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# CONTROL ALGORITHM OF THE AIRPORT'S WATER-SAVING PROCESSES

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**Abstract**. An integrated approach to the solution of the water resources utilization problem at all airport management levels is presented in this article. The assessment of the demand for water resources is carried out at organizational and economic level of management. Optimization of water consumption aimed at normal functioning of air-transport production process is carried out taking into account water reuse. Determination of suitable characteristics for waste water purification control is carried out at the airport's productional level, while functionality minimization for the equation of standard cleaning processes dynamics allows to define a matrix of the operating impacts during any disturbance concerning a controlled object. The last task is solved at the technological level of management.

The aim of the research is to implement the integrated approach to airport's water-saving production processes and presentation of the control algorithm. To sum up, realization of the specified algorithm using the computer equipment will allow to increase the sewage treatment efficiency and considerably reduce the consumption of fresh water.

**Keywords:** aviation production processes, environmental pollution, wasterwater, integrated automated control system (IACS), IACS of the airport, control algorithm, objective function, software of IACS.

## Introduction

The condition of the nature-territorial complexes situated near the aircraft equipment operation and repair enterprises is extremely critical. The main source of environmental pollution is the discharge of sewage from specialized aviation enterprises, making make a significant contribution to the environmental pollution. Earlier, the management system in Ukraine did not contribute to the development of industrial wastewater treatment, therefore the reservoirs of the country have gradually suffered from all kinds of pollution. Moreover, small-scale objects did not have purification facilities at all. As a result, the wastes poisoned not only surface but also groundwater.

Therefore the problem of providing the population with water suitable for consumption, becomes actual in all regions. In order to protect the environment and use natural resources rationally, standards for pollutant emissions into the environment and requirements for reducing the consumption of fresh water from water sources have been strengthened. The water cost is not low and this will, undoubtedly encourage more economic water consumption.

For characterizing closed water-flow systems the coefficient of water usage multiplicity is used.

$$n = Q_{gen} / Q_{fresh}, \quad (1)$$

where: $n$ – coefficient of water usage multiplicity; $Q_{gen}$ – total volume of water which consumed by the aviation enterprise [m$^3$/h]; $Q_{fresh}$ – raw water intake by aviation enterprise [m$^3$/h].

The higher this coefficient, the better the water supply scheme. For example, at the beginning of the 21st century in the United States, this ratio reached 7.5.

Solving the problem of economical water consumption is impossible without the use of automated control systems (ASC). This is due to the instability of such processes, and the fact that the implementation of control systems involves the need to use a large number of different blocks (sometimes over 50). Monitoring and managing a large number of data goes beyond the capabilities of even an experienced operator. According to the above-mentioned, there arises a need to implement an integrated approach to solve the problem of rational water resources use at all levels of airport enterprise management. As for the functioning of the automated control system itself, there is a need for the appropriate algorithmic support and software.

The study of the state of the problem of control of wastewater treatment processes (Dubey *et al.* 2017; Franchuk *et al.* 2013; Rahmat *et al.* 2011; Fleischman *et al.* 2003; Dochain, Vanrolleghem 2001) makes it possible to conclude that, due to the current strengthening of the norms on the emission of pollutants into the environment, local automation tasks are solved at air transport enterprises management at the technological level, which does not allow to consider the problem of reuse of water resources in a complex manner at all levels of management of production air-transport processes. In the context of water deficit, this results in the environmental damage and inappropriate use of water resources by airports.

## Main part

The proposed algorithm for rational water consumption and water purification at its first stage includes the assessment of the needs of the specialized aviation enterprises in water resources, being carried out at the organizational and economic level of management.

***Decision making at organizational and economic level.***

Objective function is:

$$W_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ji}Q_{ji}\left(1 + k_{ji}\right) \to \min. \quad (2)$$

Restrictions can be featured by the following formula:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} Q_{ji} \le \overline{C},$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} Q_{ji} \le \overline{Q_{ji}},$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} Q_{ji} \le k_{ji},\ Q_{ji} \ge 0,\ k_{ji} \ge 0,$$

where: $Q_{ji}$ is water usage, needed for normal functioning of *j*-air transport production process in *i*-moment of time; $C_{ji}$ is the price of water expenditure during a *j*-production process at the *i*-moment of time; $\overline{C}$ – expenses limits covered by scientific and financial plan; limit of water consumption during the j-production process at the *i*-moment of time.

***Decision making at production level.***

Objective function is:

$$W_2 = y\sum_{k=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} Q_{ji}\left(1 - \overline{k_{ji}}\right)n_{ki} + \sum_{k=1}^{p}\sum_{i=1}^{m} p_{ki} \to \min \quad (3)$$

$$k = 1,2..l;\ i = 1,2..n;\ j = 1,2..m;\ p_{ki} \ge 0,$$

where: $y$ is economic assessment of water; $n_{ki}$ is multiplicity of water dilution by of *k*-pollutant in the *i*-moment of time; $\overline{k_{ji}}$ is the given level of water reuse by the *j*-production process at the *i*-time point; $p_{ki}$ expenses necessary for elimination of *k*-th pollutant at the i-moment of time.

