Szent István University

Doctoral School of Environmental Science

Design of a complex monitoring system for minor water streams based on the example of Galga stream

Abstract of the PhD thesis

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1 INTRODUCTION AND OBJECTS

Seas and oceans present large proportion of our planet's living-space. However, maritime environment has numerous loads due to human activity. Practically there is not a single spot on the water-coat of Earth that has not been changed by the actions of mankind. Since man lives on Earth he produces physical and chemical waste, which changes the original composition and state of air, soil and natural water. Numerous previous research and survey prove that we have to take special care of our freshwater reserves. But these researches paid no particular attention to small streams as the primary indicators of pollution. Streams concentratedly indicate the environmental and hydrological effects but there is not sufficient data on national, European and international level about their condition or about the required methods and regulations to reach their good ecological status.

The Water Framework Directive (WFD) which governs the water-policy of the member countries took effect in December 2000 with the aim to reach good ecological status of waters. This framework only declares the targets, however, the method of execution may differ in every country.

For this there must be a change over from the sampling area-located condition-evaluation to a monitoring system capable of assess the condition of a water body and follow its temporal change. If a certain water-body is not in satisfying condition then the reasons of quality change must be found (investigative monitoring), an intervention plan must be prepared and executed and the effects of intervention must be monitored. The WFD does not compare the condition of a water body to a general standard, but the condition of the observed water body is compared to a „reference water body" of the same type. The present mainstream monitoring system in Hungary aims to analyze certain places on larger rivers and lakes. It gives very little organized information about the condition of minor water streams. This circumstance trammeled not only the design of a WFD compatible monitoring system but the absence of sufficient references also hindered the evaluation.

My doctoral work aimed at solving this problem and it was connected to several projects which established the WFD compatible monitoring of minor water streams:

Researches done in VITUKI:

- Environmental analytical examination of surface and subsurface streams, lands and sediments 2001-2005.
- National researches 2003-2008:
    - Nitrate characterization of minor water streams uncharged by settlements.
    - Mass balance of Hungary.
    - Nutritive characterization of surface waters of Hungary.
    - Evaluation of the nitrate (nitrate pollution level) and eutrophication (fertility

level of surface waters and characterization of rivers, lakes and standing waters by fertility) monitoring data of Hungary's sub aerial waters.

- International programme on Danube protection and prevention of pollution (ICPDR AEWS Eu) 2005-2008.
- Introduction of the EU WFD Soil Conservation Policy in Hungary 2008-2009.

Researches in the Department of Chemistry and Biochemistry of the Szent István University:

- Detection of changes in the environmental status with radiochemical methods at Galga stream 2001 (KAC 2001).
- Hydrological and environmental analytical evaluation of Rákos stream and the connected lake system in 2003 (KAC 2003).
- Design of an EU-WFD-compatible complex monitoring system and database applicable to differently loaded inland minor water streams, especially the Galga stream. 2004-2006 (RAGACS 2006)

My doctoral thesis is mainly based on my work in the latest project but occasionally in comparisons I used the results of all above mentioned programs.

Aims of work

Regarding the application of WFD in Hungary and in strict connection with the above mentioned research areas I set the following goals to my doctoral work on the model area of Galga stream and its catchment area:

1. Exact surveillance of the environmental condition of the Galga stream's catchment-area as an ecological model based on hydromorphological, hydrological, physical, chemical and hydrobiological analysis considering with the suggestions of EU WFD.
2. Determination the confidence interval of required sampling density in space and time on Galga stream's catchment area in connection with the water quality classification required by WFD. Based on the results development of recommendations for a generally adaptive method to monitor the minor water streams of Hungary with similar parameters to Galga stream.
3. Demonstration of a study on the displacement of heavy metal pollution in the sediment of the selected area of Galga stream's catchment area which is supposed to be the aftermath of a point source pollution caused by the former machine factory of Iklad. Verification of the origin of elements in high concentration in the sediment with geochemical statistical analysis and estimation of the time needed for clearing after the termination of pollution.

2 MATERIAL AND METHOD

2.1 Surveillance monitoring of Galga stream

The model area is the Galga stream which rises by Szandaváralja in the middle of Cserhát mountains. It has a length of 65 km, its catchment area is 552.44 km^2, its flood area is 84 km^2.

