Tájökológiai Lapok 17 (2): 179–192. (2019) DOI: 10.56617/tl.3512

# ANALYSIS RESULTS OF IN SITU WATER AND SEDIMENT QUALITY OF ÚJPEST BACKWATER

János GRÓSZ, András SEBŐK, Noémi NAGY, Andrea KOVÁCS, István WALTNER

Szent István University, Faculty of Agricultural and Environmental Sciences, Institute of Environmental Science
H-2100 Gödöllő, Páter Károly u. 1., e-mail: sebok.andras@mkk.szie.hu

**Keywords:** sediment analysis, water quality parameters, heavy metals, biological water quality, hydrocarbon pollution

**Abstract:** Water is one of the most significant and vulnerable natural resources. The aim of our study presented here was to assess the sediment and water quality of Újpest backwater and its main influencing factors. The study area is located in the north side of Budapest, a backwater of the Danube river. An industrial region of the city, also serving as recreational area for nearby residents. The average water depth is 4,5 meters and the length of the backwater is 2200 meters. The most significant economic activity is the ship-building and maintenance. In order to assess water and sediment quality, a number of physical, chemical and the microbiological measurements were carried out on both water and sediment samples. The water samples were collected at two dates, while sediments samples were taken at one date in 2015. Sediment analysis included heavy metals (Cu, Zn, Pb, Cd), TPH and PAH measurements. Water quality analysis included chemical (NH3, NH4+, NO3-, Fe, pH value, conductivity, dissolved oxygen) and microbiological parameters. The results of the study showed that the sediment contained different types of heavy metals and hydrocarbons due to the industrial activities and transportation. During the analyses, we measured high Pb, Cd, Cu, Zn, TPH and PAH concentration in the northern part of the backwater. Possible reasons of the high values include ship maintenance and repairing, ship traffic and road traffic. Measured high Pb, Cd, TPH and PAH concentrations in the sediment might carry environmental risks. Among the general water quality parameters, we found high Fe concentrations mist likely connected to railway traffic in the northern part of the sampling area, while microbial analysis showed only acceptable or lower counts.

## Introduction

The improvement of the quality of water resources is a key objective of the European Union, being primarily expressed through the Water Framework Directive. However, information about the quality of our water bodies is still relatively scarce and is often not meeting local or regional public demand. The assessment of water resources is a complex concept and task. A number of different tools and methods can be used during the evaluation process (Smakhtin et al. 2004). During a complex environment assessment, the researchers need to implement profound water quality and sediment analyses. Sediment analysis is a particularly important part of the study, because sediments could potentially store harmful organic and inorganic compounds. Water quality itself can refer to the chemical, physical and biological characteristics of water (Padisák 2005).

Heavy metal content can be a significant part of environment contaminants, since metallic elements have a relatively high density and at relatively low concentrations they are potentialy toxic or poisonous (Duffus 2002). Based on a number of scientific studies, a large amount of heavy metals derive from anthropogenic sources and discharge into aquatic environment where they are accumulated in sediment and bioaccumulated through the food chain, posing a great ecological risk to living creatures (Yi et al. 2011). Since sediments are a major sink for heavy metals in the aquatic environments, sediment quality is recognized as a significant indicator of water pollution. Furthermore, potential toxic heavy metals are not constantly bound to sediment particles, and they may be released into to water when the physical conditions of the environment alter (Wu et al. 2014). The most important heavy metals found in road run-off are cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) (Davis et al. 2001). Their sources can be very different, but heavy metals in highway, railway and road run-off are typically related to the wear and tear of vehicle parts. As a matter of the occurrence and the behavior, they can be very variable in the environment and depend on the current conditions. Regarding chemical processes, heavy metal components (Zn, Cu, Cd, Pb) are mainly attached to the sediments and the suspended solids (Ciazelaa et al. 2018). Measuring the soluble forms of the heavy metals in the aquatic environment, their dissolved concentration is much lower than in the sediments (Viersa et al. 2009). In urban areas, a significant source of contaminants can be road run-off. Former studies indicated that the main sources of pollutants on urban roads are vehicles, atmospheric deposition and roadway maintenance practices (Barret et al. 2015). Vehicles can contribute to road pollution in two different ways. On the one hand, directly, vehicle contributes to pollution from normal operation. On the other hand, indirect pollutants are solids induced by vehicles for later deposition, during extreme weather condition. (Asplund et al. 1980). With reference to the atmospheric pollutants, they are deposited through wet precipitation or dry precipitation (Winkler 2005).

In this paper we shall examine the sediment and water quality of Újpest backwater, an important area for the residents and industrial sector. The study area is located in Budapest and it is part of the River Danube that is one of the most important rivers in Europe. Within the area, there are many potential sources of pollution. Most significant is likely the ship-building and service industry which is settled around the backwater. The history of the industrial activities was investigated by (Gonda 2011). According to historical records, the ship-building and service industry has started in the 18th century so that it has a long history. However, this is also a recreational area with a number of boat-houses and sport clubs training on the calm water of the backwater.

There are many studies in the world which are dealing with proper techniques of the environmental assessment and analytical methods for the sediment and water quality measurements. Analysis methods for heavy metals in sediments were investigated by (de Groot, Zschuppel and Salomons 1982). Sediments can contain and store many harmful components for the environment and the ecosystem. The relationship between the adsorption of heavy metals and organic matter in sediments was investigated by Lin and Chen (1998). A significant number of geological surveys were implemented by research teams of the former Hungarian Institute of Geology and Geophysics. These studies have included stratigraphic studies, plate tectonics studies and general geological surveys. As a result, numerous geological maps were created about the area and the data showed that the geomorphological conditions of the area are very diversified. Prevalent geological processes were the erosion and accumulation processes. The result of the whole geological survey was published in the Annual Report of the Hungarian Geological Institute of 1987 by the research teams (Nagy and Piros 1987).