***Decision making at technological level.***

Tasks at this level refer to the class of tasks connected with optimal sewage treatment technological processes control and is formed taking into account the above-mentioned notations with the following functional given:

$$\int_{T_0}^{T_1}\left[Q^T(t)R(t)Q(t) + U^T(t)R_1^T(t)U(t)\right]dt, \quad (4)$$

where: $R$ and $R_1^T$ are integral matrixes, $U^T(t)$ is the main impact matrix.

It is necessary to determine its minimum value for the dynamics of the controlled element.

Supply of the normal air transport production processes with water resources is carried out in accordance with the algorithm of rational water reuse, implemented in the conditions of the Integrated Automated Control System (IACS) of the airport and presented in Fig.1.

The IACS information base includes data on the need in water resources at the airline's manufacturing processes, the composition of waste water, the physical and chemical characteristics of the pollution ingredient, the characteristics of reagents and equipment. The above mentioned information is formed in the structural subdivisions of specialized aviation enterprise, as a result of laboratory research in the form of documents and data electronic media data.

The main required information is filled in accordance with the data requirements for structural information. The requirements are submitted to the relational data model and come to both the operator's console and other IACS subsystems by the airline and the automated control system of the technological purification processes (ACS TP) in accordance with the levels of the IACS hierarchy.

Assessment of the need in water resources is carried out at the airport management high level (organizational and economic) in accordance with the mathematical statement of the optimization problem (2). The solution of the problem is carried out by the method of linear programming using a set of the calendar planning subsystem applications and management of air transport production processes (ACS subsystems of the airport). A distinctive feature of the solving of this problem is the water consumption optimization for the normal of the j-air transport productional process functioning being carried out taking into account its reuse.

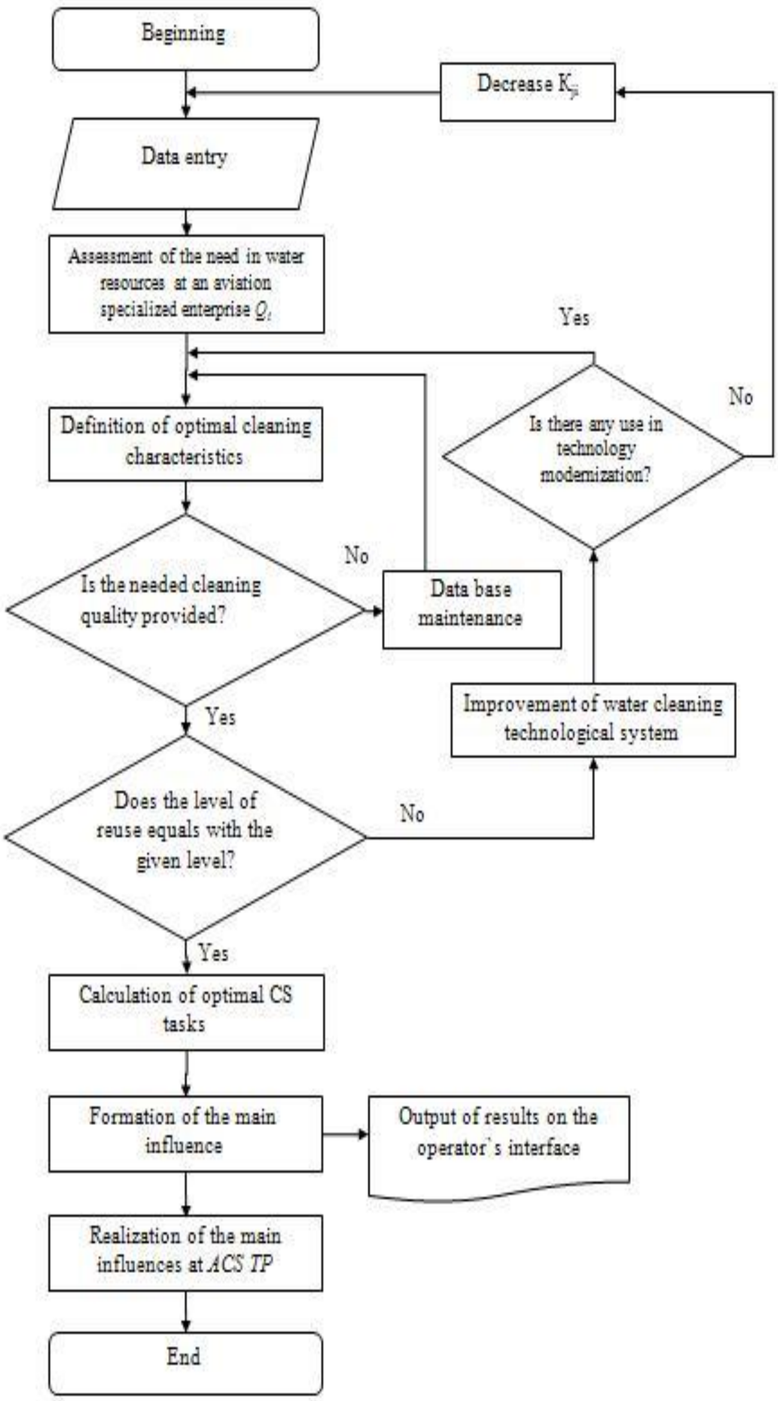


**Fig. 1.** A generalized algorithm of the airport's water-saving processes control

Optimization of the volume of water consumption allows us to assess the necessary conditions for cleaning processes flow, the need for dosage of reagents providing the required quality of wastewater treatment.