On the Galga catchment area the following four stream types can be found according to the Hungarian stream typology:

- 1st Type: Mountain minor streams, >350 m, 10-100 km^2, silicate rock, quarry-faced bed material, stoned.
- 8th Type: Hill-country brook, >200 m, 10-100 km^2, calcareous, moderately fine bed material.
- 15th Type: Flatland, <200 m, 10-100 km^2, calcareous, minor streams with moderately fine bed material.
- 18th Type: Flatland, <200 m, 100-1000 km^2, calcareous, small rivers with moderately fine bed material.

I started my research on the catchment area of Galga stream in 1999, when I pointed out 5 areas: Püspökhatvan, Galgamácsa, Iklad, and Aszód by the highway 3, and the Aszód sewage treatment plant. The selection of sampling sites were determined by environmental chemical and hydrological considerations where pollution was presumed by preliminary analysis and the usage of area. Hydrological and chemical examination was done on the selected areas. Hydrological examination was based on maps, going-overs and literary data. The longitudinal sectional view and the draft of the water system were made based on military maps (scaled 1:25000) of the area. The longitudinal sectional view shows the names of entering water streams, the entering section and length. Every time during going-overs I recorded the water level. During chemical examination I took water sample once (May 2000) and sediment sample three times (May, July and August 2000). Heavy metal concentration of the samples was analyzed.

In August 2001 the KAC 2001 project provided an opportunity to do another sampling. I took sediment samples from the five previously examined sites and analyzed their heavy metal concentration.

In 2004 the consortium composed of Department of Chemistry and Biochemistry of SZIE, the Department of Public Water Utilities and Environmental Engineering of BME and the VITUKI won the project „Design of an EU WFD compatible complex monitoring system and database applicable to differently loaded inland minor water stream" which is connected to 5th chapter of the Ministry of Education's „Environmental protection technological development subprogram". I had the following tasks in the project: organization and execution of monthly monitoring to assess the hydrological and chemical status of Galga stream, evaluation of results, examination of the effects of point source pollution, execution of hydro-morphological examinations on Galga stream and execution of physico-chemical examinations, which are applied to the examination of minor surface water streams in Europe recently. During the project work I made detailed surveying at 19 points and pointed out 9 sampling sites on the catchment area of the stream for the surveillance monitoring. These points were the following: Becske (G19), Nógrádkövesd (G18), Püspökhatvan (G12), Galgamácsa (G8), Iklad (G7), Road 3 at Aszód (G5), Aszód sewage treatment plant (G4), Tura (G2), and Jászfényszaru (G1). I have done monthly hydrological, physico-chemical examinations on the nine sites for 13 months. Biological examinations were done by the biologist colleagues from VITUKI: Dr. Béla Csányi and Andrea Zagyva, evaluation of hydrological data was done by Dr. Béla Nováky.

2.1.1 Hydrological examinations

During the measurements of water discharge to determine the flow section I measured the depth of water in every 10-20 cm with 1 cm precision versus the width. Based on this determination I calculated the flow cross-section F [m^2]. To measure the average speed in the section I measured the speed of water at 3-5 places of the surface (depending on the width) with a floating buoy. The distance for the measurement was always the 5-6-fold distance of the width of the stream. The selected sections were usually straight. To calculate the average speed versus the gauging vertical (depth of water at the measurement line) I used the $v_V = 0{,}85 v_S$ formula based on the speed of surface-water at the line of measurement v_S [m/s]). Then I calculated the average speed of the section (v, m/s) by averaging the average speed of all gauging verticals. The water discharge is the product of the section area and the average speed of the section and can be calculated with the Q [m^3/s] = F [m^2] v [m/s] formula.

2.1.2 Water sampling

I took water sample from the drift of the stream. On sampling sites where I examined the water body of the stream after an inflow, I took samples after complete mixing. I measured pH, temperature and conductivity on site with field measuring instrument. The samples were filled in polyethylene bottles and carried to the laboratory in a cool box, protected from sunshine, then stored between 2-4°C degrees till the beginning of analysis.

For the analyis of inorganic micropollutants I put the samples into 1.5 liter volume polyethylene bottles, which were washed in 10% nitric acid solution for 1 hour and then rinsed in stream water. Then I added 5 cm^3 cc. nitric acid to the samples.