A study by Bartram and Ballance (1996) is focusing on proper methods of water quality monitoring. The authors give appropriate protocols and schemes designed for freshwater monitoring programs. Techniques of trend analysis for monthly water quality data were examined by Hirsch et al. (1982). With reference to the water quality, several laboratory measurements were carried out by former studies of Szent István University. During the analysis, the physical and chemical parameters of water quality were examined by Németh (2014). The main measured parameters were $NO_2^-$, $NO_3^-$ $NH_3$, $NH_4^+$, pH, electrical conductivity (EC). According to the thesis, the $NH_4^+$ concentrations of the samples were higher than the Hungarian regulation, however the other parameters were below the limit.

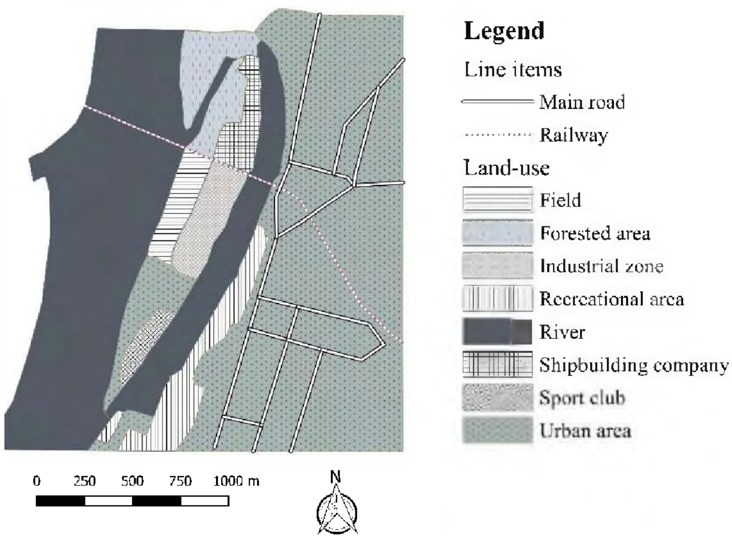


*Figure 1.*: Land–use map of Újpest backwater
*1. ábra:* Az Újpesti-öböl területhasználati térképe

Our study aimed to investigate the sediment and water quality of Újpest backwater and its main influencing factors. Analysis included a number of physical, chemical and the microbiological parameters. Regarding water quality, the focus was on general water quality parameters. The sediment analysis included analysis of:

- heavy metal content;
- total petroleum hydrocarbon (TPH) content;
- polycyclic aromatic hydrocarbon (PAH) content.

Within the framework of the current article the main objectives were the following:

- The design and application of a set of systematic in situ measurements and sampling series of sediment and water quality parameters.
- Analysis of heavy metals, TPH and PAH content of the sediment to evaluate the environmental impact and risk indicated by these parameters.
- Evaluation of local activities affecting the sediment and water quality.

## Materials and methods

The study area is the Újpest backwater, located in the north side of Budapest, in the 13$^{th}$ district. It has many significant ecosystem services for nearby residents. From these services, the most important ones are the recreational activities, highlighting the sports. Within this area, there are a number of sports clubs, kayak and canoe training facilities, fishing areas and leisure parks. The average depth of the backwater is between 4 meters and 5 meters and the length is 2200 meter. As for the economic activities, the most significant one is the ship-building and maintenance. According to economic indicators, the productivity of the industry has reduced and there are some abandoned factory sites. Nowadays, industrial activities focus on the ship servicing and the seasonal ship storing. In fact, these activities can influence and affect the water quality and the presence of hazardous substances in the sediment. During the preliminary work for the study a land use map of the area was derived, using GIS (Geographic Information System) software - QGIS 2.18. Further application of the GIS software was to create interpolated maps of the heavy metal, PAH and TPH concentration of the sediment in the backwater. Inverse Distance Weighting (IDW) interpolation method was used during the mapping process. In regard to visualization, a gray-scale classification was applied. The land-use map and element distribution maps can be seen on figures 1, 3, 4 and 5.

The sampling campaign, was divided into two different sections. The first section was focusing water sampling and analysis, while the second part was focusing on sediment sampling. The water samples have been collected at two dates, one in August and one in September of 2015. A key point, was to create a sampling protocol and then to produce a precise documentation about the measurements and environmental conditions. Therefore the designation of sampling points was based on a pre-planned initial field survey. During the planning process, the focus was on the different locations where industrial and non-industrial activities would most likely influence the backwater.

**Sediment sampling method**

The main objective of the sampling was to collect information about the pollutants accumulated in the sediment. The measurements focus on the heavy metal content, the TPH content and the PAH content of the samples. Sediment grab samples were collected in September 2015. With the average water level of 160 cm in the backwater. Within the study area, ten sampling points have been designated. Fine mud samples were collected from the surface of the river bed (0-10 cm). During the collection process, we followed the ISO 5667-12:1995 (Water quality – Sampling – Part 12: Guidance on sampling of bottom sediments) standard. The location and detailed list of sediment sampling points is presented on the Figure 2 and in Table 1.

*Table 1.* Sediment sampling point details
*1. táblázat* Üledékmintavételi pontok részletes adatai

| Sampling points | Depth (m) | Dry matter content (%) |
|---|---|---|
| Point/Sample 1 | 2.1 | 98.8 |
| Point/Sample 2 | 2.6 | 98.3 |
| Point/Sample 3 | 3.2 | 98.4 |
| Point/Sample 4 | 3.8 | 99.5 |
| Point/Sample 5 | 4.2 | 98.5 |
| Point/Sample 6 | 4.6 | 98.1 |
| Point/Sample 7 | 4.3 | 98.9 |
| Point/Sample 8 | 4.1 | 98.8 |
| Point/Sample 9 | 3.8 | 98.2 |
| Point/Sample 10 | 3.2 | 98.9 |

**Water sampling method**

Water sample collection was performed in August and September of 2015. The number of samples was different in the two dates. Six samples were collected in August and twelve were collected in September. The reason of the difference was the following: the first occasion was a general sampling, we focused on those points where the risk of pollution could have been higher. By contrast, the second was a more detailed one where we collected data from the surroundings of the risky points. Another reasonable point was that we collected samples from those points where the measured concentration of the parameters were not acceptable during the first sampling time. The water samples were taken at 10 cm below the surface stored in HDPE containers. The location of water sampling points is presented on Figure 2.

