

Igor Gopchak

National University of Water and Environmental Engineering, Rivne City
Ukraine

i.v.hopchak@nuwm.edu.ua

ORCID: 0000-0003-4774-5504

Tetiana Basiuk

National University of Water and Environmental Engineering, Rivne City
Ukraine

tanya_basyuk@ukr.net

ORCID: 0000-0003-2861-0460

Artem Yatsyk

National University of Water and Environmental Engineering, Rivne City
Ukraine

yatsyk_vg19@nuwm.edu.ua

ORCID: 0000-0003-4293-1754

Oleksandr Yatsyk

National University of Water and Environmental Engineering, Rivne City
Ukraine

yatsyk_az21@nuwm.edu.ua

ORCID: 0000-0001-5675-1645

ASSESSMENT OF ANTHROPOGENIC LOAD ON THE STOKHID RIVER BASIN

OCENA OBCIĄŻENIA ANTROPOGENICZNEGO NAD DORZECZEM RZEKI STOKHID

Abstract: The assessment of anthropogenic load on the Stokhid river basin has been performed. The method of determining the induction coefficient has been considered. Usage of land and water resources of the river basin was characterized. Water quality was determined. Quantitative and qualitative anthropogenic status has been assessed according to various indicators of four subsystems for classification of ecological status of the river basins. The level of anthropogenic load and the general ecological condition of the river basin were determined. Sources of river pollution were analyzed. Measures to improve the environmental situation in the river basin are proposed.

Key words: river basin, anthropogenic load, induction coefficient, land resources, water resources, water quality, ecological condition

Słowa kluczowe: dorzecze, ładunek antropogeniczny, współczynnik indukcji, zasoby ziemi, zasoby wodne, jakość wód, stan ekologiczny

Introduction

The growing impact of anthropogenic activity on the environment leads to a significant deterioration of the ecological condition of all its components, including bodies of water. Among the latter, rivers are the most vulnerable, as they are used for communal, agricultural and industrial purposes, while also being destinations of sewage discharges and industrial waste. Deterioration of the ecological condition of small river basins is due to deforestation, increasing area of plowed land, large-scale hydraulic reclamation, soil erosion, radionuclide pollution due to the Chernobyl disaster, expansion of industries and municipal pollution [Yatsyk et al. 2015; Hryb et al. 2012; Gopchak 2016]. This has led to a offsetting of the ecological balance in the basins of small rivers of Ukraine and emergence of a number of hydro-environmental problems (water pollution, destruction of natural landscapes in river valleys and surrounding areas etc.).

Currently, there is observable deterioration of the ecological situation in the basin of the river Stokhid, which flows in the Volyn region. Despite significant reduction in agricultural and industrial production in the region, the ecological state of the environment has not improved in recent years. With the current of water treatment facilities and respective treatment methods, state of accounting and control of the wastewater, conditions in the river basin have deteriorated significantly. Sources of pollution are discharges of insufficiently treated wastewater, as well as unauthorized connection of sewage systems from residential buildings to storm drains of enterprises, placement of latrine landfills, non-compliance with water protection regulations in the settlements of the river basin. In addition, situation is exacerbated by the fact that in recent years the territories of banks and floodplains of rivers are actively allocated for cottage construction, gardening and horticulture. All these changes require clear, operational control and response, which is possible only with a realistic assessment of the anthropogenic load on the Stokhid river basin. The river basin is an indicator of the “health” of surrounding environment, which is under anthropogenic pressures, with changes in landscapes, soils, forests, water quality and flora and fauna. In this regard, the study of anthropogenic pressure and the determination of the ecological status of the river basin as a single geosystem are of particular importance.

Methodical approaches to determining the criteria for assessing the anthropogenic load on small river basins are covered in the scientific works of A.V. Yatsyk [Yatsyk 2004], Z.V. Timchenko [Tymchenko 2000], O.V. Kirilyuk [Kirilyuk 2010] and others. The works of I.Y. Myskovets [Myskovets 2003], I. Netrobchuk [Netrobchuk 2014] are of significant scientific interest, in which the ecological condition is analyzed and different types of anthropogenic load on basins of small rivers of Volyn region are

assessed. The analysis of the modern scientific literature shows that now the research devoted to anthropogenic transformation of a certain territory and development of restorative measures on optimization of environmental management prevails. However, the work on the assessment of the definition of indicators of anthropogenic pressure on river basins is insufficiently covered in the literature, so there is no doubt regarding the relevance and importance of afformnetioned research topic.

