Report on the

ICPDR – UNDP/GEF workshop

Nutrients as a Transboundary Pressure in the DRB

26-27 January 2004, Sofia

Prepared by
Helmut Kroiss, Christoph Lampert and Matthias Zessner
Institute for Water Quality and Waste Management,
Vienna University of Technology

February 2004

1. Introduction

The following chapters report on the ICPDR – UNDP/GEF workshop "Nutrients as a Transboundary Pressure in the Danube River Basin". The report is structured in a way that chapters 2 to 6 follow the sequence of the workshop und summarise presentations and workshop discussions. Chapter 7 is a summary of the most important conclusions of the workshop from standpoint of the authors of this report. In the Annex the agenda of the workshop, abstracts of presentations, slides of the presentations, participants list and other workshop material is collected.

2. Welcome and Introduction to the Workshop

Zavadsky, Project Manager, UNDP/GEF Danube Regional Project points out the future role of GEF in the Danube Basin, which is to strengthen the Implementation Capacities for Nutrient Reduction and Transboundary Cooperation in the Danube River Basin.

Weller Executive Secretary, ICPDR, outlines the scope of the workshop. The scope is twofold: to give the participants an overview on the scientific work that is going on the Danube Basin and second to illustrate the legislative framework and challenges for WFD roof report.

The scientific goal of the workshop is a Common understanding of the system Danube Basin - Western Black Sea. This includes

- the interrelationships between emissions of nutrients and measured instream concentrations
- the role of nutrients as a pressure on water quality
- the transport of nutrients in the river system
- the impact of nutrient discharges of the Danube on the Western Black Sea ecosystem
- to identify challenges for nutrient management in the DRB
- to understand the impact of environmental and socio-economic factors

Therefore the goal was not to provide solutions or to give recommendation for future actions. It should be pointed out, what has been achieved so far and what are the challenges for the future.

The non-scientific goal is to define the content of WFD Roof Report 2004/2005 related to nutrient pressure.

Political implications should be avoided in the course of the workshop. No recommendations on measurements related to individual countries should be drawn.

3. Session I: Scientific background; presentation of results from the daNUbs project

Zessner from the Institute for Water Quality and Waste Management, Vienna University of Technology, was the next speaker. He introduced the daNUbs project ("Nutrient management in the Danube Basin and its impact on the Black Sea", EVK1-CT-20000-00051), starting with the background and the concept of the project. He mentions the basic steps of the project (i) the improvement of the process understanding, (ii) the development of mathematical models (MONERIS, DWQM, DDM, Shelf models) and (iii) the strategic planning step. In the current stage of the project most of the preparatory work has been done in the meantime. Now the synthesis of the work package results has to be made and different scenario calculations will be carried out. Finally he presented some results obtained in the case study investigations. He stresses the fact that regional natural conditions (climate, geology) heavily modify the nutrient emissions to the river system.

Behrendt, Institute of Freshwater Ecology and Inland Fisheries, Berlin, presented results on nutrient inputs in the Danube Basin in the past and in the present. He highlighted the various sources including the natural background concentrations resp. loads. The present load in the Danube is for both nutrients below the values of the early seventies and reduced by about 20 to 30 % (N) and 40 to 50 % (P), respectively, compared to the maximum values. The causes for the changes of the nutrient loads are change of waste water treatment for N and P, changes of N-surplus in agriculture and phosphorus use in detergents. His analysis shows that a potential for further reduction of nutrient loads exists at least for P. For nitrogen this potential is lower.

Van Gils, Stichting Waterloopkundig Laboratorium, Delft Hydraulics, presents load calculations of DIN and TP during the period 1988 to 2002. In the upstream stretches of the Danube phosphorus is to a considerable part adsorbed to the suspended solids and can be sedimented in slow flowing river stretches or reservoirs. Downstream of the Iron Gate relatively more phosphate is dissolved. This behaviour has to be considered in the interpretation of data (e.g. measurements of dissolved P). These differences also cause different effects of the same measure taken in an upstream region or a downstream area. Inorganic Nitrogen (NO_3, NH_4, NO_2) comprises the main part of the total N-load. However in down stream sections of rivers the share of organic N increases. The data on organic Nitrogen concentrations in the rivers is scarce and/or inconsistent.

The overall retention in the river systems is 39% for N and 69% for P. The small waters contribute most of the retention of N. The Danube and its large tributaries contribute less. The retention in the Danube and its large tributaries is distributed for N, but concentrated for P: the Iron Gates reservoir is believed to retain about 10 kt/y of P. The contribution by the Delta is small to negligible, simply because most of the Danube water never reaches the Delta.

Horstmann, Institute of Marine Research, University of Kiel, reported on the effects of reduced Danube nutrient discharges on the North-western Black Sea Ecosystem. In 1997 phosphorus became the limiting factor for the phytoplankton growth in this area. The improvement of the marine ecosystem with reduced Danube nutrient loads can be recognised when observing the near bottom oxygen development during the last 20 years. During the mid eighties, extensive areas with anoxic conditions were observed in the bottom layers of the North Western Black Sea shallow waters. By the end of the nineties almost no anoxic conditions were observed in this region. The macrobenthic organisms have increased from 22 to 38 species in the Romanian waters during the last 5 years.

Further north in the Ukrainian waters the situation must not necessarily be the same since additional nutrient loads from the Dnjepr and Dnjestr are discharged into these waters. However extreme long lasting calm and warm weather periods may still lead to anoxic conditions in shallow water areas in front of the Danube delta. Still there is a severe demand for a regeneration of the pelagic food web. Up to now the gelatinous zooplankton and predominately the Medusa Aurelia aurita as well as the Ctenophore Mnemiopsis leydii, are dominating the zooplankton community and apparently do not allow fish stocks to recover.

Schönbäck from the Institute of Public Finance and Infrastructure Policy, Vienna University of Technology, introduces economic instruments complementary to the well known “command and control instruments” (bans, permits and quotas for products, emissions, activities, and technologies, extended producer responsibility, mandatory environmental labelling or licensing, as well as fines in the case of non-compliance). Economic instruments for example are: environmental charges or taxes on emissions or products, tax differentiation (higher taxes on polluting activities), deposit-refund systems, tradable permits as well as subsidies.

As a future step those instruments will be identified which are suitable for the challenges in the Danube Basin. This means: keeping nutrient emissions low with a simultaneously development of the economy (esp. agriculture and industry).

Isermann, Bureau of Sustainable Agriculture, Hanhofen, Germany gave a lecture on the interrelationship of human nutrition and agriculture. Especially he discusses healthy and sustainable diets and concludes that a tolerable animal production would be a specific animal stock of 50 kg live weight per capita and year. Based on the best available organic soil matter (SOM) conditions he derives a optimum of 1 Gross Weight Unit per hectare.

The final speaker of the first day was **Kroiss**, Institute for Water Quality and Waste Management, Vienna University of Technology, the Coordinator of the daNUbs project. He gives a summary of interim results from the daNUbs project and an outlook on further perspectives.

The Danube is the main contributor to eutrophication phenomena in Western Black Sea Coastal Waters (WBSC). The economic crises and decrease of soluble P by P free detergents and P removal at treatment plants (A, D,CZ) has led to a decrease in the discharge of N and P. Agriculture is the main driver for nitrogen emission to water systems, strongly influenced by the geologic, morphologic and climatic condition and the agricultural practice. For P point sources are essential too.

The actual status of WBSC is close to “good” (except fish population), probably due to favourable climatic conditions during the last years. Actually the WBSC is phosphorus limited.

The actual data as well as historic records reveal important inconsistencies, which result in difficult calculation and validation problems for the models. Therefore the data basis for the models has to be improved in the future in order to improve accuracy of modelling results.

The establishment of a clear correlation between measures taken and the response in the status of Danube and WBSC needs long term reliable monitoring adapted to the questions to be answered.

Economic development will increase the agricultural production, a return to a fertilizer management as before 1989 and the return to a centralized meat (animal protein and fat) production has to be prohibited.

For point sources a sewerage development without adequate wastewater treatment (P and N-removal) has to be avoided. Industrial development has to include adequate nutrient discharging control for their wastewaters and NO_X emissions from combustion processes. Climatic conditions (including climate change) can lead to increase the pressure. Nutrient management needs a long lasting strategy for sustainable development with a prospective of about 30 years for stable success.

After every presentation there is room for some short question. Working groups A – C are dedicated for longer discussions on the presentations on the scientific background. In the following main outcomes of the working group discussions are summarised.

4. Session II: Discussion on scientific background, conclusions of working group discussion

A. Regional Differences of Sources, Pathways and Storage for Nutrients in the DRB (drivers and pressures)

Chair: Horst Behrendt, rapporteur: Matthias Zessner

The discussion in this working group was mainly dedicated to report „Harmonised Inventory of Point and Diffuse Emissions of Nitrogen and Phosphorus for a Transboundary River Basin" (MONERIS application for the Danube River Basin). Statements of this working group can be summarised as follows:

- Some country representatives (Germany, Czech R. , Slowak R., Austria) in general agree to the results but some doubts on details were raised (e.g. Czech R.: accuracy of erosion estimates; Austria: Emissions by snowmelt and surface runoff, N-surplus in agriculture, emission estimates for non sewered areas and estimates for residence time in groundwater).
- Other country representative (e.g. Romania) reported that results have not been checked in detail or that the responsible experts are not present.
- Representatives of those countries where specific data have not been provided up till now (Serbia-Montenegro, Croatia, Bulgaria) and where estimates have been made based on

general data available on country level promised to try to provide the missing data. They were invited to IGB in Berlin to get instructions of the required format of data. The question was raised who could pay the travel costs.