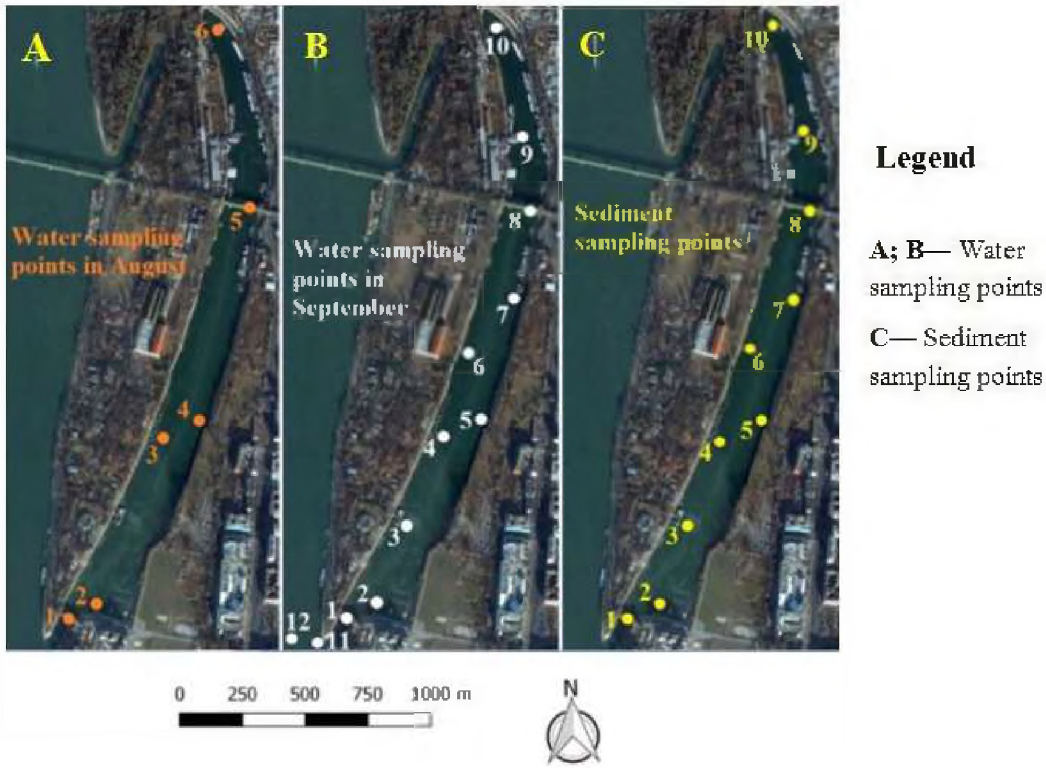


*Figure 2.* Location of sampling points in the three sampling campaigns
*2. ábra* Mintavételi pontok elhelyezkedése a mintavételi időszak alatt

**Analysis methods**

In-situ and laboratory examinations were the major part of our study. In order to acquire useful data about the water quality and the sediment, we have implemented a number of measurements during the sampling campaign.

**Sediment analysis**

The main goal of sediment analysis was collect data about the general status of the accumulated pollutants. The most important selected compound groups were the TPH (Total Petroleum Hydrocarbons), PAH (Polycyclic Aromatic Hydrocarbons). The selection process was based on historical records. During the analysis, we focused on those compound groups that were mostly related to the ship-building and service. Pre-processing of the sediment samples included drying, grinding and drizzling (0,2 mm hole diameter sieve). The investigated parameters, the measurement methods and the instruments can be seen in the Table 2.

*Table 2.* Sediment investigations
*2. táblázat* Üledékminta vizsgálatok

| Investigated parameters | | | Examination methods | Instruments |
|---|---|---|---|---|
| Elements | Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd) | | MSZ 12739/4-78 | Atomic Absorption Spectrometer (AAS, Perkin Elmer AAnalyst 800) |
| Total Petroleum Hydrocarbon (TPH) | Extractable Petroleum Hydrocarbons (EPH) | EPH ($C_{10}$-$C_{12}$) | MSZ 2184-7:2009, MSZ 21470-94:2009, MSZ 1484-4:1998, MSZ 21471-92:1998, MSZ 21470-105:2009, MSZ EN ISO 9377-2:2001 | Gas Chromatograph with Flame Ionization Detector (GC-FID, Agilent 6890) |
| | | EPH ($C_{13}$-$C_{40}$) | | |
| | Volatile Petroleum Hydrocarbons (VPH) | Benzene | | Gas Chromatography with Mass Spectrometer (GC-MS, Shimadzu GCMS-QP2010) |
| | | Toluene | | |
| | | Ethylbenzene | | |
| | | 1,3-Xylene and 1,4-Xylene | | |
| | | 1,2-Xylene | | |
| | | VAPH ($C_6$-$C_{12}$) | | |
| | | n-Hexane | | |
| | | n-Decane | | |
| | | VALPH ($C_5$-$C_9$) | | |
| | | VALPH ($C_{10}$-$C_{12}$) | | |
| | | MTBE | | |
| Polycyclic aromatic hydrocarbons (PAH) | | Naphthalene | MSZ 1484-6:2003, MSZ 21470-84:2002, MSZ 21978-40:1999, MSZ 15527:2009, MSZ 21862-29:1988 | Gas Chromatography with Mass Spectrometer (GC-MS, Shimadzu GCMS-QP2010) |
| | | 2-Methyl Naphthalene | | |
| | | 1-Methyl Naphthalene | | |
| | | Acenaphthylene | | |
| | | Acenaphthene | | |
| | | Fluorene | | |
| | | Phenanthrene | | |
| | | Anthracene | | |
| | | Fluoranthene | | |
| | | Pyrene | | |
| | | Benzo [a] anthracene | | |
| | | Chrysene | | |
| | | Benzo [b] fluoranthene | | |
| | | Benzo [k] fluoranthene | | |
| | | Benzo [e] pyrene | | |
| | | Benzo [a] pyrene | | |
| | | Indeno [1,2,3-cd] pyrene | | |
| | | Dibenzo [a, h] anthracene | | |
| | | Benzo [g, h, i] perylene | | |

**Water quality analysis**

A key goal of the study was to gain more information about the water quality through general physical, chemical and microbiological parameters. The investigated parameters and the instruments are presented in Table 3.

