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Hydroecological state of the Poltva river and its tributaries

Abstract

The Poltva river, the left tributary of the Bug, is the sewage collector within Lviv city, causing the severe pollution of its water. Therefore, research of water quality of the river is necessary.

During the 2012-2014 summer-autumn low-water season we have been studying water quality of the Poltva river and of its main tributaries. Water quality parameters are compared with the standards for fresh waters needing fish protection and with the standards for bathing water quality, valid in Ukraine and in the European Union. Assessment of rivers' water quality is made on a basis of the Water Contamination Index.

In consequence of considerable excesses of water quality parameters the water of the Poltva river is characterized as «extremely dirty», according to Water Contamination Index, and also unsuitable either for bathing (cultural and community use) or for fish life.

The water of tributaries of the Poltva was «clean» or «moderately polluted» at the limit of «clean». Excesses of MAC of BOD5 were often observed, sometimes excesses of the norms of COD and of nitrites were found. The insufficient content of the dissolved oxygen under the European rules in the tributaries was discovered.

Key words: hydroecological state, water quality, Maximum Allowable Concentration, Water Contamination Index, the Bug river basin.

Introduction

The Poltva river is a left tributary of the Bug, which is the tributary of the Narew through the Zegrze Reservoir, belongs to the Vistula basin (Fig. 1). The length of the river is 60 km, its basin area is 1440 km^2. According to the EU Water Framework Directive it is the large mid-altitude river of the ecoregion «Eastern plains». The Poltva originates in Lviv in Ukraine, being a sewage collector throughout 7 km within the city. After water treating the river is flowing open channel and after 50 km flows into the Bug river, causing its severe pollution. Since the Bug flows into the Zegrze Reservoir, which is the source of water supply of Warsaw city, the question about water quality of the Poltva river is of urgent importance.

The water quality of the Poltva river was investigated by L. Kurhanevych (2001), M.Zabokrytska (2005), N. Voznyuk (2006), T. Bodnarchuk (2010) etc. A joint Ukrainian-German project carried out modelling, monitoring and management-integrated analysis of water quality aspects at the headwater of the Bug basin, including in the Poltva river basin (Blumensaat et. al. 2010). Public services are monitoring Poltva water quality downstream of treatment facilities and at the mouth river section.

Fig. 1. The Poltva sub-drainage basin within the Bug drainage basin. (source: Budowa… 2009).

DATA AND METHODS

Research of hydroecological state of the rivers of the Poltva basin was carried out by us within four years.

Our research focus on detailed study of the water quality of the rivers of the Poltva basin. During the summer-autumn low-water season in 2011 we made an assessment of water quality in 15 sampling sites along the Poltva river and in its main tributaries (Shipka 2013). According to British «The Surface Waters (River Ecosystem) Classification» (1994), the water quality of the Poltva and of its largest tributaries was identified as unsatisfactory. In particular, considerable fluctuations of the Poltva river water quality parameters were discovered due to changes of quantity and quality of sewage, thrown into the river. The content of pollutants in the Poltva river had a insignificant tendency toward decreasing downstream, indicating self-purification processes, caused by severe dilution of water by its numerous tributaries.

During the 2012-2014 summer-autumn low water we continued our study of the Poltva river water quality and its tributaries, taking samples in 7 sites annually. Chemical analyses were made by the Water and Soil Monitoring Laboratory of Lviv hydrogeological and land-reclamative expeditionary department.

According to the Ukrainian legal system and due to the rules of the Ministry of Ecology and Natural Resources of Ukraine on the monitoring of pollution of surface waters, the comparison of water quality parameters in the Poltva river basin should be carried out under the standards for fisheries waters (Postanova Kabinetu Ministriv Ukrainy… 1996; Nakaz Ministerstva agrarnoyi polityky… 2012; Obobshchennyiy perechen… 1990). Average values of the laboratory results are also compared with the norms for cultural and community water use, valid in Ukraine (Saniternye pravila i normy… 1988), which actually are the existing rules for recreation, with the standards for fresh waters needing protection or improvement in order to support fish life (Directive 2006/44/EC) and with the norms of bathing water quality (Council Directive 76/160/EEC), adopted in the European Union (Tab. 1).