To determine the dissolved metal content I filtered the samples on site through a membrane filter with 0.45 μm pore size. For the determination of mercury I put the samples into bottles which were washed thoroughly with a 1:10 mixture of bromic reagent solution and hydrochloric acid and then rinsed with dionized water (MSZ 1484-3-1998).

2.1.3 Sediment sampling

Sampling points were selected on a length of 1.5 km between the inflow point of the machine factory of Iklad at 25+900 rkm (previous pollution) and the bridge of the highway No. 3 at Aszód. Nine sampling points were selected for the examinations. These nine points were selected by the bend of course and based on the shore-building activity of the stream. Considering the hydro-meteorological effects, samplings were done after heavy rainfalls and extreme droughts. Samples were gathered in May, July and August 2000. Sampling in May was done right after the spring rains, the one in July happened during the hot summertime and the sampling in August was done after the drought. Sediment sampling was performed in August 2001 and December 2003 when there was not significant precipitation.. Samples were gathered in March, May and June 2004 after heavy rainfalls. I measured water level, water speed and the wetted cross-section of the course at the places of sampling. Sediment samples were taken from the convex side of the course. These mixed samples were placed in polyethylene boxes after immersion and transported in a cool box. The sampling and preservation of samples were done according to MSZ EN ISO 5667-3: 1998.

2.1.4 Determination of inorganic pollutants in the water samples

The following components were determined from the water samples: COD_{ps} (MSZ 448-20-1991), alkalinity (MSZ 448-11-1986), total hardness (MSZ 448-21-1986), calcium (MSZ 448-3-1985), magnesium (MSZ 448-3-1985), sodium, potassium (MSZ 448-10-1977), sulphate (MSZ 448-13-1983), ammonium (MSZ ISO 7150-1-1993), nitrate, nitrite (MSZ 448-12-1982), organic nitrogen, total nitrogen (MSZ 448-27-1985), dissolved ortophosphate and total phosphorus (MSZ 448-18-1977). The uncertainty of chemical analysis was in accordance with the related standards.

2.1.5 Sample-preparation for elemental analysis

The conserved (strained) water sample of known quantity was measured into a PTFE bomb, then 4 ml 65% nitric acid and 2 ml hydrogen peroxide were added; the container got secured then I started the following program on the microwave digestor: 5 minutes 250 W power, 2 minutes 0 W, 5 minutes 400 W, 5 minutes 250 W, 5 minutes 700 W, 5 minutes cooling. After the digesting program I waited for the sample to completely cool down. Under exhaustor I removed the top of the containers and the solution was filtered through 0.45 μm pore size membrane filter into a 25 cm^3 volumetric flask filled to the mark.

I used the particles of sub fluvial sediment sample that are smaller than 63 μm. The correct size range was selected with the help of AS 200 Control “G” analytical sieve shake. Samples obtained this way were homogenized by wet stirring, freeze-dried and the air-dry sample was homogenized. Further sample preparation was done as described in the water sampling section.

2.1.6 Elemental analysis from water and sediment samples

From the prepared samples element concentrations were measured by Jobin-Yvon 24 sequential ICP-AES device. The prepared solutions were introduced into the plasma by a Meinhard type nebulizer with the help of peristaltic pump with 1.1 ml/min nebulization speed. The device selects the wavelengths of analytical lines in increasing order and adjusts the monochromator. Examined elements were: As, Zn, Cd, Fe, Mn, Cr, Cu, and Al.

The inductively coupled plasma atomic emission method is theoretically capable to detect 70-80 different elements and determine their quantity by using the photoemission of excited free atoms and ions produced in plasma. The sample solution is nebulized and transported into the inductively coupled plasma (ICP). There the components of the sample evaporate and atomize, the nascent free atoms and ions get excited and emit photons of specific wavelength. The photoemission of plasma dispersed spectrally and the intensity of given wavelength spectrum line of the individual elements can be measured by photoelectric detection.

2.1.7 Statistical examination

The spatial variability of chemical components of water samples was determined by Szilágyi’s method (2005), that is based on the determination of the interrelation between the relative error and the number of samples with interval estimation.

Single and multivariate statistical analysis methods were used to examine the data series of the sediment. Outliers were identified by visual examination of cumulative frequency curves on Steam-and-Leaf histograms (where the sample value substantially differed from the other values). Determination of outliers made possible to track the displacement of pollution. Data was analyzed with the help of STATGRAPHICS Centurion XV software.

