurrence and accidents progression are determined on assessment of engineering-geological and natural-climatic conditions of HTU location, design-layout solutions and current status of hydro-technological utilities.

Quantitative assessment of likelihood of a scenario with significant risk level is performed using literary and statistical data on equipment failures and malfunctions, personnel errors, as well as information about frequency of natural impacts and the ability to cause accidents. The danger degree for given indicators is determined separately for each of them at particular level based on expert estimations [6].

Various kinds of damage, including damage for surface water resources, land resources, fisheries, environment, and social damage are estimated using appropriate methods and are identified in accordance to the classification of natural and technogenic emergencies for each NPC [7].

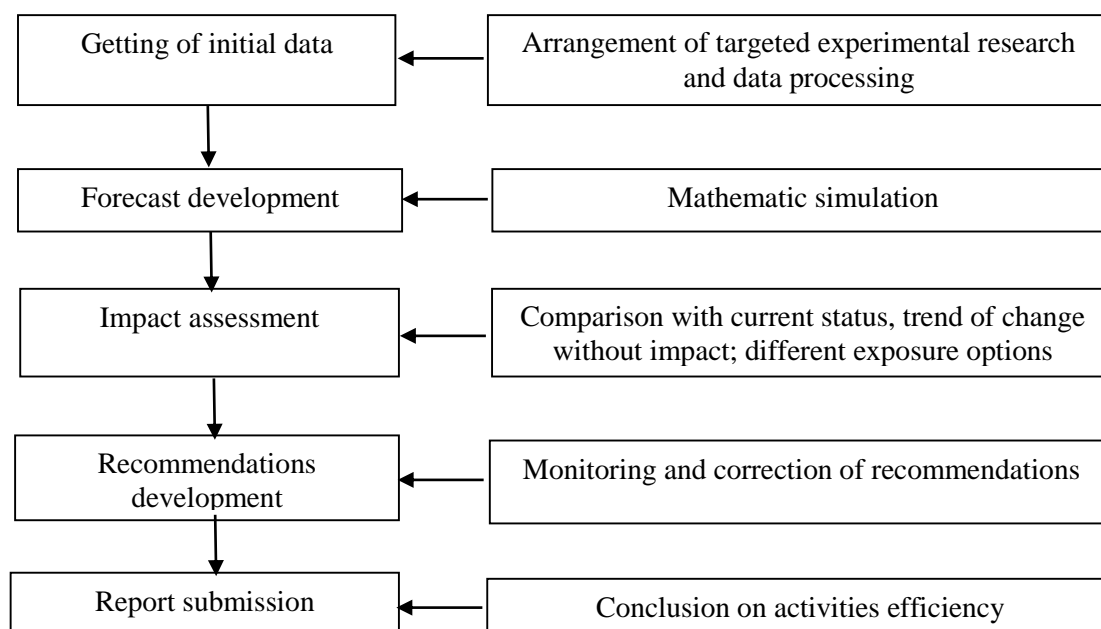


Figure 2. Methodology tasks during hydro-ecological assessment of technical systems impact.

The proposed methodology of hydro-ecological assessment of interaction between natural-industrial complexes can be used in development of programs for integrated use and protection of water bodies for any basins.

References

- [1] Shishkin I A, Shishkin A I and Zhil'nikova N A 2018 Modern conception and methods of standartization of technogenic load to water bodies and flooding prevention *Biosfera* **10** 143-75
- [2] Fedorov M P 2012 *Monitoring of Environment and Technosphere Dangers* ed Fedorov M P et al (Saint-Petersburg: State Polytechnical University) p 259
- [3] Shishkin A I 1981 *Mathematic simulation of pollution transfer and forecasting of environment quality* ed Maksimov V F (Leningrad: LTA) p 123
- [4] Antohina Ju A, Zhil'nikova N A and Semenova E G 2017 *Environmental Management of Territorial Arctic Natural- Technical Complexes Based on Geoinformation Technologies* (Saint-Petersburg: SUAI) p 237
- [5] Arefev N V, Badenko V L and Osipov G K 1998 Basin-landfill approach to environmental monitoring on hydro-energy complexes based on geoinformation technologies *Hydrotechnical building* **11** 25–8
- [6] Kozlitin A 2012 *Intgrated risk of technigenic systems. Theoretical foundations, evaluation methods and quanitive assessment* (Saarbrücken: Palmarium Academic Publishing) p 260
- [7] Akimov V A, Novikov V D and Radaev N N 2001 *Natural and technogenic emergency situations: dangers, hazards, risks* (ZAO FID "Delovoy ekspress") p 344

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.