

Pressures and impact analysis in the Dnipro river basin within Ukraine

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Introduction

Objectives. The Dnipro river is the main waterway in Ukraine and covers 48% of its territory. The purpose of this work was to analyse anthropogenic pressures and related impact for the Dnipro River Basin within Ukraine territory and support the Dnipro River Basin Management Plan.

Methods. An analysis of the main anthropogenic pressures in the Dnipro Basin was first performed according to the requirements of WFD. Model DPSIR developed by European Environment Agency, served as a methodological background for analysis. The core of this model is a sequential analysis of factors like Drivers → Pressures → State → Impact → Response. The state pollutant release register 2-TP Vodhosp for the year 2017 served as an information source concerning dumping of the contaminants into the surface water bodies (SWB). Register contains data on the volumes of dumped waste waters and particular substances from about 1 292 municipal water users, 2 063 different Ukrainian industrial enterprises, 1 970 agricultural enterprises, and 736 fishery enterprises. Only data of enterprises disposing water to the surface water objects were considered.

Data concerning intake of organic substances and nutrients from the settlements has been established in parallel by the mean of calculation-based pollutants emission coefficient from individual, population number and degree of pollutants utilization by the treatment facilities. Calculated coefficients taken from the EEA Methodology. Register 2-TP Vodhosp did not contain information on the majority of priority polluting substances. Therefore, expert judgment has been applied when assessing the hazardous substances impact. Data regarding water discharges at the SWB scale are taken from the map of specific discharge for the Dnipro Basin which has been specifically developed for the needs of analysis.

Results

Economic activity being conducted within the rivers catchments is one of the key factors of the influence on total state of water ecosystems:

- Municipal sector - population – 21.64 mln. people.; 1 city PE > 1 mln.; 18 settlements PE > 100 ths., 180 settlements with PE>10 ths.; 170 UWWTP.
- Industry- 2063 enterprises mainly of siderurgy, machinery engineering, electrical power engineering, chemical, light and food industries.
- Agriculture - agricultural lands cover 77% of the 4 basin, presence of large livestock complexes, application of fertilizers, plant protection products.
- Hydromorphological alterations - cascade of 6 reservoirs on the Dnipro and 498 other reservoirs, > 24 ths. ponds, 6 large and 47 small hydropower plants, 4 large canals, 10 waterways, 1,072 dams and other man-made structures, drinking and industrial water intakes, straightening, dredging, strengthening of shores.

Load by organic substances

Due to anthropogenic factors in the Dnipro Basin load of organic compounds is being formed annually reaching 114,8 ths tons (by BOD₅ indicator) and 186,1 ths tons (by COD indicator). Surface water pollution by organic substances and nutrients is principally attributed with point sources, among which the municipal wastewaters play the dominant role. The main load by organic substances and nutrients is caused by the wastewater discharges of big cities with Population Equivalent >100 000; 89% of such cities are located within the sub-basins of Middle Dnipro and Lower Dnipro (Figure 2).