*Table 3.* Analyzed parameters of the water samples and used instruments
*3. táblázat* Vízminőség vizsgálatok és alkalmazott berendezések

| Investigated parameters | | Measurement location | Instruments |
|---|---|---|---|
| Physical parameters | Water temperature | On-site measurement | ADWA AD630 DO&Temperature |
| | Secchi depth | On-site measurement | Secchi disk |
| Chemical parameters | Ammonia | Laboratory measurements | HANNA Instruments HI 83099 photometer |
| | Ammonium | Laboratory measurements | HANNA Instruments HI 83099 photometer |
| | Iron | Laboratory measurements | HANNA Instruments HI 83099 photometer |
| | Nitrate | Laboratory measurements | HANNA Instruments HI 83099 photometer |
| | pH value | On-site measurement | ADWA AD8000 pH/mV/TDS&Tempe rature |
| | Electrical conductivity | On-site measurement | ADWA AD8000 pH/mV/TDS&Tempe rature |
| | Dissolved oxygen | On-site measurement | ADWA AD630 DO&Temperature |
| Microbiological parameter | *Escherichia coli* | Laboratory measurements | Microplate |
| | Intestinal *Enterococci* | Laboratory measurements | Microplate |

A number of physical and chemical (pH, EC, DO) parameters were measured on site directly after the samples have been taken. The remaining chemical ($NO_3^-$ $NH_3$, $NH_4^+$, Fe) and microbiological analyses were carried out in the laboratory after the sampling. Preservation of the samples were ensured by transporting them in a cooled storage container. Sample preparation included field vacuum filter with 0,45 μm hole diameter filter paper. With reference to the microbiological examination, we measured two microbiological parameters: *Escherichia coli* and intestinal *Enterococci*. The examination steps included creating two dilution series from the samples and adding them into MUG microplates. Samples had been incubated at 44°C for 72 hours. Finally the results were evaluated under 366 nm UV light.

## Results

The main purpose of the current study was to create a complex environmental analysis of the backwater. Results had been analyzed and evaluated on the grounds of Hungarian regulations and law. The sediment samples had been assessed on the basis of statute 6/2009 of Ministry of Environment, Ministry of Health and Ministry of Agriculture. The water samples had been evaluated on the score of statute 10/2010 of Ministry of Rural Development and ISO 9308-3:2000, ISO 7899-1:2000.

**Evaluation of the sediment measurements**

Within the framework of the study, 10 sediment samples were examined. The first parameter cluster was the heavy metal content of the sediment. Zn and the Pb contents were higher than the threshold of Hungarian regulations in a number of sampling points. At sample 9, the Zn concentration was four times higher than the limit. Zn is one of the most commonly used metals in industrial activities. The solubility of the Zn is increasing in acidic environment. According to the results, the biggest difference between the limit and the determined concentration was in the Pb content. In Sample 8, it was ten times higher than the threshold. The source of Pb pollution is widespread. It can come from the car industry, paint production, battery manufacturing and the transportation. The Cd concentrations of the samples were higher than the limit in every case. In one case (Sample 9) the Cd concentration was twice higher than the Hungarian limit. Cd could pass into the aquatic ecosystem by the wearing of tires and use of diesel oil. In the presence of chloride and sulfate ions, the Cd mobilization processes could occur quickly. Going further among the examined elements, the best results were measured in the Cu examinations as Cu concentrations stayed below the regulation limit. After analysis of the results, a number of sampling points showed significantly higher results than the others. These points were the seventh, the eighth, the ninth and the tenth sampling points. This was the area where the industrial activity was the most prominent. The results of the laboratory examination of sediment can be seen in the Table 4. Interpolated maps of heavy metal concentrations are presented in Figure 3.

*Table 4.* Results of the sediments analysis
*4. táblázat* Üledékvizsgálati eredmények

| **Sediment samples** | **Concentration (mg kg$^{-1}$)** | | | |
|---|---|---|---|---|
| | Zn | Cu | Pb | Cd |
| Threshold of Hungarian regulation | 200.0 | 75.0 | 100.0 | 1.0 |
| Sample 1 | 107.9 | 13.2 | 34.7 | 1.0 |
| Sample 2 | 120.0 | 22.9 | 36.2 | 1.6 |
| Sample 3 | 85.0 | 25.1 | 71.7 | 1.4 |
| Sample 4 | 112.0 | 26.4 | 67.5 | 1.3 |
| Sample 5 | 179.0 | 42.5 | 302.0 | 1.5 |
| Sample 6 | 127.0 | 30.1 | 134.0 | 1.4 |
| Sample 7 | 132.0 | 40.0 | 347.0 | 1.1 |
| Sample 8 | 407.5 | 47.3 | 1017.0 | 1.4 |
| Sample 9 | 804.0 | 59.0 | 436.0 | 2.1 |
| Sample 10 | 240.0 | 38.5 | 268.5 | 1.7 |