- The question was raised if the MONERIS model and its application to the Danube Basin is available. Behrendt said that in principal this is possible and he intents to do that, but he pointed out that it has to be ensured that one official version with a common parameter set has to be available (for instance at the ICPDR) were parameters only can be changed in agreement of the countries, because otherwise the indented harmonisation of the emission inventory will fail.
- Behrendt explained that agricultural point source have not been included into the harmonised emission inventory up till know, because no reliable information did exist. Popovici announced that this inventory will be available soon from the EMIS-expert group. A new version of the inventory for municipal and industrial point sources is available as well.
- Behrendt shows results from other river catchments as compared to the nutrient emissions in the Danbue Basin. It can clearly be seen that the area specific emissions in the Danube are relatively small as compared to other catchments.
- Schwaiger suggested to include a table into the presentation of the results, where the emissions form different countries and sources are shown and background loads are shown separately.
- Finally agreement was found that a workshop on the MONERIS model for instance organised by the EMIS expert group would be useful.

B. Danube River as Conveyer Belt for Nutrients and their Impacts on Western Black Sea (state and impact)

Chair : Jos von Gils, rapporteur : Christoph Lampert

Conclusions are given first for the catchment area of the Danube and consecutive for the Black Sea.

Conclusions for the Danube and its tributaries:

- The river structure is very important for the retention. From retention point of view a natural river is more efficient than a strongly canalized river.
- The Gabcikovo and the Iron Gate reservoir have two completely different retention systems:

- Iron Gate: if flow velocity decreases, sedimentation takes place in the reservoir. This happens mainly during low flow and mean flow conditions.
- Gabcikovo: retention mainly during flood conditions as former river stretches are dotated with water resulting in a deposition of sediments in the river bed and the flood plains.

- one possible relevant effect of climate change was identified: higher winter temperatures may cause higher mineralisation of N in the soils and higher emissions of N to the hydrosphere.
- Stocks in reservoirs, flood plains and the river beds represent a sink in the present situation. No remobilisation phenomena has been observed on the scale of the Danube as whole but we have observed such phenomena for one small case study area in summer time.
- Taking into account the volume of the Iron Gate reservoir (2,1 km^3) and the annual deposition of sediments the time scale for "filling up" could be in the order of 100 years.
- The target accuracy of the Quality assurance-system in the TNMN is 20%. For some parameters this accuracy is achieved for others not.
- The accuracy of the models is not so high in an absolute sense but the models will be able to reproduce the relevant spatial and temporal gradients.
- The weakest point in the load calculations is not the sampling frequency but the accuracy of the concentration measurements.

Conclusions for the Black Sea:

- A lot of work is going on in the Black Sea area, sometimes making use of satellite images. We have exchanged information on this subject which will benefit further work.
- The direction of the movement of the Danube plume in the Black Sea is determined by the wind and the overall current patterns. We need concrete information about the precise area of influence of the Danube and of the other rivers in the area (Dnjepr, Dnjestr, Bug).
- It makes sense to target the reduction of the limiting nutrient P. The reduction of N would be more expensive and probably not effective.

However we should be careful to draw to strong conclusions!

C. Socio-economic Development in the DRB and its Impact for Future Nutrient Management

Chair: Wilfried Schönbäck, rapporteur: Helmut Kroiss

Participants from the following countries were present at the workshop: Croatia, Hungary, Romania, Bulgaria, Slovakia, Austria

Conclusions from the discussion:

- The nutrient emissions represent a challenge for the political and administrative complex in the following areas of decision making:
  - Environment
  - Agriculture
  - Economy, Finance, Trade
  - Regional Development
- The governmental distribution of responsibilities is different in different countries but in no case all the responsibilities are concentrated in one ministry.
- The flow of information plays a decisive role in decision making for nutrient management, exchange of information within the administration as well as to the public (NGOs) is essential
- Information transfer between administrations (ministries) and to the interested public should be improved in order to find better solutions, better acceptance of solutions and confidence building between the actors . This gap should be closed
- There is not enough agricultural expertise in water management administrative bodies and vice versa; the same phenomenon is with education, research and professional associations. Water and agricultural experts are not used to communicate enough.
- Water quality management does not have much confidence in economic tools influencing market mechanisms to improve nutrient management in agriculture but prefers command and control strategies. The use of funding – usual in all EU countries – should be used to improve nutrient management in agriculture.
- Economic instruments influencing market mechanisms for agriculture have not been studied enough as an alternative to command and control systems, because they have to be adapted to the specific regional (economic) situation. There is a lack of knowledge in this regard.
- The funding of EU for WWTP construction with a relatively high portion of grants is in favour of nutrient removal for the economists, as more funds reach the country.

- The actual legal framework for command and control to reduce nutrient emissions is already quite elaborated but does not affect very much agricultural activity in regards to nutrient transport to the Black Sea. Nitrate Directive mainly improves groundwater protection it is not as effective for achieving a reduction of the nutrients flows to Black Sea.
- Industrial development is not seen as a major problem in all areas where EU legislation will be applied, as they are obliged to implement IPPC and UWW Directives for new industries, while the old polluting industries will disappear because they can not afford the environmental requirements
- The influence of nutrient removal requirements on the waste water charges (reflecting the total costs) is overestimated in most of the EDC.
- An adequate accounting system for all waste water services is necessary in order to have enough information about decisive cost factors in the future (benchmarking) also for decision making. ICPDR should promote the use of adapted accounting systems for WWTP and sewerage in the Danubian Countries in a way that comparability of cost data can be achieved.
- The TNMN system has been subsidised by EU funds. In order to increase the quality of monitoring it is necessary to have a continuous flow of investment to maintain the quality of the equipment and for the training of the staff.

5. Session III: Legislative and Institutional Background of Implementation

Schmedtje and Barth give an overview on the implementation of the EU Water Framework Directive in the Danube river basin. They show the evolvement of the European Water Framework Directive (WFD), measures covered by this directive and the environmental objectives. Water policy has to be integrated with other EU polices like the Common Agricultural Policy, the Marine Strategy, the Protected areas – Natura Directives and the Global EU Water Initiative. Within 4 Pha ses the WFD shall be implemented until 2015. Phase A, the Analysis of the current state has to be finalised until the end of 2004. This includes the identification of pressures on surface waters and the groundwater. Schmedtje outlines the content of the Roof report and presents a preliminary table of definitions on significant pressures. Barth very much stresses the importance of linking water protection policies with agricultural policies.

6. Session IV: Discussion on Implementation Aspects

D. Identification of Challenges for Nutrient Management in the DRB and Definition of Content of WFD Roof Report 2004/2005 Related to Nutrient Pressure

Chair: Ursula Schmedtje, rapporteur Hellmut Fleckseder

First criteria for definition of significant pressures from diffuse sources of were discussed: The EMIS group, Austria, Czech Republic, Germany and Slovenia shall prepare suggestions for refinements: The catchments areas in the MONERIS approach differ very much in their size; it would be better to relate the pressures to larger areas as according the national subdivisions made for the implementation of the Water Framework Directive. Discussion on this will take place during the EMIS 19 (16/17 Feb. 2004) and the RBM 13 (26/27. Feb. 2004) meeting. Decision will be taken what to include in the roof report.

From further discussion on the following issues were stated as important for the roof report:

- The information from Horstmann on the state of the Western Black Sea shelf including the P-limitation and the state of the pelagic food chain (probably influenced by over-fishing). Additional information from Romania on the status of the Black Sea coastal area shall be included. It seems that the state of the BS can be considered as "good" except the pelagic food chain.
- The development of the process of eutrophication in the shelf area shall be illustrated.
- The table comprising the nutrient emissions into the small rivers and creeks should be illustrated also graphically including the total discharge of the nation.
- The difference between load calculations based on measurements and loads based on modelling shall be depicted in figures.
- The low efficiency of wetlands along the Danube in regard to nutrient retention should be reported.
- It should be mentioned that the area specific diffuse loads in the Danube Basin are considerably lower as in other European catchments as the Po the Rhine or the Rhone.

The reaction of total P loads on measures taken is much faster as for total N. However natural conditions like dry or wet years cause a strong variation in the river loads. These variations can be even higher as the effects of measures taken.

P-inputs from upstream countries are retained stronger in the river systems and the Iron Gate compared to inputs below the Iron Gate.

P-precipitation at sewage treatment plants, the replacement of P-containing washing powder shall be implemented in all Danubian countries. P-emissions from agricultural point sources shall be avoided. These measures are of high importance especially in locations close to the Black Sea.

Soil erosion should be minimised in order to reduce the transport of particulate P.

Not all the information required is available. Results of chemical analyses can include an accepted deviation. Quality control should be reinforced. This is not only related to the chemical analyses but also to the sampling methods and the conservation of samples.

There is no mean to estimate the impact on the development of the economy on the nutrient discharge. However some scenario estimations should be made.

Comparison of agriculture should not be restricted to the Danube Basin and also include the EU 15.

E. Identification of Challenges for Nutrient Management in the DRB and Definition of Content of WFD Roof Report 2004/2005 Related to Nutrient Pressure

Chair: Fritz Barth

Barth as chair of the working group defines the tasks for the group: What tables/maps should go the roof report and which main messages should it contain? Later on the definition of significant pressure for diffuse sources form agricultural areas was discussed. Following main statements can be summarised:

The working group is not in the position to decide which content goes into the roof report. It will prepare a technical proposal which is submitted to the "drafting group" for the roof report.