3 RESULTS

3.1 Results of hydrological examinations

Anthropogenic effects were confirmed by the temporal development of monthly runoff coefficient. In the Galgamácsa section of Galga the runoff coefficient occurred as exhibitive of natural streams. It was low (1.5-3.0 %) during the summer months, it starts increasing during the winter months and it reaches its peak value during melting. In the Hévízgyörk section the small increase in runoff coefficient values of summer months refers to human effects, the water inlets between Galgamácsa and Hévízgyörk.

In the mainstream network sections the expeditionary measurements stood comparison with the discharge values calculated from discharge curves. The closeness of the regression connection can be described with the 0.85 correlation factor. The close connection indicates that the expeditionary measurements are acceptable (at least in the measured interval) and instrumental measurement can be substituted with the simplified measuring method. Analysis of the relations shows that with the simplified measuring method the discharge value is underestimated under approx. 150 l/s discharge; but it is overestimated if the actual discharge is above 150 l/s.

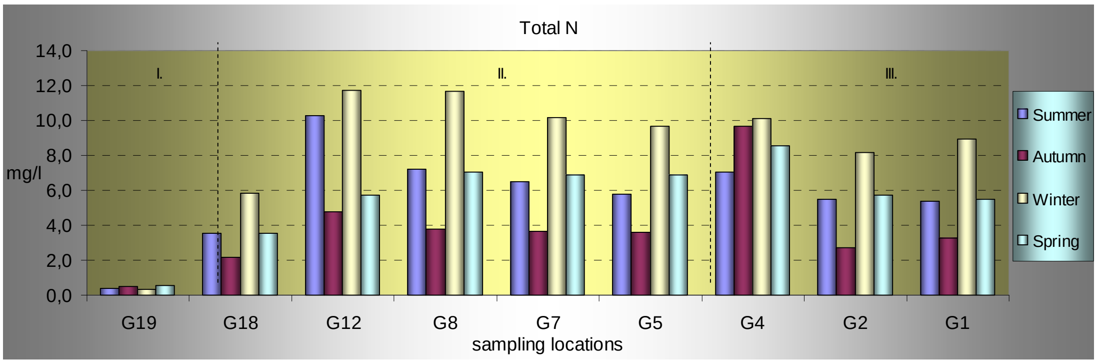
3.2 Results of hydro-morphological examinations

The dominant hydro-morphological deformation on Galga is embankment of the riverbed. Also there are sewage water inflows; the most significant comes from Aszód (1500 m^3/d). The total sewage water inflow is approximately 2700 m^3/d. The riverbed is made of terra, the escarps are grassed and clothing is only around the bridges. At the estuary of the stream there are 1500 m long embankments both side. Because of the back-impounding effect of Zagyva a water-holding waste-pile was built until the interior of Tura. There are several reservoirs on that area; each has different function.

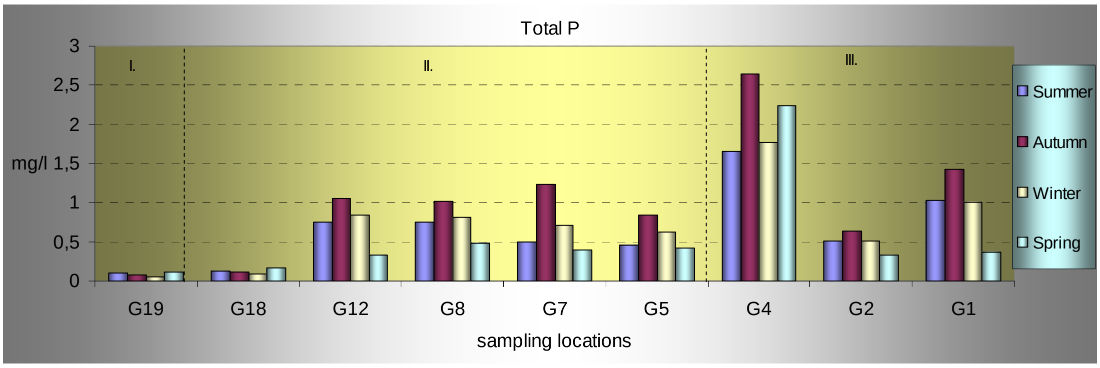
3.3 The change of chemical quality of water based on the surveillance monitoring in 2004/2005