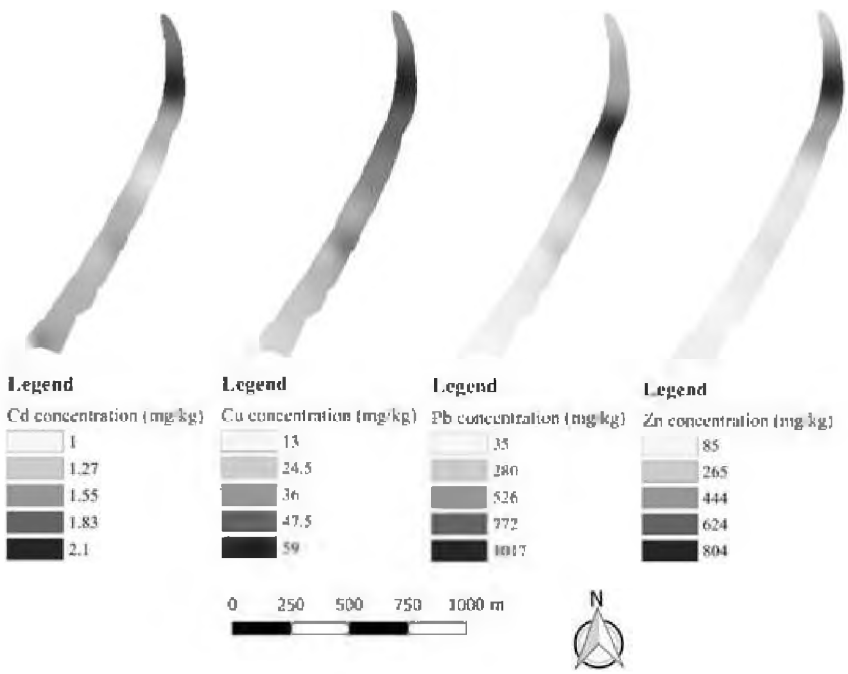


*Figure 3.* Interpolated maps of heavy metals content of the backwater
*3. ábra* Nehézfém tartalom eloszlása az öbölben

The evaluation of the maps suggest the northern section of the backwater was the most polluted, with industrial activities more dominant in the area, as well as due to increased sedimentation due to the specific hydraulics of the backwater. The runoff from railway and road networks could also be responsible for some of the pollutants present. These findings also proved that these industrial activities and traffic-related sources significantly affect the sediments heavy metal content. As it can be seen from the figures, the less affected part of the backwater was the southern region. This is well illustrated by the interpolated maps because the measure concentrations were lower than the other parts. The southern section of the area is mostly surrounded by sports clubs recreational areas.

In order to get more detailed information about the sediment, the second parameter cluster included the TPH and the PAH indicator groups. As in the previous step, interpolated maps had been created regarding the concentration of the two mentioned hydrocarbon groups. The interpolated maps can be seen on Figure 4.

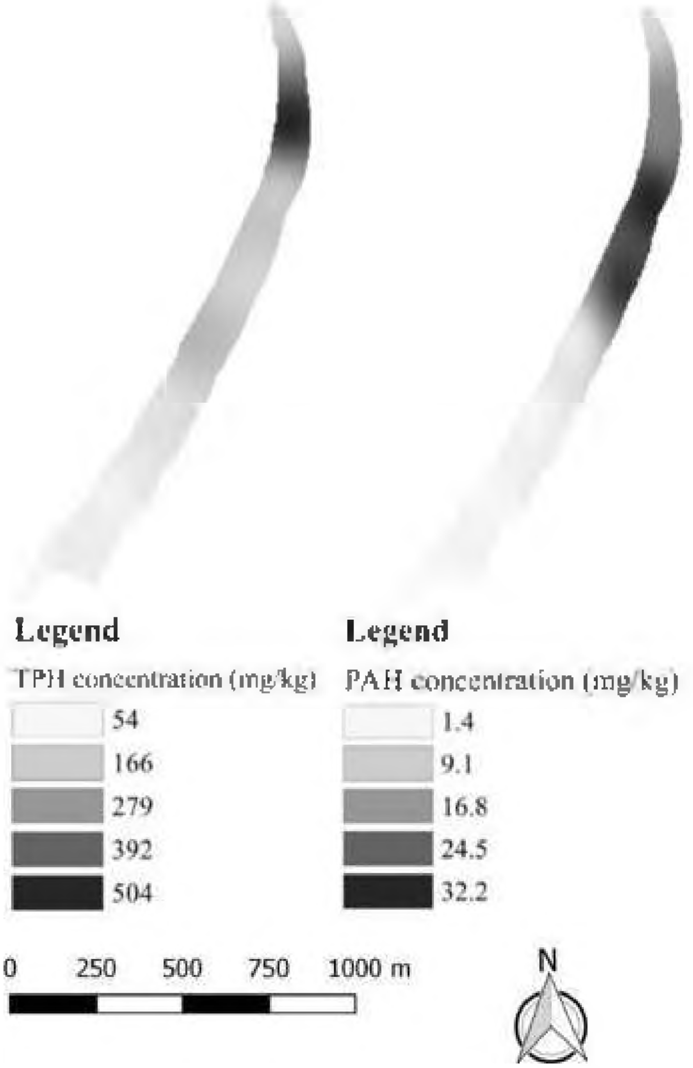


*Figure 4.* Interpolated maps about the TPH and PAH content of the backwater
*4. ábra* TPH és PAH származékok eloszlása az öbölben

The figures reveal the same patterns what were present in the case of heavy metals, with the northern section of the area highly affected by the pollutants. In all cases PAH concentrations were above the limit. In addition to this, really high PAH concentrations were measured in samples 7, 8 and 9. In a prominent case (sample 8), the PAH concentration was more than thirty times higher than the Hungarian threshold. With reference to the results of the TPH measurements, they showed the same patterns. In several cases (Sample 8 and Sample 9), the TPH concentrations were four and five times higher than the limit. Conceivable reason for hydrocarbon pollutants could be the ship repairing and transporting activities and potentially related accidents. The TPH and PAH compounds could get into the water by ship traffic, used diesel oil and hydraulic oil. The human and environmental risk of the parameter groups are very high because of the accumulation process. The results of the TPH and the PAH examinations of the sediment can be seen in the Table 5.

