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5. Nutrient balance for the Yalpugh and Cahul river basins in Moldova

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Abstract: Actual study is focused on calculation of nutrient loads, which reach water ecosystems of the Yalpugh and Cahul rivers, which discharge to the lower Danubian lakes Yalpugh and Cahul located in Ukraine. Article refers to quantitative estimations of nutrient loads originating from different sources and sectors of local economy. On the base of calculation of nutrient coming from main sectors of regional economy a total nutrient budget is calculated for the case-study area. Study showed that main flow of nutrients comes from agricultural lands with superficial runoff, which is responsible for more than 80% of all nutrients. Nitrogen loads predominate in total flow and its ratio to phosphorus could be estimated as 10-13: 1. Presented data show that phosphorus loads are rather limited and for agricultural development this element is a vital one. Loads of nutrients calculated for the region show necessity for development of different scenarios for its reduction and implementation of the soil erosion measures seem to be the most efficient one.

Keywords: nutrients, water ecosystem and wetlands, erosion, loads, soil, sediments.

INTRODUCTION

High nutrient loads and their consequences are recognized as one the most severe problems in the region together with the water scarcity. Nutrient reduction measures and monitoring on theirs' efficiency present a priority for local environmental authorities and actual study contributes to development of measures aimed at the reduction of nutrient loads.

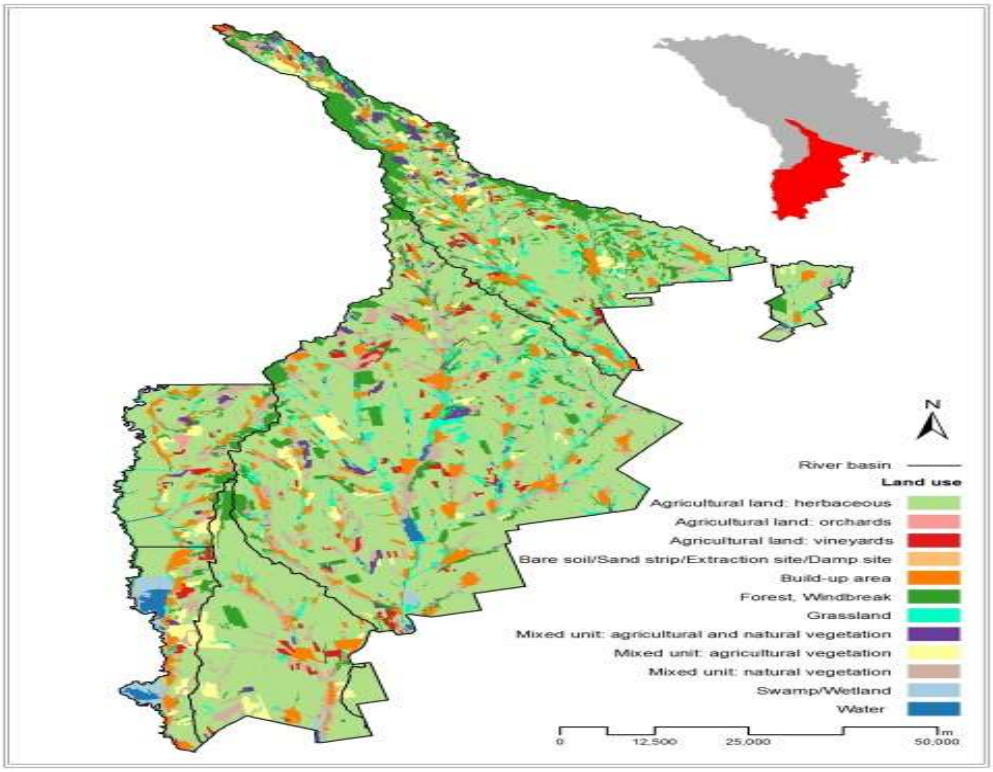
Recent study is based on the detailed data collection from statistical sources on nutrient consumption in the region, content of nutrients in the components of environment, results of sampling campaign, etc Nutrient balances were calculated on the base of data from national and regional statistical sources, scientific data obtained from different reports and articles, sampling campaign developed in the frame of actual project.

Case-study area is located in the southern part of the Republic of Moldova and cover total area of around 4300 km ^{2} (see map 1). Main sector of local economy is agriculture and most part of local population (around 270000 people) lives in rural areas (1). Main water bodies created on the Yalpugh river and its tributaries have high percentage of TDS (2-3 g/l) (2) and due to the changes in climate change (increasing of temperature) one could expect further intensification of eutrophication processes in which nitrogen and phosphorus loads could contribute to further deterioration of water quality and in general state of water ecosystems (5).