3.3.1 Water analytical results

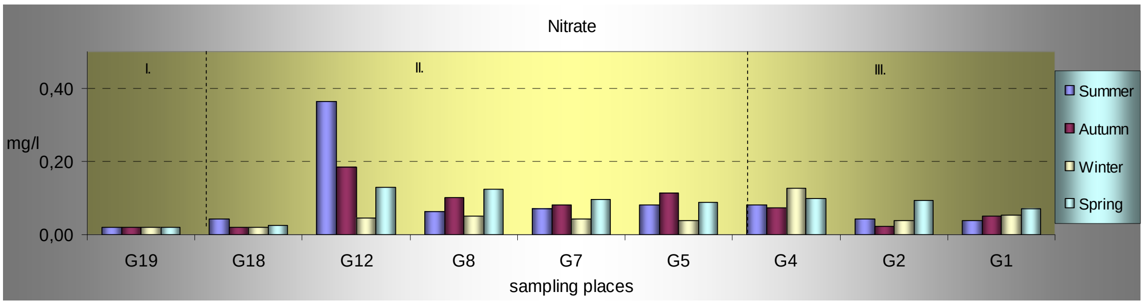
Detailed examination of monitoring results is denoted in a database and some are presented with the following graphs:



Graph 1: seasonal change of total nitrogen concentration in the water samples of Galga stream



Graph 2: seasonal change of total phosphorus concentration in the water samples of Galga stream



Graph 3: seasonal change of total nitrate concentration in the water samples of Galga stream

3.3.2 Effects of point source pollution

The change of water quality of Galga stream, especially in case of different forms of nitrogen and phosphorus, clearly displays the inflow of treated sewage water and settlement loads. Concentration measured during wintertime was higher then in the other seasons. Outliers were measured at Püspökhatvan after the inflow of treated sewage water of Acsa and at the sewage plant of Aszód. After these points there are high concentrations in the water of Galga stream, but we measure lesser value at Tura. At Jászfényszaru at the entry of Zagyva the value of phosphorus forms were high again but the concentration of nitrogen forms decreased significantly. Sewage plants along the stream affects the quality of water but the illegal sewage water inflows modified the condition of the stream even greater. Above the sewage plant of Püspökhatvan there is a rainwater trench which transports untreated liquid manure. During rainy season the cattle manure pent in that trench loaded directly into the Galga stream. These effects significantly modified the concentration of nutritive indicators measured at Püspökhatvan. Concentrations were significantly decreased after the inflow of treated water from sewage plants indicating the attenuating effect of influent streams to the Galga stream.

3.3.3 Effects of diffusive pollution

Significant amount of contamination enters into the Galga stream from the catchment area by sideward seepage. There are numerous groundwater wells on the catchment area of Galga. But according to the data of National Healthcare and Medical Officer Service (ÁNTSZ) and the Ministry of Environment and Water the groundwater under each and every settlement is highly polluted hence undrinkable. Evolvement of so called „sewage lakes" under the cities and villages are typical. This can be led back to the missing canalization and the pollution of many decades. Typical pollutants are nitrite, nitrate and other organic pollutants (VKS, 2002). The eutrophic effect is strengthened by agricultural cultivations and the usage of artificial fertilizers and pesticides on the areas along the Galga.

Ammonium, nitrate and nitrite load was indicated at Püspökhatvan but then it gradually decreased towards the estuary. At Galgamácsa significant pollution arrived through the Némedi stream from the settlement. Agricultural is significant in the catchment area and the canalization of the settlement is not complete. Load of phosphorus is similar to nitrogen forms but most of the phosphorus arrives from the sewage plant of Aszód into the basin of Galga stream. The load from non-point sources is totally 53-69 tons of phosphorus per year and 175-226 tons of nitrogen per year.

The ratio of households connected to channeling is not adequate. The degree of canalization is less than the national average. Water escaping from the sewage works indicates that removal of phosphorus must be insisted.

