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EVALUATION OF ABILITY FOR NATURAL PURIFICATION OF THE PSYOL AND VORSKLA RIVERS

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ABSTRACT

This paper deals with current issues of assessing the ability of rivers to the process of natural purification. The theoretical basis of calculation is the description of the process of natural purification through rate reduction of the concentration of pollutants in the water during movement of water masses in the river. The result was the method of determining and predicting the concentration of pollutants in the lower river alignment based on their discharge in the upper sections and an inflow time. The determination of the inflow time is based on the calculations of mutual correlation function between outflow charges in upper and lower sections.

Keywords: ***Self-cleaning, inflow time, wastewater, contaminants. [For Keywords are required.***

1. INTRODUCTION:

Psyol and Vorskla rivers are left tributaries of the Dnipro river which is the main artery of Ukraine (Fig. 1). Given rivers take their origins from Central Russian Upland, which is located on the territory of the Russian Federation. Mean annual outflow of the Psyol river is 170 million m^3 per year, wherein 600 million m^3 comes from the territory of Russia. Vorskla river's average multi-year discharge is 1100 million m^3, 200 million m^3 of this amount is formed in Russia.

Figure 1.-Geographical location of the basins of the Psyol and Vorskla rivers(yellow color marks the drainage boundary of the rivers)

There's Kursk magnetic anomaly located on the Russian part of water collectors. Iron ore reserves of the Kursk zone amounted to 10 million tons in 2000 year. The largest producing field is Mikhalkovskaya , which contains up to 400 million tons of ore (Psyol river) . There's Yakovlevsky mine situated within water collector territory of the Vorskla river(Russia).

Beside this, there are gas and petroleum deposits being developed within the territory of Ukraine. Significant impact on the chemical composition of the waters of the cities has wastewaters of Sumy and Poltava cities. Accounting of the water availability season has a particular importance in assessing the quality of the water. Therein, there's period of mean water extracted, when not only the quantity of water required for household purposes is limited, but the necessity appears concerning setting limitations of wastewater discharges, even relatively clean, because the ability of watercourses on dilution of these waters and their natural-purification decreases.

According to the water quality index the highest pollution is observed during spring season. According to the sanitary –toxicological criteria index the highest contamination period takes place of the season"summer- autumn", when the river is fed by an inflow of groundwater and dilution is not intense.

The main pollutants are Fe and Mg, relating to indicators of the sanitary - toxicological regime;

SSAS- relating to the indicator of organoleptic regime; phenols relating to the indicator of sanitary regime [1].

2. REVIEW OF THE LITERATURE

The set of all processes to restore the original water chemistry in accordance with pre-existing balance is called natural purification of the water body [2]. Most pollutants are unstable and eventually removed from the solution under the influence of various processes that promote natural purification. Natural purification and installation of biological balance is the result of combined action of physical, chemical and biological factors. Natural purification processes of the rivers are dependent on physical and chemical factors. In lakes and ponds natural purification is evaluated primarily through hydro biological parameters (development of phytoplankton, bacterial plankton and zooplankton). Under the physical factors it's necessary to take into account the river flow rate intense; sedimentation of insoluble precipitates, the effect of ultraviolet radiation, and others. Among the factors, chemical oxidation of organic and inorganic substances is noted. Heavily polluted river by the way of natural purification can move from a state of saprogenous zone to mesosaprobic and even to oligosaprobic zone under condition of absence of constant replenishment of the contaminants.

During the process of natural purification there is improvement of the physical properties of water going on by the way of adsorption hanging particles of organic substances, heavy metals, microorganisms, coagulation and sedimentation of suspended inorganic and organic substances, mineralization of unstable organic substance. When natural purification is on oxygen content should increase due to aeration and aquatic vegetation, pathogenic bacteria should die, the presence of saprophytic microorganisms dramatically reduced. Through natural purification process small contamination cannot change the natural state of water bodies. But each reservoir has a limit of natural-purification capacity of pollutants, followed by a sharp deterioration of the characteristics of the sanitary condition of water bodies. The process of natural-purification in the rivers occurring more favorable due to higher water flow movement than in lakes and reservoirs. When study of natural-purification processes the following factors are important: correlation of pollutants and the volume of water mass, flow velocity, depth, wind mixing conditions, temperature and others.