MATERIALS AND METHODS

The results of sampling of main natural components together with the sampling of runoff from different types of the landscapes gave information for the calculation of the fluxes of nutrients in environment of the case-study area.

Data on water quality were obtained based on the national statistics (1; 4) for the monitoring stations and sampling campaign during the study. The water and bottom sediment sampling was undertaken in the frame of the project for the water bodies created in the Yalpugh and Cahul rivers.



Map 1 Case-study region

RESULTS AND DISCUSSIONS

Total amount of nitrogen and phosphorus entering and leaving ecosystems have been calculated based on the use of data on the content of nutrients in different goods, soil, waste disposal and production, and the results of sampling campaign. Measurements made in sampling campaign showed that total dried biomass in the floodplains of Yalpugh and Cahul rivers in the artificial lakes is on the level of 30 tons per ha. Artificial lakes created in the bed of the rivers have total area of around 6 km^2 or 6000 ha (1)) and are covered by the reeds with total area of 30-35%. Thus total area with reed belts in the basin could be estimated around 2 km^2 or 2000 ha. This means that total biomass of reed could be estimated around 16500 tons.

According to the results of the sampling campaign performed in the frame of the study, average nitrogen concentration in the dried biomass is 23200 mg/kg and 2820 mg/kg for phosphorus. This means that total amount of nitrogen stoked in water vegetation is around 700 kg per ha and around 85 kg of phosphorus, thus water vegetation stocks around 385 tons of nitrogen and 46,8 tons for phosphorus. Terrestrial vegetation biomass is around 2 tons per ha. in the wetland biomass average content of nitrogen in dried biomass is around 18000 mg/kg and phosphorus - 6900 mg/kg. Total area of meadow vegetation is around 600000 ha. This means that total biomass of grass vegetation is around 1200 000 tons. Thus total amount of nutrients accumulated in the dried biomass is around 40000 tons for nitrogen and around 1600 tons for phosphorus. Agricultural vegetation was estimated as a harvested biomass of around 3 tons/ha (4). Content of nutrients in the biomass of agricultural areas is approximately same as for meadow grass vegetation (fertilizers practically are not used). This means that approximately same amount of nutrients, which is accumulated in grass vegetation, is removed due to the agricultural activities.

Inputs from agricultural soils

Deposition. An average rate of atmospheric deposition of 3.8 kgN/ha and 0.35 kgP/ha per year was assumed based on the average concentration of N and P in atmospheric precipitations in this region

and average annual rainfall during the last decade(3; 4). Thus the total nutrient input on agricultural soil by deposition was 205 tons N + 19 tons P the region.
N-fixation. The flux of nitrogen induced by the N-fixation activity of micro-organisms was estimated around 1 100 tons.

Mineral fertilizers. The whole amount of mineral fertilizer applied on agricultural soil within the reference case-study areas is rather low (2, 1991) and on the base of annual application the load of N for in the region could be estimated as 200 tons and for P as 20 tons.

Crops. The total nutrient removal with harvested crops was derived from the harvest statistics [1] and nutrient concentrations in different crops. The output from agricultural soil with crops was estimated as 4100-4700 tons N and 620-780 tons P in the region.

Percolation, agriculture. Percolation from non-fertilized soil (assuming a percolation rate for arable soil and perennial plantations of 6.5 kg/ha and for grassland 2 kg/ha per year): in the region of Yalpugh and Cahul rivers: 590 tons.
Supplemental percolation, from application of mineral fertilizers (assuming a percolation rate of 15% from the fertilizers (as N) applied on arable land and perennial plantations, and 4% - from fertilizers applied on grassland):
442 from arable (2 946 tons*0.15) + 38 from perennial (254 tons*0.15) + 31 from grassland (777 tons*0.04) = 511 tons.
Thus the total agricultural percolation of nitrogen can be estimated as 1068 tons in Yalpugh river basin and 508 tons in the Cahul basin.
It was assumed that less than 1% from the phosphorus applied on agricultural land as fertilizer percolates into groundwater (2). For the case-study regions that means a flux of 5-10 tons P/year.