Tables/maps that are suggested to be included to the roof report are: corine landcover map, maps characterising fertiliser and pesticide use as well as the animal density. Further the table suggested by Austrian representatives showing the sources of nutrient emissions from different countries depicting also the share of natural background conditions should be included. Information on runoff data from different countries should be included in this table as well. The idea to create a map out of this table was discussed but not finally decided. A further picture to be included is the comparison of the historical development of nutrient loads in the Danube based on monitoring and model calculations as shown by Behrendt. Coastal water maps should show the positive development of the last decade in chlorophyll and nutrient concentrations, macro-zoobenthos regeneration and oxygen supply of bottom sediments (reduced anoxia). Additional data sets from Romania are needed, and should be compared to Bulgarian data.

The main messages that should be included are:

- The situation in the Western Black Sea coastal area has improved significantly since the late eighties and early nineties. Reduced nutrient inputs led to reduced euthrophication, regeneration of zoobenthos and regeneration of phytoplankton. The situation is close to the sixties now. Only the fish stock is out of balance still, where fisheries play an important role.
- The improvement is caused by reduced nutrient inputs by Danube river. Transported phosphorus loads are reduced to about 50 % of the situation around 1990. As Phosphorus is the limiting nutrient now, the decreased P discharge can be seen as the main reason for improvement. This change is not only the result of improved nutrient management in the Danube Basin but to a high extent a result of the economic break down in parts of the Danube Basin (agriculture, fertiliser industry) as well.
- For protection of the Black Sea the present state of Danube loads to the Black Sea coastal area should be aimed at. This is no long term guarantee for a good ecological status of the Black Sea coastal area, but a meaningful target for the next years.
- The main risk of not reaching good ecological status in respect to euthrophication is the recovery of the economic situation which might lead to increasing nutrient loads to the Black Sea (e.g. agriculture, fertiliser industry). The challenge is the recovery of the economic situation without increasing the sum of loads from Danube to the Black Sea.

In respect to the criteria for definition of significant pressures a technical improvement is necessary. Especially the criterion for diffuse agricultural source was criticised. What should be avoided is the definition of regions as significant pressure where no measures can be taken to improve the situation. A new approach has to be developed. This should be the task of the countries (EMIS EG) in cooperation with Behrendt.

7. Summary of conclusions of the workshop

In the following the main scientific conclusions of the workshop are summarised in one block.

- The situation in the Western Black Sea coastal area has improved significantly since the late eighties and early nineties. Reduced nutrient inputs led to reduced euthrophication, regeneration of zoobenthos and regeneration of phytoplankton. The situation is close to the sixties now. Only the fish stock is out of balance still. This is mainly a result of over fishing.
- The improvement is caused by reduced nutrient inputs by Danube river. Transported phosphorus loads are reduced to about 50 % to the situation around 1990. As Phosphorus is the limiting nutrient now, this can be seen as the main reason for improvement.
- The current relatively low discharges of N and P to the Black Sea are to a certain degree a result of the economic crisis in the former communistic countries resulting in a dramatic decrease of the application of mineral fertilizers, the closure of large animal farms (agricultural point sources) and the closure of nutrient discharging industries (e.g. fertilizer industry). It is not quite clear if the improvement of the Western Black Sea ecosystem is mainly caused by decreased amounts of nutrient discharges or to what extent the favourable natural conditions in the last decade are supporting this situation.
- The main risk for not reaching good ecological status in respect to euthrophication is the recovery of the economic situation which might lead to increasing nutrient loads to the Black Sea (e.g. agriculture, fertiliser industry).
- However an economic development in these countries is desired even an increase in the level of production probably will lead to an increase of nutrient emissions to the environment. Therefore the challenge will be to buffer these possible increases by a decrease of emissions from various sources and to level the increase of emissions. A "stand-still" scenario can only be related to the nutrient load to the Black Sea but not to the economic development in the eastern countries.
- In respect to phosphorus points sources still play a decisive role. P-free detergents, P-removal at municipal and industrial waste water treatment plants and the avoidance of

agricultural point sources are important measures in order to keep emissions of easily available dissolved P-compounds low. In addition erosion preve ntion is important to reduce the input of particulate phosphorus into the river system and the Black Sea which servers as a potential P-source for algae growth even if it is not immediately available.

- In respect to nitrogen optimised agriculture and food production is the main task to keep emissions low. In addition nitrogen removal at treatment plants can bring a relief in respect to nitrogen emissions.
- Retention (sedimentation and denitrification) of nutrient emissions in the river system mainly happens in the small river systems. The river structure is very important for the retention. From retention point of view a natural river is more efficient than a strongly canalized river.
- The Danube and its main tributaries play a minor role for nitrogen retention. In respect to phosphorus the iron gate dams are a major point sink still. It can be expected that this retention function is limited in time.
- The Danube Delta has a minor function in respect to nutrient retention simply because the main discharge is through the main channels.
- High quality data are prerequisite to improve model accuracy. Models can not substitute data, but they can help their interpretation.
- TNMN is the most important source for surface water quality data in the Danube Basin. Improvement still is needed in respect to the reliability and completeness of data (e.g. TP, TN).

As final remarks it was mentioned that for the next meeting a broader audience should be invited. In addition to the water related persons policy makers as well as representatives of agriculture should be addressed. A dialog with the representatives of agriculture has to be implemented proactively. This is happening already now but not on a overall level. On the contrary water managers should gain more influence on agricultural matters.

It will be necessary for the future that nutrient management in the Danube Basin has to be linked to the European marine strategy on the long run. The cooperation of ICPDR with the

Danube Regional Project will be continued and the cooperation between the ICPDR and the daNUbs project has to be intensified.

There was an agreement of Kroiss, Zavadsky and Weller in their final statements that the goal of the workshop, to increase the common understanding of the Danube-Black Sea interrelations has been reached. Policy discussion and measures that will be taken have to be based on sound scientific results. Therefore scientific information needs to be translated into popular, understandable terms and distributed to policy makers, which is a major task of the Danube Regional Project. The workshop was an important step in this direction.

Finally Weller as executive secretary of ICPDR thanks the local organizers, the Institute for Water Quality and Waste Management of the Vienna University of Technology for the co-organisation of the workshop, the lecturers of the daNUbs team for their presentations, the team from the UNDP/GEF Danube Regional Project for organisation and financial support and finally all participants for their contribution to the workshop.

Annex

Agenda of the ICPDR workshop in SOFIA

Revised papers

Presentations

Questions distributed as a base for discussion in the working groups

List of participants

ICPDR – UNDP/GEF workshop

Nutrients as a Transboundary Pressure in the DRB

26-27 January 2004, Sofia

Agenda

Day 1: Monday, January 26, 2004

Chair: Helmut Kroiss

09:00 **Welcome and Introduction to the Workshop** (explanation of aim, tasks and approach of the workshop, introduction of participants)

Ivan Zavadsky, Project Manager, UNDP/GEF Danube Regional Project,

Philip Weller, Executive Secretary, ICPDR

Session I: Scientific background; presentation of results from the daNUbs project

09:45 daNUbs "Nutrient Management in the Danube Basin and its Impact on the Black Sea": Background, Concept and Status of the Project

Matthias Zessner, Institute for Water Quality and Waste Management, Vienna University of Technology, Austria

Ranges of Nutrient Inputs and Loads in the Danube River Basin – from Background to Present State and Draft Results for Possible Changes (MONERIS model)

Horst Behrendt, Institute for Freshwater Ecology and Inland Fisheries - Berlin, Germany

11:00 coffee break

11:30 Transport & Retention of Nutrients in the Danube River and its Large Transboundary Tributaries (The Danube Water Quality Model)

Jos van Gils, Stichting Waterloopkundig Laboratorium, Delft Hydraulics - Delft, Netherlands

Effects of Reduced Danube Nutrient Discharge on the Northwestern Black Sea Ecosystem

Ulrich Horstmann, Institute for Marine Research - University Kiel, Germany

12:45 – 14:00 Lunch

Chair: Christoph Lampert

Session I: continuation

14:00 Developing the Concept of an Hierarchical Economic Analysis to Assess Nutrient Management Scenarios in the Danube River Basin

Wilfried Schönbäck, Institute of Public Finance and Infrastructure Policy – Vienna University of Technology, Austria

Challenges for Sustainable Nutrient Management in the Danube River Basin (DRB) with Special Reference to Agriculture and Human Nutrition

Klaus Isermann, Bureau of Sustainable Agriculture - Hanhofen Germany

Nutrients as a Transboundary Pressure in the DRB – Summary of Interim Results from the daNUbs Project and further Perspectives

Helmut Kroiss, Institute for Water Quality and Waste Management, Vienna University of Technology, Austria

15:45 Coffee break

Session II: Discussion on scientific background

16:15 working groups

A. Regional Differences of Sources, Pathways and Storage for Nutrients in the DRB (drivers and pressures)

   Chair: Horst Behrendt, rapporteur: Matthias Zessner

B. Danube River as Conveyer Belt for Nutrients and their Impacts on Western Black Sea (state and impact)

   Chair : Jos von Gils, rapporteur : Christoph Lampert

C. Socio-economic Development in the DRB and its Impact for Future Nutrient Management

   Chair: Wilfried Schönbäck, rapporteur: Helmut Kroiss

Day 2: Tuesday, 27 January, 2004

Session III: Legislative, Institutional and Scientific Background of Implementation