*Table 5.* Results of the TPH and PAH analysis
*5. táblázat* TPH és PAH vizsgálatok eredménye

| Sediment samples | Concentration (mg kg$^{-1}$) | |
|---|---|---|
| | TPH | ∑ PAH |
| Threshold of Hungarian regulation | 100.0 | 1.0 |
| Sample 1 | 57.0 | 1.6 |
| Sample 2 | 82.0 | 1.4 |
| Sample 3 | 68.0 | 1.1 |
| Sample 4 | 107.0 | 1.5 |
| Sample 5 | 100.0 | 1.1 |
| Sample 6 | 211.0 | 3.1 |
| Sample 7 | 144.0 | 30.0 |
| Sample 8 | 165.0 | 32.2 |
| Sample 9 | 504.0 | 18.9 |
| Sample 10 | 435.0 | 6.5 |

**Evaluation of the water quality measurements**

A combined number of 18 water samples were analyzed during the two related sampling campaigns. For water quality analysis, measurements were made in the three parameter clusters: physical, chemical and microbiological parameters. The microbiological evaluation of the samples has been based on MPN (most probable number) method. It involved two microbiological indicators, *Escherichia coli* and *Enterococci.* The results of microbiological measurements of the water can be seen in Figure 5.

According to the results, the majority of the samples were excellent and good, except for one sampling point during the first sampling period in August. This sampling point is located in the main branch of the Danube more precisely at the entrance of the backwater. The *Escherichia coli* MPN value was 969 while the mean MPN value of this sampling period (for all 6 samples) was 28. Results showed the same pattern during the second sampling period in September, with high counts measured at the entrance of thy backwater. In this case, the maximum MPN value was 1116 while it was much lower or zero in the rest of the area. The data would seem to suggest that MPN value of the *Escherichia coli* was higher in the Danube than in the bay. Possible cause of higher value was a probable source of pollutants above or at the entrance of the bay (such as the North-Pest Wastewater Treatment Plant) or the microbiological process was more active in the water of the Danube than in the backwater. Regarding the intestinal *Enterococci* content, the classifications of the results were excellent. The results of microbiological measurements of the water can be seen in the Figure 5.

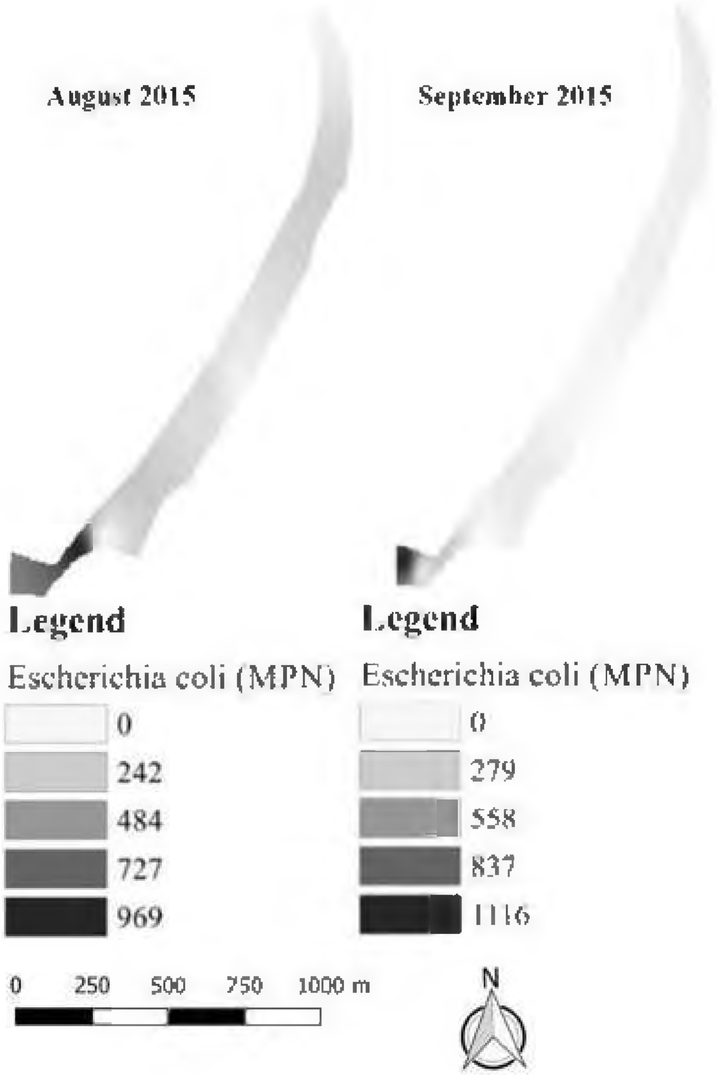


*Figure 5.* Interpolated maps about the *Escherichia coli* content of the backwater in August and September 2015
*5 ábra Escherichia coli* tartalom eloszlása az öbölben