Tab.1. Water quality requirements in Ukraine and in the European Union. (source: Nakaz Ministerstva agrarnoyi polityky… 2012; Obobschennyy perechen… 1990; Sanitarnye pravila i normy… 1988; Directive 2006/44/EC; Council Directive 76/160/EEC)

Parameters	Ukraine, for fisheries waters	EU, fish protection (Cyprinid waters)		Ukraine, water for cultural and community use	EU, bathing water
		G	I		I
Ammonium, mg/l NH4	-	-	-	-	-
Ammonium nitrogen, mg/l N	≤ 0.5	≤ 0.2	≤ 1.0	≤ 2.0	-
Nitrites, mg/l NO2	≤ 0.08	≤ 0.03	-	≤ 3.3	-
Nitrates, mg/l NO3	≤ 40.0	-	-	≤ 45.0	-
Phosphates, mg/l PO4	-	-	-	≤ 3.5	-
Phosphates, mg/l P	≤ 0.7	-	-	-	-
COD, mg/l O2	≤ 50.0	-	-	≤ 30.0	-
BOD5, mg/l O2	≤ 3.0	≤ 6.0	-	≤ 4.51	-
Dissolved oxygen, mg/l O2	≥ 4.0	50 % ≥ 8 100 % ≥ 5	50 % ≥ 7 100 % ≥ 4	≥ 4.0	-
Dissolved oxygen, % saturation O2	-	-	-	-	80 – 120

G – guide; I – mandatowy

Assessment of the rivers' water quality is made under the Water Contamination Index (WCI). It is a method, recommended for use in the structure of the state hydrometeorological service of Ukraine, allowing assessing water quality adequately, using a small number of parameters. Calculation of the WCI for surface waters needs consideration of at least six parameters, while necessarily are dissolved oxygen and BOD5 (Kukurudza 2009). Since the assessment of water quality of the Poltva and its tributaries for the estimation of the degree of its organic and biogenic matter pollution was made, we selected the following parameters: BOD5, COD, dissolved oxygen, ammonium, nitrites, nitrates and phosphates.

SAMPLE SITES

The sites of observation of water quality were located at the river's headwater (Borschovychi village) and at the downstream river section (Busk town) of the Poltva, and near the mouths of its largest tributaries as well (Bilka, Perehnoyivka, Yarychivka, Dumnytsya, Holohirka) (Fig. 2).

The parameters of water quality are compared with Ukrainian norms for fisheries waters and for cultural and community water use (for recreation).

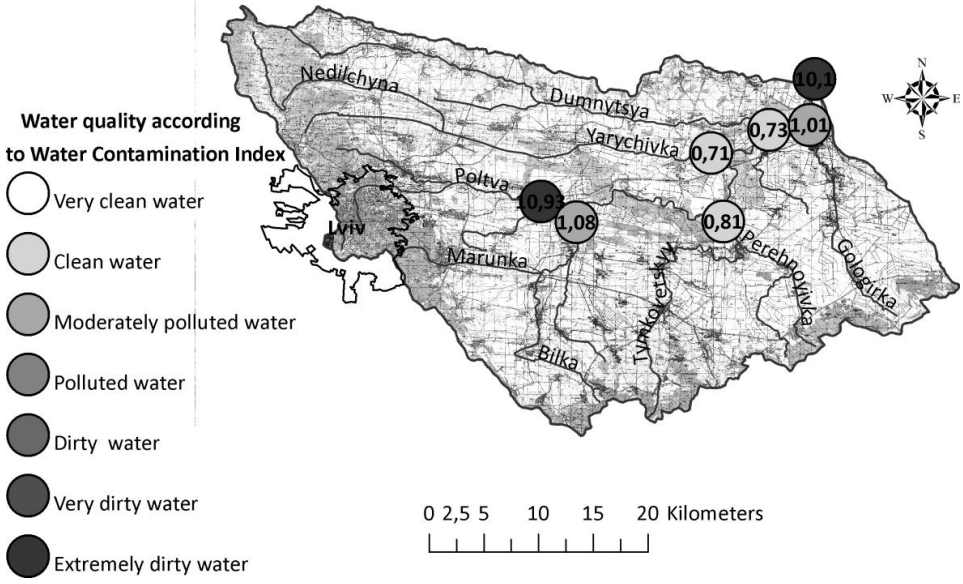

Fig.2. Water quality according to Water Contamination Index. (source: own works).

