Earth Sciences Doctoral School

PH.D. DISSERTATION THESES

The Appearance of the Impacts of Anthropogeneous Activities in the Water Quality of Dráva and Its Main Domestic Side-Currents

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I. INTRODUCTION

Water is an essential condition for life as well as a natural resource. Its value is getting higher day by day. The water supply goes through quality renewal during its natural cycle. Water pollution interferes into this cycle and generates changes in the quality of waters which prevent or cease the sustainability of natural vital processes. The increase of the punctual load of our superficial waters was rather quick from the 1950's to the late 1970's. Parallel to this, the number and danger of diffuse contamination sources have risen, relating to the anomalous solid and fluid waste management and allocation, the increased use of fertilizers and pesticides, in addition, the different substance storage and haulage. Due to load of communal, industrial, and agricultural water usage the conformation of our superficial waters' quality has manifested itself in the change of water quality parameters.

In Hungary, consequently, in the Dráva and in its main domestic side-currents the organized, regular water quality tests have taken place within the frames of the stock-network since the late 1960's. The general water-rating system has gone through more alterations during the previous decades. Afterwards, tests have been carried out on the basis of MSZ (Hungarian Standard) 12749 "Hungarian Standard – The Quality of Superficial Waters, Quality Typicalities and Ratings" since 1994. The system rated water on the basis of measurements of the fundamental chemical typicalities and some pollutants of water. There were only a few parameters that related to the biological and ecological condition of water.

As a result, there have been a huge amount of data accumulating in the previous decades with respect to the chemical parameters of currents. Only a few publications, apart from a few research reports and conference materials on the environmental condition of Dráva's (partial) catchment-area could be seen about the water quality development of the river and the factors influencing it – contrasted to other large domestic rivers.

With the intention to join the European Union, our country had tasks of approximation of law, then, with the actual joining, the introduction of the 2000/60/EC directive "about defining the frames of community activities in the field of water policy" became an obligatory task of ours. The directive came into operation on 22 December 2000 and it was known by the public as the Water Framework Directive (WFD 2000; in our country VKI).

The Water Framework Directive protects all waters with the aim that all European waters – besides providing sustainable water usage - should comply with "good condition" (good chemical condition and good ecological condition/potential) requirements by 2015.

One of WFD's significant difference compared to previous monitoring systems is that gaining information and stating the typical condition of surface water, even more, the numerical reliability of the condition, does not have to be done from a given sampling area, but from the entire body of superficial water. Its view is nature-focused, ecological conditions can predominate to a greater extent. It opens up space to integrated monitoring systems, to catchment-area regional agriculture, and also to involve the public. In the workflow of the way leading to achieving a "good" condition, the all-inclusive measurement of not only the punctual, but also the diffuse pollutants are indispensable together with the exact knowledge of their impacts made numerical. Due to the above mentioned facts, the practical implementation of WFD has made and makes Hungarian water economics experts face serious tasks to solve.

The dissertation could be diverse both from the point of view of causes and solutions on the basis of the information and title presented above in the field of water quality. The environmental-geography topic selection and the line of the work that was started within the doctoral program and whose theme is "The Territorial-Environmental Problems of Social-Economic Activity" are fundamentally dual. On the one hand, it can be considered a stop-gap work because of the chemical water quality data and the investigation of their causes collected from 1968 (the beginning of stock-area observations) to 2006 on the less researched and published Dráva and its main domestic side-currents (the sampled water-courses flowing into the river between the water-sampling points at Őrtilos and Drávaszabolcs). On the other hand, together with analyzing previous data and their processing and results, it is the basis of the appropriate forming and conversion of the water quality monitoring system based on the Water Framework Directive. Due to the interdisciplinary nature of the topic, though as a result of the extent of the dissertation, the objective disclosed first will be in the focus. There were implications regarding the second objective, since taking the extension of the topic into account, it might as well be another dissertation as a continuation of the present one.

II. SETTING OBJECTIVES

The basic objective of the present dissertation is the observation of water quality in the sampled side-currents of the river Dráva and in the South-Transdanubian region, retroactively from the beginning of the stock-network system to its end, from the point of view of the appearance of anthropogeneous activities. A further objective is partly to provide the basis for the water-management of the relevant catchment area–planning subordinate units by collecting and analyzing the polluting anthropogeneous activities, on the other hand, to contribute to the forming and conversion of the indeed new chemical monitoring system adequate to WFD by the environmental-geography based revision of the former investigation system, by processing and assessing the data and the experiences gained from them. To be able to deliver the above mentioned objectives the dissertation is made up as follows:

1. It demonstrates and briefly scopes out the water environment-protection, including the main points of the changes and developments in water quality and water assessment, furthermore, future's guiding based on the examples of the river dráva nd its main domestic side-currents. All this is linked together with the investigations, research and publications published in this topic connected to the water quality of the observed water-courses. Consequently it exceeds investigation historical revisions and it constitutes as the starting point of the dissertation.
2. It briefly overviews the environmental-geographical circumstances of Dráva and its (partial) water-catchment area, those relating to the observed water-courses and their water-catchments in the focus.
3. It collects and analyses the anthropogeneous factors and activities affecting the water quality of the observed water-courses. Within this, it studies the economic, social-political background of the environmental changes in the observed area. It elaborates on the situation and the changes in sewage handling, agriculture, mining and the treatment of waste in the observed time period regarding the whole observed area, furthermore, regarding the partial catchments and the water-catchment planning subordinate units based on WFD.
4. It collects, systematizes, then analyzes chemical water quality data of the stock-network from the point of view of the appearance of the impacts of anthropogeneous activities that have been convened over 40 years. First, it scopes out the tendency of data, then comes the pragmatic method related to the observation of the impacts of anthropogeneous activities. A detailed chemical and technical analysis and synthesis is not an objective (and it cannot be an objective) of this dissertation due to its environmental-geographical orientation and the quality of the data. Finally, it overlooks the problems experienced during the above mentioned analyses, it draws up remarks which it suggests take into account when working out future observation systems.

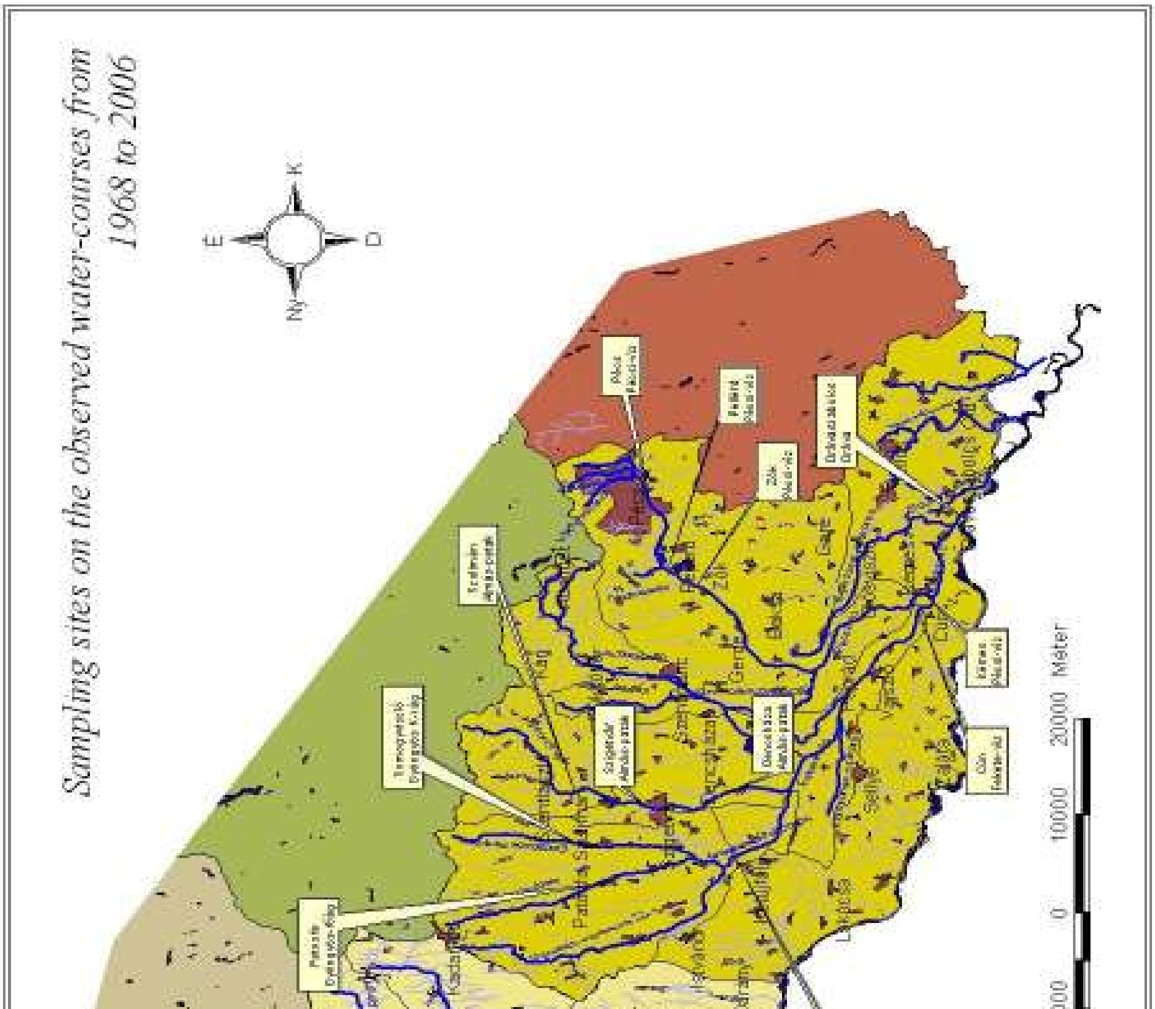
III. RESEARCH METHOD

Realizing the objectives of the dissertation, in compliance with the topic's interdisciplinary quality the research methods were also versatile, adapting to deliver partial objectives. I propound the applied methods by following the construction of the dissertation.