The characteristics of natural-purification are quantitative indications that are defined for chemical and biological processes [3]. When contamination of rivers with household wastewater, the leading factor pushing natural purification process is the decomposition of organic substance, which is the final product of mineral compounds. In anaerobic decomposition oxygen consumption is increased and correlated with indicators of biological oxygen demand. These parameters characterize the degree of decomposition of unstable organic substance. Constant K of decomposition rate depends on the composition of pollutants and has different meanings. For household water it is about 0.1 and has about the same value with the decomposition of phytoplankton. Industrial pollutants cause greater fluctuations of K. Decomposition rate of organic substance of the bottom sediments in 20-50 times lower than that for domestic wastewater. The rate of quantity change of bacteria possesses great importance for the characteristics of natural purification. During the first 15 hours of dying 70% of the initial level of bacterial contamination, and on the fifth day it is only parts of one percent [4,5].

The processes of natural purification are investigated on special control points. These researches are carried out in the area of Kcontamination of rivers or ponds, where due to pollutants violated natural biochemical processes and concentration of pollutants for sanitary or other indicators exceeds the norm. Research is conducted in three cross-sections (background, main and locking). Background section should be located above the discharge of contaminated water. Concentrations of pollutants in this section should not exceed the maximum allowable. Additional cross-sections are established between the main (control) and locking section. The number of sections is dependent on the task of research, local conditions (environmental) and composition of pollutants. They are located below the release of contaminated water with sequential increasing of the distance between them (six - nine cross-sections). Additional sections may be added under condition of the presence of the lateral inflow within research section. Such cross-sections are set above and below tributaries in its mouth. Definition of natural-purification capacity of water bodies is performed for specific contaminants, presence of which can be found in the water during expeditionary research, as well as water pollution indicators such as chemical oxygen demand, biochemical oxygen demand. Determination of the temperature, pH, and capacity of dissolved oxygen are required. These parameters characterize the

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conditions and processes of natural purification [1]. Observations of water pollution are performed several times a year in typical phases of the hydrological and hydro-biological regime. Duration of observations is determined by the necessity of obtaining of reliable material characteristics on natural purification capacity of watercourses in the years with varying degrees of water content (abundant, shallow, medium).

Water samples are taken from cross-sections with the accounting of water inflow duration from the upper cross-section to the next one, which is located below.

However, described detailed researches require large material expenses; hence calculation methods using the data of stationary observations are becoming a matter of great importance.

Natural purification ability of water on the site or the degree of natural purification is calculated as percentage reduction of pollutant concentration relative to its initial concentration [6]

$$C3 = \frac{C_B - C_H}{C_B} 100\% \quad , \qquad (1)$$

Where $C3$ -evaluation of natural purification ability, %; C_B - concentration of the pollutant in the upper section, mg / dm3; - Concentration of the pollutant in the lower section, mg / dm3.

To solve the hydrological and ecological problems associated with prognosis of moving volumes of water and dissolved or suspended in it substances the following term is widely used "inflow time" which is interpreted as "time during which the water mass passes the given distance."

Constant K_C (day^{-1}) of a reduction rate of total concentration of pollutant in water is determined by formula given by V.G. Streeter:

$$K_C = \frac{2.3}{t} \lg \frac{C_B}{C_H} \quad , \qquad (2)$$

Where - K_C summary coefficient of natural purification (day^{-1}); t - period of time between measuring the concentration of substances (day).

3. THE MAIN RESULTS

The purpose of the work is to develop methods of determining and predicting of concentrations of pollutants entering the river water in the locations of major cities, and further reduced in the process of natural purification.

Development of methods of calculations is performed on materials of hydro- meteorological network of stationary observations of flow characteristics and water chemistry from 1997 to 2007, in hydrological cross-sections of the rivers Psyol and Vorskla. Evaluation of the ability of natural purification was performed by the concentrations of pollutants and outcomes measured in the upper and lower cross-sections. The main site of polluted water in the river Psyol is Sumy city and for the river Vorskla is Poltava city.

If the summary coefficient of natural purification and inflow time from upper section to lower section are available it's possible to find out the concentration of polluting substance in the lower section that equals to the inflow time τ.

$$\frac{C_B}{C_H} = 10^{\frac{\tau K_C}{2.3}} ; \qquad (3)$$

$$C_H^{'} = C_B 10^{-\frac{\tau K_C}{2.3}} \quad , \qquad (4)$$

where $C_H^{'}$ - calculated concentration in the lower section.

Inflow time from upper section to lower section was determined using mutual correlation function between the water flow in the upper and lower cross-sections with a shift in time [7].

Determination of mutual correlation functions is executed by the following formula.

$$r_{xy}(\tau) = \frac{K_{xy}(\tau)}{\sigma_x \sigma_y} = \frac{\sum_{i=1}^{n-\tau} (x_i - \overline{x_i})(y_{i+\tau} - \overline{y}_{i+\tau})}{\sigma_x \sigma_y (n - \tau - 1)}, \quad (5)$$

Where $R_{xy}(\tau)$- the correlation function with shift of τ; $\overline{x}, \overline{y}$ -the arithmetic mean of the series X, Y; σ_x, σ_y square deviation of the two series of observations with length n.