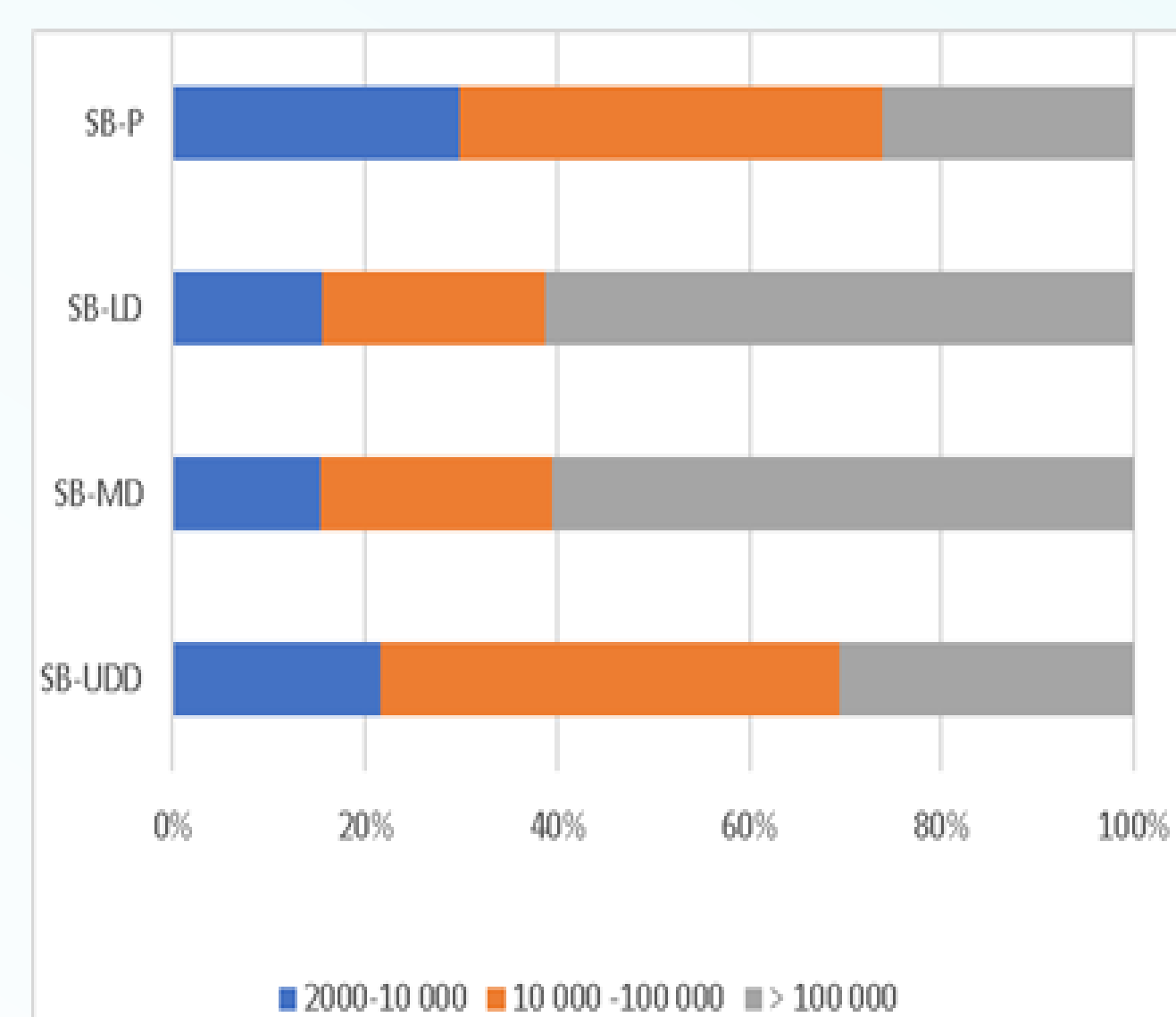


Figure 2: Anthropogenic load caused by urban agglomerations of different types at sub-basins scale, PE (SB-UDD - sub-basin of the upper Dnipro and Desna; SB-MD sub-basin of the middle Dnipro; SB-LD - sub-basin of the lower Dnipro; SB-P - sub-basin of the Prypiaty River)