The ***research-historical summary*** of the dissertation required – due to the quality of the topic – the measurement-historical amplification, furthermore an *analyzing* amplification that *demonstrates* the guidelines of the present and the future. This part contains the *collection, summary and analysis* of the *special literature* and the *legal material*.

Demonstrating the ***environmental-geographical facilities*** of the observed area was carried out mainly by surveying special literature. *The impoundment of the observed area*: The initial factor was the location of the water quality stock-network sampling points (between 1968 and 2006) on the river Dráva. Therefore the domestic water-courses sampled with the aim of water quality observation flowing into the Dráva between the Őrtilos (VM code: 05ff16; dipper: 225,00 RKm) and Drávaszabolcs (VM code: 05FF18; vehicular bridge; 68,00 RKm) sampling points have got into those to be observed. Furthermore, the domestic (partial)water-catchment area belonging to the two above mentioned sampling sites of the Dráva will also be observed from the point of view of the impact of anthropogeneous activities. For the sake of the observations, this has been *deconvoluted in conformity with the partial water-catchments of the water-courses* ("direct" refers to those areas at each water-course on which the pollutants are located so as not to be able to observe their impacts directly because of the lack of sampling site on the relevant water-course.) Because of the future appropriation of the dissertation to planning tasks related to the Water Frame Directive, the use of the deconvolution based on the relevant (3-2 along Rinya and the 3-3 Fekete-water) water-catchment planning subordinate units seemed expedient. The impoundment of the observed area together with the sampling sites are demonstrated in ***map 1***.

For ***the observation of the anthropogeneous activities***, it was essential to collect and systematize the contamination sources, on the other hand, there was a need to analyze and evaluate them. All activities according to WFD can be considered a contamination source from which the certain environmental elements – at present the superficial waters are (factual contamination source) or can be (potential contamination source) subject to non-recurrent, continuous or periodic load (pollutant or energy).



1. map: *Sampling sites on the observed water-courses*

(Source: by using DDKÖVIZIG's and the DDKTVF's basic-layers edited by D*OLGOSNÉ* K*OVÁCS* *A.)*

Collecting contamination sources concerning the beginning of the observed time period (1968–2006) proved to be rather problematic. It was carried out mainly from research reports, damage-prevention schemes, surveys of condition, and manuscripts. The South-Transdanubian Environmental-Protection, Nature Conservation, and Water Conservancy (hereinafter referred to as DDKTVF) and the South-Transdanubian Environmental-Protection and Water Directory (hereinafter DDKÖVIZIG) provided me the *raw data to be written up* and to be necessary for the dissertation. (The data-suppliers are liable for the genuineness of the data communicated in the data sheets and in the documents marked in the guides) Detailing the *origin* of these:

1. table: *The origin of raw data in the chapters observing the anthropogeneous activities and their changes*

Sewage handling	"The main technical-economic data of the public service water supply and sewerage activities" – by OSAP 1376. data sheets, Settlement Sewage Informational System (TESZIR), the Ministry of Environmental Protection and Water Conservancy (formerly KTM, then KöM) annually published issues titled "The Quality of Our Waters"
Other sewage handling establishments	The database of the subsurface water and geological substance registry system (FAVI) (on the basis of writing up the data sheets "FAVI-ENG" submitted by the obligated)
Animal husbandry	DDVIZIG (1986A, 1986B) Defense Regulations, DDKTVF (2005) Interreg III. B. study, FAVI database
Leasehold and fertilization	The relevant statistical data of the Somogy County Statistical Almanac and the Baranya County Statistical Almanacs of the Central Statistics Office (KSH)
mining	The registry system used by the Mine Captaincy of Pécs
The situation of waste materials	The majority of them are from the database of landfills (LANDFILL), Concerning the carrion pits from the Compensation Informational System (KÁRINFO), some data from the South-Transdanubian Region's Territorial Waste Management Scheme
In ***"Others"*** chapter ***collector, container establishments*** are discussed	The database of subsurface water and geological substance registry system (FAVI) (on the basis of writing up the data sheets "FAVI–ENG" submitted by the obligated)

(ed. DOLGOSNÉ KOVÁCS A.)

Collecting, systematizing, and writing up the above mentioned source data proved to be a more serious task than I had thought at the beginning of my research. Namely, the database of the contamination sources did not exist in the first ¾ of the observed time period. Later on, in turn, a part of the data, for example LANDFILL, KÁRINFO, FAVI from the National Environment Protection Informational System (OKIR) were based on a single survey and data supply made between 2002 and 2004, so a part of them might as well have been obsolete occasionally at the end of the observed time period. This latter problem is negligible concerning the water quality aspect of the dissertation, namely the database contains the setout of the operation of the contamination sources – so the appearance of their impacts on water quality has become assessable – and by the end of the observed time period, if they had ceased, their "bequests" had remained due to their character, which mean potential contamination sources in the future as well. Correlated to the conditions between 2002–2004, formerly their polluting impact – surveying the economic, environmental protection situations – probably presented themselves more dynamically. *I made tables for the analysis and scoping out of my derivative data gained after writing up the raw data* (except for the data obtained from the almanacs of the Central Statistical Office). I prepared the *map*s using and further editing DDKÖVIZIG's basic coverages by applying ArcView GIS (3.2 version) The contamination sources got into the maps marked by factual (T) and potential (P).

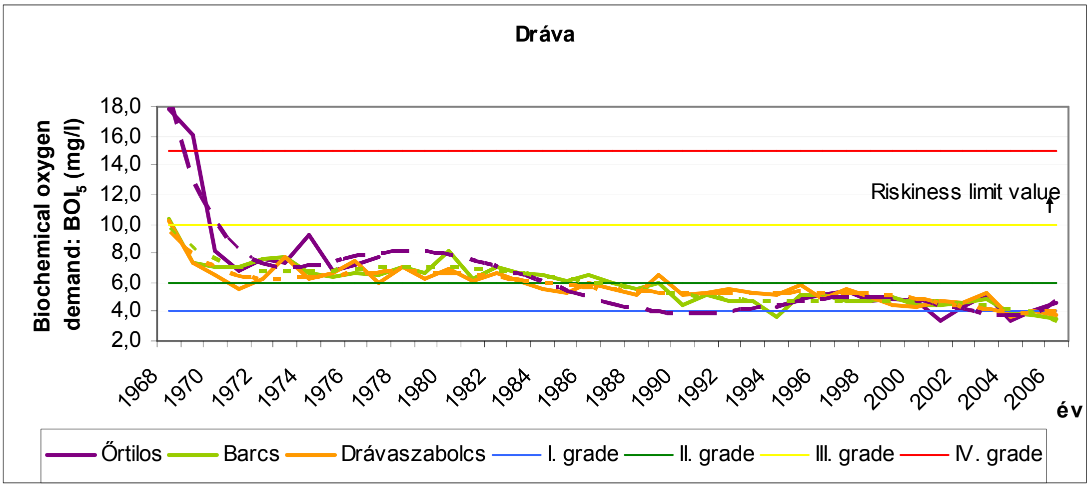
I got the ***water quality raw data of the observed water-courses*** through DDKTVF Authorities. They provided me the *use of VM 2000* (quality of superficial waters) *program* with which I started *writing up* the data treated as primary sources in the database. With this, I made an annually split statistical data sheet for each sampling site for the water quality parameters given by *MSZ (Hungarian Standard) 12749:1993* and measured by the authorities. Afterwards, it was this from which I gained the 90% durability data and average values to be used at the evaluation.

2. table: *Water qualityParameters observed in the dissertation*

Water quality caharcteristics		
Group A: Characteristics of oxygen balance		Solute oxygen; Oxygen saturation; biochemical oxygen demand (BOI_5); chemical oxygen demand (KOI_{ps}), (KOI_k); Total organic coal (TOC); index of saprobity (Pantle–Buck)
Group B: The characteristics of nitrogen and phosphorus balance		Ammonium-nitogen (NH_4–N); Nitrit–nitrogen (NO_2–N); Nitrate–nitrogen (NO_3–N); organic nitrogen; total phosphorus, orthophosphorus-phosphorus (PO_4–P); a-Chlorophyll
Group C: Microbiological characteristics		Colpihorm number by 1 ml; Faeces coliphorm number by 1 ml; Faeces streptococcus by 1 ml
Group D: micropollutants (and toxicity)	**Group D_1: Inorganic micropollutants**	Aluminium; Zinc; Mercury; Cadmium; Chrome; Nickel; Lead; Copper
	Group D_2: Organic micropollutants	phenols; Anionactive detergents; crude oil and its produce
	Group D_4: Radioactive substances	Total β-activity
Group E: Other characteristics		pH; Specific conduction (at 20°C); Iron; Manganese
		Total loose substance; Total solute substance; Natrium; Potassium; Calcium; Magnesium; Hydrogen-carbonate; Induration; Sulphate; Chloride

(ed.: DOLGOSNÉ KOVÁCS A.)