If the required quality of cleaning is not provided, further studies on the quantitative and qualitative composition of waste water should be carried out with the database administration being updates, as a consequence. On the basis of the input information, the conditions of cleaning and necessary control influences evaluation processes are reviewed.

If the level of water reuse does not meet the given level, then as it is shown in the algorithm, the technological scheme of purification is foreseen. This task is solved by the head specialist. The procedure is carried out according to the external contour of the considered algorithm.

After calculating the optimal goal of the control system, the control impacts are formed. These impacts are implemented within the ACS TP and come directly to the technological treatment package, as well as to the operator's console. The functional responsibilities of an operator include: control the quality indicators of the cleaned water, to correct the tasks of the control system, management of switching operations.

The operator's panel provides the following functions:

- display and control of the current technological processes of wastewater treatment;
- definition of technological purification processes characteristics and their transfer to the control level;
- warning and emergency alarm;
- reception and display of the wastewater treatment test results from the laboratory's workstation;
- registration and formation of accounting documents;
- archiving and viewing archival documents.

Automated workplace "Laboratory" can provide input and transfer to the remote operator up to 27 results of express sewage tests. Technically, the workstation "Laboratory" and the operator's panel operate on the basis of personal computers and network operating system Windows (Embulaev *et al.* 1999). The database is unique for solving a set of tasks at all levels of the management hierarchy and it functions in DBMS PostgreSQL environment.

Implementation of the considered algorithm within the IACS of an airport allows improving the quality of wastewater treatment, having an effective impact on the operation of the air transport enterprise itself and significantly reducing the cost of additional water consumption.

Applied software for automated solving of optimization tasks, presented above, should be implemented in a high level programming language. The selected database management system (PostgreSQL) has support for downloading additional modules for different programming languages. Based on the tasks of developing a subsystem of automated control of the processes of water absorption of the airport, the most effective is the use of the Java programming language with the connection of the corresponding add-in. Such an appropriate module is part of the PostgreSQL DBMS. It is called "PL/Java" and has the following properties:

- ability to write functions, triggers, user-defined types using the latest versions of Java;
- standardized utilities to install and maintain Java code in a database;
- standardized display of parameters and results. Support for user defined scalar and compound types (UDT), pseudo types, arrays and sets;
- built-in, high-performance JDBC driver that uses PostgreSQL SPI internal procedures;
- metadata support for the JDBC driver. To implement this function, the module includes DatabaseMetaData and ResultSetMetaData;
- integration with PostgreSQL;
- ability to use parameters IN, INOUT and OUT.

Developing solutions in the Java programming language will provide a number of benefits:

- one of the main benefits of Java language is the ability to transfer programs from one system to another. Since applications in the Java programming language do not depend on the platform at both the source code level and the binary level, they can be run on different systems. It also provides the ability to further integrate solutions into the World Wide Web (Zhuchenko, Osipa 2016).
- Ability to create modular programs whose source code can be used multiple times.
- JVM (Java Virtual Machine) is optimized for large multi-core processors and can handle hundreds of data streams without any problems.

## Conclusions

This article is substantial to represent the algorithm for controlling the processes of water saving at the airport enabling a three-level consideration of the management peculiarities: organizational-economic, productional and technological. For the indicated levels of management, the target functions allowing optimal control of water-saving processes have been developed.

The proposed water saving algorithm of the airport provides the adaptation of the purification processes depending on the quantitative and qualitative composition of the waste water, the concentration of reagents, the parameters of the purification processes. It also takes into account the small life cycle of water use allowing it to be used not only at the stage of the system operation, but also at the stage of its development and continuous evolvement.

The further development of automation control facilities will be primarily related to the development of the corresponding software of the subsystem. The choice of programming language (PL/Java) for the implementation of algorithmic provision of automated control of the processes of water conservation of the airport (with appropriate justification) - another result of this work. Based on these advantages, it can be argued that the software of the automated control system of the airport's water conservation processes will be implemented as a single software platform. This platform allows you to manage on a common information basis with high performance.

Based on the data, received by Ukrainian and foreign researchers, it can be stated, that air-transport production processes are an intensive source of natural water pollution. Therefore the solution of economical water consumption problems and tasks of airport sewage treatment on the basis of the automated control systems use methods is very timely.

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