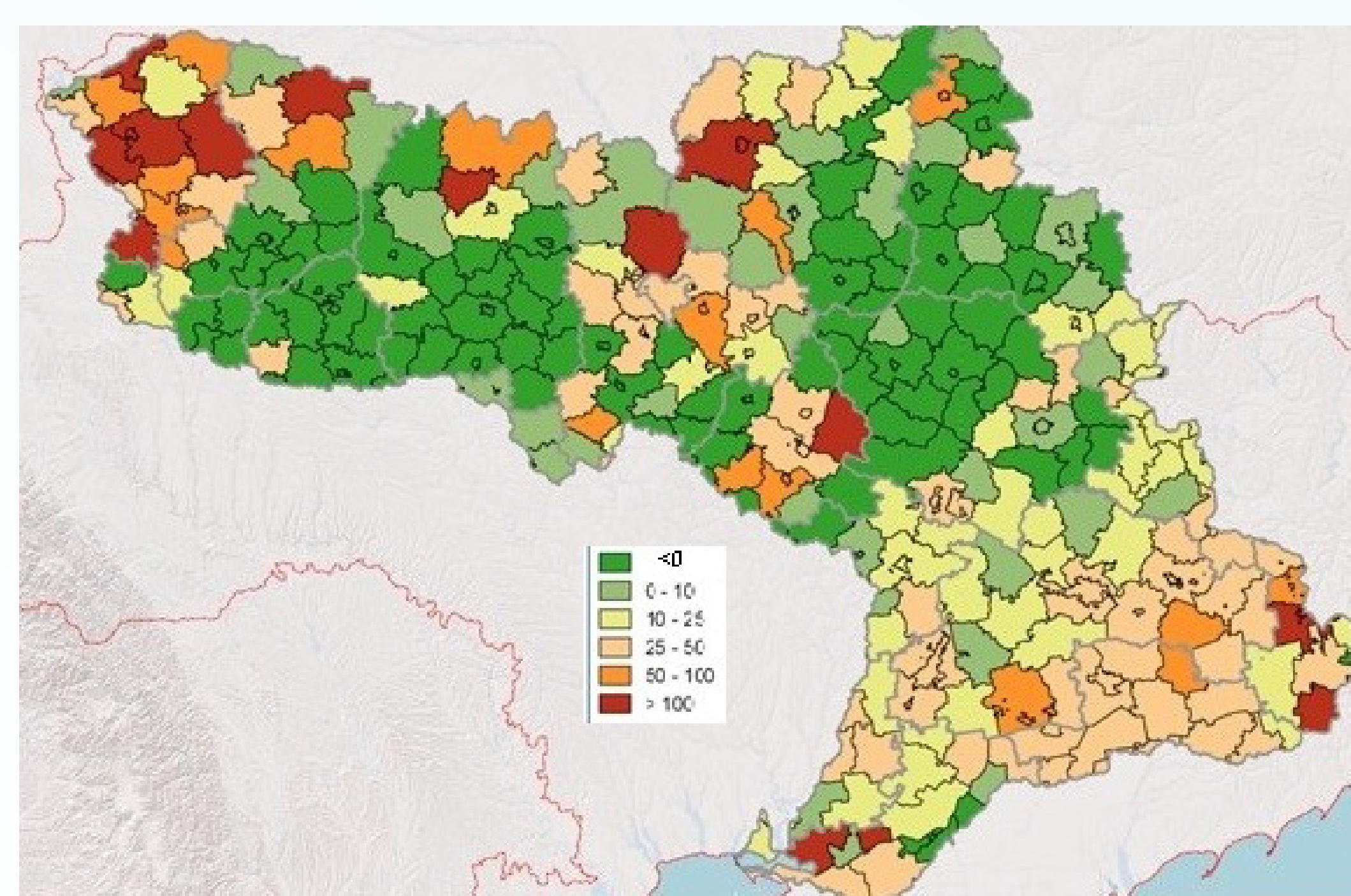


Figure 4: Nitrogen surplus in the Dnipro basin, per Rajons kgN/ha

Nutrients load

Natural conditions in the River Basin are one of the reasons of nitrogen load significant share (33%). Humus compounds and nitrogen compounds enter into water bodies due to the high boggiess of the Dnipro Basin upper part, especially the Prypiaty Basin. This leads to winter and summer anoxia in the rivers and upper reservoirs and creates prerequisites for eutrophication of the Dnipro cascade reservoirs. Rivers of the Prypiaty sub-basin, Upper Dnipro, and Desna sub-basins are extremely vulnerable to anthropogenic pollution by nutrients and organic substances that generates the increased background of organic compounds and nitrogen in the Dnipro reservoirs cascade. Totally within the year additional inflow of total nitrogen compounds and total phosphorous compounds originated from anthropogenic sources equals 21,9 ths tons and 5,8 ths tons respectively (Figure 3).