Chair: Philip Weller

8:30 Legislative framework and challenges for WFD roof report

ICPDR (Ursula Schmedtje, Fritz Barth)

9:30 Discussion

10:00 Reports from working group discussion in view of implementation aspects

Group A: Horst Behrendt and Matthias Zessner

Group B: Jos van Gils and Christoph Lampert

Group C: Wilfried Schönbäck and Helmut Kroiss

10:30 coffee break

Session IV: Discussion on Implementation Aspects

11:00 working groups

D. Identification of Challenges for Nutrient Management in the DRB and Definition of Content of WFD Roof Report 2004/2005 Related to Nutrient Pressure

(Chair: Ursula Schmedtje)

E. Identification of Challenges for Nutrient Management in the DRB and Definition of Content of WFD Roof Report 2004/2005 Related to Nutrient Pressure

(Chair: Fritz Barth)

13:00 Lunch

14:30 presentation of working group results

Group D and Group E

14:50 Final plenary discussion

(Chair: Philip Weller)

16:00 **End of the meeting**

ICPDR – UNDP/GEF workshop
Nutrients as a Transboundary Pressure in the DRB
26-27 January 2004, Sofia

Abstracts of Presentations of Results from the daNUbs project

Table of contents

Acknowledgement

The results presented stem from the project "Nutrient Management in the Danube Basin and its Impact on the Black Sea" (daNUbs) supported under contract EVK1-CT-2000-00051 by the Energy, Environment and Sustainable Development (EESD) Programme of the 5th EU Framework Programme. Details on the project can be found on the project homepage: http://danubs.tuwien.ac.at

daNUbs "Nutrient Management in the Danube Basin and its impact on the Black Sea": Background, Concept and Status of the Project

Matthias Zessner

Institute for Water Quality and Waste Management, Vienna University of Technology, Karlsplatz 13, 1040 Wien, Austria (mzessner@iwag.tuwien.ac.at)

Background of the project

Quality of human life and health are strongly related to a good ecological status of the environment. Water quality in the Danube Basin and in the Western Black Sea is significantly influenced by the quality of nutrient management in the Danube Basin. Management decisions have to be made now, but due to long lasting processes it might take decades until their effectiveness becomes apparent. In many regions of the world there are problems with eutrophication of marine estuaries due to excessive transport of nutrients by large rivers. This problem was one of the causes for the move towards the idea to establish river basin management plans incorporating point and diffuse sources.

In the nineties in the Danube Basin main research initiatives as the EU-PHARE Danube Applied Research Program or the UNDP/GEF Danube Pollution Reduction Program have addressed this basin wide approach supporting the work of the ICPDR (International Commission for Protection of the Danube River) with scientific knowledge. In both initiatives already the questions of the interrelation between human activities in the catchments, nutrient emissions and transported nutrient loads as important factor for the ecological status of the Black Sea were addressed in specific projects. Results of these projects significantly increased the knowledge on this subject. Nevertheless due to the complexity of the system significant gaps of knowledge were detected as well. In the years 1999 and 2000 a research initiative was launched in order to bring together major research groups working on the topic of nutrient management on a Danube Basin wide scale and on the effects of nutrient discharges on the Black Sea and specifically address open questions detected in the previous studies. The main idea was to integrate research within the Danube Basin with research on the Black Sea. Besides aspects of natural science also socio-economy should be considered.
This initiative resulted in the formulation of the daNUbs project, which started in 2001 with 17 partner organisations. The institute of Water Quality, Vienna University of Technology, is the Coordinator of this project. The duration of the project is four years from 2001 to 2005.

Concept of the project

Earlier research projects have shown, that the nutrient loads (N, P) from point sources are comparatively small as compared to diffused sources caused by the application of fertilisers in the whole catchment as well as by atmospheric outfall coming from combustion processes (traffic, industry, power production) and agriculture (ammonia from manure). It also could be shown that there was a strong increase of nutrient load discharge starting in the end of the 1960ies up to the political and economic changes in 1989/1990 in the former communistic countries. Another interesting result of these research projects was that the nutrient loads measured in the receiving waters (especially in river Danube) were much lower than the values calculated from the emissions into the riverine environment. The Danube Water Quality Model (DWQM) developed in the middle of the 90ies was a first attempt to connect the emission with the in stream loads in river Danube. Within the daNUbs project the DWQM is revised.

The motivation for the daNUbs project can be characterised by the following aims:

- Understanding of the fate of nutrients (N, P) from their sources (especially the diffuse sources) to the sea as a base for the development of adequate mathematical models.
- Understanding of the role of river pollution for the eutrophication process in the Black Sea resulting in information on sustainable nutrient load discharges for the Western Black Sea region.
- Development of technical and operational tools able to derive strategies to manage discharge of nutrients in order to provide good marine water quality on a long term run, with special emphasis on agriculture and land use.
- Evaluation of socio-economic tools (political actions) which can influence the development of nutrient loads.
- Development of monitoring procedures to observe the effects of measures implemented.

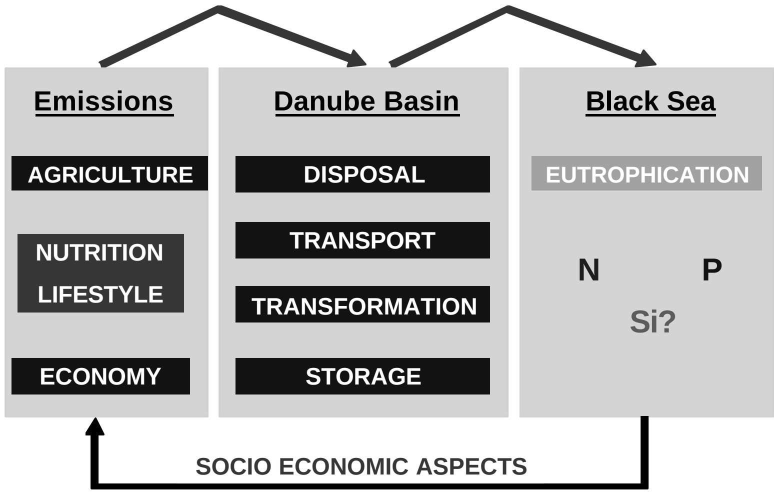


Fig. 1: Concept of the daNUbs research project

The expected benefit of the daNUbs project is to develop tools for decision support within nutrient management and effect assessment in river basins in order to abate eutrophication in receiving rivers and seas and ground water pollution.

From the research point of view the Danube catchment and the Western Black Sea area are used to develop and to verify the scientific models which can be applied worldwide. The Danube region is of special interest, because the effect of a severe change in policy and economy which lead to strong reductions of fertilizer production and application in agriculture and severe changes in food industry (e.g. meat production) in all CEE countries can be investigated in full scale. During the first 10 years after the breakdown of the communist system a certain recovery of the Black Sea can already be detected. There is the hope that the economic recovery can be influenced in a way that it does not result in the same problems again.

The whole project is subdivided into 3 basic steps:

I. Improvement of the process understanding of nutrient driven natural processes in the Danube Basin and the Western Black Sea. Information from literature and data reviews will be expanded by additional field work:
   i. Performance of comprehensive nutrient balances in the 6 case study regions as test regions.
   ii. Transport, retention and losses of nutrients (N, P, Si) along river Danube (literature, data review and monitoring)
   iii. Functioning of the Black Sea with focus on the influence of Danube
II. Development of mathematical models. Based on the results of the first step the mathematical models will be harmonized and improved for application as decision support tool. Assessment of nutrient fluxes from the Danube catchment and their impact on Black Sea using the following models:
   i. MONERIS: nutrient emission model from source to surface waters
   ii. Danube Water Quality Model (DWQM): transport and transformation of material fluxes along the river system
   iii. Danube Delta Model (DDM): transport, transformation and retention of nutrients in the Danube Delta
   iv. Shelf Model: hydraulic and quality modeling of the Danube influence on the Western Black Sea
III. Strategic planning. Further elements will be elaborated concerning strategic planning in catchment scale:
   i. Development of a handbook of information that is needed as basis for a comparable, periodic, basin wide nutrient balance considering the national data availability
   ii. Evaluation of different scenarios of future development by political, socio-economic and technical measures for different economic regional situations using cost efficiency analysis.

Figure 2 shows the relationship between the different elements and expected results of the research project.