The purpose of the study is to assess the anthropogenic load and determine the ecological status of the Stokhid river basin to develop measures to improve the condition of th latter.

To achieve this goal, it was necessary to conduct the following tasks:

- 1) assess the quantitative and qualitative anthropogenic state of the river based on various indicators within individual subsystems;
- 2) determine the level of anthropogenic load and the general ecological condition of the river basin;
- 3) propose measures to improve certain indicators of individual subsystems.

Research methods

Calculation of anthropogenic load and assessment of the ecological status of the river basin were performed in accordance with the “Methodology for calculating the anthropogenic load and classification of the ecological status of small river basins of Ukraine” [Metodyka... 2007]. The logical-mathematical model of hierarchical structure built on the ecosystem principle allows to monitor the state of river basins by different indicators in terms of individual subsystems (“Radioactive contamination of territory”, “Land usage”, “Use of river runoff”, “Water quality”) and as a whole. An important feature of the proposed model is that the assessment of system states and subsystems in this model is performed in parallel and in two directions - quantitative and qualitative: the qualitative state of subsystems is assessed, with subsystems determining the quantitative measure of the whole system.

According to the method [Metodyka... 2007], the values of the primary indicators of the subsystem of land and water resources were transformed into points and given a qualitative description of each of them. Subsequently, a comprehensive indicator was calculated and the class of the state of use of the subsystem was determined on the appropriate scale. In general, the assessment of anthropogenic load on the river basin was carried out by the induction coefficient (*ICAL*) according to the formula:

$$ICAL = 0,3 \times C_{lr} + 0,2 \times C_{wr} + 0,5 \times C_{wq},$$

wherein *ICAL* is the induction coefficient of anthropogenic load on the river basin; 0.3; 0.2; 0.5 – weights cumulatively equal to 1.0; C_{lr} , C_{wr} , C_{wq} – complex indicators of land and water resources use, water quality.

As a result of the assessment of the state of all four subsystems, the overall assessment of the state of the entire basin system can be carried out. The following grades of the river basin determine the value of the quantitative measure of the qualitative state of the whole system: “good”, “minor changes”, “satisfactory”, “bad”, “very bad”, “catastrophic”. The grade given to the basin reflects the degree of anthropogenic load and the response of the ecosystem to this load.

The source materials for the calculation of anthropogenic pressure were statistical and cartographic data on ecological conditions and usage of land and water resources in the basin of the Stokhid River.

The results of the study

The Stokhid River is a right tributary of the Pripjat and flows within the Volhyn region. The source is located near the village Yalovats’k, Kamin-Kashyrskyy district. Stokhid originates near the village of Semeryns’ke, in Volhynian Polissya, within the Volhynian-Podolian Upland. It flows mainly to the northeast. It flows into Pripjat near the southern outskirts of the village of Svalovychi. The valley in the upper course is clearly delineated, up to 4.0–4.5 km wide, in the lower course – indistinct, up to 7.0–10.0 km wide. The floodplain is bilateral, swampy, from 0.4 km wide (at the top) to 2.5 km (at the bottom). The river is traced mainly in the upper reaches, where in places its width is 20–25 m, depth 0.5–1.5 m. Origin of water is mixed, with a predominance of snow. The river freezes in early December, with ice decaying in March [Molchak, Mihas 1999; *Metodyka...* 2007].

According to the method [*Metodyka...*, 1998], we performed calculations of anthropogenic load and determined the ecological status of the Stokhid river basin.

The assessment of the state of the subsystem “Radioactive contamination of the territory according to [*Metodyka...* 1998] in the basin of the river Stokhid was not taken into account, because no radioactive elements were detected during the study period. Therefore, we can assume that the ecological status of the Stokhid river basin is satisfactory with a quantitative measure of 0. This subsystem will not affect the calculation of the induction coefficient of anthropogenic load.