For the *evaluation of water quality changes* I prepared graphs from *the derivative data* in a split according to the parameters of the above mentioned standard, which – due to their extension – have been placed into the appendix, however, they account for an essential part of the dissertation. On the graphs there are the annual data on the one hand, and also the trendline of the change where there is possibility for it. Furthermore, the marginal values of MSZ 12749:1993 Hungarian Standard (marked by a line of appropriate colour), and the marginal values of riskiness (with arrow and text fittings) suggested by WFD also got onto the graphs. The following graph demonstrates the above mentioned information as an example.



1. graph: *Example for the demonstration of the changes in each water quality parameters (ed. DOLGOSNÉ KOVÁCS A.)*

In the case of crude oil and its produce, because of the applied analytical methods and measurement methodology change (from the summer of 2003), the measurement results cannot certainly give a characteristic picture of the related contamination of the observed water-courses. The measured values of the water-courses could have arisen a little higher than real because of analytical problems.

At ***evaluation***, at first I evaluated the chemical water quality and its changes in the observed water-courses on the basis of the alterations of parameters, then I observed the appearence of the impacts of anthropogeneous activities polluting the water-course factually and/or potentially, correlating with the research results obtained in the previous chapter. ***Finally***, I collected briefly the experiences, perceptions and suggestions gained during my research activity in connection with the future's "real" chemical water quality monitoring and research system.

IV. SUMMARY OF RESULTS

The structure of the dissertation is in compliance with what was stated in the setting of objectives. Writing up points 1 and 2 has become the basis of the further points, so the parts relevant to them logically got into the end of the summary of the results. Results obtained while writing up point 3 have been levelled in the chapter concretely dealing with the water quality of water-courses. These results will not be separately demonstrated here due to the extension limits of the thesis booklet. I would remark though that point 3, as a separate study may stand on its own, and serves as the base for a newer survey/actualization of contamination sources and their impacts in the preparation of water-catchment management scheme in relation to the Water Framework Directive (since the latest data written up by me were from 2005-2006).

1. Dombó-channel

● *Dombó-channel got into the water-courses to be sampled from 1988. Somogyudvarhely* was assigned as sampling site, that remained until the end of the observed time period. Because of the few number of samples initially, it was only after 1997 when there was opportunity to evaluate the 90% durability concentrations. On *Zsdála-spring there were measurements only between 1989 and 1994*, with only a few sample numbers, so for the anthropogeneous impacts it was possible to draw just minimal consequences concerning the appearance in the chemical condition of water-courses. All this is partly due to the fact that there was no communal and industrial activity along the spring as a result of the characteristics of the frontier. On the other hand, the sampling site was located right after the flowing-in of Dombó-Channel, so actually the chemical parameters of the water-course reflected mainly the condition of the channel.

● For the changes of the values of characteristic parameters related to the ***oxygen balance***, a factual polluting point-source at the partial catchment was the ***Csurgó Settlement Sewage Cleaning Plant*** and the ***Csurgó Cheese Factory***. Significant organic substance load occurred in the values in 1989. However, the impact of the Cheese Factory's sewage on the water-course (primarily on the Márjás-spring) presented itself only in the beginning of the observed time period since the factory closed down at the early 1990's. Before that, there was no sampling.

Further contamination sources were mainly smaller industrial sewage farms and dryings tied to Berzence and Csurgó – the amount of sewage emitted by them in order of magnitude was dwarfed by the above mentioned -, and the Csurgó sniffed sewage drainage and handling plant. Besides these, the ***Csurgó, Berzence and Somogyudvarhely animal husbandry plants*** had crucial effects on the formation of the oxygen balance – mainly until the early 1990's. Due to the changes in the technologies of animal husbandry the quantity of dilute fertilizer being dangerous for the water-courses has fallen, but ***the lack of fertilizer storage units having appropriate technical protection*** has remained a frequent problem – based on the condition of 2006, 78% of dilute fertilizer storage unit's capacity at the water catchment did not have any technical protection. Because of all these, the average concentrations of biochemical oxygen demand in the early 1990's were between II.-V. grades, then they fell under grade I. The average concentrations of chemical oxygen demands were mainly in the "bearable water" range until 1999, then there was some improvement in water quality, however, due to the inappropriate operation of Csurgó sewage farm – in the process of the reconstruction and expansion and under the effect of the introduction of not sufficiently pre-cleaned industrial sewage-water – the organic substance load of water went up significantly again and this could be traced in the formation of the oxygen balance parameters, too. From 2000 on, water grading has been of III-IV. grade.

● For the changes of the parameters of ***nutriment balance*** fertilizing also had an effect apart from the above mentioned establishments and activities due to the leasehold typical to the water-catchment, though ***the trend of parameter changes showed primarily the "programme"of operation in Csurgó sewage farm.*** Besides however, on the basis of the values demonstrating higher nutriment load in 1997 it is possible/probable that there was pollution in connection with the fertilizer storage units of ***Somogyudvarhely Hog Farm*** that did not possess any technical protection that time. From 2000 on, water grading has been of III.-IV. grade regarding the nutriment balance as a whole.

● The ***inorganic micropollutants***, that is for the development of metals' average concentrations the potential contamination source was a ***smaller galvanizer plant in Csurgó*** in the first part of the observed time-period. In the whole time period it was the high-risk water leakages of the ***Porrog and Berzence landfills*** that did not possess any insulation.

Apart from these, as there were ***more agricultural plants*** on the territory – ***machinist workshop, colour-spaying devision*** – it cannot be excluded that the load on their activites for the metal-polluting conformation of water-courses. The higher (higher than II. Grade limit) copper-concentrations might have arisen from **pesticide**s. However, the average concentrations of heavy metals within the observed time period remained well under the limit value of grade I. In the case of inorganic micropollutants the amount of aluminium was determinant every year, whose concentration was mainly between grade limits II and III.

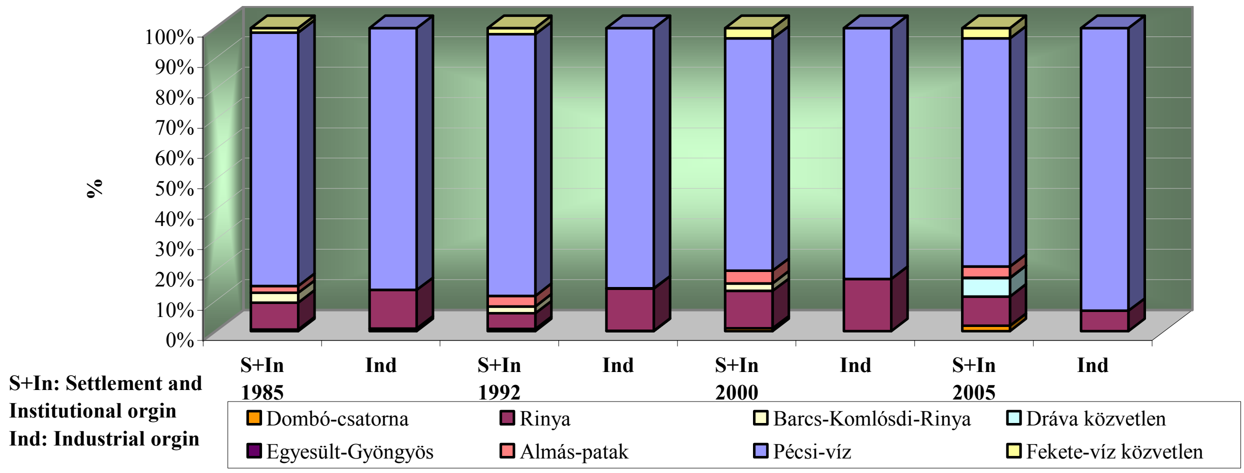
● In the case of **organic micropollutants** crude oil and its produces, sometimes the phenols were determinant. The average concentrations of **crude oil and its produces** were between the limit values of grade II and III but until the early 1990's, reaching "strongly polluted water" grading was not infrequent either. The origins of the pollutions might have been partly the averages occurred coincidentally/ due to carelessness of **agricultural utilization of machines**, **the rather high number of collector and storage establishments,** secondly the **flows during hydrocarbon research/mining** – rather in the beginning of the period -, from which (by means of the flushing substance) phenol could have derived possibly, thirdly the breakdown of machines during the **Gyékényes pebble stone mining** and the **problems occurring during shipment**. Though there is no data concerning this, the **diffuse load flowing down from the surface by fall** could also be influential to the concentration change of crude oil and its produces. The grading of water has been of grade III-IV from 2000 regarding the whole of micropollutants. On the basis of 2006 year data, all collecting, storage establishments at the partial water catchment were connected to crude oil derivatives.

● With respect of ***other characteristics*** mainly **manganese and iron concentration** were determinant. The **cause** of both can be ascribed to **insufficient drinking-water preparation** (getting rid of manganese and iron), furthermore they can be connected to the higher concentration of manganese, as it is of layer-water origin, and to the already mentioned layer water taken out earlier during **hydrocarbon research/mining, then dried out/flown away.** The average concentrations of manganese were mainly of grade III-V. From 2000, the grading of water has been of grade IV-V regarding the whole of other characteristics.

