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Environmental safety in the irrigation and watering systems design stage

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Abstract. At the present stage of water management complex development as a part of the agricultural-industrial complex (AIC), there is an ambitious task to create fundamentally new technologies for using water resources for existing and emerging irrigation and watering systems (I.W.S.). Based on the transformations in natural environments natural processes unity (atmosphere, hydrosphere, upper layers of the lithosphere and soil cover) aimed at the water resources formation (surface and underground runoff) within the basin geosystem under consideration spatial limits, with water use technological processes at I.W.S. as a part of the natural-technical system (NTS) "Environment - I.W.S. – Population" ("E.- I.W.S. - P."), presents the comprehensive studies results of the processes of interconnection, interaction and relationship (IIR) of the I.W.S. technogenic component with E. and living P., on the basis of which the methodological foundations were developed for putting forward the new ideas on water resources use, where the central concept is the "Ecological Acceptability" of design decisions, stipulating the system principle of the principal role of the whole in relation to the main problems of Energy, Water, Food and Ecology. The I.W.S. environmental acceptability is determined by the current regulatory environmental requirements for environmental safety (ES) in the areas of I.W.S. influence. Based on the comprehensive research results, the constructive and technological requirements are formulated for providing electronic components in design solutions, as factors in providing electronic information for I.W.S.

Introduction

Modern agricultural production, as the economic activity most important branch, is largely associated with providing the population with food (Goods) in its importance among the most global system's important problems "Nature - Society – Man" ranks the third after the problems of Energy and Water [1]. It should be noted that along with the most important problems of the Energy, Water and Food society modern development, there are seven more important problems - ecology, poverty, terrorism and war, disease, education, population demography and democracy. Without solving the first three problems, the next seven problems' solution is impossible [2, 3].

The systematic causal relationship between the Energy and Water problems acts both within the spatial limits of the Earth's biosphere ($W_{b.sp.} = 1 \times 10^{10} \text{ km}^3$) of the global system "Nature - Society – Man" and at the local basin geosystems level where quantitative and qualitative indicators of water resources, used in significant amounts on irrigation and watering systems (I.W.S.) of agricultural production, which determines their dominant role over the problem of "Food" and, accordingly, other seven most important problems. The analysis of the systemic interconnection, interaction and



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interrelationship (III) of the “Energy”, “Water” and “Food” problems is dominated by “Energy”, the continuous flows of which come from the external environment from the primary source - the Sun. Consequently, over the systemic III of the problems of “Energy”, “Water” and “Food” within the Earth’s biosphere, a system of a higher hierarchical level operates in the form of a dominant problem that governs the main problems – “Energy”, “Water” and “Food”, which is important and relevant in the design methodology for environmental protection as a part of natural-technical systems (NTS) “Environment - irrigation and watering systems – Population” (“E. - I.W.S. – P.”).

Research methods

Based on the three main problems of Energy, Water and Food, the problems of Water in agricultural production as a renewable natural resource, in a systematic analysis, are determined by the global moisture circulation processes, which spend about 20% (135600 TW) of Solar Energy reaching the Earth’s land surface ($149.1 \times 10^6 \text{ km}^2$) and the World Ocean ($361.1 \times 10^6 \text{ km}^2$) and the technologies for its use, in particular, on the created I.W.S. At the design stage, “I.W.S.”, as a technogenic component, is considered in the III with “E.” and living “P.” as part of the “E. – I.W.S. – P.”, which determines the characterized ecological state (“ES”) that determines the matter, energy and information (MEI) flows movement nature and intensity in the influence zones of “I.W.S.” [4, 5, 7]. To ensure an acceptable “ES” as a dominant factor in the “environmental safety” (“ES”) normative acceptable level formation in the projected “I.W.S.” influence zones it is important to determine the objective contradictions between the applied technologies for using irrigation water and the natural processes of transformation in “P.S.” under the influence of an anthropogenic component in the form of “I.W.S.” and the population (“P.”) life [2, 6, 8].

Based on modern requirements for ensuring “E.S.” on the designed “I.W.S.” influence zones and the economy agricultural sector sustainable development, it became necessary to develop a set of methodological approaches to ensure the normative ecological state as a factor for ensuring ecological safety in the “I.W.S.” influence zones.

Research Results

Based on the operating “I.W.S.” many years research results in the basin geosystems territories of the Kuban rivers ($F_w = 57.9$ thousand km^2), the Lower Don ($F_v = 100.6$ thousand km^2), Terek ($F_w = 43.2$ thousand km^2) and in particular on the territory of the Stavropol Territory ($F_{\text{St.L.}} = 67.6$ thousand km^2) on the I.W.S. of the Bolshoi Stavropol Canal (BSC-1, BSC-2, BSC-3, BSC-4) within which about 6,000 different types of hydraulic structures (HTS) function to resolve the contradictions between the applied technologies for water resources use and the transformation into “E.” processes (atmosphere, natural and artificial hydrographic network, upper layers of the lithosphere, soil cover) and the P. life in the I.W.S. influence zones [11, 12].

Currently operating “I.W.S.” in the Stavropol Territory with a total irrigation area of 201.3 thousand ha use water resources up to 2 km^3 / year, which are formed within the spatial limits of the basin geosystem of Verhnyaya Kuban, were designed and built in the first and second half of the 20th century, when almost no attention was paid to the ecological safety issues at the “I.W.S.” design stage. Currently, during the reconstruction of existing and the creation of new “I.W.S.” to meet the modern environmental requirements, comprehensive studies are underway to develop the methodology foundations for assessing the impact of “I.W.S.” on “E.” and vital functions of “P.”. The studies have found that of the issues requiring in-depth study multifaceted complex, the most important are the issues related to the technology of using water resources, the creation of environmentally acceptable design solutions that should be based on the modern ideas and a systematic approach [8, 10].