3.4 Determination of water bodies on Galga stream

I separated three different types of water bodies on Galga stream based on hydrological, hydro-morphological, physical, chemical and biological examinations:

- From the source to the entry of Becskei stream. Agricultural cultivation is not considerable on this area and there is no point source pollution or settlement.
- From the Becskei stream to the entry of treated water from the sewage treatment plant of Aszód. From Becske until the next settlement the riverbed is arranged and the stream runs in a coated bed. Despite of that on the long sections between settlements the condition of the bed allows the evolvement of a community which strengthens the „natural" characteristic of the stream, however it does not reach good condition.
- The water body from the entry of sewage works of Aszód to the estuary is in critical condition. This section is regarded as a separated water body because chemical risks can

occur by the effect of sewage water.

3.5 Results of biological examinations

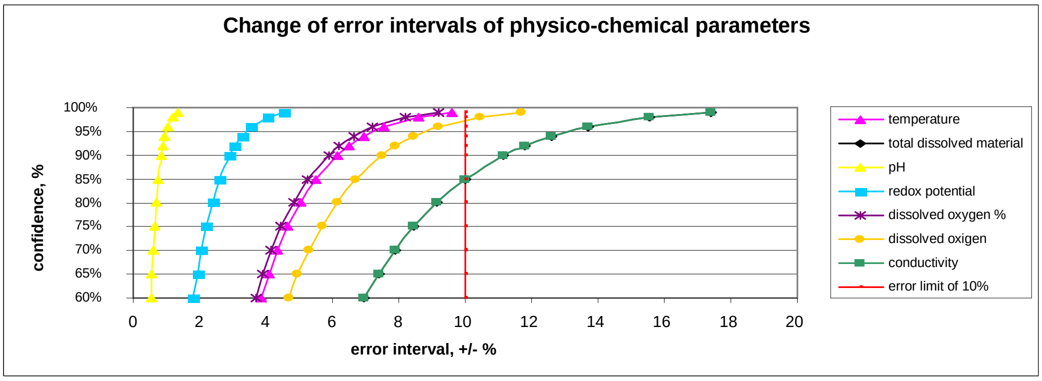
According to the WFD the categorization of water-bodies are based on the Environmental Quality Ratio. This is the ratio of observed biological variables on the given water body and the reference value relevant to that type of water body. The WFD requirement of the ecological rating is the appointment of type-specific reference places and determination of reference conditions. Based on these references the class borders of the five groups of organisms must be determined and a qualification system must be worked out (WFD, 2000). Having these are the fundaments of the WFD rating and the usage of EU standard methods (phytobenthos - MSZ EN 14407:2004, macrophyte - MSZ EN 14184:2004, macro invertebrate - MSZ EN ISO 8689-1:2000, fish - FAME, :2004).
The biological validation of preliminary categorization by biological community was done as the following:

- A professional estimation was applied to the case of the fluviatile phytoplankton and phytobenthos. The examination of lacustrine phytoplankton was according to the qualification system of Judit Padisák. (Szilágyi et al. 2004b).
- In case of the macrophyte the estimation of risk was not done but the WFD does not require it for every group of organism.
- In case of macroscopic invertebrate a WFD-compatible five-division system was made from the seven-division system based on the BMWP/ASPT strain-based qualification system by Csányi (Csányi 1998).
- The determination of risk related fish is done by the simplified system of FAME.

All the three sections of Galga stream are natural water bodies according to the preliminary categorization. The status of the upper section of the stream is excellent according to the algological study, while the middle section is in moderate ecological condition. The chemical risk is indicated by the saltatory changes in the quantity and composition of phytoplankton inside the water body (sewage water effect). For example multiple times *Euglenophyta* taxones (*Euglena* and *Phacus sp*.) appeared in great quantities in the Acsa section. Another example is the extremely high value of biomass and the change of dominance relations between Iklad and Domony in autumn 2004. The quantitative algological indicators correspond to good ecological condition however the species combination of algal associations (phytoplankton, phytobenthos) slightly differs from standards related to the 18th water type.

3.6 Estimation of variability in time and space

Based on the data of detailed simultaneous assessment of water quality I examined if it is possible to characterize the given water body by one point under the usual conditions (90% reliability with +/-10% margin of error: Graph 4).