The sampling site at the Poltva headwater (Borschovychi) is situated 14 km downstream from the wastewaters discharging point of the Lviv city treatment facilities. At this site, the water is characterized as «extremely dirty». High BOD5, COD, ammonium, nitrite and phosphate levels, low nitrate and dissolved oxygen concentrations indicate considerable organic impurity of water and insufficient self-purification intensity of the Poltva river.

The site in the Poltva downstream section is located in Busk town, 0.3 km from the river mouth. At this site, the water could be also characterized as «extremely dirty». Dissolved oxygen didn't reach the relevant norms, severe excesses of the standards of BOD5, COD, ammonium, nitrites and phosphates were found. Discharge waters of Lviv city have the greatest influence on the water quality at this site too. Obvious tendencies of improvement of the water quality downstream of the Poltva were not discovered. Pollution of the river's water mainly depends on the significant variations of the quantity and quality of Lviv waste water, of meteorological factors and on the pollution of the river by unorganized wastewaters downstream from the treatment facilities. In particular, in Busk, upstream from the sampling site, the permanent discharge of unorganized wastewater was found.

The site in the Bilka river is located 1 km upstream from the mouth, within Nyzhnya Bilka village, so the impact of unorganized wastewaters on the river is possible. Its water at the site was «moderately contaminated» at the limit of «clean». BOD5 and the level of nitrites surpassed the Maximum Allowable Concentrations (MAC) for fisheries waters.

The sampling site on the Perehnoyivka is 1.4 km from the river mouth. During the 2012-2014 summer-autumn low water season the river was «clean». Exceeding of the BOD5, sometimes COD and nitrites norms was discovered. Impact of unorganized wastewater on water quality at this site due to proximity of Zheniv village (140 m) and Glynyany town (3 km) is probable (mainly domestic sewage).

The site on the Yarychivka river is located 2.4 km from the river mouth and 3 km downstream from the nearest village. At the sampling site the water is characterized as «clean», excesses of the norms of BOD5 and sometimes COD were found. The impact of wastewaters of Dublyany town, where the University and the campus are located (28 km), of Novyj Yarychiv village (13 km), which also has a centralized sewerage, as well as of big confectionery (17 km) and of the slaughter (18 km) on the water quality of the river is probable.

The sampling site on the Dumnytsya river is located within Bezbrody village. The river was «clean», excesses of the BOD5, sometimes COD norms were discovered. Up to and including 2011 the greatest impact on water quality of the river had sewage of the plant of juices manufacturing in Remeniv village (27 km) during the enterprise's work in the late summer and early autumn. Nowadays, unorganized wastewaters have the most probable impacts on water quality - 11 settlements are located along the bank.

The site of observation on the Holohirka river is 1.3 km from the river mouth, 200 m downstream from Ostriv village and 1.5 km downstream from urban village Krasne. At the sampling site, the water was «moderately contaminated» at the limit of «clean». Exceeding of the norms of BOD5, nitrites, sometimes COD and ammonium were discovered.

PARAMETERS OF WATER QUALITY

Parameters of water pollution are compared with Ukrainian and European norms for fish protection and for bathing (recreation).

The content of dissolved oxygen indicates the quality of water and also the potential of self-purification of water bodies. The average concentration of dissolved oxygen in the Poltva river was 2.1 - 3.2 mg/l O2, 23 – 34 % saturation O2, not reaching the relevant standards (Tab. 1, Fig. 3). Deficit of dissolved oxygen in the Poltva, caused by its absorption for decomposition of organic pollutants, implies the insufficiency of self-purification processes in the river. During the 2012 - 2014 summer-autumn low water season the concentration of dissolved oxygen in the tributaries was 6.7 - 7.2 mg/l O2, 74 – 80 % saturation O2. According to Council Directive concerning the quality of bathing water (76/160/EEC), the content of dissolved oxygen in the tributaries was insufficient, which indirectly points to the consumption of a large amount of oxygen for decomposition of pollutants.