The inflow time was defined as the time shift between rows of outcomes where mutual

correlation function reaches its maximum value. An example of such a graph is shown in Figure 1.

Inflow time between the hydrologic cross-sections located along the length of both rivers was determined on the basis of mutual correlation functions. Figures 2 and 3 show the calculated changes in length of inflow time of the river from their source to mouth. The value τ can be set for any unexplored areas of the rivers researched using these graphs.

The calculations of summary natural-purification coefficient for various chemical substances were executed by the formula (2) based on observations in hydrological cross-sections of rivers Psyol: Sumy city – Zapsillya village; r.Vorskla:Poltava city- Kobeliaky city. The coefficients K_C were determined at different times and phases of water regime and were averaged for the further usage. For example, the section Poltava-Kobeliaky K_C =0,070for copper and K_C =0,197 for the iron. During determination of water pollution of the river Vorskla with such substances within section of Poltava (for example, C_{Cu} =4,4 mkg/dm^3),it's possible to predict by the equation that after 2 days (inflow time from Poltava to Kobeliaky) copper concentration will be equal 2,96 mkg/dm^3 in maximum permissible level of contamination for drinking purposes of 1mg/dm^3. The proposed approach can be used for the calculation and prediction of concentrations of pollutants of the river lower section on the base of data for their concentration in the upper section.

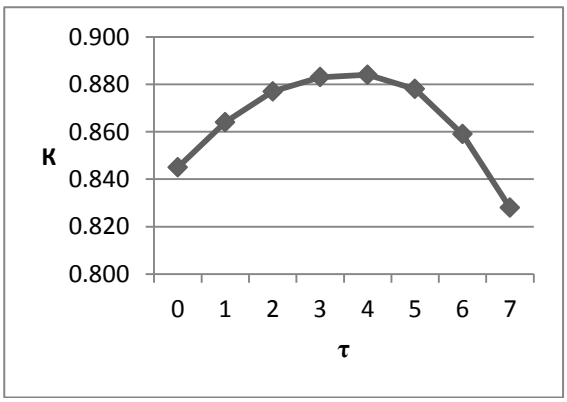

Figure 2. - Mutual correlation function between the consumption of upper and lower cross-sections
Upper section: Vorskla river –Chernechchina village; Lower section:Vorskla river –Kobeliaky city;

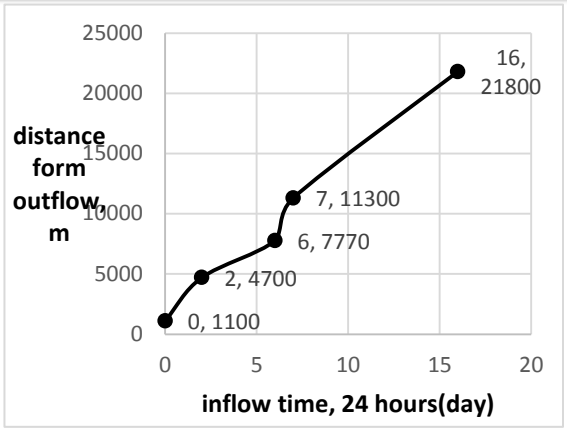

Figure 3. - Dependence of the inflow time from the distance from outflow of the Psyol river.

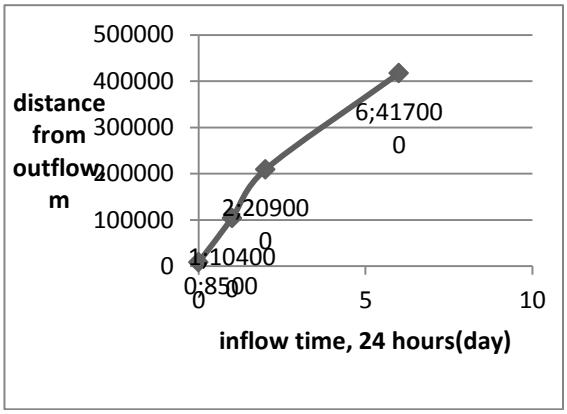

Figure 4. - Dependence of the inflow time from the distance from outflow of the Vorskla river.

4. CONCLUTIONS

The article shows the possibility of calculations and forecasts of concentrations of pollutants in the river based on the data of their discharge in the upper sections and inflow time. The theoretical basis of calculation is the description of the the processes of natural-purification through rate reduction of the concentration of pollutants in the water during movement of water masses in the stream canal.Authors had proposed to use the mutual correlation function for determination of the inflow time.

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