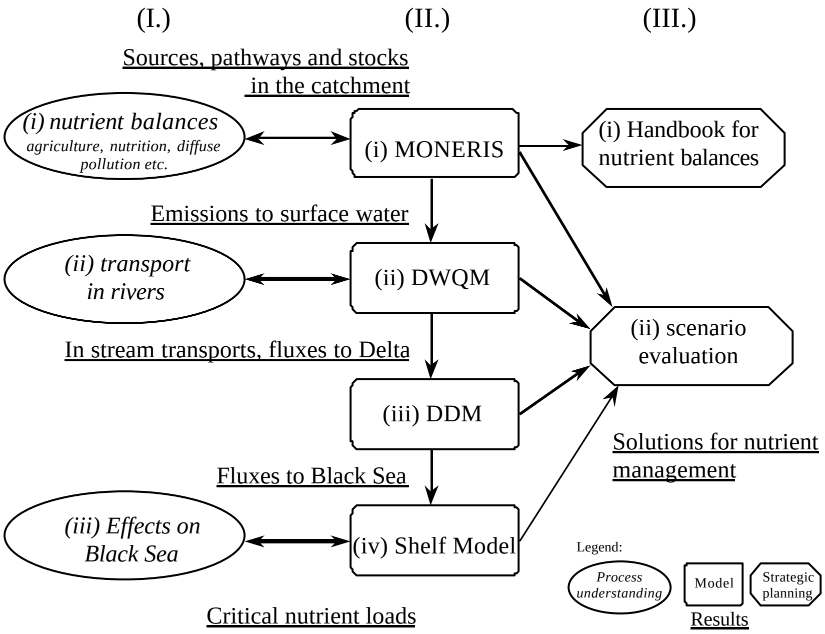


Fig. 2: Schematic workplan of daNUbs research project

Based on the description of the actual state of the system applying the mathematical models mentioned scenarios of a possible future development shall be evaluated. Figure 3 shows the interrelation between the possible measures and tools used for evaluation of the scenarios in terms of nutrient loads and effects on the Western Black Sea

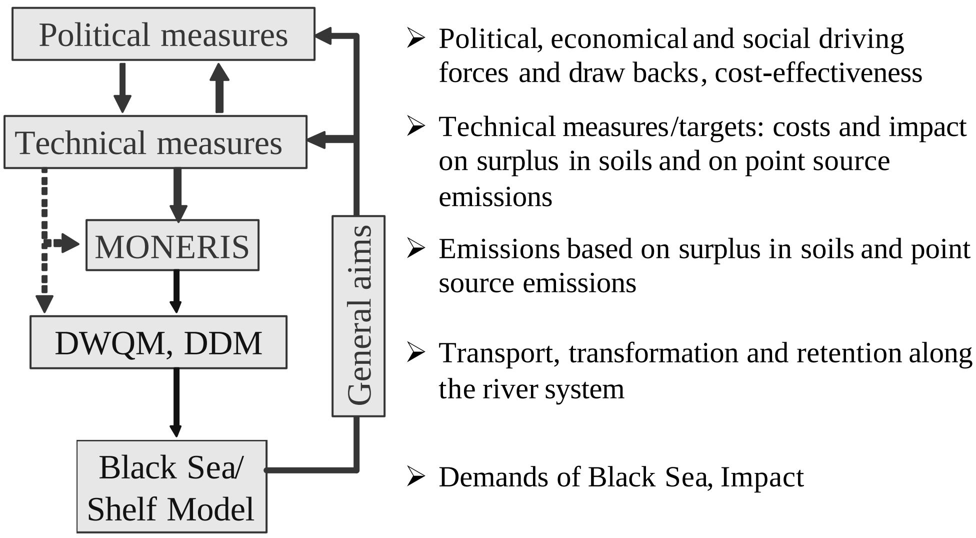


Figure 3: Concept of Scenario evaluation and socio-economic analyses

Status of the project

In the first two years of daNUbs, the work has mostly been concentrating on the building blocks of daNUbs: the individual Work Packages. Most activities had a preparatory character: data collection and analysis, model set-up and calibration, etc.. The challenge for the third year of daNUbs was to begin the synthesis of the project as a whole, based on the achievements within the individual Work Packages. Special focus is on a limited number of aspects, which are of vital importance for the success of the project. These aspects will be outlined below by means of a selected number of statements and questions. The statements will have to be verified (or rejected) in the third and fourth year of daNUbs, the questions will have to be answered.

A) Scenario building

⇒ The combination of the MONERIS emission model, Danube Water Quality Model, Danube Delta Model and Shelf model provides an appropriate tool to link management strategies in the Danube Basin to effects on the Black Sea Shelf ecosystem.

⇒ A rapid growth of the economies of the Central and East European countries probably will lead to an increase of emissions of N and P in the Danube River Basin influencing the ecological status of the Western Black Sea.

⇒ It is possible to prevent these from happening by adopting a sound agricultural policy.

⇒ Does the protection of the Black Sea require a limitation of animal consumption and production on the basis of 0,1 GWU$\cdot$capita^{-1} $\cdot$ yr^{-1}(= 50 kg life weight$\cdot$ capita^{-1}.$\cdot$yr^{-1})?

B) Lessons learnt from the Case Study Areas for the basin-wide analysis

⇒ Through the Case Study Areas, it can be verified that the MONERIS model is suited for the basin-wide estimation of nutrient emissions if appropriate data are available.

⇒ In addition to intensity of agricultural production diffuse emissions of nitrogen very much depend on regional conditions as hydrology, geology and soil types.

C) Transport and retention in the river system

⇒ A quick response of the dramatic changes of agricultural production on the Danube nutrient discharges to the Black Sea can not be expected. Changes so far mainly reflect changes in (agricultural and municipal) point source emissions.

⇒ The impact of the Danube Delta and other wetland areas of the Danube river on nutrient removal is negligible.

⇒ At present, the Iron Gates reservoir and to a lesser extent the Gabcikovo reservoir constitute relevant "point sinks" for phosphorus. Can we accept that as a sustainable fact on a time scale of several decades?

⇒ The Iron Gates reservoir and the Gabcikovo reservoir are no relevant sinks for nitrogen and silica.

⇒ How much of the emissions of phosphorus eventually reach the Black Sea in a bio-available form?

D) Effects of the Danube outflow on the Northwestern Shelf of the Black Sea

⇒ It is not necessary to further reduce the Danube nutrient loads, a standstill at the levels of 2001-2002 is sufficient.

⇒ The question of how much Silicates are supplied by the Danube river is not relevant in view of the development / restoration of a healthy ecosystem in the Black Sea.

⇒ A further reduction of phosphorus is not useful when the N-compounds are still high.

daNUbs partners

- Vienna University of Technology, Institute for Water Quality and Waste Management, Austria
- Danube Delta National Institute for Research and Development, Tulcea, Romania
- Stichting Waterloopkundig Laboratorium, Delft Hydraulics, Delft, The Netherlands
- Bureau of Sustainable Agriculture, Hanhofen, Germany
- Institute of Fisheries and Aquaculture, Varna, Bulgaria
- Institute for Freshwater Ecology and Inland Fisheries, Berlin, Germany
- Vienna University of Technology, Institute of Hydraulics, Hydrology and Water Resources Management, Vienna, Austria
- Institute for Land and Water Management, Bundesamt für Wasserwirtschaft, Petzenkirchen, Austria
- University of Kiel, Institute of Marine Research, Kiel, Germany
- National Centre for Marine Research, Athens, Greece
- National Institute for Marine Research and Development, Constanta, Romania
- Water Resource Research Centre Plc., Vituki Plc., Institute for Water Pollution Control,
- Budapest, Hungary
- Technical University Budapest, Department of Sanitary and Environmental Engineering, Hungary
- Vienna University of Technology, Institute of Public Finance and Infrastructure Policy, Austria
- University of Sofia, Department of Meteorology and Geophysics, Bulgaria
- Institute of Water Problems, Bulgarian Academy of Sciences, Sofia, Bulgaria
- University of Bucharest, Department of Systems Ecology, Romania

Ranges of Nutrient inputs and loads in the Danube river basin – From Background to the present state and draft Results for possible changes

Horst Behrendt[1], Jos van Gils[2], Laszlo Ferenc[3], Heide Schreiber[1] and Mathias Zessner[4]

[1] Institute of Freshwater Ecology and Inland Fisheries, Mueggelseedamm 310, D-12587 Berlin, DE
[2] Delft Hydraulics, Stichting Waterloopkundig Laboratorium, Rotterdamseweg 185, 2629 HD Delft, NL
[3] Institute for Water Pollution Control – Vituki, Kvassay Jeno út 1, 1095 Budapest IX, HU
[4] Institute for Water Quality and Waste Management, TU Vienna, Karlsplatz 13, A - 1040 Wien, AT

Abstract

Within the Danube catchment a population of 82 Million people lives, which is 43 % of the total population within the Black Sea basin. The Danube catchment covers 33 % of the Black Sea basin and contributes about 55% to the freshwater discharge of this sea. For the understanding of the changes of within the ecosystem of the Black Sea it is necessary to know the changes of the nutrient loads from the Danube into the Sea. Because the conditions of human impacts mainly from agriculture and waste water discharges were changed to a large extent within the last decade especially for the eastern European countries within the Danube basin, it is important to know what is the change of the nutrient loads.

Different sources exist giving values of the nutrient loads for the Danube or its main tributaries from the 1950 to the present state. From this one could conclude that the change of the nutrient amounts a factor of five up to the late eighties, whereas the present nitrogen load is only 20% higher than in the fifties. But some of this data are inconsistent and are not in correspondence to other load figures. The estimation of the load changes in the past by the use of the modelling of nutrient inputs and loads can help to clarify the situation. For this task the model MONERIS was applied for situations from the fifties to the mid of nineties. On the other hand this was also done to show the possibility of the model to describe the changes of inputs and loads, which is a precondition for the calculation of scenarios for the possible development in the future.