According to the natural and agricultural zoning of Ukraine, the Stokhid River basin is located in the Western Polissya Province. Elements of the subsystem “Land usage” are indicators of forest cover (f_{fc}), natural state (f_{ns}), agricultural development (f_{ad}), plowing (f_p), urbanization (f_{ur}) and erosion (f_{er}) of the basin. According to the calculations, the indicator of land urbanization, which corresponds to the state of land use “below the norm”, has the worst value among all indicators. Indicators of forest cover and the degree of natural condition have an “improved” condition, and other indicators – “good”. The complex indicator of C_{lr} is 2.0 and establishes the state of the subsystem “Land Usage” in the basin of the river Stokhid as “close to normal”.

Assessment of the ecological status of the river by the subsystem “Use of river runoff” is carried out on the following indicators: the actual use of river runoff (q_{rr});

irreversible water consumption (q_{iwc}); discharge of water into the river network (q_{dw}); discharge of polluted wastewater into the river (q_{dpw}). Each value was calculated separately using data such as: water abstraction from the river network (W_a); the size of losses of river runoff due to extraction of groundwater that is hydraulically connected to the river network (W_l); factual river runoff (W_p); the volume of water discharged into the river network (W_d); the volume of discharge into the river network of polluted wastewater (W_{pw}).

According to calculations, insignificant values of discharged polluted wastewater and use of river runoff were noted in the Stokhid river basin. In general, the state of the subsystem "Use of river runoff" in the basin of the river Stokhid in terms of water consumption is classified as "good" with a quantitative measure of 3.0.

Subsystem "Water Quality" is designed for environmental assessment of surface water quality and classification of the river basin by the level of anthropogenic water pollution. Ecological assessment of water quality of the Stokhid River was performed in accordance with the "Methodology of ecological assessment of surface water quality by relevant categories" [Metodyka... 1998]. In general, this subsystem includes three blocks: the block of indicators of salt composition of water (I_1); the block of trophosaprobological (ecological and sanitary) indicators (I_2); the block of specific toxic substances (I_3). Based on the results obtained for each block of indicators, the integrated ecological water quality index (I_E) was determined, which is the arithmetic mean of the previous three indices. In fact, its value is often very approximate to real state of water pollution, so the quality in the subsystem should be classified according to the index of trophosaprobological indicators. The latter mostly characterize the usual components inherent in water bodies, the concentration of which in water changes under the influence of human activity. According to the values of the integrated ecological index, the state of the subsystem "Water Quality" in the basin of the river Stokhid is characterized by class IV water quality ("polluted") with a quantitative measure of -1.

The general assessment of anthropogenic load on the river basin is carried out by the induction coefficient, using complex indicators of individual subsystems and weights. According to the results of a comprehensive assessment of all subsystems, the ecological status of the Stokhid river basin is classified as having "minor changes", the level of anthropogenic load by the value of ICAL is 0.7.

To improve the environmental situation in the Stokhid river basin, it is necessary to take the following priority measures:

- 1) enforce compliance with the current requirements of environmental legislation and exiting rules;
- 2) impose penalties for non-compliance with current water protection legislation.
- 3) limit the use of nitrogen fertilizers in order to prevent them from entering the river waters as runoff from agricultural fields;
- 4) establish water protection zones along the riverbed, where plowing and reclamation should be strictly prohibited and a stricter regime of economic

activity within the water protection zones and river banks in the basin should be enforced;

- 5) exercise control over discharges and enforce compliance with water purification requirements.

Conclusion

Thus, based on the calculations, it can be argued that, in general, the ecological status of the Stokhid river basin can be defined as having “insignificant changes”, and the level of anthropogenic load outlined by the value of the induction coefficient, that is 0.7. There is no radioactive contamination of lands in the Stokhid river basin. The state of the subsystem “Land usage” is classified as “close to normal” with a quantitative measure of 2.0, and the subsystem “Use of river runoff” – as “good” with a quantitative measure of 3.0. Water quality in the river basin is characterized by class IV water quality (“contaminated” water) with a quantitative measure of –1.0. To improve the ecological conditions of the river basin, it is proposed to enforce compliance with current water protection legislation.