2. Rinya

● The *Rinya* got into the water-courses to be sampled from *1968* with *Babócsa and Nagyatád sampling sites,* however there were measurements at only *Babócsa* every year. On the basis of the sample numbers there was possibility to evaluate 90% durability concentrations at both sampling sites. Since however, at Nagyatád there was sampling occasionally only (local sampling site) it rendered the exhaustive observation of anthropogeneous impacts more difficult, as the factual contamination sources of the partial water catchments were exactly next to the phase being above the sampling sites. On the side-currents of Rinya (Taranyi, Szabási, Lábodi) there were no sampling sites so the impacts of the contamination sources loading them or their side-currents could only be alleged by considering data of emission or sewage penalties.

● Nagyatád communal sewage farm, Nagyatád Thread Factory and to the early 1990's Nagyatád Cannery meant a factual polluting point source for the changes of the values of parameters characteristic to the ***oxygen balance***. It is true that later the cannery was linked to public channel but its sewage disposal still had problems. Apart from these the point polluters of the side-currents from the early 1990's have been the Segesd Social Home, from the early 2000's the Böhönye and Somogyszob sewage farms and as an industrial polluter, the Lábod Meat Processing Plant. The sewage quantity emitted by the former plants was dwarfed by the bigger emitters, so their impacts could only be rendered probable. The settlement and industrial emissions besides Pécsi-water partial water-catchment at Rinya water-catchment, within that they dominated with Nagyatád. As for the settlement and institutional emissions the partial water-catchment appeared in 5–12%, as for the industrial emissions in 7–17%, as demonstrated in the graph below:



2. graph: *The sewage emission led into the superficial water-courses in a distribution between the water-catchments, in 1985, 1992, 2000 and 2005 on the observed areas of Dráva's (partial)catchment (Source:on the basis of DDKTVF data ed. DOLGOSNÉ KOVÁCS A.)*

Apart from the above mentioned, for the conformation of the oxygen balance, the **intensive large-scale animal husbandry** that was realized at numerous plants of **state farmlands and agricultural collective farms** meant significant influencing impact. It can be stated that the impact of these first appeared at Nagyatás sampling site. Due to the changes in the technologies of animal husbandry (except for Segesd where there is composite husbandry) the quantity of dilute fertilizer emission dangerous for the rivers has fallen, but the lack of fertilizer storage units having appropriate technical protection is still a big problem at the (partial) catchment area. All in all the **well-definable impacts** could be tied to the **Nagyatád settlement sewage farm, to the cannery and to the thread factory.** At the settlement sewage farm (from 1990 together with the sewage of the cannery) there has been only mechanical and biological partial cleaning. There were fines imposed on the establishment in the observation period almost without exception. As for the peaks, the year 1997 is to be highlighted, because then the load was due to the extraordinary pollution of Nagyatád Cannery. As a result of the above mentioned facts, the concentrations of the oxygen balance parameters were mainly over the limit values of grade II at Babócsa until the early 1990's, then they fell under that, so except for some peaks the grading of water was of grade II in each case. However, at Nagyatád, concentrations were in the scales of "polluted water" and "strongly polluted water" mainly all the time. From 2000, the grading of water has been of grade V at Nagyatád, at grade III-V at Babócsa concerning the oxygen balance as a whole.

● For the changes of the parameters of ***nutriment balance*** fertilizing also could also have some kind of an effect **apart from the above mentioned establishments and activities** due to the leasehold typical to the partial catchment. We could think of the **average** occurred due to the unaccomplishedness/carelessness of fertilizer storage at Babócsa for example in **1971**, when the

90% durability value was 69.00 mg/l. This was nearly double of the limit value of "strongly polluted" water, furthermore, as the reservoirs and fishponds on **Rinya's spring-branches** are mainly in a muddy condition, **they meant/can mean** "**nutriment bomb**" with inappropriate operation to the superficial water-courses' nutriment balance.

In connection with the parameters of nutriment balance the determinant at both sampling sites were the ammonium-nitrogen (mainly until 1994: at Nagyatád – grade V., at Babócsa – grade IV.; afterwards: at Nagyatád – III-V, at Babócsa – II-III.) and all phosphorus (at Nagyatád – grade V., at Babócsa – grade III-IV). From 2000 the grading of water has been grade V at Nagyatád, grade III-V at Babócsa concerning the nutriment balance as a whole.

● For the **microbiological characteristic**s there was coliphorm number determination at Babócsa only. Water was mainly graded as "bearable", however in 1996 and in 2005 it spepped into the "polluted" category. Due to the above mentioned facts, as main cause the pollution of thesettlement sewage of Nagyatád sewage farm (at the observed area of Somogy county partial catchment the ÁNTSZ (Public Health Service) does not prescribe obligatory sterilization, so there is no sterilization) and the pollution of animal fertilizer got into the water-courses from the animal husbandries in the higher phases can be given.

● For the ***inorganic micropollutants***, that is for the development of the metals' average concentrations – in the second part of the observed time priod – **potential** contamination sources were the **Segesd hot dip galvanizer plant** (**formerly machine industrial plant**, **Ferrokov**), and in the entire period the leakage waters of **high-risk landfills at Tarany, Görgeteg, Somogyszob and right next to Rinya at Háromfa, not having insulation, being near the water-courses.** Besides, deficiencies and activities discovered at several plants at the already mentioned Dombó-channel might have led to pollutions. At **Böhönye** and in **Segesd**, there was a **pesticide warehouse** operating. From heavy metals the average concentrations of mercury and copper were higher (in 1994 grade II) within grade I. This can be attached to pesticide pollution, furthermore chrome was to be highlighted in 2002 (grade IV.) when a non-recurrent pollution is alleged to happen. In other years and on the basis of the concentrations of the other heavy metals water was "excellent", so in the case of inorganic micropollutants, it was usually the quantity of aluminium that was determinant. Based on its concentration water was of grade II-III.

● In the case of ***organic micropollutants***, **crude oil and its produces**, sometimes the phenols were the **determinants**. The concentrations of crude oil and its produces at Nagyatád until 1998 were mainly between grades V, then grade IV. At Babócsa, the trend was equably falling, from grade V in 1989 to grade III by 2006.

Because of the mentioned **analytical problems** however, the factual pollution of the water-course might have been a little lower than the measured data. According to the values of phenols water can be rated mainly to grade III, but until 2000 it often stepped into grade IV. The reasons for the phenols and crude oil produces' getting into water-courses can actually be explained by the **basic-causes analyzed at Dombó-channel,** furthermore it was the **collecting and storage establishments** connected to several crude oil derivatives at all bigger settlements of the partial catchment. From 2000 the grading of water was IV-V at Nagyatád, III-IV at Babócsa concerning the micropollutants as a whole.

● With respect to the ***other characteristics*** the **determinant was mainly the manganese concentration, and the specific conduction as a second one.** The cause of the former one is equal with what was mentioned at Dombó-channel. The average concentrations of manganese at Babócsa were higher, water was mainly "polluted". At Nagyatád, in the 1980's it went up from grade I then it also got grade IV. **Specific conduction** refers to all salt contents, on the basis of this water was of grade II at Babócsa and grade IV at Nagyatád mainly. As the **cause** of the load, **the induction of used water from the thread factory and from spas to the superficial receptives can be determined. In addition, in Nagyatád**, **thermal water** is used **as communal hot water** which **appears in the local sewage farm as used water,** then from there, induced into the **receptives they raise its salt contents.** As a result of all these the relevant ion concentrations were also higher, furthermore it is **pH** that should be highlighted at Nagyatád – also **connected to the thread factory** – because water was grade V alkaline acidity not only in the 1970's but also at the end of the observed time periods occasionally.

3. Barcs-Komlósdi-Rinya

● Barcs-Komlósdi-Rinya got to the water courses for sampling in 1990, with the test hole under the sewage farm in Barcs. On the basis of the sample figures there was a possibility for the assessment of the concentrations with 90 % durability.

● The real contamination source of the shift of the parameters of the **oxygen balance** in Barcs-Komlósdi-Rinya was **the sewage farm of the settlement Barcs**, and on its anabranch **the smaller sewage farm of the settlement Somogytarnóc from 1992 on**. Apart from them **the stock farms of Viktorpuszta and Alsógyörgyös-puszta**, associated several times with the unique liquid manure contamination, had a significant influence. On the sewage farm of the settlement Barcs there were a mechanical and biological partial cleaning in the period tested, however, the cleaning of the sewage water proved to be mostly insufficient due to regular operating and capacity problems. Similarly, the sewage water went away from the farm of Somogytarnóc in an inadquately clear state, too. In the period tested it was a penalized building. **Public illegal sewege contamination might be detected as well, both in concentrated and diffuse form.** Consequently, salient oxygen demands (V. grade water) were identified in 1990 and 2000-01, however, as far as the other components were concerned the water was of III.-V. grade. **In 2003 a considerable improvement might be seen in the figures, however, this did not mean the increase of the cleaning efficiency of the farms, but indicated that the new sewage farm was completed in Barcs, and the cleaned sewege water was directed from there not to this water course but to the Zimona-brook.**

● Because of the the use of the ground concerning most part of the subwater basin **fertilizing also** had an impact on the change of the ***nutrient balance*** apart from the above mentioned establishments and activities. However, regarding the nutrient balance **the above-mentioned stock-farms meant the higher risk** in agriculture. In connection with the parameters of the nutrient balance the ammonium-nitrogen and the phosphorous forms were the class determinants. Consequently, the water was „highly polluted" till 1994 and between 2000 and 2002, in the other years it was mostly of IV. grade, occasionally of II.-III. grade. The phosporous concentration exceeeded the risky limit value set by the Water Frame Directive every year except for 2004 and 2005, the water was mostly „highly polluted", occasionally „polluted". The trend of the ortophosporus-phosporus showed a similer tendency.