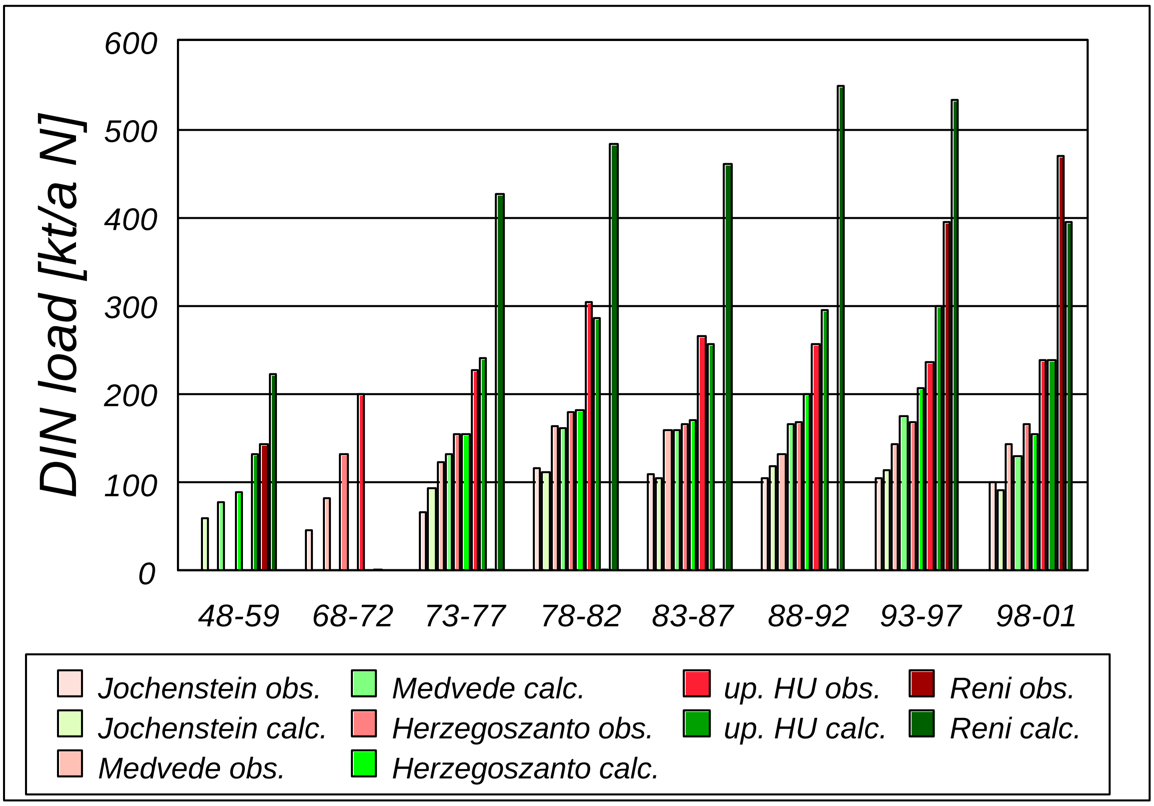
As the results of the analysis the load of P and N along the Danube river and for the main tributaries was calculated from 1950 to 2000. The mean deviation between the calculated and observed loads is for the time period between 1970 to 2000 12% for nitrogen and 18 % for phosphorus.

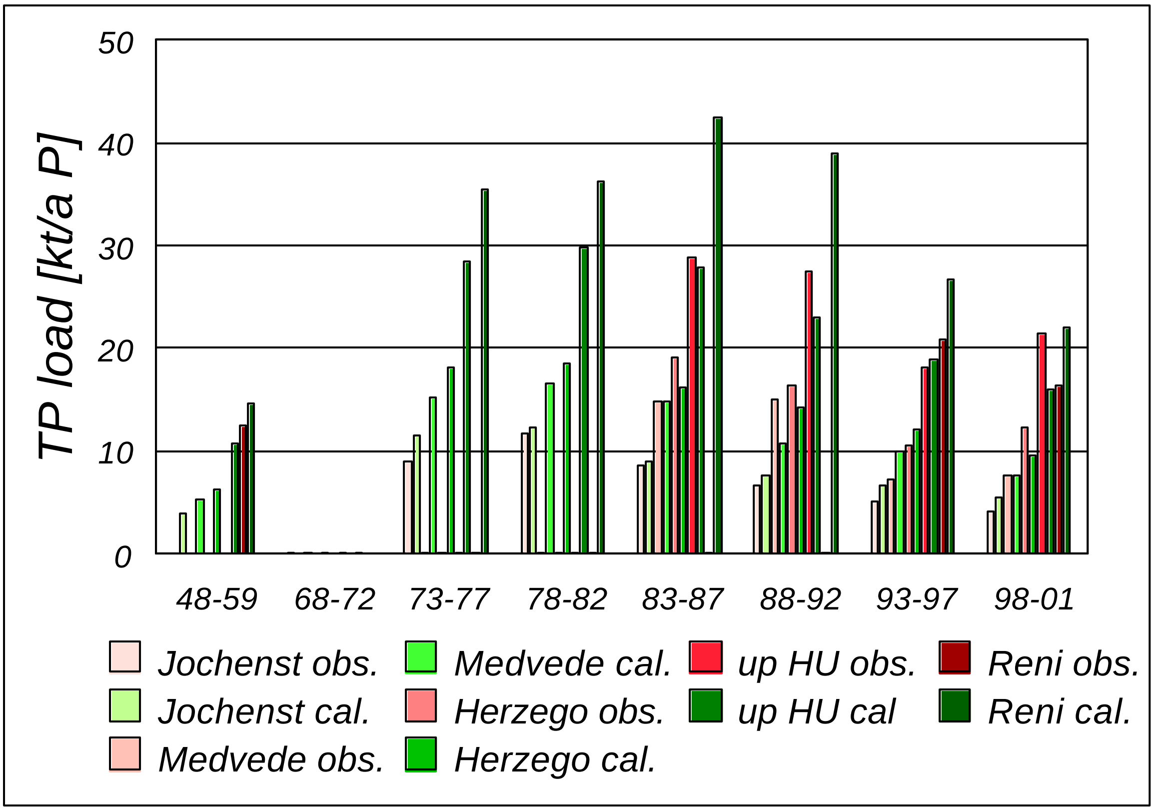
Based on this analysis it can be concluded that the nitrogen load in the fifties was between 200 and 250 kt/a N and for phosphorus the load was in a range of about 15 kt/a P. Both are significant higher than the published data for the period 1948-1959 (Almazow, 1961). The reason can be that the number of measurements was low and mostly in the summer period, where especially the nitrogen concentrations are significant lower than in the winter period.

The highest load of nitrogen was estimated for the period of 1988 to 1992 (550 kt/a N) and was only 2.5 times higher than in the fifties. For phosphorus the highest load was about 42 kt/a P, which was 2.9 times higher than in the fifties. This highest level was realized in the period 1983-1987.

The present load in the Danube is for both nutrients below the values of the early seventies and reduced by about 20 to 30 % (N) and 40 to 50 % (P), respectively, compared to the maximum values. The causes for the changes of the nutrient loads are change of waste water treatment for N and P, changes of N-surplus in agriculture and phosphorus use in detergents.

Based on the analysis of the past possible changes for the future are calculated. This analysis shows that a potential for further reduction of nutrient loads exists at least for P. For nitrogen this potential is lower.





Transport and Retention of Nutrients in the Danube River and its Large Transboundary Tributaries

Jos van Gils

Stichting Waterloopkundig Laboratorium, Delft Hydraulics, P.O.Box 177 2600 Delft, The Netherlands

Introduction

The transport of the plant nutrients N and P by the Danube River has increased significantly during the second half of the 20th century (see Figures 1 and 2). This increase of the Danube River loads was caused by increased anthropogenic emissions to the Danube River and its tributaries. It has resulted in increased eutrophication of surface waters influenced by the Danube River: in particular of the North-western Shelf of the Black Sea. Figures 1 and 2 demonstrate that in the last decade of the 20th century the phosphorus load has decreased substantially, no doubt due to the economic transition in the middle and lower part of the basin. For nitrogen, such a decrease can not be observed.

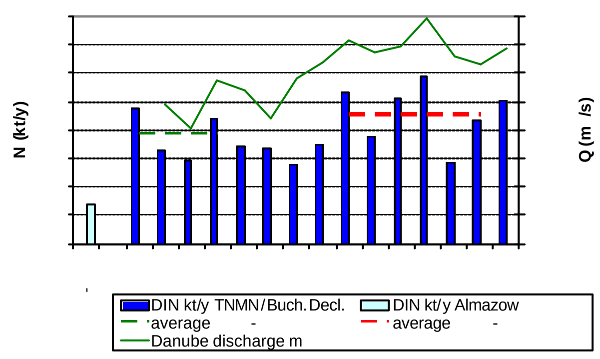


Figure 1: Historical development of the Danube River load of Inorganic Nitrogen.

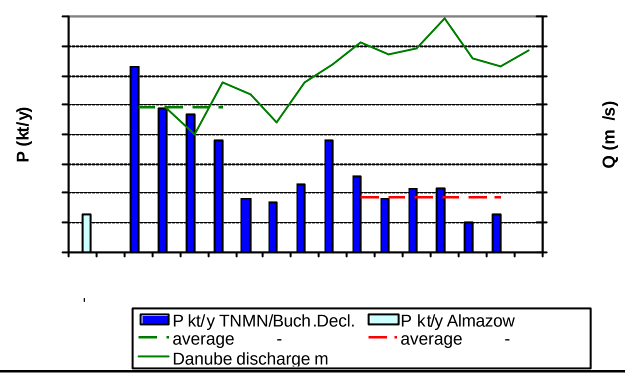


Figure 2: Historical development of the Danube River load of Phosphorus.

Silica (Si) is another plant nutrient, which is (contrary to N and P) not emitted by human activities. It reaches the river by natural processes. However, due to human interventions, the Si content of the river is probably reduced (see Figure 3). This could be an important factor for the river ecology and the ecology of the North-western Shelf of the Black Sea.