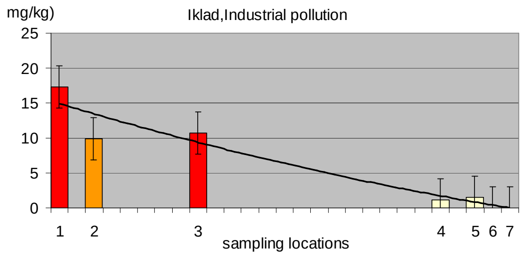


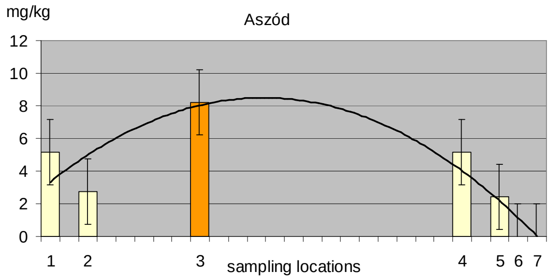
Graph 4: change of error intervals in case of one sampling point at the middle section of Galga stream

In case of the pH, the redox potential and the temperature the stream can be characterized by one sampling point, but more points are needed for the conductivity. In case of the other chemical parameters it is deducible that beside the nitrate-ion every other component must be sampled at more than one place. I determined the correlation between the decrease of error and the increase of number of samples in the case of those parameters which are not enough to be examined in a single place. It is enough to measure pH, redox potential, conductibility, nitrate ion at one place; the dissolved oxygen at two places, the total dissolved element, sodium ion and calcium ion concentration, alkalinity, the total hardness and chloride must be measured at three places; the measurement of potassium ion and the KOI_{ps} require five places; the total nitrogen requires six, the Mg-ion and organic nitrogen require seven; the Kjeldahl nitrogen and sulphate require eight; the nitrite ion requires ten, and the rest of the components must be measured at twelve places. Therefore there are components which are enough to be sampled once (pH, redox potential), but there are such components as well which requires measurement in 12 sampling sites (ammonium ion, phosphorus forms).

3.7 Displacement of heavy metal pollution in the sediment

In May 2000 there was a big Cd concentration (17.3 mg/kg) at the source (25+900fkm); I also measured the examined element at the end point (24+125 rkm) of the observed section in small concentration (2.43 mg/kg). In August 2000 (9.9 mg/kg) and August 2001 (10.7 mg/kg) Cd was present in significant amount straight after the influx of meteoric water trench from the former machine factory. In December 2003 there was a high concentration of cadmium (9.41 mg/kg) at 70 meters away from the source). In March 2004 I measured low concentration in every bend of the observed section and in May the quantity of the measured element was under the detection limit in the bed sediment. In June 2004 cadmium was present in traceable amount at only one place at the bend of the stream at 25+830 rkm. In March 2004 the extreme amount of rain displaced the pollution. Heavy metals moved along with rolling material thus they were hardly traceable in June (Graph 5. A and 5. B).

A 

B 

Graph 5 A and B: change of cadmium concentration at the source of pollution (A) and at the end (B), plotted against time

Legend:

1: May 2000, 2: August 2000, 3: August 2001, 4: December 2003, 5: March 2004, 6: May 2004, 7: June 2004.

Red column: concentration exceeds the limiting value given in Executive Decree 40/2008. (II. 26.)

After the rainy months the hydrological parameters of the bed have changed as well. Heavy falls produced high water level and faster water speed which increased the transport of the sediment and then the pollution was subsided at the bends where the shore-building activity was intense. These places behave like sediment traps and the heavy metal accumulated and it got transported away only after another increase in transporting ability of the stream. The accumulated polluted sediment was further transported by the heavy rains fallen on the basin. Without additional supplies the observed section of the stream got cleared of pollution. Several survey data on the concentration of heavy metals (Cd, Zn, Cr, Ni) confirm the displacement of contaminated sediment. The best way to track this is with the concentration profile of Cd and Zn which can be unequivocally linked to the point sources.

90% (20 results out of 22 measuring result) of the two anomalous groups of the cadmium values were measured under the inflow of the machine factory. 7 outliers were found at and under of the inflow of the machine factory in 2000. Measuring values derived from smaller groups were above the inflow, and in March, May and June of 2004 they were at the source. In December 2003 the measuring values of the examined elements were accumulated at two places away from the source.

The limiting value of Zink (Zn<80.9 mg/kg) is derived from three smaller groups. Elements derived from smaller groups were above the inflow and at later moments in March, May, June of 2004 they were at the source. 67% (16 samples out of 24 samples) of the two anomalous groups are located under the inflow of engine-works. 7 outliers were found at and under of the inflow of the machine factory in 2000 and they were found further away from the source of pollution in March and May 2004.