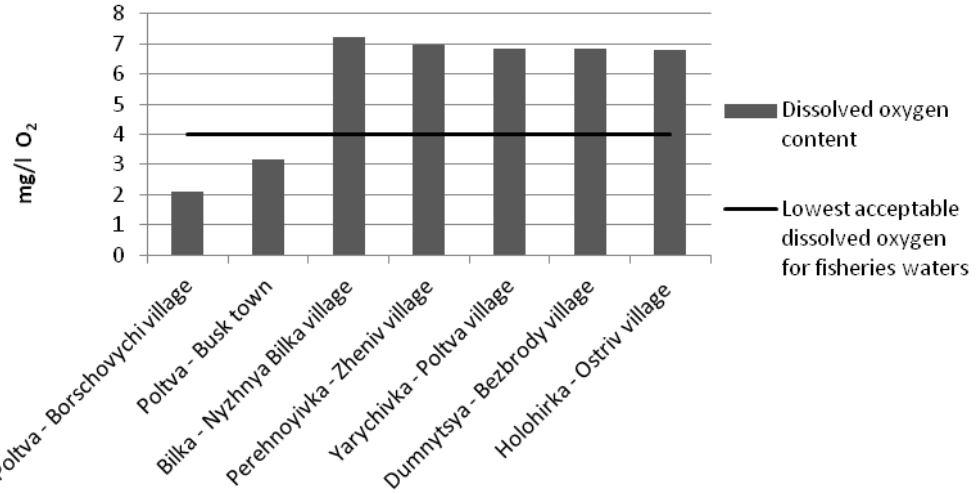

Fig.3. Dissolved oxygen content in the Poltva basin rivers. (source: own works)

BOD5 indicates the level of water pollution by organic compounds, which are easily oxidizing. BOD5 rate in the Poltva river was 27 – 32 mg/l O2, BOD5 in the tributaries varied from 4.7 mg/l O2 in the Perehnoyivka and Yarychivka rivers to 6.5 mg/l O2 in the Bilka river (Fig. 4). High levels of BOD5 in the Poltva was caused by the Lviv waste water discharges and elevated BOD5 in tributaries evidence of pollution of the rivers, including by unorganized wastewater discharging and of secondary contamination of the rivers due to poor sanitary conditions of the channels as well.

COD indicates the general pollution of water by organic and inorganic pollutants. It was high in the Poltva river, always exceeding the norms, fluctuating within 68 – 111 mg/l O2 (Fig. 5). The average indicator of COD in the tributaries' waters was 22 – 27 mg/l O2, occasionally surpassing the norm for cultural and community water use.

Biogenic matters (ammonium, nitrites, nitrates, phosphates) content characterizes water pollution by organic substances.

Ammonium nitrogen concentration in the Poltva varied from 9.5 to 11.3 mg/l N, exceeding all the mentioned norms (Tab.1, Fig. 6). The most often content of ammonium nitrogen in the tributaries was 0.3 – 0.4 mg/l N, surpassing the guide MAC of the European Union for fresh waters needing protection or improvement in order to support fish life.

Ammonium, which is derived as a result of the decomposition of organic matter, is oxidized by nitrobacterias to nitrites, and then - to nitrates.

The concentration of nitrites fluctuated from 0.4 to 0.55 mg/l NO2 in the Poltva river and from 0.02 mg/l NO2 in the Yarychivka to 0.15 mg/l NO2 in the Holohirka river (Fig. 7). These values often exceeded Ukrainian standards for fisheries waters and the European Union guide rules for fish protection.