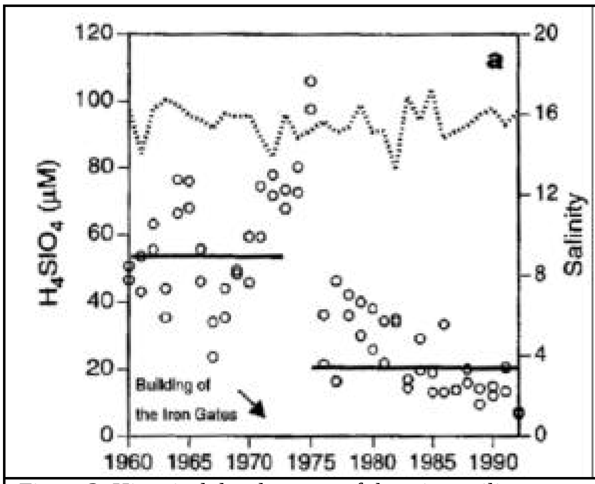


Figure 3: Historical development of the winter silica concentration in the Black Sea off Constanta.

The open circles represent the mean winter silica concentrations at the Constanta station. The bold lines represent the median values over 1960-1972 and 1973-1992 respectively. The dashed line represents the average winter salinity values at the Constanta station. The decrease of the silica concentrations is associated with changes in the input of silica by the rivers, with the Danube being the most important one. These changes are probably the result of the building of reservoirs in the Danube and its tributaries. The salinity remains unchanged over the years, indicating that the amount of fresh water carried by the rivers at the Constanta station has not changed.

The fact that nutrients are effectively transported by the Danube and the large transboundary tributaries makes the increased nutrient emissions a transboundary pressure. Therefore, it is relevant to analyse quantitatively what exactly is happening in the river system. This is the subject of the present paper. The paper is based on the (preliminary) results from the *daNUbs* project (5th FP of the EU).

The river loads are the net result of the emissions of N and P and the retention of N and P in the surface water system. The quantification of the emissions is discussed elsewhere. The present paper deals with the quantification of the retention and the river loads.

Fate of N, P and Si in the river surface waters

The fate of N, P and Si in the river surface waters is different. This is connected to the different behaviour of these substances. We describe this behaviour in broad lines.

N and P reach the rivers from emissions, mostly resulting from human activities. Initially, they are present mostly in inorganic form (ammonium NH_4 and nitrates NO_3, phosphates PO_4). While ammonium and nitrates are present in dissolved form, a significant fraction of the phosphates (typically about 50%) is sorbed to suspended solids. Si reaches the rivers by natural processes, the weathering of rocks and soils. Initially, it is present in the river in dissolved form (silicates SiO_2).
The inorganic forms of all three nutrients can be taken up by phytoplankton (algae). This creates live organic matter with a certain amount of N, P and Si in it. Live phytoplankton eventually dies, and the content of organic nutrients is recycled to the inorganic forms by bacterial activity (mineralization). The growth of phytoplankton shows a seasonal variation: the process is virtually absent in winter and proceeds at its maximum rate in the summer.

Consequently, we can characterise the state of the three nutrients in the river waters as listed in Table 1.

Table 1: Indicative distribution of N, P and Si in the river water.

	N		P		Si	
	winter	summer	winter	summer	winter	summer
Inorganic dissolved (%)	85	65	40	40	100	0-100
Inorganic sorbed (%)			50	25		
Organic forms (%)	15	35	10	35	0	100-0

It should be noted that a significant part of the organic nutrients consists of particles: typically about 50% for N and P, about 100% for Si.

Depending on the state of the nutrients, different retention processes affect them. We distinguish:

- Denitrification is a loss process for nitrates. Nitrates are used as an oxidator in the mineralization of organic carbon and as a result nitrogen gas escapes to the atmosphere. The process takes place in the reduced part of the river sediments. It proceeds fast in the summer and much slower in the winter.
- The inorganic sorbed part of the phosphates can settle to the river sediments and be stored there semi-permanently. This happens in floodplains, wetlands and reservoirs.
- The organic nutrient particles can settle to the river sediments. There, a part of them is recycled and escapes to the overlying water in inorganic form. The remaining part is

stored semi-permanently. The recycled fraction is large for N and smaller for Si and P. Again, this happens in floodplains, wetlands and reservoirs.

The three retention processes affect N, P and Si differently. Where denitrification is the main retention process for N, settling of inorganic sorbed matter is the most relevant for P and settling of organic matter is the most relevant for Si.

Quantitative description of the retention of nutrients

In the *daNUbs* project, the retention of N, P and Si is quantified by mathematical modelling. There is a three-step approach:

1. The retention in the lakes, small creeks and smaller tributaries of the Danube Basin is modelled on a yearly-averaged basis by empirical relations (MONERIS).
2. The retention in the Danube and its main tributaries is modelled time-dependently by deterministic formulas (DWQM).
3. The retention in the Danube Delta is modelled time-dependently by the same deterministic formulas (DDM).

The empirical formulas use “hydraulic load” as a factor to explain retention of N. The hydraulic load is defined as the runoff divided by the area of surface waters. This quantity reflects the nature of the denitrification process: it represents the amount of water to be “purified” per square meter river sediment.
The retention of P is a less unambiguous process. The empirical formulas use both the hydraulic load and the “specific runoff” as factors to explain retention. The specific runoff is defined as the runoff per unit of catchment area; it represents the degree of “flushing” of a certain area.

There is a spatial variation in retention characteristics. Figure 4 demonstrates that the ranges of hydraulic load (HL) and specific runoff (SR) found in the Danube catchment correspond to very low to very high retention.

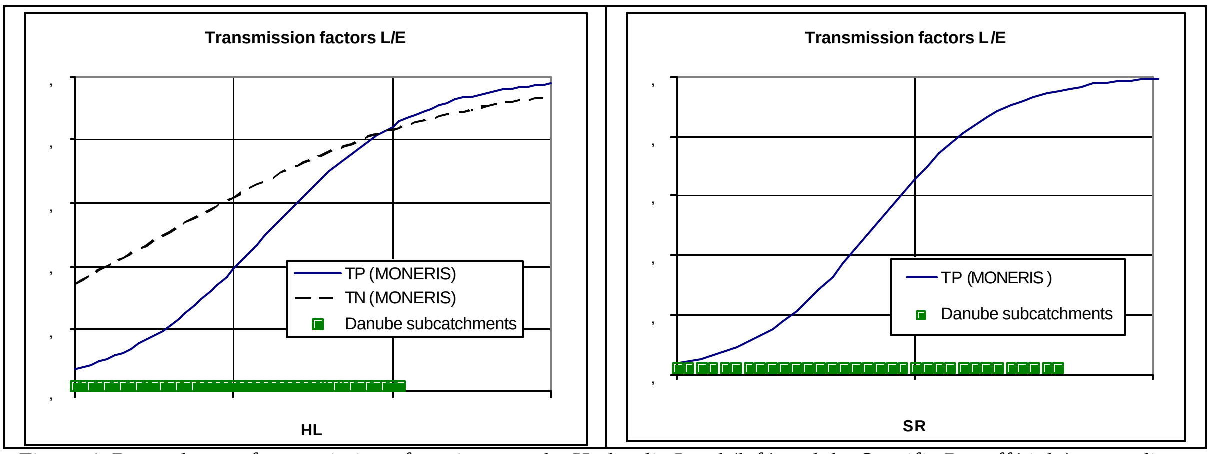


Figure 4: Dependency of transmission of nutrients on the Hydraulic Load (left) and the Specific Runoff(right), according to MONERIS (transmission = river loads / emissions = 1 – retention / emissions).

Quantification of river loads

The river loads are calculated from simultaneous observations of concentration and river discharge. The MLIM-EG has adopted a standard methodology.

Water quality data on a basin wide scale are only provided by the TNMN. Given the scope of *daNUbs*, the TNMN data constitute the key data set. The data from other information sources are considered in a supportive way. The quality assessment of the available data is summarised in Table 2.

Table 2: Quality assessment of river water quality data in the DRB.

Parameter	Remarks with respect to completeness	Remarks with respect to consistency
River discharge	Rather complete	Fully consistent
Nitrogen	Rather complete for Dissolved Inorganic Nitrogen (DIN), sparse data for Total and Organic Nitrogen	DIN: TNMN database by and large consistent for DIN, significant discrepancies between TNMN and other data sources. Total and Organic N: no consistency assessment possible.
Phosphorus	Rather complete	TNMN database not consistent, significant discrepancies between TNMN and other data sources.
Silica	Sparse data	No consistency assessment possible.

Basin-wide balances of N, P and Si

Basin wide balances of N, P and Si are drafted by trying to estimate emissions, retention and river loads, and by matching the result. The preliminary results are listed in Table 3:

Table 3: Balance of nutrients N, P and Si (preliminary results).

	N (kt/y)	N (%)	P (kt/y)	P (%)	Si (kt/y)	Si (%)
Emissions	687	100	67.8	100	570	100
Retention “small waters”	236	34	36.1	53		
Inflow to DWQM	451	66	31.7	47		
Retention in DWQM	20	3	10.2 (Iron Gates)	15		
To delta (calculated)	430	63	21.5	32		
To delta (observed)	*460* *(DIN !)*		*24.5*		*400*	*70*
Retention delta	10	1	0.5	1		
To Black Sea	420	61	21.0	31		

Table 3 shows distinct differences between N and P. The overall retention is 39% for N and 69% for P. The small waters contribute most of the retention of N. The Danube and its large tributaries contribute less. The retention in the Danube and its large tributaries is distributed for N, but concentrated for P: the Iron Gates reservoir is believed to retain about 10 kt/y. The contribution by the Delta is small to negligible, simply because most of the Danube water never reaches the Delta.