● As far as the ***inorganic micropollutants*** are regarded it can be stated that the water had an „excellent" rating based on the yearly average of every dissolved metal except for aluminium; slightly higher rates inside the class were observed only in case of copper and mercury concentrations. As there were not any significant industrial activities connected to metal on this subwater basin (in the period tested), the **potential contamination source was identified with the pesticide storage of Csokonyavisonta.** The heavy metals' getting into the environment connected to the machine assembling and spatter-working activities of the **agricultural premises** with surface washing down/in of the precipitation, furthermore it might have happened in connection with **the return flows of the dump of Csokonyavisonta**, where a huge amount of wastage is placed inordinately and without covering.

● **The mineral oil and its products** were the class determinants among ***the organic micropollutants*** in the period tested. Among the peaks the one in 1992 is salient, when the rates with a 90% durability exceeded the limit value of the V. category (250 µg/l) five times, and in 2001, 2,5 times. Judging from the trend **the loading is likely to have been even more significant** on this water course. In other years the water rating was mostly „polluted”. The **reasons were the same as the ones already mentioned in case of the Rinya**.

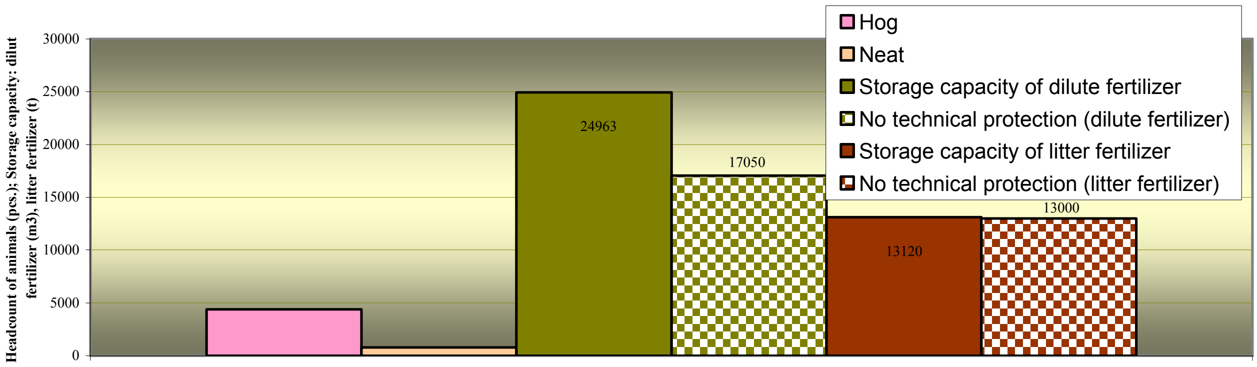
● As for ***the further characteristics*** the **class determinant was mostly the manganese** concentration, **and the specific conduction**. On the Barcs-Komlósdi-Rinya **the main reasons** for the trend of the further characteristics were **identical with the ones of the Rinya.**

4. The water system of the Fekete-water

a. Gyöngyös-parent branch, Gyöngyös Eastern branch, United-Gyöngyös, Almás-Brook, Fekete-water

● *On the water system of the Fekete-water the samplinsg began in 1969 on the United-Gyöngyös at Kétújfalu, on the Almás-brook at Szigetvár, on the Fekete-water at Cún.* On the other test holes samples were taken from the rivers at the earliest in 1988. The test holes with periods tested did not always fit the emerging problems on the given area, which made the examination of the contamination effect on the given water course notably difficult. Furthermore it was not always possible to evaluate the concentrations with 90% durability relying on the sample figures.

● The real contamination source of the shift of the parameters of the ***oxygen balance*** on the subwater basin was **the sewege farm of the settlement at the *Almás-brook*, the Packing House of Szigetvár** till 1970 (later it set up a poplar sewage farm at Patapoklos), and the **Shoe Factory of Szigetvár** (till its connection to a public canal. The waste water of the sewage farm usually partially, in some years totally, mechanically and biologically cleaned played the main role int he shift of the parameters of the oxygen balance on the test hole of Dencsház. Besides the packing house (the impact appeared even on the test hole of Szigetvár) polluted often – in 2003 it was even verified – the Almás-brook due to its malfunctioning. On the test hole of Szulimán the trend of the parameters might have been influenced by **the fertilizer getting into the water courses due to the operation of the stock farms of Szentlászló and Boldogasszonyfa** – as there were neither settlement nor industrial sewage sanitary and emitting establishment above it. Obviously this had an impact on the nutrient balance of this section. In the water samples of Dencsház – as there were not any significant contamination sources between the two lower test holes (next to the above-mentioned sewage farm of Szigetvár – its introduction was under the test hole of Szigetvár) the impacts of the contamination activities of Szigetvár appeared, however, the concentrations and consequently the qualifications (possibly) emerged more favourable due to the self-purification. **There were not any possibilities for direct comparison due to the different test periods.** On the upper branch of the river the water was of II.-III. grade ont he basis of the samples of Szulimán, on the branch under Szigetvár it was mostly „highly polluted” based on the samples of Szigetvár, following the 1990s maybe just „polluted", while on the lower branches the samples of Dencsház provided „satisfactory", occasionally „polluted" rating. **The analyses lead to the conclusion that the most serious direct loading affected the Szigetvár branch of the Almás-brook (and the one immediately under Szigetvár) among the water courses, these were the most obvious on the figures demonstarting the concentration shifts.** On the subwater basin of the ***United-Gyöngyös*** – as there were not any registered settlement and industrial pointsource polluting the water courses with waste water – **the trend of the water quality parameters can be attributed on the one hand to the sniffled sewage farms (Kadarkút, Nagydobsza), several waste water dehumidifiers and the unsolved waste water problems of the townships, consequently to the illegal sewage installation. On the other hand** in farming and stock-raising villages **surface deepenings in caused waste water/fertilizer loading,** and on the subwater basin there were sevaral **risky dumping-grounds** (56% of the the dumping grounds), through which not only organic but also any kinds of pollutant or toxic material could actually infiltrate into the rivers. The following figure aims to demonstrate the frequent unsolved problem of the technical protection of the fertilizer storage with the example of the subwater basin of the United-Gyöngyös.



3.figure: *Stock-raising and fertilizer storages on the subwater basin of the United-Gyöngyös (Sources:ed. by DOLGOSNÉ KOVÁCS A.on the basis of FAVI data 2006)*

The parameters of the oxygen balance in the section of Kétújfalu were moving mostly between the II.-III. grade. On the test hole of ***the Fekete-water*** the oxygen balance was affected by both the earlier (in 2000 a small portion was cleaned fully) only partially cleaned waste water of **the sewage farm of Sellye** through the Körcsönyei-canal and the organic substance load through Okor. Because of the high KOI_k value and ammonium-nitrogen concentrations of its waste water the sewage farm of Sellye meant a significant load to Fekete-water between 2002-2004. Among the numerous stock farms on the immediate subwater basin **the liquid manure pig farm of Baranyahídvég** was a potential contamination source. The parameters of the oxygen balance in the Cún section of the Fekete-water were moving between the limit values of the II.-III. grades.

● The shift of the parameters of ***the nutrient balance*** **was connected with the analyzed data in case of the oxygen balance**, and as significant agricultural activity was practised on the area, due to the ground use **the organic manuring/artificial manuring habits** influenced the nutrient balance as well. Concerning any incidental **damages** a **potential contamination source** connected to a big amount of **nitrogen-artifical fertilizer worked in Szigetvár** (officially from 1990 on – however, there had been a storage there earlier as well). **The effects of the agricultural activities manifested themselves mainly in the samples from the test holes of Szulimán and the Gyöngyös.** This can be seen for example on the phosphorous concentration of the water courses as well, the reason for which can be identified mainly as the agricultural diffuse contamination.

On the basis of the analyses the ammonium-nitrogen concentratios were the class determinants on the test holes of Dencsház and *Almás-brook* as far as the nutrient balance was concerned, consequently the water was mostly „polluted" and „highly polluted". On the *United-Gyöngyös* and its spring branches the water was mostly „polluted", on the point of Kétújfalu it was „satisfactory". **On the Cún test hole of the Fekete-water the load of the Almás brook emerged as more intensive, from the perspective of the nutrient balance water quality parameters its quality was worse than that of the United-Gyöngyös, and better than that of the Almás-brook.**

● ***Microbiological characteristics*** were measured exclusively at Cún. The reason for the peaks leading to the „highly polluted" rating is the great amount of fertilizer coming abrupt **from the stock farm near the Fekete-water in 1994-95, and from the farm between the Almás-brook and the Eastern branch of Gyöngyös** – for example due to the surface erosive activity of sudden, big amount of precipitation. Unfortunately **the introduction of illegal fertilizer/waste water cannot be excluded,** either. The reason for the high mcrobiological contamination can be additionally specified as **the lack/inadequacy of the disinfection** of the waste water emmissioned from the sewage farms.