3.8 New scientific results

I. Categorization of water bodies is not unambiguous in every case; the confirmation of the water body's preliminary categorization requires the comparison of hydrological, hydromorphological, chemical and biological conditions. Based on the detailed survey at 19 locations of the catchment-area of Galga stream 9 regular sampling points were selected where examinations were done within the frame of surveillance monitoring for thirteen months. Condition of Galga stream was rated by hydrological, hydro morphological, chemical and biological examinations applying the aspects of EU Water Framework Directive (WFD). Also biological examinations indicated the hydrological changes which have been significant to the rating of condition; but these effects have not emerged unambiguously in the biota of the stream. Therefore the rating of the stream's condition was decided by the results of chemical examinations. I determined that the Galga stream can be separated into three water bodies and I proved this by hydro-morphological, chemical and biological methods.

II. I determined the confidence interval of sampling frequency in space and time for the water bodies of Galga stream which is required to the 5 degree water quality rating of water bodies. There are chemical components which requires only one sampling in space but other components have fluctuating concentration therefore they would require sampling at up to twelve locations. It can be a possible solution to the emerged problem that in the water bodies sampling should be done by the most variable component. Then the aliquot or discharge-weighted amount of samples is mixed to make an integrated sample and that is analyzed to all components. In this case sampling costs slightly increase but the analysis is more cost-efficient. I worked out a monitoring plan to the point source and diffuse pollutions of streams. The possibilities of risk and reach of good condition were determined. I elaborated a generalizable guide to the practical execution of WFD-compatible monitoring of "Galga-type" streams. The pursuit of being representative, reliable and cost-efficient meats with several obstacles hence a solution, which optimizes the information and the costs, is required to examine the minor water streams in regard of the specifics and characteristics different from large river.

III. I experimentally proved the deflation of identified point source pollution at the selected sector of catchment area of Galga stream, and I used geochemical statistical methods to follow the displacement of the heavy metal pollution of the deposit. With geochemical statistical methods I proved that the Cd and Zn elements of galvanic mud originated from industrial pollution put out it effect in the sediment for a long time, and the pollution connected to the sediment's fraction smaller than 63 μm is traceable at faraway trap-places. I proved the close relation between the meteorological, hydrological and element-analytical result. I defined that in given hydrological circumstances if the industrial activity is stopped and the pollution has no fresh supply then heavy metal pollution is displaced through six months and during the second part of this period – three months – the concentration of elements decreased under the detection limit.

4 CONCLUSIONS AND SUGGESTIONS

The categorization of Galga stream was not unequivocal. The hydro-morphological changes were significant on the stream and this was indicated by the biological examinations. Even so these effects were not unequivocally presented in the biota of the stream. The pollution load of the stream is mainly from diffuse load and the role of point sources is less. The biological effects of the loads were not unequivocally bad. The stream is in the edge of endangered condition and not-endangered condition. So the classification of the stream is “not endangered” but its condition is not good. At the same time there is possibility to reach good condition till 2015.

From evaluation of the chemical data lines it can be concluded that on the Galga stream more than one sampling point is required on the particularly examined water body. A possible solution could be to the emerged problem that in the water bodies sampling should be done by the most variable component. Then the aliquot or discharge-weighted amount of samples is mixed to make an integrated sample and that is analyzed to all components. In this case sampling costs slightly increase but the analysis is more cost-efficient.

Straight conclusions can be acquired from the relation of the hydrological and elemental analytical results. The outliers of statistical examinations and the intact condition of background sample proved that the Cd and Zn pollution came from the inflow of the engine-works in 2000. In later moments the values from smaller groups indicates that the Cd and Zn pollution ceased on the observed area by 2004. The variability of Cd, Zn proves that the cause for extreme value of cadmium was the pollution arrived to basin from outside source. The heavy metal pollution, which arrived from the inflow of the former machine factory, has been already displaced by the flow. In 2004 during the dredging of Galga stream the transported sediment was placed onto the embankment therefore it was not possible to carry out other examination on that section. To prevent further pollution from the inflow it would be advisable to perform a complete dredging.

The complex monitoring system based on the hydrological, morphological, physico-chemical and biological examination on the catchment area of Galga stream can proved a basis to the examination of other similar inland minor water streams.

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