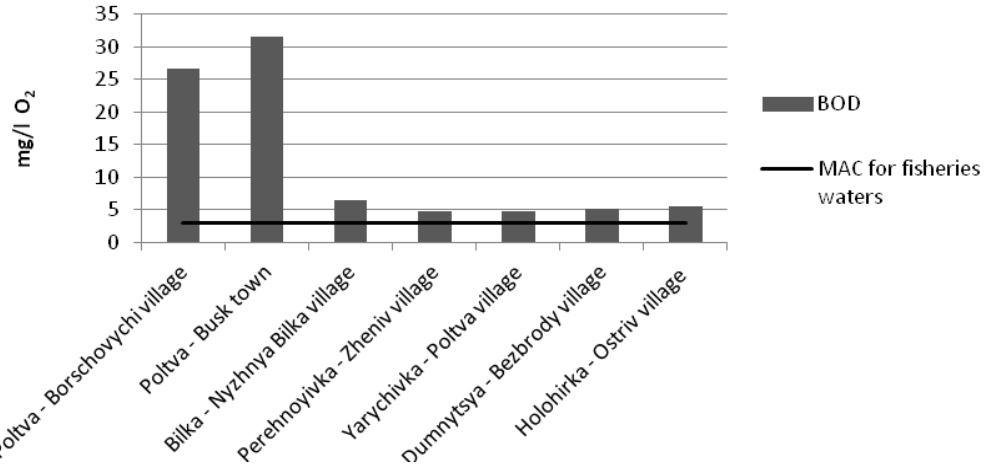

Fig.4. BOD5 in the Poltva basin rivers. (source: own works).

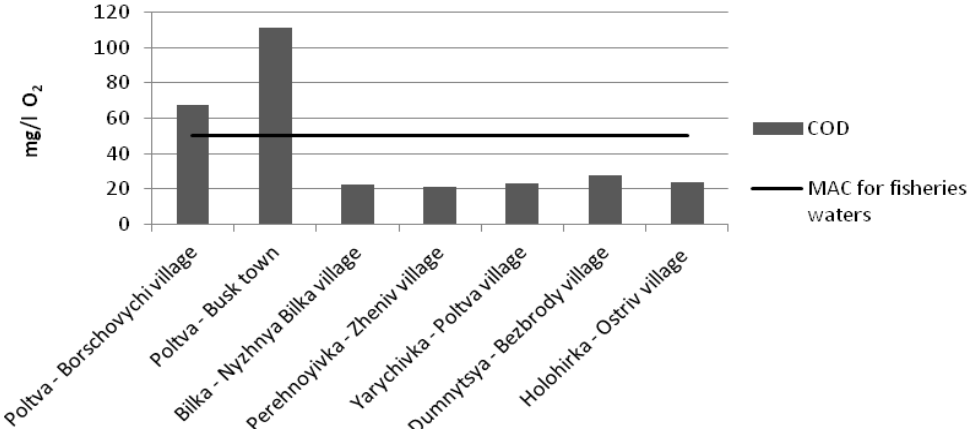

Fig.5. COD in the Poltva basin rivers. (source: own works).

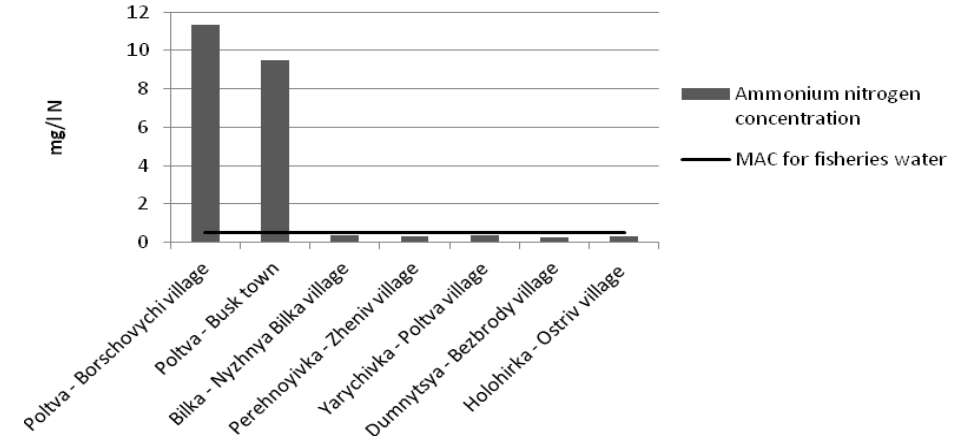

Fig.6. Ammonium nitrogen concentration in the Poltva basin rivers. (source: own works).