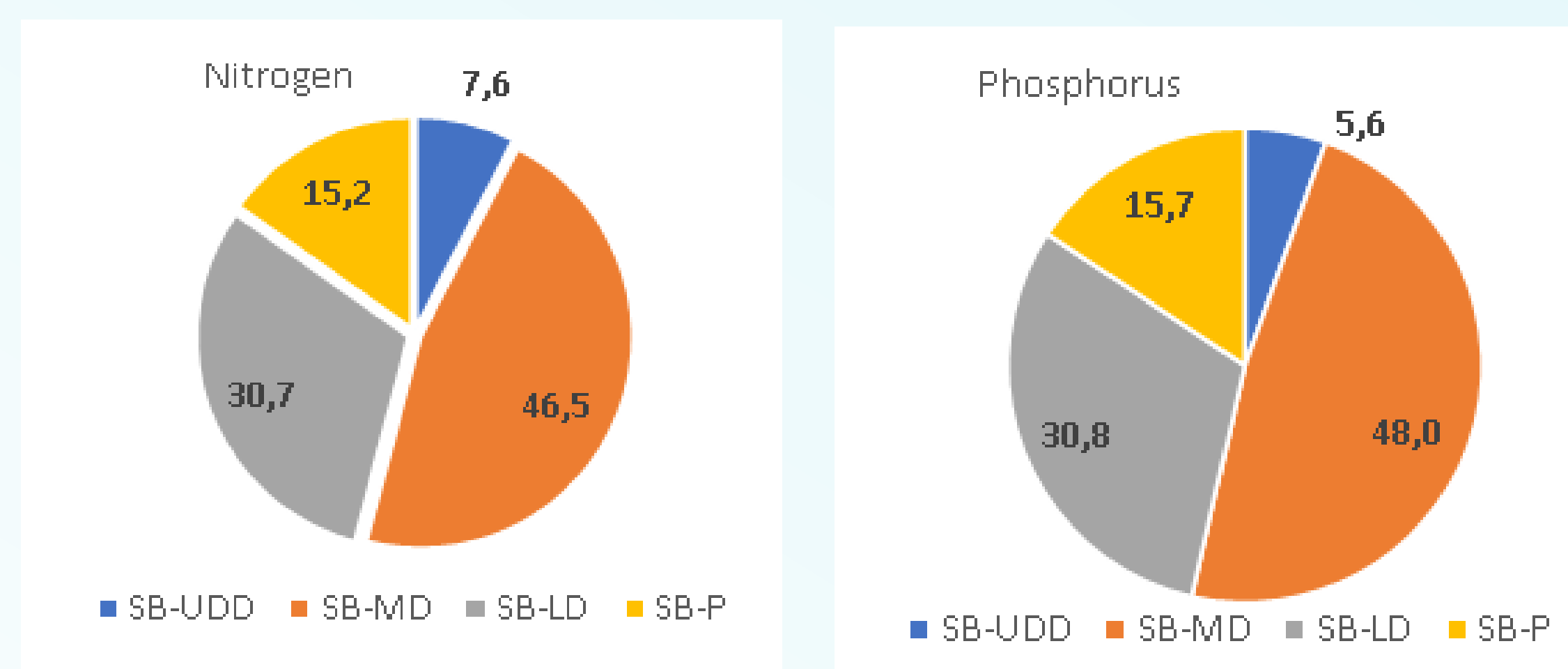


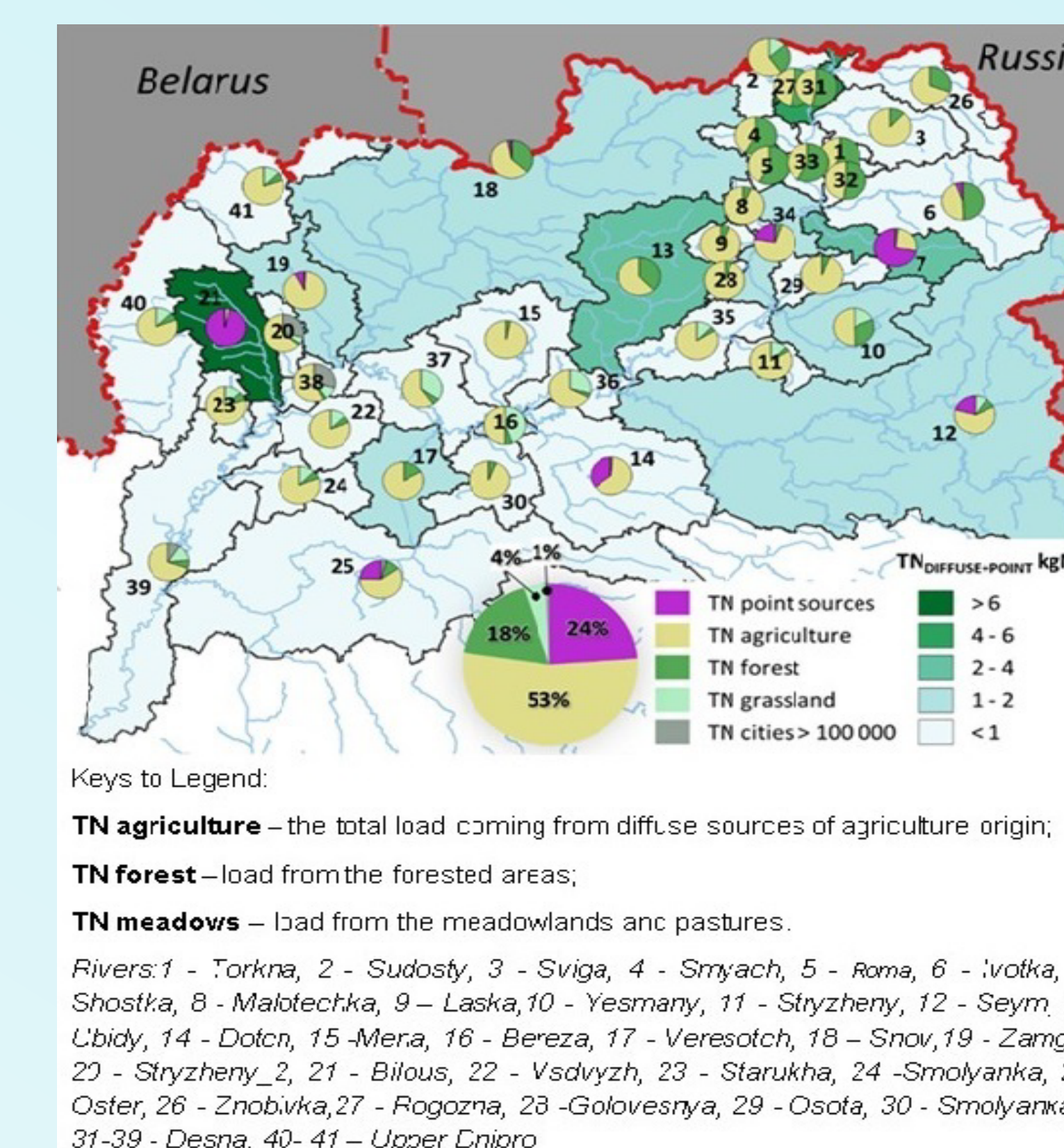
Figure 3: Relative contribution of the sub-basins of the Dnipro Basin in municipal nutrient load, % (SB-UDD - sub-basin of the upper Dnipro and Desna; SB-MD sub-basin of the middle Dnipro; SB-LD - sub-basin of the lower Dnipro; SB-P - sub-basin of the Prypiaty River)

Rural population in the Dnipro Basin emits 6 492 tons of total nitrogen compounds and 911 tons of total phosphorous compounds yearly. Diffuse sources related to agricultural production cause incoming of 29% of nitrogen and 36% of phosphorus. On the basis of statistical reports, the characteristics of spatial diffuse loading of nutrients were obtained due to mineral fertilizers and manure (Figure 4). 57% of nutrients load originated from diffuse sources in the Dnipro Basin is formed within 6 Oblasts: Dnipropetrovskyka, Sumsyka, Kyivsyka, Poltavskyka, Chernigivskyka, and Cherkasyka.



Figure 1: Spatial location of large urban agglomerations in the Dnipro basin with PE > 100 ths.

Results



Quantitative load of water objects by biogenic elements in low period is calculated for the SB-UDD with employing of the model with distributed parameters. Modeling results show that diffuse sources provide the main contribution in nitrogen compounds incoming to surface water (76%), (Figure 5). Share of point sources is just 24%; however, their influence is identified in some basins only. The highest load was noted in the rivers of Bilous and Shostka which is caused by waste waters discharge of cities Chernigiv and Shostka respectively

Figure 5: Nitrogen compounds emission from point and diffuse sources in the SB-UDD

Hazardous substances

The load of the Dnipro Basin surface water by hazardous substances (especially synthetic) still remains insufficiently studied. Currently, information is only available regarding load by heavy metals included to the list of priority substances and some other ones. Water pollution by metals is noted mostly in the Lower Dnipro sub-basin where the most of the metallurgical enterprises are located (Figure 6). The high application of pesticides (> 3 kg/ha) in 4 administrative Rayons leads to the appearance of risk conditions for pollution of xenobiotics in 50 surface water bodies (Figure 7).