● From the ***inorganic micropollutants***, on the basis of average concentrations of the heavy metals the water rating was mostly of I. grade, ocassionally of II. grade in the period tested. **The contaminations appeared mainly on the upper sections of the rivers, where there were not any registered metallurgical, surfacing activities.** However, quite **a lot of agricultural premises** operated on the area, on the majority of which there were **machine-shops** as well, where **spatter-work and surfacing** might as well been practised, furthermore the **scrap metals, batteries** were deposed **on the premises (in worse cases outside the premises), very often without protection**. So the toxic metals from the premises and settlements could appear in the surface water courses as well with percipitation through **surface downflow**, furthermore metals (and organic substances, nitrogen forms, inorganic salts) could get into natural waters from **the usage of pesticides (and the storage of them in Szigetvár)**, and **the return flows of dumping-grounds**. From the perspective of such contamination of the area potential sources were **the sites of Somogyviszló, Somogyapát, Somogyhárságy and Patapoklos on the water basin of the Eastern branch of Gyöngyös; the site of Vásárosbérc along the parent branch of Gyöngyös; the sites of Homokszentgyörgy and Nagydobsza on the subwater basin of the United-Gyöngyös.**

● In case of ***the organic micropollutants*** **the mineral oil and its products, sometimes the phenols were the class determinants**. The concentrations of the mineral oil and its products were in the category of „polluted" water, in case of the peaks in the category of the „highly polluted" water on almost all test holes till the end of the 1990s. In the following years it improved („satisfactory"), but on the test hole of Dencsháza the water rating continued to be mostly „polluted". The contaminations might have stemmed **on the one hand from the usage of agricultural machines, and the accidental and careless damages coming from the numerous collector, storage establishments. On the other hand, the diffuse load flowing down from the surface along with the precipitation** might have had an influence on the shift of the concentration of the crude oil and its products, however, there are not any concrete data supporting this. Apart from the above-mentioned the discussed analytic problems might have had a role in the trend of the concentrations, too.

● As for the ***further characteristics*** **the manganese concentration and the specific conduction were the class determinants. The reason for the former** one can be attributed to the already mentioned **inadequate water preparation** (to the appearance of the manganese in the used water). The average concentrations of the manganese were mostly of IV. grade, occasionally of III.-V. grade. **On the bases of the values of the specific conduction referring to the total salinity the Almás-brook was the most loaded** among the water course. The qualification of the majority of the water samples taken at Szigetvár between 1969 and 1980 was „polluted", what is more it became „highly polluted" in 1978-78. The samplings started at Dencsház from 1994 on resulted in a high total salinity of the water there, too (of IV., V. grade in 2000 and 2003). **The contamination from the packing plant** appeared unambigously in the samples from the Fekete-water, and it can be associated with **the introduction of the used water with high mineral salt content of the thermal bath of Szigetvár to the Almás-brook**. Furthermore, **in Szigetvár thermal water is used as communal warm water**, which appears as **used water on the sewage farm of the settlement**, then from there it **increases its salinity** introducing it to the **receptacle**. The ionconcentrations relevant for the total salinity had a trend in accordance with the above-mentioned on the area tested.

4.The water-system of the Fekete-water

b. The Pécsi-water

● The *Pécsi-water* was selected as a river for sampling *in 1968*; Kémes-Cún was designated as the test hole, which was not modified till the end of the period tested. Further test holes were determined on the upper sections of the river, at *Tüskésrét (Pécs) and Pellérd from 1988 on, then at Zók from 1996 on.* On the basis of the sample figures there was a possibility for the evaluation of the concentrations with 90 % durability.

● **There were quite a lot of real and potential contamination sources** resulting in the shift of the parameters of ***the oxygen balance*** **compared to the other analyzed subwater basins, due to the geographical location of Pécs and the river as compared to each other. The significant pointsources** on the upper section contaminating the river with organic substances were **the sewage farm of the settlement (especially the one of Pécs) and especially the Leather Factory of Pécs among the industrial pollutants** (as the majority of the factories was operating connected to public canals). As for the settlement and institutional pollutants Pécs can be associated with the Pécsi-water being responsible for 75-84% of the emitted amount, and as for the industrial emission it gave the majority of the emissions (83-93 %) on the subwater basin tested. **The effects could be unambigously observed not only in the section of Pellérd, but also in that of Kémes-Cún.** As the results from the test holes imply **the signs of the self-purification were not too frequent as getting closer to the lower section of the river**. The **reason** for this might be the **huge pollutant load** coming from the direction of Pécs, and **the operation of the stock farms on the lower sections (especially Bicsérd, Szabadszentkirály)**. Consequently the oxygen deprivation of the water was characteristic on the test hole of Kémes-Cún till the middle of the 1980s, and from the perspective of oxygen saturation it was later alson mostly of IV. grade. On the highest test hole (at Tüskésrét) the oxygen balance values were the most favourable during the test period, however, the sewage farms of Széchenyi and István pit operating with inadequate cleaning efficiency often caused a sudden decrease in the values of the parameters**. The sudden jump in the samples of Pellérd after 1996 did not arise unfortunately from the decrease of the load of the brook contamination but from the translocation of the sewage farm of Pécs. Consequently, its load manifested itself first under the test hole of Pellérd, at Zók.** So the parameters of the oxygen balance were moving in the „polluted", „highly polluted" water categories on the lower three test holes. Significant organic substance load contaminated the river in 2003, during the reconstruction of the aeration pools on the sewage farm of Pécs. This had an impact on the parameters of the nutrient balance, too. The signs of improvement could be observed in the last two years of the period tested. Concerning the total oxygen balance the water rating was nevertheless of III.-V. grade at Kémes-Cún from 2000 on.

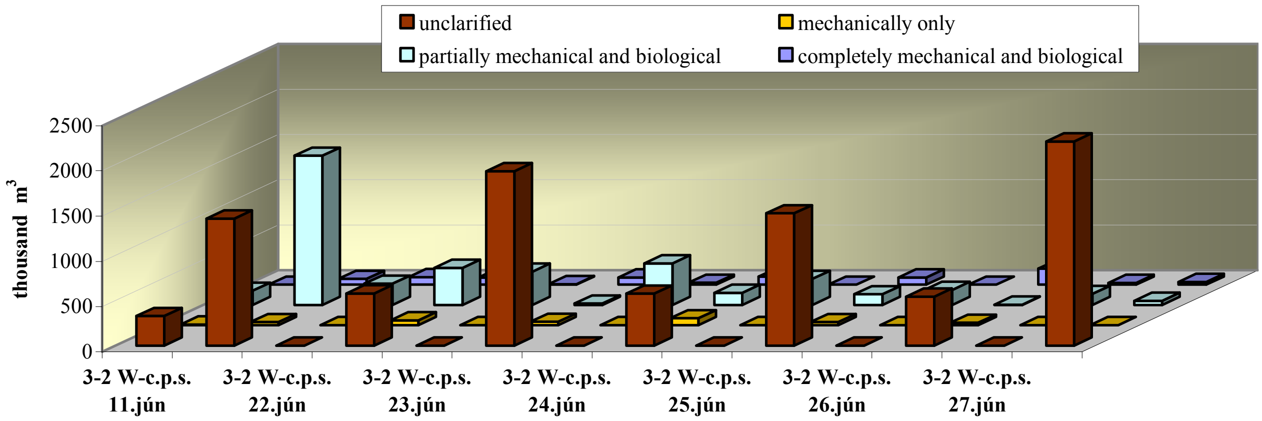
- As the data also supports, **the contamination sources already mentioned in connection with the oxygen balance had an obvious impact on the trend** of the parameters of the ***nutritient balance***. In the leather factory the load data concerning the ammonium-nitrogen decreased significantly from 1992, it had nevertheless considerable effect ont he recipient river. On the sewage farm of Pécs (already on the new farm) the more efficient cleaning of the water and the removal of the nutritive was more and more sought – however, their beneficial effect on the trend of the parameters did not manifest itself till the end of the period tested. By virtue of their dimensions the above-mentioned loads all appeared at **Kémes-Cún**, on **the lowest test hole of the water course**; and as mostly agricultural activity was/ is practised along the banks before the test hole – stock farms, ploughlands, artificial fertilizer washing-in – the brook does not have enough time for self-purification, so **the signs of the eutrophication emerged mostly as well**. Consequently **the ammonium-nitrogen and the phosporous forms were the class determinants on the lower three test holes**. Their values were moving in the „highly polluted", sometimes in the „polluted" categories except for the last two years. On the test hole of Tüskésrét the concentration values were mostly of one class lower. Here, in the vicinity of the power plant **the settlement parts without canals could have had diffuse contamination effect**, with the precipitation flowing down from the area, which had an influence on the parameters of the oxygen and nutrient balance as well.
- The ***microbiological parameters*** (Coliformnumber, Faeces Coliformnumber) were analyzed from 1994 on and only at the test hole of Kémes-Cún. The significant – mostly of IV.-V. grade – pollution of microbiological characteristics might stem **from the washing- in/out of the crude waste water from the sewage farm of Pécs, and from the washing-in of the great amount of flitter and liquid fertilizer with the perticipation from the agricultural and stock farms near the river.** On the Baranya county part of the area tested the ÁNTSZ (National Public Health and Medical Office Service) imposes the **disinfection obligation** upon the settlement sewage farms, but **the water chemical results very often indicated its violation.**
- As for the ***inorganic micropollutants*** the contamination sources were various **industrial establishments** on the **upper section** of the Pécsi-water, and **machine repair shops and spatter-work units** along the **lower section**, as mostly agricultural and stock-raising activities were practised there. **The Leather Factory of Pécs determining significantly the chromecontent of the water can be regarded as substantial pointsource** among the industrial establishments. Just to mention an example for the chrome pollution, in 1996 on the test hole of Pellérd the value with