Denitrification, agricultural soil. Basing on the literature data the following average denitrification rates were assumed: for arable land - 9.5 kg/ha per year, for perennial plantations - 24 kg/ha, for grassland - 4 kg/ha, for irrigated soil - 33 kg/ha.
According to these data the total amount of N-losses by denitrification from agricultural soil in the case-study region was estimated as 1450 tons.

Gaseous losses of N-compounds, agricultural soil. Assuming that 20% of the total amount of N contained in manure applied on agricultural soil is lost, one could estimate this quantity as approximately 400 tons. The N-loss of mineral fertilizer is assumed by 15-20% and taking into account very small volumes of their actual applying this factor can be neglected.

Erosion, agriculture. The natural and agricultural activities in the region make it very susceptible to water erosion. The relief is rather fragmented; 90% of the arable land have a slope exceeding 1 degree. The precipitations fall mostly in summer time and are highly intensive. The granulometric composition of soils also conditions the washing out of soil particles. The part of perennial crops supporting erosion (*Zea mays*corn, sunflower) is rather high on the watersheds (till 65% of all agricultural lands in the case-study region).

According to the estimations of local experts (2) 18 tons of soil per year are washed away from a hectare of arable land due to water erosion. For orchards and vineyards this amount is estimated as 12.5 tons/ha per year. Assuming for grassland a value of 2 tons/ha per year one may estimate the total quantity of soil washed away from the agricultural land. For both Yalpugh and Cahul river basins this amount exceeds 700 000 tons of soil, which means an annual loss of about 1400 tons N and 700 tons P.

Another important part of the nutrient load to surface water with the runoff originates from the agricultural soil. A coefficients of 30% for N and 20% for P were assumed due to poor storage conditions and agricultural practices. The resulting loss of nutrients can be estimated as 205 tons N + 9,5 - 10,5 tons of P.

Stock, agricultural soil. On the base of analysis performed during the study one could estimate the average amount of nutrients in the 1-meter layer of agricultural soil as 20 tons N and 19 tons P per hectare. So the agricultural stock of nutrients is 1,080,000 tons N and 1,000,000 tons P for each case-study region.

Nutrients in groundwaters

Infiltration, surface water. The infiltration rate from water bodies to groundwater is estimated by local hydrologists at 300-400 litres per year per m2 of the water body (2). Total area of water ecosystems in the region is around 1500 ha. So the volume of infiltrated water can be estimated at 400 000 - 600 000 m3/year, what means 2-3 tons N and very insignificant for P.
Base flow. The Yalpugh river valley is considered to be an area of discharging of shallow groundwater into surface waters (Cahul flow is very small and was not taken in calculation). Total groundwater resources in the case study region is estimated at 5800 m^3/day. This means that the contribution of shallow groundwater to the Yalpugh river could be estimated as 30 000 m^3/year. Considering an average concentration of nitrogen in shallow groundwater of 20-40 mg/l the local N-flux through base flow can lie in the range between 0,5 and 1 tons per year. The input of phosphorus into surface waters through base flow is insignificant.

Run-off. This good correspond to the nutrient content in annual flow of Yalpugh river. The average yearly discharge of the Yalpugh river is 1 mln m^3,(4). The assumed concentrations are 6-7 mgN/l and 0.3-0.5 mgP/l (Comprehensive Territorial Nature Protection Scheme of the Republic of Moldova, Kiev, 1991). The resulting flux is 7-10,2 tons N + 0,5-1 tons P per year.

CONCLUSIONS

Main source of nutrient loads in the region is agricultural activity. This sector is responsible for around 90% of all nutrient loads in the region. That is why reduction of nutrient loads on water ecosystems should be organized in order to introduce best agricultural practices on the watersheds and wetlands. Deterioration of wetlands could be limited trough stopping of deepening of the river bed, limitations on grazing, rising of public awareness, etc.

Total erosion in the region – 56400 kt Loads with the background N – 1241 kt and P – 282 kt. Total load from WWTPs in the region is around: for N - 0,035 kt and P - 0,001kt. While total loads could be estimated as for N 1244 kt and P – 284 kt.

Wetland restoration activities could lead to reduction of around 25% - 40% of nitrogen load. Removal of phosphorus by wetlands is difficult to estimate due to limited data, but one could estimate removal capacities of wetland areas as for nitrogen.

Organic forms predominate in the nutrient stocks in the region and serve as a main source for the mineral forms of nutrients. Fresh pollution with nitrogen comes mainly in the form of ammonia. Mineral forms constitute around 3-7% of nutrient loads.

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