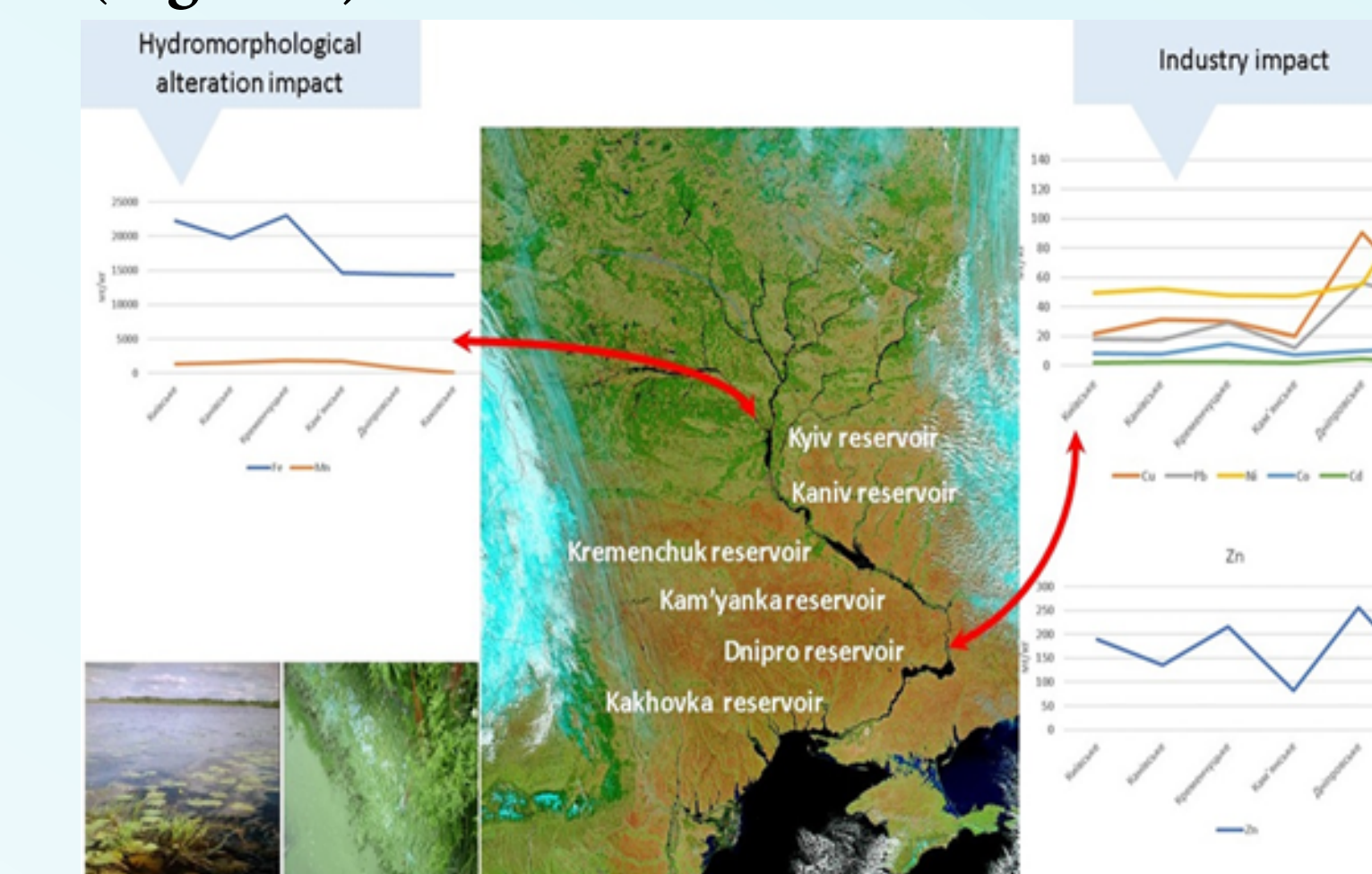


Figure 6: Spatial distribution of Dnipro reservoirs bottom deposits pollution by some of the heavy metals