90 % durability was approximately seven times as much as the limit value of the IV. category. Both the further establishments, the **two bigger plating factories,** industrial areas, presses, small- and mediumsized enterprises specialized in paints, metal trading, metal wastage, collection and storage of toxic waste and the diffuse sources – to be washed down/in with precipitation - from their premises contributed to the pollution of the Pécsi-water with metals. **The shutdown of the two surfacing factories resulted int he decrease of the metal pollutions attributed mainly to them.**

● Concerning the ***organic micropollutants*** in the whole period tested **the mineral oil and its products were the classdeterminants on each test hole** on the basis of the measurement data. Till the end of 1997 all sections were „highly polluted", of V. grade. The highest values were measured at Pellérd (for example in 1984 9050 μg/l, more than the thirty-sextuple of the limit value of the IV. category), and as long as no measures took place there, they appeared at Kémes-Cún. As a whole there were significant falls in the measured concentration values from 2004-05 on; till then on the test holes the rating was mostly of V. grade, at Kémes-Cún and Tüskésrét occasionally of IV. grade, then of III.-IV grade. **The reasons for the contaminations were the numerous collector, storing establishments on this subwater basin and the accidental or careless extraordinary pollutions connected to them.** For example ÁFOR (its successors) was a penalized company because of the oil pollutions between 1990 and 1999. The obvious load of these premises manifested itelf in the data on the test hole of Pellérd. Furthermore the industry, the transport and further public activities use various oil derivatives, so these could gravitate into the surface waters from the city **due to the surface washing-in caused by rains, and the inadequate percipitation outlet of the city.** Apart from these the mentioned **analytic problems** and **the measurement methodology shift** might as well have played a role in the trend of the concentration values.

● From the ***radioactive pollutants*** all the β-activities were analysed at Kémes-Cún from 1994 on. The water rating was mostly „polluted". The presence of the radiactive substences can be attributed to the **uranium mining and dressing** controlled by the former Mecsek Oremining company, **and its legacy**.

● From the ***further characteristics*** the **specific conduction indicating the total salinity** was the class determinant of Pécsi-water on all test holes. Compared to the beginning of the period tested the specific conducton decreased approximately to its two-third by the beginning of the 1990s at Kémes-Cún, so the rating fell from V. grade to IV. grade. On the other test holes much higher rates were registered. Before 1990 the high total salinity on the test hole of Kémes-Cún, then of Pellérd was attributed primarily to **the emissions of the Leather Factory of Pécs and those of surfacing factories.** Besides due the **uranium mining** water leaking under from the slurry-storages appeared, which has a high salinity, and after the shutdown of mines it gets to the Pécsi-water through the **one-pointed outlet of Mecsekérc** – it should be desalted in the factory, which is not in progress yet. The reasons for the high specific conduction on the spots of Tüskésrét can be connected to the already discussed **mine water raisings** and the emerging return flows. Besides the **return flows of the liguid slurry cassettes of the thermal station** loaded the brook occasionally with high salt concentration water at the beginning of the period tested. In the last 15 years of the period tested, as also illustrated in the figure below, on the tested area of the subwater basin the industrial water introduced without cleaning can be connected to the subunit of the water basin plan subunit of the Fekete-water, and on the basis of the sources it can be attributed unambigously to the discussed mining activities.



4. figure: *The amount of the waste water introduced into surface waters from the perspective of treatment on the tested area of the water basin plan subunit of the Rinya (3-2) and the Fekete-water(3-3) in 1989, 2000-2005 (Source:ed by DOLGOSNÉ KOVÁCS A on the basis of DDKTVF data)*

5. Dráva

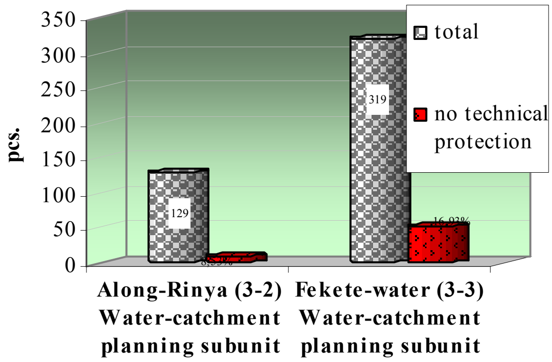
● *On the Dráva the stock network samplings started in 1968*, in the sections of *Őrtilos, Barcs and Drávaszabolcs.* But at the beginning of the 1980s the sampling was terminated at Őrtilos. According to experts one of the reasons for that can be attributed to the fact that the results of the samples taken from the then test holes (from the bank) indicated rather the water quality of the Mura and not that of Dráva, on the other hand in the 1980s the number of the test holes was decresed due to „cost saving”. After the construction of the Őrtilos-Botovo bridge (test hole) – from 1994 on – there was a possibility for the representative sampling. *This made the investigation of the change of the water quality on the Drava more difficult, mainly in case of the trend of the water quality values of Barcs.*

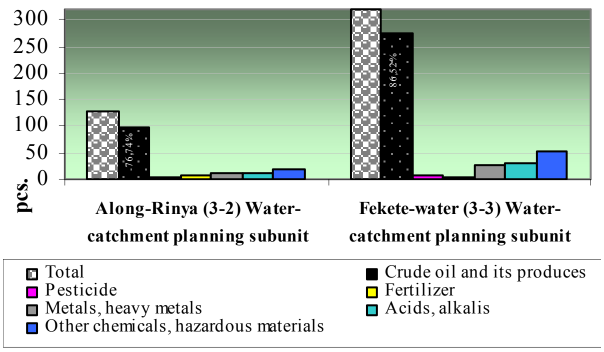
● As for the parameters of the ***oxygen balance*** the values of the dissolved oxygen and the oxygen saturation proved to be favouarble as a whole on all of the three test holes, the water had an „excellent” rating from the 1990s on on the basis of the values with 90 % durability. These values were not significantly influenced by the **inflowing side-currents of the Drava**, due to the their various origins, and the differences in their hydromorphology and their discharge. The concentrations indicating the amount of the organic substances in the water were the highest in the 1970s, generally at **Őrtilos**, which indicated loads stemming from **areas not tested**. This did not change considerably until the middle of the 1980s, and on all three test holes the water rating was just „satisfactory" on the basis of the oxygen demands. Then an improvement was observed, and from the 1990s on the values of *Drávaszabolcs* showed a higher organic substance load – due to the **loads stemming from the water-basin plan sub-unit of the Fekete-water.** Considering the whole period tested the lowest values emerged generally on the test hole of Barcs. Except for the beginning of the period tested there was no immediate introduction of uncleaned sewage from the area tested, and the amount of cleaned waste water was also minimal – what is more in the last years there was no more. **The inflowing inland side-currents had** – as implied above – **mostly a high organic substance content, the effect of which emerged in some cases and in a minimal degree also in the samples taken from the section of Barcs and often those of Drávaszabolcs.** The trend of these parameters on the test hole of Bracs was influenced by the pollutant load coming from the direction of Őrtilos and – as for the side-currents – through the Barcs-Komlósdi-Rinya. From 2000 on, concerning the total oxygen balanvce the water was of III. grade on the test holes.

● Concerning the ammonium-nitrogen values the parameters of the ***nitrogen balance*** were unfavourable at Őrtilos in the 1970s, the water was of III.-IV. grade, then it was followed by an improvement. **The trend of the shift was already mentioned in case of the oxygen balance.** It was noticeable that the higher pollutant load of the water in the Drávaszabolcs section increased from the 1990s on, mainly due to the Pécsi-water. **As a whole the indicators of the nitrogen balance on the Drava had a rating higher with several categories than that of the inflowing water courses.** As for the phosphate balance the most unfavourable values emerged on the test hole of Drávaszabolcs and at Őrtilos at the beginning of the period tested. The former can be attributed to the **pollutants transported by the Fekete-water system**, the latter can be connected to the pollutants coming **from outside of the area tested**. On the basis of the ortophosphate-phosphate concentrations the water rating was mostly „good" on the test holes from the mid-1990s. **Besides the loads of the side-currents, as potential contamination sources the stock-farms of the immediate area of the Drava contributed to the trend of the nutrient balance due to the unsolved fertlizer storage.** The higher values of Drávaszabolcs (as opposed to Barcs) were supported – in case of all relevant water quality caharacteristics - by the results of the the assessment of the fertilizer storages. Based on the data of 2006 the storage capacity of the liquid manure was only 67 % on the 2-3 subunits without technical protection, as opposed to the 83 % on the 3-3 subunits. In case of the litter manure this proportion was approximately the same, 73% and 77%. As a whole it can be established that from the point of view of the storage of both types of fertilizer the Fekete-water subunit is more endangered, independently from the fact that the number of the animals was here slightly fewer than that on the Rinya-subunit. As for the total nutrient balance, from 2000 on the water was of II.-III. grade on the test holes.