Based on the objectively existing interconnection between the problems of “Energy”, “Water” and “Food” and the fourth most significant problem of “Ecology”, the water resources use in limited conditions is a special type of economic activity, which actually makes it urgent to improve the already applied and the creation of new technologies, in particular at I.W.S. agricultural production. New approaches in the practice of designing “I.W.S.” require the new ideas that contribute to the

opportunities growth to meet the vital and necessary needs of present and future generations in accordance with the laws of nature and, as a result, environmentally sustainable development (ESD) [3, 4, 5].

The experience of using water resources in agricultural production, and in particular at I.W.S., identified the promising areas for putting forward the new ideas:

- The ideas related to the renewable energy sources (RES) use in the technological processes of irrigated agriculture;
- The ideas related to the use of the relief at I.W.S. in the form of natural differences between the water source and the irrigated area;
- The ideas related to the new materials use in the new designs creation of sprinkler machines, intra-system hydraulic structures;
- The idea associated with the wastewater use from livestock complexes as a type of waste on irrigated lands;
- The ideas related to the use of modern information technologies for monitoring irrigation regimes and other in-system technological processes.

A systematic approach to creating the new and improving the existing "I.W.S." as a part of the "E. – I.W.S. – P." is considered as orderliness and integrity, where the system integrity is determined by the dominant role over its components "E.", "I.W.S.", "P."

In the methodology for the formation of new ideas related to the water resources use at I.W.S., as established by the research, it is important to proceed from the predominant role system principle of the whole in the III with the dominant problems of Energy, Water and Food in the TCP under consideration "E. – I.W.S. – P.", in which the "I.W.S." as an anthropogenic component requires continuous constructive improvement in terms of reducing non-renewable resource costs with replacing them with the renewable ones, taking into account increasing environmental requirements for the water resources rational use in accordance with the physiological needs of crops. In accordance with the recommended methodology for the new ideas' formation, the concept of "Environmental Acceptability" is important. It integrates the whole dominant role system principle in the III with the problems of Energy, Water, Food and Ecology [2, 4, 3].

For the considered "I.W.S." in functioning as part of the TCP "E. – I.W.S. – P.", based on the comprehensive research results, the constructive and technological requirements are formulated to ensure the "Ecological Acceptability" (EA) of the developed design solutions, taking into account the current regulatory environmental requirements [2, 4].

1. EA "I.W.S." depends on the structural and technical perfection of the used hydraulic structures, related devices in the form of fish protection and fish passage, etc.;

2. EA "I.W.S." is characterized by the III processes with "P.S." and "P.", under the influence of which an ES is formed under the influence of the HTS streams introduced from the flows changing in motion;

3. EA "I.W.S." is dependent on the resource intensity, energy efficiency in the technological processes of construction and operation;

4. The dominant indicator in the cause-and-effect logic of the III "I.W.S." with "E." and "P." within the spatial limits of the influence zones when evaluating the EA "I.W.S." is E.;

5. EA "I.W.S." promotes the self-organization processes as a universal model of interconnected transformations in "E." under the influence of "I.W.S." as part of the TCP "E. – I.W.S. – P.";

6. EA "I.W.S." contributes to the dominance of the transformations natural processes in "P.S." and a decrease in the increase rate in the entropy level;

7. EA "I.W.S." as a part of the "E. – I.W.S. – P." contributes to the structural and technological elements adaptation processes of "I.W.S." to "E." by means of constructive transformations in "E.";

8. EA "I.W.S." as a part of the TCP "E. – I.W.S. – P." is characterized by quantitative, qualitative and functional indicators;

9. EA "I.W.S." as a part of the TCP "E. – I.W.S. – P." is determined by conducting a continuously periodic systemic integrated environmental monitoring (SIEM).

Ecological acceptability of “I.W.S.” as part of the existing and created TCP “E. – I.W.S. - P.” is determined by a system-constructive and functional property that provides a steady trend in the use of renewable energy sources, modern achievements in the field of fundamental and applied sciences, and practical experience in the application of new constructive solutions in the creation and improvement of “I.W.S.” [9, 13].

“I.W.S.” ecological acceptability as a part of the TCP “E. – I.W.S. - P.” to a certain extent can be considered as a kind of “copy” of the natural system, in which there are continuous processes of transformation of the forms of “Energy” with a tendency to reduce the entropy growth rate, which is expressed in the form of agricultural products with optimal energy consumption [3].

Summary

Based on the comprehensive studies results of the III “I.W.S.” processes with “E.” and the living “P.”, it was found that the ecologic safety in the anthropogenic component influence zones in the form of “I.W.S.” is provided by ES in “E.”, which is formed under the influence of the technogenic component acting as part of the TCP “E. – I.W.S. - P.”

To ensure an acceptable “ES” as the dominant factor in providing electric power in the influence zones of the designed “I.W.S.”, the constructive and technological requirements for providing electric power in the influence zones of the designed “I.W.S.” have been formed, and the structural and technological requirements are formulated to ensure the electronic design of the design solutions being developed, based on the recommended new ideas for the I.W.S. improvement.

When reconstructing the existing and creating the new “I.W.S.” the principles of ES at the design stage are recommended to be considered as a kind of natural system “copy”, in which “the “Energy” forms transformation processes are taking place with a tendency to reduce the entropy growth rate.

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