Further evaluation of the additional water quality parameters showed that the average $NH_4^+$ concentration was 0.2 mg $l^{-1}$ during the sampling campaign. The average concentration of $NO_3^-$ was 0.7 mg $l^{-1}$. As a matter of fact, the dissolved oxygen concentrations were low in some cases, with particularly low concentrations at the 7$^{th}$, the 8$^{th}$ the 9$^{th}$ and the 10$^{th}$ sampling points. This low dissolved oxygen concentration ranged from 1.5 mg $l^{-1}$ to 2 mg $l^{-1}$ and the temperature of the water samples were 20 °C. Interesting point of the results was that the 9$^{th}$ and the 10$^{th}$ sampling points with the lowest concentrations were in the end of the backwater. The low dissolved oxygen concentrations could have been due to two reasons: on one hand the currents were really slow in this part of the area with was almost a still water. On the other hand, the activity level of the biological degradation may have been higher than in the other part of the water body. As for the $NH_3$ content, there were some sampling points where the measured results were higher – around 0.3 mg $l^{-1}$ to 0.37 mg $l^{-1}$ – than the mean concentration ranging from 0.1 mg $l^{-1}$ to 0.15 mg $l^{-1}$. These mentioned higher concentrations were measured at the 2$^{nd}$ and the 9$^{th}$ and the 10$^{th}$ sampling points. Fishing is a popular activity as well in the area and the fishermen feed the fish in these areas, which might have caused excess nutrient accumulation. Another reason of the higher $NH_3$, $NH_4^+$ and $NO_3^-$ content in the northern part of the bay could be sewage. The Fe content of the water samples was very low. In many cases the results were under the detection limit or around 0.01 mg $l^{-1}$. But there was an exception during the examinations. This higher Fe concentration – that was around 0.62 mg $l^{-1}$ - was measured at the 8th sampling point during the second sampling period. There could be two explanations: on the one hand, there was a railway bridge above the sampling point. Higher Fe concentration may have come from the railway traffic. Furthermore, there is a harbor or a kind of storage for those ships that the companies have to repair or renew. This could have been the second reason of the higher Fe concentration. We carried out measurements with Secchi disk and the result was that most of the bay had a turbid water. The average Secchi depth ranged from 30 cm to 40 cm. Measured pH values were between pH 7 and pH 8.

*Table 6.* Results of the water quality measurements (2015 September)
*6. táblázat* Vízminőség vizsgálatok eredményei

| Water sample | pH | T (°C) | EC (µS cm-1) | DO (mg $l^{-1}$) | $NO3^-$-N (mg $l^{-1}$) | $NH_3$-N (mg $l^{-1}$) | $NH_4^+$-N (mg $l^{-1}$) | Fe (mg $l^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.93 | 20.4 | 569 | 4.24 | 0.0 | 0.14 | 0.18 | 0.00 |
| 2 | 7.16 | 20.7 | 583 | 5.43 | 1.7 | 0.37 | 0.18 | 0.00 |
| 3 | 7.92 | 20.4 | 584 | 4.58 | 0.0 | 0.14 | 0.17 | 0.00 |
| 4 | 7.60 | 18.4 | 552 | 4.48 | 0.0 | 0.13 | 0.15 | 0.00 |
| 5 | 7.57 | 18.4 | 571 | 4.26 | 1.2 | 0.12 | 0.18 | 0.00 |
| 6 | 7.26 | 20.0 | 589 | 4.01 | 0.0 | 0.14 | 0.12 | 0.00 |
| 7 | 7.73 | 20.4 | 586 | 2.27 | 0.7 | 0.10 | 0.18 | 0.20 |
| 8 | 7.81 | 20.1 | 641 | 1.56 | 5.2 | 0.18 | 0.48 | 0.62 |
| 9 | 7.92 | 20.2 | 610 | 1.85 | 3.2 | 0.31 | 0.40 | 0.25 |
| 10 | 6.81 | 20.8 | 670 | 1.23 | 4.6 | 0.34 | 0.44 | 0.00 |
| 11 | 8.04 | 19.8 | 615 | 5.44 | 1.0 | 0.18 | 0.23 | 0.00 |
| 12 | 7.52 | 18.3 | 655 | 5.95 | 1.0 | 0.15 | 0.25 | 0.16 |

## Discussion

Our study was focusing on a complex approach to assess and evaluate the water and sediment quality of the study area. The sediment examinations were a very significant part of the study because we investigated many different pollutant components that could have accumulated over the past decades of industrial activity. By and large, the result of the sediment examination was that heavy metals content –particularly Cd, Zn and Pb concentrations – were high in the samples. In some cases, the concentrations of the elements were four times (Zn) and ten times (Pb) higher than the Hungarian regulations. Cd content, it was the worst because the measured concentrations of each sampling points were higher, on average almost twice, than the Hungarian limit. TPH and PAH examinations had shown the same spatial pattern as heavy metal analysis. The TPH and PAH contents of the sediment sample were higher in the northern part of the backwater than in the southern segment. Possible reason of higher values, the economic activities especially the ship maintenance and repairing which could have affected the environment. In point of the ship-building, it has very long history in the area and the pollutants could have accumulated in the sediment during this long period. The ship maintenance and repairing has been going on since the first half of the 19th century. It could have influenced the sediments heavy metal, TPH and PAH contents.

The analysis of water quality focused on the general water quality parameters. Chemical and biological water quality of the bay were good but there were some higher values among the Fe and dissolved oxygen concentration. Possible reason of the high Fe concentration was the busy railway bridge over the sampling area. We measured low dissolved oxygen concentration in the northern side of the bay because the currents were very low and organic matter content could be high. The analysis of the sediment revealed that the Pb, Cd, TPH and

PAH concentrations are posing the higher environmental risk among the measured parameters. The environmental load began in the 19th century when the industrial activities rose. The high Pb and Cd concentration of the sediment have a high human and environmental risk because of the mobilization processes which is driven by the changing chemical and biological conditions. The sediment stored remarkable amount of pollutant due to the past and present industrial and transportation activities. Systematic monitoring could be a very important part for future action because the area has been under constant development in the last decades and the dominance of industrial activities is expected to further shift towards recreational services. Regarding potential further studies, focus should also be on other potential pollutant groups: Polychlorinated biphenyls (PCB) and Polybrominated biphenyls (PBB) which can link or relate to the ship-building and can have a profound impact of the ecosystem. An important future study would be a detailed long-term water quality monitoring, particularly in the light of increasing recreational activities.

**Acknowledgements**

This publication was supported by the EFOP-3.6.1-16 -2016-0016 project: Improvement of the research and training profile of the SZIU Campus in Szarvas in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production. The underlying research was supported by the Higher Education Institutional Excellence Program (1783-3/2018/FEKUTSRAT) awarded by the Ministry of Human Resources in the framework of water-related research of the Szent István University, Gödöllő (Hungary).

**References cited**

Asplund, R., Ferguson, J. F. and Mar, B. W. 1980: Characterization of Highway Runoff in Washington State. Washington State Department of Transportation.