- The parameters indicating the ***microbiological*** pollution were the most favourable in the section of Őrtilos and the most unfavourable in the section of Drávaszabolcs. Te reasons for the microbiological pollution are basically the **inadequacies of the disinfection of the settlement's sewage farm**. **The reason for the Drávaszabolcs „peaks"** might be **a big amount of fresh faeces contamination**, which got to the water course with the **Pécsi-water** (and beforehand in the Fekete-water). From 2000 on the basis of the biological parameters the water rating was of III.-V., II.-III. grade on the test holes.
- On the basis of the ***inorganic micropollutants*** of 90 % durability the water was mostly „excellent", in case of aluminium its rating was „good". As for the test holes the data of Barcs were generally the most favourable, as – although within the same category – higher values were measured because of the pollution coming **from outside of the area tested** at Őrtilos, and from the **water basin plan subunit of the Fekete-water** at Drávaszabolcs.
- Of the ***micropollutants*** **the mineral oil and its products were the class determinants during the whole period tested – on the bases of the results of the measurement**. Till 1996 the water was „highly polluted" on the test holes except for some years. The figures of Őrtilos mostly indicated a big amount of contamination coming **from outside the area tested**. Those of Barcs can be attributed to the hydrocarbon exploitation ont he already mentioned areas, the water pollution during **the drawings of the bed material (int he region of Heresznye and Barcs) specifically in the Drava,** and the not really high-volume, but from the 1970s again active **shipping on the Drava**. On the test hole of Drávaszabolcs, besides **the loads coming from upper regions the mineral oil products transported by the Fekete-water system** contribute to the trend of the data, too. The already discussed **analytic problems and the measurement method shift** also played a role in the trend of the concentration values.

The following figures provide information about the collector, storage establishments of the area tested. Compared to the subunit along the Rinya ont he plan subunit of the Fekete-water there are altogether 2.5 times as many collector, storage establishments. The same proportion is valid on the basis of the quality of the stored substances, too; except for the fact that artificiel fertilizers might be more dangerous ont he subunit of Rinya, while pesticides might mean a bigger danger ont he subunit of the Fekete-water. As for the objects without technical protection there are double as many of them on the 3-3 subunit.





5. figure: *Collector, storage establishments on the tested areas of the water basin plan subunits of the Rinya (3-2) and the Fekete-water (3-3) based on the 2006 condition*

6. figure: *Collector, storage establishments on the tested areas of the water basin plan subunits of the Rinya (3-2) and the Fekete-water (3-3) according to the categorization connected to the quality of the collected and stored substances based on the 2006 condition*

As a whole, also from the perspective of micropollutants the 3-3 plan subunit is more endangered, and the Drávaszabolcs test hole of the Drava is contaminated.

- The *further caharcteristics* indicate a favourable water quality on the test holes. It can be established that the **loads of the side-currents tested did not have a significant impact** on them. **However, it is important to note that the pollutants getting from the water basin plan subunit to the Drava increased the concentrations of Drávaszabolcs sligthly above the ones of Barcs almost in case of all parameters. Compared to the Danube and the Tisza, the Drava has the lowest rate of dissolved substance concentration,** maybe it is the cleanest river of Hungary.

Reflections, suggestions

- **The samplings for water quality parameters and the place, time and frequency of the hydrographical observations in the period tested were in most cases different.** But as the behaviour, the spread of the pollutants in water is effected by the delivery and further physical factors, ***the integration of the quality and quantity monitoring*** on each test hole is henceforth indispensable to the water quality modelling of the water courses, more detailed water quality research and all emergency repairs plans needed to all water courses and water bodies.

● In the period tested ***the allocation of the test holes*** –between 1980 and 1994 – mostly aimed to protect the water quality of **the main recipient, in this case that of the Drava. The majority of the test holes on its side-currents were not far from the confluence into the Drava, so the pollutant load of the side-current was significant only in connection with the Drava. (However, because of the discharge differences suggested above the load of the side-currents tested did not cause any considerable changes in the chemical water quality of the Drava – in the water samples taken from the test holes). So these served with data only implying the pollutant load of the upper sections of the side-current itself.** According to the investigation of the Fekete-water and the Pécsi-water – there were not any stock system test holes on Fekete-water after the inflow of the latter one (into the former one) – the Pécsi-water transported mostly a lot bigger load of pollutants even on the basis of the water samples taken from the lowest test hole (Kémes-Cún) than the Fekete-water. As follows **the test holes placed under the contamination sources could be found only in few cases.** It emerged as a **further problem** of the investigation that **samplings did not take place when the real pollutants continuously polluted it, so when it started only allusions could be made to earlier bigger pollutions due to factory reconstruction then termination.** Furthermore the **Water Frame Directive does not think in terms of water courses and their side-currents but in terms of integrated husbandry of water resources**, and **waterbasin plan subunits**, and **water bodies** on lower levels. Consequently **the smaller water courses have the same priority as the bigger ones as for the target of water protection** and **the „good" condition**. As a further step, **in the monitoring system the test holes should be designated by also being adjusted to the boundaries of the water body.** In case of water body points to be designated **the place of all real and potential contamination sources and their potential shift in time should be taken into consideration**.

● The above mentioned shed light on a further task: the ***exact exploration*** of the ***real and potential,*** or according to a different categorization that of the point and diffuse sources on the (sub-)water basin. Unfortunately, earlier there were not any databases of the contamination sources polluting surface waters (despite the fact the more significant ones are controlled by authorities, earlier it was also complicated to accomplish that; sewage samplings started in 1980), nowadays the inspectorships make summaries about the point sources and their emissions. However, **the complex task of the exact exploration of the diffuse sources and the conversion of their load on the surface waters to numerical data have been**

completed concerning only some sample areas, due to the capacity problems of the authorities. In present disseratation I have collected the contamination sources on the (sub-)water basin and their emissions within the range of possibility. They were mainly point sources, so the impact of any further contamination sources on the water quality of the water course tested might be only implied – although they had an obvious impact.

● In the period tested, ***the scope of the water quality parameters*** **on the water courses were approximately the same, but there was a considerable difference int he frequency of sampling. Because of the low number of samples values of 90% durability could not often be found and assessed**; and as the frequency of samplings even on the same water course were often different, **the real pollutant load of the water course and its behaviour between the test holes (for example self-purification) could be implied just cautiously.** Furthermore – though the instructions of the **Water Frame Directive monitoring** are strict, so first following the exploratory monitorings – **a system adjusted to the use of area and its changes, where the scope of the test parameters would be in accordance with the quality of the load of the contamination sources.** So it is underlined that the range of the test holes and the sampling parameters considering the above-mentioned should be **flexible avoiding mechanical periodacility**. The review of the chemistry-related monitoring systems could be completed by a **more extensive hydrobiological monitoring**, which raises the question of **social inclusion** (involving academic researchers) emphasized also by the Water Frame Directive, too.

● The ***automatic monitor stations*** would be suitable for tracing the chemical condition of the water bodies. Their installation and the professional proccessing of the data would not only contribute to the observation of damages and alarm, but also to the more detailed research on water quality. However, in Hungary this is just a utopia.

● The ***practical application of the above-mentioned requires numerous further research***, which raises the question of financial feasibility and ***cost effectiveness***, too.

V. APPLICATION OF THE RESULTS

Becuase of interdisciplinery character of the physical geographical topic, the dissertation got to the attainment of the goal through the elaboration of several subtasks. Consequently, on the one hand there are numerous possibilities for the application of the results, on the other hand the further direction of the research might be manifold.

The potential applications:

- Collection, systematization, analysis of the accumulated data on the Drava and the investigated side-currents from the beginning of the water quality stock system to its end; in connection with their evaluation the occasionally 40-year old data are not „wasted effort" because of the start of the Water Frame Directive monitoring, on the other hand the elaboration of a – so far just partially, inadequately – published physical geographical topic is at the same time suppletory for present and future
- As a subunit, the chemical water quality analysis from the perspective of the impacts of the anthropogeneous activities, might contribute to the framing of the environmental targets of the water-basin economy plan of the Water Frame Directive as for the area tested
- With the extensive collection (considering the present possibilities in terms of data, instrument) and analysis of the anthropogeneous contamination sources relevant with the water courses tested, it might serve as a basis of their future revision, the more special survey of their effects and the selection of the appropriate actions
- The experience, observations gained during the research contribute to the elaboration of a new, more representative chemical monitoring system compared to the stock-network water quality system

Further directions of the research:

- Effect of the load of the real and potential contamination sources ont he change of the water quality through modelling (first an up-to-date database should be established)
- Investigation and analysis of the concentrations appearing on the priority list of the Water Frame Directive and that of „further pollutants" on the (sub-)water basin

- Water body-specific determination of the range of the chemical water quality parameters depending on the contamination source loads, so as to operate a more economical and as for the goal of the research, also a more efficient monitoring system
- Natural geographical and cost-effective relevances of the location possibilities of further automatic monitoring stations on the area of the (sub-)water basin of the Drava.

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