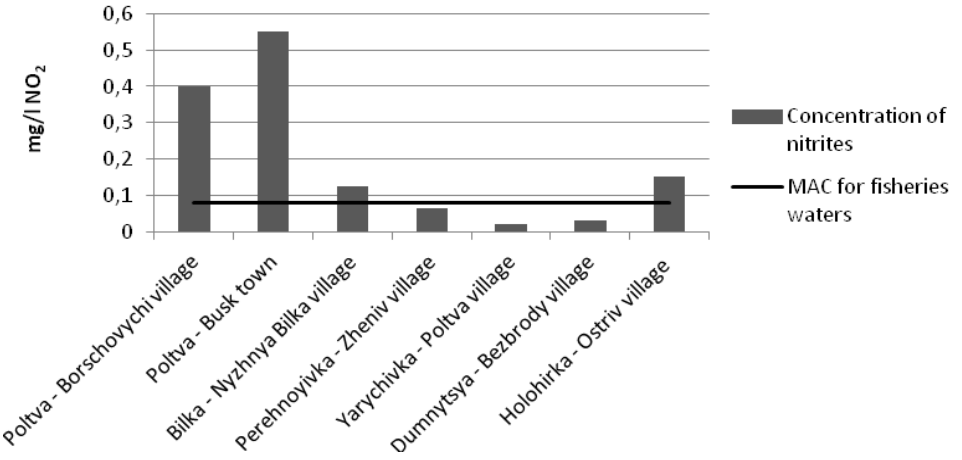

Fig.7. Concentration of nitrites in the Poltva basin rivers. (source: own works).

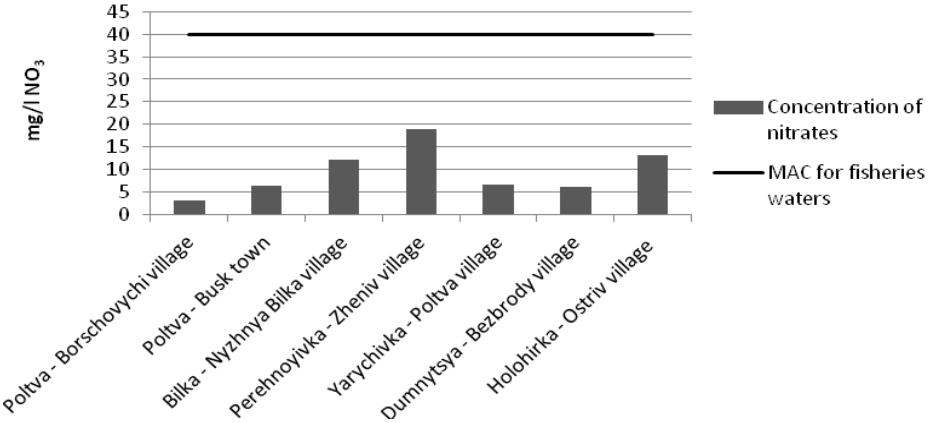

Fig.8. Concentration of nitrates in the Poltva basin rivers. (source: own works).

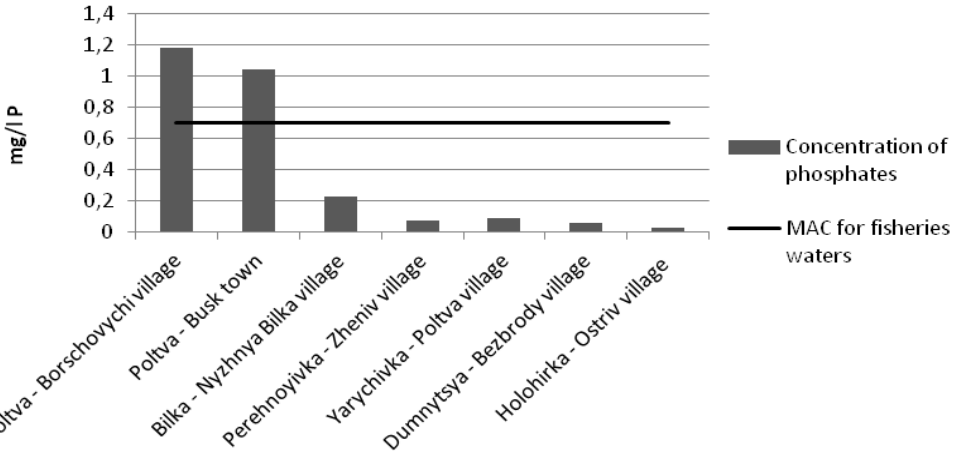

Fig.9. Concentration of phosphates in the Poltva basin rivers. (source: own works).

The average content of nitrates was the lowest in Poltva (3.1 – 6.5 mg/l NO3), as well as in Dumnytsya and Yarychivka. Its highest concentration was detected in the Perehnoyivka river (19 mg/l NO3), still it didn't surpass the norms (Fig. 8).