Barret, M. E., Zuber, R. D. and Collins, E. R. 2015: Review and Evaluation of Literature Pertaining To the Quantity and Control of Pollution From Highway Runoff and Construction. Texas: The University of Texas at Austin. pp. 5–18.

Bartram, J., Ballance, R. 1996: Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. Conference Record Southcon. UNEP and WHO, E & FN SPON and Chapman & Hall.

Ciazelaa, J., Siepakb, M. and Wojtowiczc, P. 2018: Tracking heavy metal contamination in a complex river-oxbow lake system: Middle Odra Valley, Germany/Poland. Science of The Total Environment, 616–617, 996–1006.

Davis, A. P., Shokouhian, M. and Ni, S. 2001: Loading estimates of lead, copper, cadmium and zinc in urban runoff from specific sources. Chemosphere, 44(1): 997–1009.

Duffus, J. H. 2002: Heavy metals – A meaningless term. Pure and Applied Chemistry 5: 793–807.

Gonda B. 2011: A hajóépítés kezdetei Újpesten. Újpesti Helytörténeti értesítő 18(1): 4–6.

de Groot, A., Zschuppel, K., Salomons, W. 1982: Standardization of methods of analysis for heavy metals in sediments. Hydrobiologia 92: 689–695.

Hirsch, R. M., Slack, J. R., Smith, R. A. 1982: Techniques of trend analysis for monthly water quality data. Water Resources Research, 18(1): 107–121.

Lin, J.-G., Chen, S.-Y. 1998: The relationship between adsorption of heavy metal and organic matter in river sediments. Environment International, 24(3): 345–352.

Nagy, E., Piros, C. 1987: Annual report of the Hungarian Geological Institute of 1987. Budapest.

Németh N. 2014: Környezeti problémák vizsgálata megváltozott területhasználatú városrészeken. Szent István Egyetem.

Padisák J. 2005: Általános Limnológia. Budapest: ELTE Eötvös Kiadó.

Smakhtin, V., Revenga, C., Döll, P. 2004: Taking into Account Environmental Water Requirements in Global-scale Water Resources Assessments. Water International. Comprehensive Assessment of Water Management in Agriculture 2, Colombo. p. 24.

Viersa, J., Dupréa, B., Gaillardetb, J. 2009: Chemical composition of suspended sediments in World Rivers: New insights from a new database. Science of The Total Environment, 407(2): 853–868.

Winkler, M. 2005: The characterization of highway runoff water quality. Graz: Technischen Universität Graz, pp. 207–228.

Wu, B., Wang, G., Wu, J., Liu, C. 2014: Sources of Heavy Metals in Surface Sediments and an Ecological Risk Assessment from Two Adjacent Plateau Reservoirs. Online Research, PLoS ONE, 9(7): e102101.

Yi, Y., Yang, Z., Zhang, S. 2011: Ecological risk assessment of heavy metals in sediment and human health risk assessment of heavy metals in fishes in the middle and lower reaches of the Yangtze River Basin. Environmental Pollution 159: 2575–2585.

## AZ ÚJPESTI-ÖBÖL VÍZMINŐSÉGÉNEK ÉS ÜLEDÉKÉNEK VIZSGÁLATA

GRÓSZ János, SEBŐK András, NAGY Noémi, KOVÁCS Andrea, WALTNER István

Szent István Egyetem, Mezőgazdaság- és Környezettudományi Kar, Természetvédelmi és Tájökológiai Tanszék
2100 Gödöllő, Páter Károly u. 1., e-mail: sebok.andras@mkk.szie.hu

**Kulcsszavak:** üledék vizsgálatok, vízminőség vizsgálatok, nehézfémek, biológiai vízminőség, szénhidrogén szennyezés

**Összefoglalás:** Vízkészleteink a legjelentősebb és legsérülékenyebb természeti erőforrások közé tartoznak. Az itt bemutatott tanulmány célja az Újpesti-öböl vízminőségének és üledékének, valamint az azt befolyásoló tényezők vizsgálata volt. A vizsgált terület a Duna egykori mellékága, Budapest északi területén található. Az öböl környékén elsősorban ipari létesítmények találhatók, ám egyben rekreációs, illetve sportolási tevékenységek helyszíne is. Az átlagos vízmélység 4,5 méter, a z öböl hossza 2200 méter. A legjelentősebb gazdasági tevékenyég a hajóépítés és karbantartás. A vízminőség, illetve az üledék vizsgálatához különböző fizikai, kémiai és mikrobiológiai paramétereket vizsgáltunk víz- és üledék mintákon. A mintavételezés 2015-ben vízminták esetén két időpontban, üledék esetén egy alkalommal történt. Az üledék vizsgálata kiterjedt azok nehézfém (Cu, Zn, Pb, Cd), valamint a TPH és PAH tartalmára. A vizsgált vízminőségi jellemzők közé tartoztak kémiai és fizikai (NH3, NH4+, NO3-, Fe, pH, vezetőképesség, oldott oxigén), valamint mikrobiológiai paraméterek. A vizsgálat eredményei kimutatták, hogy az üledék számos helyen tartalmazott nehézfémeket és szénhidrogéneket, melyek összefüggésbe hozhatók az ipari és közlekedési tevékenységekkel. Magas Pb, Cd, Cu, Zn, TPH és PAH koncentrációt mutattunk ki az öböl északi részén, mely valószínűsíthetően összefüggésben áll az ott zajló karbantartási és javítási munkálatokkal, hajóforgalommal, illetve közlekedéssel. A üledékben mért magas Pb, Cd, TPH és PAH tartalom jelentős környezeti veszélyeket hordozhat. A vízminőségi vizsgálatok során mért magas Fe tartalom összefüggésbe hozható az öböl felett áthaladó vasúti forgalommal. A mikrobiológiai vizsgálatok ugyanakkor jellemzően elfogadhatóan alacsony értékeket mutattak.