Assessment of nutrient concentration in reservoir bottom sediments

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Abstract

Sediment delivered from water erosion causes substantial waterway damages and water quality degradation. Characterization of bottom deposits is an important factor in the study of water quality because they are responsible for transporting a significant proportion of many contaminants, particularly nutrients. They also mediate their uptake, storage, release and transfer between environmental compartments. Most sediment in surface waters derives from surface erosion and comprises a mineral component, arising from the erosion of bedrock, and an organic component arising during soil-forming processes. An additional organic component may be added by biological activity within the water body. Sediment quality also nearly always complicates sediment management. Enormous volumes of sediments have to be dredged worldwide for both maintenance and also environmental reasons. However dredged material is increasingly regarded as a resource rather than as a waste. Dredged sediments have a wide range of uses but first we must know their quality.

The aim of this paper is presenting the results of determination the total nitrogen, phosphorus and potassium content in reservoir bottom sediments in dependence on sampling location and sampling depth. The results of chemical analyses confirmed the literary information that the concentration of nitrogen, phosphorus and potassium in chosen sediment samples is diverse due to irregular sediment deposition in the reservoir and increases with proportion of the finest particle fraction. Also it was found out that nutrients content in sediment increases with sampling depth. This fact probably corresponds to higher fertilizer application in the high ’80s and low ’90s.

Keywords: Nutrient; sediment; reservoir

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1. Introduction

Sediments originate in river basins mainly through land and channel erosion processes and are transported in river systems with the reservoirs being the final sink. In many regulated rivers, sediments are trapped behind dams and reduce the sediment supply downstream. Besides quantity, quality of sediment affects downstream areas. Many toxic substances and contaminants in water became preferentially attached to sediment, particularly to fine sediments and accumulate within deposition zones [1]. Contaminated sediments remain potential sources of adverse affects on water resources through the release of contaminants (such as heavy metals, nutrients, pesticides and other organic micro-pollutants) to surface waters and groundwater. Furthermore, contamination adversely effects sediment management, as handling of contaminated material, e.g. in the case of dredging. For the assessment of contaminated sediment, there is not one „best“ method available. Chemical analysis can be used to determine concentrations of selected hazardous chemicals and then it can be checked if the concentrations exceed pre-defined standards or guideline values [2].

2. Material and methods

2.1. Study area

Assessment of nutrient concentration in reservoir bottom sediments was conducted in the Klusov small water reservoir, which is situated in the Tisovec river catchment area in Bardejov district, Slovakia. The area of this catchment is about 6.0 km² with annual average discharge 0.045 m³/s and it falls in the Topla partial river basin. The Klusov reservoir was built for fishing, irrigations, recreation and for retention of high water and its basic attributes are shown in table 1. The land-use of the catchment was found to be mixed type. The upstream part and middle part of the Tisovec catchment is an area mainly covered with forest and pastures, while the lower part is an arable land mainly used for cereals (spring barley, winter wheat), corn silage and winter oilseed rape growing. The rest of the land area is for other uses.

Table 1. Basic attributes of the Klusov small water reservoir

| Altitude [m above SL] | Average depth [m] | Surface area [ha] | Total capacity [m³] |
|-----------------------|------------------|-------------------|---------------------|
| 343.0                 | 3.5              | 2.2               | 72,128              |

In 2004, Slovak Water Management Enterprise realized the siltation measurements of this reservoir. According to the measurements it was followed that the quantity of sediments in the Klusov reservoir was approximately 24,507 m³. This fact resulted in decreasing of the reservoir capacity about 33 % during 19 years. Therefore this reservoir was run the water off from 2005 to 2007 and we make use of this fact for the sediment collection due to better sediment quality monitoring.

2.2. Sample collection

For determining the total nitrogen (N), phosphorus (P) and potassium (K) concentrations in reservoir bottom sediments, 22 composite sediment samples (Fig 1) were taken from each selected localities –along the reservoir, near the reservoir dyke, especially due to deposition of finest particles preferentially attaching the nutrients [2,3] and in various sampling depths from one locality because of stratigraphical sediment quality assessment (Fig 2). The weight of the collected composite samples represented about 3
kg [4,5]. In laboratory conditions, the samples were air dried at room temperature, any coarse lumps were crushed and samples were homogenized. Bottom sediment samples were analyzed for total nitrogen, phosphorus and potassium in accredited laboratory of State Geological Institute of Dionyz Stur Spisska Nova Ves.

Fig. 1. Position of sediment sampling localities

Fig. 2. Stratification of bottom sediment samples (samples S10-S14, S15-S18, S19-S22)
3. Results and discussion

In sediment samples S10-S14, S15-S18, S19-S22, collected from the various sampling depths (Fig. 2), the stratigraphical sediment quality assessment was realized (Fig 3-5). The chemical analysis results of samples collected from the various sampling depth of the reservoir (Fig 3-5) show that the total nitrogen, phosphorus and potassium contents in reservoir sediment samples rise with increasing of the sampling depth [5]. This fact probably corresponds to higher fertilizer application in the high '80s and low '90s. After 2000, the trend of consumption of commercial fertilizers is fluctuating with a tendency towards gradual increase.

In sediment samples also impact of sampling location (distance from the dyke) on the total nutrient concentration in reservoir bottom sediments was studied (Fig 1). The chemical analysis results of collected samples are given in Fig 6.

Fig. 3. Total nitrogen content in sediments depending on sampling depth

Fig. 4. Total phosphorus content in sediments depending on sampling depth
The results from chemical analyses shown in Fig 6 confirmed the literary information that the total nutrient concentrations in collected sediment samples are diverse due to irregular sediment deposition in the reservoir and increase with proportion of the finest particle fraction [3]. The coarse materials are deposited at the entrance to the reservoir and the fine particles are transported a much greater distance into the reservoir, often as a density current. The density current is stopped by the dam and deposition of fine particles may occur just upstream of the face of the dam [6]. This fact also declares the chemical analysis results in samples collected near the dyke – S1-S5, where the concentrations of followed chemical elements are the highest and in samples S1-S9 collected along the reservoir, where the proportion of fine particles decreases with the increasing distance from the dyke. Therefore the total nutrient concentrations in sediment samples are lower (S8, S9) [4,5].

4. Conclusion

The results from chemical analyses of total nitrogen, phosphorus and potassium concentrations confirm the literary information that the highest nutrient contents in bottom sediments are connected to the proportion of fine particles. Because the fine particles settle down near the dyke, also the total nutrient content in sediments collected near the dyke are the highest.

The chemical analysis results of samples collected from the various sampling depth of the reservoir show that the total nitrogen, phosphorus and potassium contents in reservoir sediment samples rise with
increasing of the sampling depth. This fact probably corresponds to higher fertilizer application in the high '80s and low '90s.

This information can contribute to solve a problem with utilization of sediment waste extracted from water reservoir which could be appropriate for the direct reuse on soils complying with the requirements given in Act No. 188/2003 of Code on application of sludge and river bed sediments on agricultural and forest soil.

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