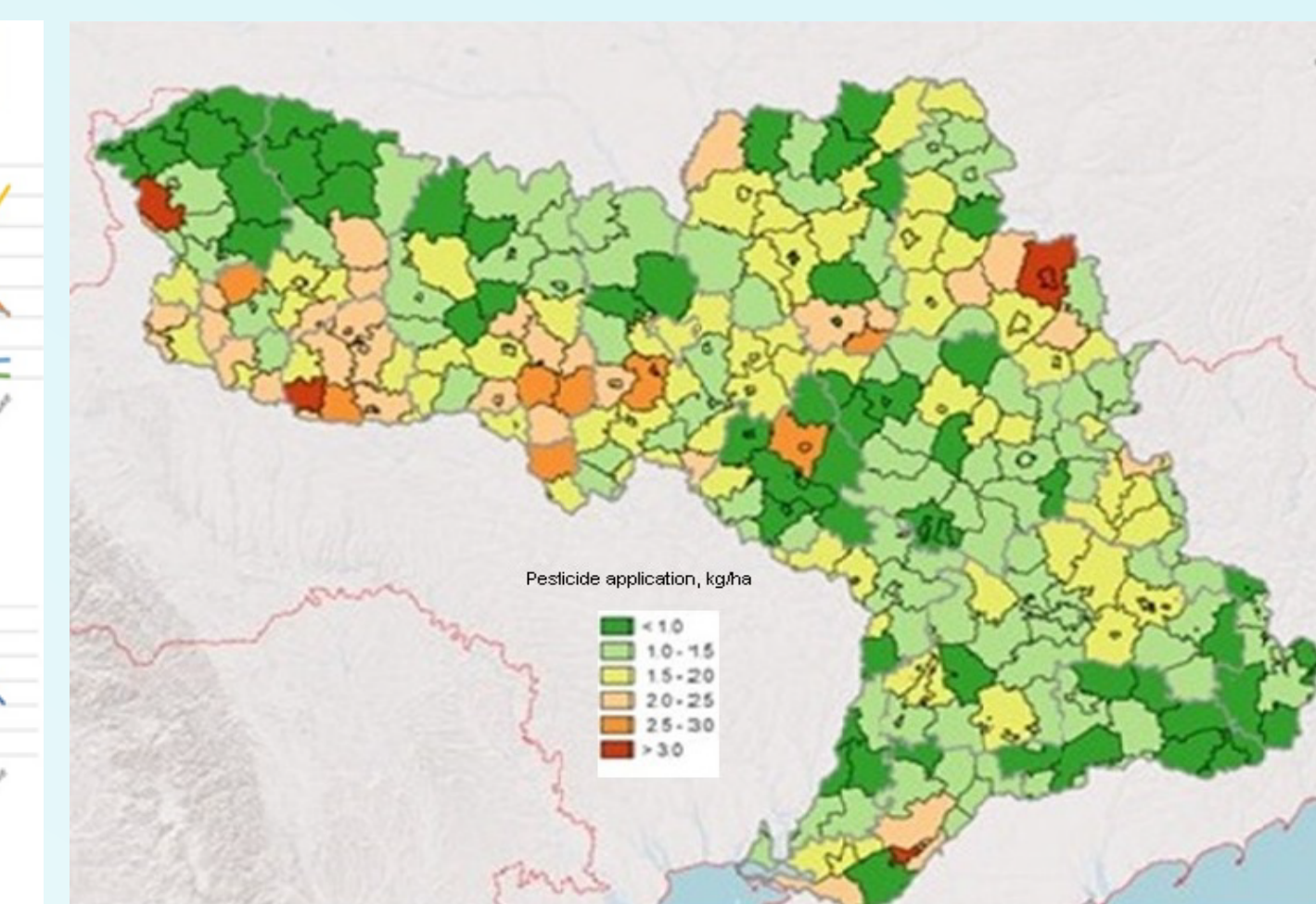


Figure 7: Pesticide application parameter in the Dnipro Basin at Rayons scale, kg/ha

Conclusions

The main water-ecological problems in the Dnipro Basin are identified as anthropogenic pollution by organic substances, biogenic elements, hazardous substances and hydromorphological alterations. 93 municipal, industrial, and agro-industrial diffuse sources out of the total number of water users of 6060 disposing the sewage waters in the Dnipro Basin cause significant impact on the status of water ecosystems. A bit more than 50% of organic matter load, 60% of nitrogen compounds load, and 67% of phosphorous compounds load is formed by significant sources. Significant anthropogenic load has caused 56% of the Dnipro basin surface water bodies are at risk of failing the "good" ecological status.