The high content of ammonium and nitrites and, at the same time, low concentration of nitrates in the Poltva indicates considerable organic pollution and insufficiency of self-cleaning processes. Self-cleaning processes in the Poltva river are suppressed because of the dissolved oxygen deficit and as a result of inhibiting bacterial activity by toxic substances. The low content of ammonium and nitrites in tributaries testifies of sufficient intensity of nitrification, so - to usefulness of self-cleaning processes in these rivers. However, frequent exceeding of norms of nitrites indicate permanent water pollution by organic substances.

Phosphates concentration was 1 – 1.2 mg/l P in the Poltva river, exceeding Ukrainian standards for fisheries waters and for cultural and community water use (Fig. 9). High content of phosphates in the Poltva river points to huge discharges of these substances as components of detergents in sewage of Lviv, that raises a question of necessity of using of ecological detergents. Its content in the tributaries varied from 0.03 to 0.09 mg/l P. Only in the Bilka river it was 0.2mg/l P, this value don’t surpass the norms.

CONCLUSIONS

According to the evaluation of water quality for the WCI during the 2012 – 2014 summer-autumn low water season the water of the Poltva river is characterized as «extremely dirty», the waters of its tributaries were «clean» or «moderately polluted» at the limit of «clean». There were detected severe excesses of Maximum Allowable Concentrations of the parameters indicating organic pollution of water, except nitrates in the Poltva river. Excesses of MAC of BOD5 were often observed in the tributaries of Poltva, sometimes also excesses of the norms of COD and of nitrites were found.

According to the rules accepted in Ukraine and in the EU, the water in the Poltva river was suitable neither for bathing (cultural and community use) nor for fish life.

The water quality of the tributaries met the requirements for the fisheries waters on all parameters except BOD5, in the Bilka and Holohirka rivers except nitrites. Some deficit of dissolved oxygen was detected in the tributaries according to the guide rules of the European Union for fresh waters needing protection or improvement in order to support fish life. The mandatory norms of the content of ammonium were respected, however excesses of the guide levels of ammonium and BOD5 were revealed in all the rivers.

Poltva tributaries were available for cultural and community water use (for recreation) for all the parameters except BOD5. According to the guide requirement of the European Union concerning bathing water, the sufficient content of dissolved oxygen was only in the Bilka river. However, garbage (plastic, splinters etc.) was found in all the channels, making these rivers unsuitable for this type of water use.

Breaking of the water legislation of Ukraine by inhabitants and, in particular, of water protection within the bank protection zones established along channels width of 25 m rules don't contribute to self-purification of the rivers (natural vegetation is absent in some places).

River regulation in the Poltva basin (due to significant reduction of water content, silting of channels, leaching of nutrients into the water bodies) have the most negative impact on the ecological state of the smallest streams and on the drained basin in general.

To improve quality of the Poltva river and its tributaries' water, it is advisable to enhance treatment of Lviv city and of enterprise's facilities, to clear channels, to comply with environmental requirements, especially within bank protection zones zones and water-conservation zones as well as to raise ecological awareness of the population.

REFERENCES

Bodnarchuk T. (2010) *Formuvannya hidroloho-hidrohimichnoho rezhymu ta yakosti vody u verhivyah baseyniv Dnistra ta Zahidnoho Buhu (Avtoreferat dysertatsiyi na zdobuttya naukovoho stupenya kandydata heohrafichnyh nauk)*. Kyyivskyy natsionalnyy universytet imeni Tarasa Shevchenka, Kyiv.

Blumensaat F., Helm B., Terekhanova T., Mykhnovych A., Traeckner J. (2010). *Modelling, monitoring and management-integrated analysis of water quality aspects in the upper Western Bug basin. Resursy pryrodnyh vod Karpatskoho rehionu*. Problemy ohorony ta ratsionalnoho vykorystannya. Materialy Devyatoyi mizhnarodnoyi naukovo-praktychnoyi konferentsiyi, Lviv, 27 - 28 travnya 2010 roky. (223 – 237). Lviv: LvTsNTEI.