Assessment of anthropogenic pressure on the river basin is very important, especially for the formulation of necessary environmental protection measures and activities in the river basin, as well as establishment of the set of indicators that have the greatest impact on its ecological status. All this indicates prospects of further research into Ukraine’s small rivers, which should focus on a detailed assessment of the ecological statuses of their basins.

Bibliography

- Gopchak I.V., 2016, *Analiz antropohennoho navantazhennia na baseiny malykh richok Ukrainskoho Polissia // Heodeziia. Zemleustrii. pryrodokorystuvannia: prysviachuitsia pamiati P.H. Cherniahy: Vseukr. Nauk.-prakt. konf., 9–10 lyst. 2016 r.: tezy dop.* Rivne: NUVHP, 2016, s. 119–121.
- Hryb Y.V., Klymenko M.O., Sondak V.V., Hryniuk V.I., Voityshyna D.Y., 2012, *Vidrodzhenia system transformovanykh baseiniv richok ta ozer*, Rivne: NUVHP, s. 246.
- Kyryliuk O.V., 2010, *Otsinka peretvorenosti malykh richkovykh baseiniv yak krok do vyznachennia antropohennykh zmin hidromorfolohichnykh umov*, Hidrolohiia, hidrokhimii ta hidroekolohiia : nauk. zb. K., T. 18, s. 283–289.
- Metodyka ekolohichnoi otsinky yakosti poverkhnevyykh vod za vidpovidnymy katehoriiai-my*, 1998, Kyiv, s. 28 (in Ukraine).
- Metodyka rozrakhunku antropohennoho navantazhennia i klasyfikatsii ekolohichnoho stanu baseiniv malykh richok Ukrainy*, UNDIVEP, Vydannia 2-he, pereroblene i dopovnene. Kyiv : «Polimed», 2007, s. 71.
- Molchak Ya.O., Mihas R.V., 1999, *Richky Volyni*, Lutsk: Nadstyria, s. 176.

- Myskovets I.Ya., 2003, *Antropohenni zminy v baseinakh malykh richok (na prykladakh Volynskoi oblasti)* : avtoref. dys. kand. heohr. nauk. Chernivtsi.
- Netrobchuk I.M., 2014, *Otsinka antropohennoho navantazhennia na basein verkhnoi Prypiati v Ratnivskomu raioni Volynskoi oblasti*, Nauk. zapysky Sumskoho derzh. ped. un-tu imeni A.S. Makarenka. Heohrafichni nauky. Vyp. 5. Sumy, s. 10–18.
- Palamarchuk M.M., 2001, Zakorchevna N.B., *Vodnyi fond Ukrainy: Dovidkovyi posibnyk*, Kyiv: Nika-Tsentr, s. 392.
- Tymchenko Z.V., 2000, *Otsinka ekolohichnoho stanu malykh richok/ Ukraina ta hlobalni protsesy*: heohrafichni vymir: zb. nauk. pr.: v 3 t. Lutsk. T. 2, s. 317–320.
- Yatsyk A.V., Hopchak I.V., Pasheniuk I.A., Basiuk T.O., 2015, *Naukovi zasady normuvannia antropohennoho navantazhennia richkovykh baseiniv*, ETEVK-2015: Mizhnarodnyi Konhres, 8–12 chervnia 2015 r.: zb. dop. Kyiv: TOV «PRAIM-PRINT», s. 314–322.
- Yatsyk A.V., 2004, *Vodohospodarska ekolohiia*: u 4 t, Kyiv: Heneza, № 4, s. 480 (in Ukraine).

Streszczenie

Dokonano oceny obciążenia antropogenicznego w dorzeczu Stokhid, rozważono metodę wyznaczania współczynnika indukcji, scharakteryzowano wykorzystanie zasobów lądowych i wodnych dorzecza. Określono jakość wody. Ilościowy i jakościowy stan antropogeniczny oceniono według różnych wskaźników czterech podsystemów klasyfikacji stanu ekologicznego dorzeczy. Określono poziom obciążenia antropogenicznego oraz ogólny stan ekologiczny dorzecza. Przeanalizowano źródła zanieczyszczenia rzek. Proponowane są działania na rzecz poprawy sytuacji środowiskowej w dorzeczu.