Europejski Fundusz Rozwoju Regionalnego (2009). *Budowa polsko-białorusko-ukraińskiej polityki wodnej w zlewni Bugu. Projekt NEB/PL/LUB/2.1/06/66. Grant contract TACIS: 2008/154-946. Raport z realizacji projektu – podsumowanie I recomendacje*. Retrieved from: http://www.bugriverbasin.eu/raporty/raport_synt_pl.pdf

The Council of the European Communities (1976). Council Directive 76/160/EEC of 8 December 1975 concerning the quality of bathing water (OJ L 31, 5.2.1976, p. 1). Retrieved from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31976L0160&from=EN

European Parliament and the Council (2006). Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life. Text with EEA relevance (Official Journal of the European Communities Vol. 49 25.9.2006 No L 264 / 20 – 31). Retrieved from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2006.264.01.0020.01.ENG

Kabinet Ministriv Ukrainy (1996). Postanova Kabinetu Ministriv Ukrayiny No 552 vid 27 travnya 1996 roku Pro perelik promyslovyh dilyanok rybohospodarskyh vodnyh obyektiv (yih chastyn). Retrieved from: http://zakon2.rada.gov.ua/laws/show/552-96-%D0%BF

Kukurudza S., Perkhach O. (2009) *Vykorystannya ta ohorona vodnyh resursiv: Navchalnyy posibnyk*. Lviv: Vydavnychyy tsentr Lvivskoho Natsionalnoho Universytetu imeni Ivana Franka.

Kurhanevych L. (2001) *Ekoloho-heomorfolohichnyy analiz baseynu Zahidnoho Buhu (Dysertatsiya na zdobuttya naukovoho stupenya kandydata heohrafichnyh nauk)*. Lvivskyy natsionalnyy universytet imeni Ivana Franka, Lviv.

Ministerstvo ahrarnoyi polityky ta prodovolstva Ukrayiny (2012, 30.07). Nakaz No 471 vid 30.07.2012 Pro zatverdzhennya Normatyviv ekolohichnoyi bezpeky vodnyh obyektiv, scho vykorystovuyutsya dlya potreb rybnoho hospodarstva, schodo hranychno dopustymyh kontsentratsiy orhanichnyh ta mineralnyh rechovyn u morskyh ta prisnyh vodah (biohimichnoho spozhyvannya kysnyu (BSK-5), himichnoho spozhyvannya kysnyu (HSK), zavyslyh rechovyn ta amoniynoho azotu). Retrieved from: http://zakon4.rada.gov.ua/laws/show/z1369-12

Ministerstvo rybnogo hozyaystva SSSR. Glavnoe upravlenie po ohrane i vosproizvodstvu rybnyh zapasov i regulirovaniya rybolovstva (1990). Obobschennyy perechen predelno dopustimih kontsentratsy (PDK) i orientirovochno bezopasnyh urovney vozdeystviya (OBUV) vrednyh veschestv dlya vody rybohozyaystvennyh vodoemov. Moskva.

Ministerstvo zdravoohraneniya SSSR. Glavnoe sanitarno-epidemiologicheskoe upravlenie (1988). SanPin 4630-88. Sanitarnye pravila i normy ohrany poverhnostnyh vod ot zagryazneniya. Moskva.

National Rivers Authority (1994). *The Surface Water (River Ecosystem) (Classification) Regulation. (Statutory Insruments No 1057)*. England and Wales. Retrieved from: http://www.legislation.gov.uk/uksi/1994/1057/contents/made

Shipka M. (2013). *Otsinka yakosti vody richky Poltvy ta yiyi prytok*. Hydrologia, hirohimiya i hydroecologia, 3(30), 82 – 91.

Voznyuk N. (2006). Otsinka *ekolohichnoho stanu ukrayinskoyi chastyny baseynu riky Zahidnyy Buh (Avtoreferat dysertatsiyi na zdobuttya naukovoho stupenya kandydata heohrafichnyh nauk)*. Derzhavnyy ahroekolohichnyy universytet, Zhytomyr.

Zabokrytska M. (2005). *Hidrohimichnyy rezhym ta otsinka yakosti richkovyh vod baseynu Zahidnoho Buhu na terytoriyi Ukrayiny (Avtoreferat dysertatsiyi na zdobuttya naukovoho stupenya kandydata heohrafichnyh nauk)*. Kyyivskyy natsionalnyy universytet imeni Tarasa Shevchenka, Kyiv.