It should be noted that large uncertainties exist in the computed emissions, retention and river loads. Therefore only major phenomena can be distinguished, and the balances presented above are to be considered indicative.

Consequences for water management

On the basis of the information provided, several relevant observations can be made.

Retention processes are most effective in the smaller waters. This means that once the nutrients are in the large tributaries and the Danube itself, the retention is small: the load is simply too concentrated for the river to do much about it. There is an exception for P in the Iron Gates section, where about 1/3 of the river load is stored semi-permanently in the reservoir sediments.

Consequently, looking at individual pollution sources the location of a pollution source is very important. If a pollution source is located on a small river, it may cause problems locally (low dilution) but the retention in the river system will be maximal. If the same source is situated on the Danube itself, it will not cause local problems (high dilution) but the retention is minimal and most of the pollution load will be transported downstream.

The retention characteristics of the basin are not uniform. Areas with high specific runoff (SR) and high hydraulic load (HL) have the lowest retention. Areas with high SR/HL and high area specific emissions can therefore be seen as the "hot spots" of transboundary pressure.

The joint retention potential of reservoirs, floodplains and wetlands is high. Therefore, they deserve preservation for this reason alone. However, they cover a large surface, so in order to significantly increase the potential for retention on a basin-wide scale, large areas of new reservoirs, floodplains and wetlands need to be constructed. It should be noted that the construction of new wetlands and floodplains can be a solution for pollution problems on a smaller spatial scale, especially in areas where the pollution is not immediately diluted and transported downstream.

It should be noted that only denitrification is a real <u>loss</u>. The other retention processes related to sedimentation represent <u>storage</u> and increase the stocks of nutrients in the river sediments. To consider these storage processes as permanent, is not always a sustainable way to practice water management. Especially wetlands are sensitive to rapid siltation. On longer time scales, the storage capacity in reservoir sediments is also not guaranteed.

The Danube Delta is not the significant filter it seems to be. Although it effectively purifies the water that reaches the Delta, almost all Danube water just passes by unaffected through the three main channels Chilia, Sf. Gheorghe and Sulina.

The TNMN data constitute an indispensable source of information. They can not only be used to describe the present situation, but they are also a vital piece of information to analyse causes and effects of water pollution, to assess the future development and to asses to response of the system to interventions. Therefore, the TNMN deserves lasting support.

Effects of Reduced Danube Nutrient Discharge on the North-western Black Sea Ecosystem

Ulrich Horstmann and Alexander Davidov

Institute of Marine Research, University of Kiel, Düsternbrooker Weg 20, 24105 Kiel, Germany

Abstract

In the early seventies, nutrient freights, discharged by the Danube river into the Black sea have increased considerably. This includes phosphorous and nitrogen components which both are essential for the primary productivity in the marine environment. In the mid eighties, Danube nutrient discharge reached its peak, with the consequence that the mass production of phytoplankton had severe deleterious effects on the shallow water ecosystem of the North Western Black Sea shelf, including hypoxia in the near bottom water layers (Mee, 1992).

In the beginning of the nineties the nutrient loads of the Danube decreased considerably. This is especially true for phosphate which has been reduced by more than a factor of 2 during the last 10 years. With respect to nitrogen, there is still some controversy regarding dissolved nitrate data of different laboratories for its discharge into the Black Sea. Data range from a reduction of only a few percent up to a factor of 5.

Reasons for the reduction is the collapse of the agriculture and industry of the eastern countries in the Danube catchment area, but also improved sewage treatment in the Danube catchment area further west.

First results of the EU fifth framework project DANUBS show a positive development of the shallow water ecosystem in the North Western Black Sea.

The development of phytoplankton blooms observed from ocean colour registering satellite sensors has decreased during the last years compared to the extension of strong phytoplankton blooms in the 1980ies (Zaitzev et al. 1989). Surface chlorophyll concentrations in the central Black sea have also decreased considerably between 1993 and 1995 (Sorokin 2002).

In the Black Sea waters off the Danube delta dissolved phosphorus concentrations were low before 1969 and became high between 1972 and 1996 while the total nitrogen remained almost on the same level during that period with the consequence that in 1997 the N/P ratio increased up to 16 (Redfield ratio) and phosphorus became the limiting factor for the phytoplankton growth in this area.

Investigations in the Danube influenced waters in September 2002 off the Danube Delta showed a rapid decrease of dissolved phosphorus and nitrate. Furthermore Chlorophyll concentrations decreased rapidly with increasing distance from the Danube discharge area.

The improvement of the marine ecosystem with reduced Danube nutrient loads can be recognised when observing the near bottom oxygen development during the last 20 years. During the mid eighties, extensive areas with anoxic conditions were observed in the bottom layers of the North Western Black Sea shallow waters (Zaitzev and Mamaev 1997). By the end of the nineties almost no anoxic conditions were observed in this region which has been regularly investigated by the Romanian monitoring program.

The significant increase of macrobenthic organisms from 22 to 38 species in the Romanian waters off the Danube delta show a considerable improvement of the benthic ecosystem during the last 5 years (Domitrake 2003).

Investigations conducted in the frame of the EU-DANUBS project in September 2002 showed on underwater video recordings the presence of healthy growing epibenthic organisms especially Mytilus galloprovinzialis and Ciona intestinalis on a station grid, extending 50 km

off the Danube delta. There were no signs of recent anoxic conditions in front of the Danube delta.

These first indications of an improvement of the Danube influenced ecosystem in the North Western Black Sea are obtained from data of the Romanian waters in front of the Danube delta. Further north in the Ukrainian waters the situation must not necessarily be the same since additional nutrient loads from the Dnjepr and Dnjestr are discharged into these waters.

There is also the possibility of extreme long lasting calm and warm weather periods, which may lead to the development of strong pycnoclines and stagnation which in terms may still lead to anoxic conditions in shallow water areas in front of the Danube delta. This was observed during September 2001 in some shallow water areas in front of the delta.

In this presentation we have emphasised primarily the influence of a decreased nutrient discharge as the main reason of improvement of the shallow water ecosystem in the north western Black Sea. However it is hypothesised and there are data indicating, that climate change and especially the increased winter temperature as indicated in the north Atlantic oscillation may lead to a decrease in convection and consequently to a decreased vertical nutrient transport (Oguz et al 2003).

Besides the positive effects of reduced eutrophication in the Black Sea, there is still the severe demand for a regeneration of the pelagic food web. Up to now the gelatinous zooplankton and predominately the Medusa Aurelia aurita as well as the Ctenophore Mnemiopsis leydii, which has been introduced to the Black Sea with bulk water in the early eighties are dominating the zooplankton community and apparently do not allow fish stocks to recover.

Literatur cited:

Domitrake, C. (2003): RMRI – Constanta, Romaia, personal communication.

Mee, L.B. (1992): The Black Sea in crisis. Ambio 21, 278-286.

Oguz, T., Cokacar, T., Malanotte-Rizzoli, P. and Ducklow, PH. W. 2003 Climatic warming and accompanying changes in the ecological regime of the Black Sea during 1990s. Global Biogeochemical Cycles, Vol. 17, No.3.

Sorokin,Y.I. (2002): The Black Sea, Ecology and Oceanography. Backhuys Publishers, Leiden, The Netherlands 875 p.

Zaitzev, Y.P., Gorkavaya, G.P., Nesterova, D.A. and Polishchuk, L.N. (1989): Danube as a main source of the Black Sea eutrophication. Hydrobiol. Journal. (Kiev), 25 (4), 21-25

Zaitzev Y.P. and Mamaev V. (1997): Marine biological diversity in the Black Sea. UN New York, 207p.

Developing the concept of an hierarchical economic analysis to assess nutrient management scenarios in the Danube River basin

Wilfried Schönbäck

Institute of Public Finance and Infrastructure Policy, Resselgasse 5; 1040 Wien, Austria

Introduction

The daNUbs project seeks for management strategies to limit the discharge of anthropogenic nutrients by way of the Danube River into the Black Sea to an ecologically compliant level. The project therefore has to answer a lot of questions concerning the amount of nutrients emitted into the River Danube and consecutively into the Black Sea and the effects of the nutrients on the surface waters and their ecosystems. These questions mainly can be answered by ecologists and water scientists. However, the nature as well as the implications of the problem are directly related to economic action, population dynamics and social issues. Therefore the socio economic view of the problem is of high importance in order to elaborate suitable strategies to solve the problem.
The aim of the this short paper is to provide an introduction to the perception of environmental problems and their problem solving from the viewpoint of economics.

Hierarchical economic analysis

The fact that environmental problems often can not be solved by one single national state but needs the cooperation of many, for what the nutrient problem being subject of the daNUbs project is the best example, makes the socio-economic analysis difficult and in some respects requires a bottom-up approach.
The task of developing sound ecological and economic management instruments for nutrients in the Danube River Basin therefore comprises four levels:

1. the single instrument level,
2. the scenario level,
3. the macro economic level,
4. the transboundary level.

The single instrument level

Since the first occurrence of environmental pollution the national states counteracted by through environmental policy. Environmental policy typically combines the identification of a goal (either general or specific) with some means to achieve that goal, called policy instruments. In practice, these two components are often linked within the political process.

The conventional policy approaches to regulating the environment are often referred to as command-and-control or regulatory policy instruments. Command and control instruments for instance are: bans, permits and quotas for products, emissions, activities, and technologies, extended producer responsibility, mandatory environmental labelling or licensing, as well as fines in the case of non-compliance.

Command and control instruments are preferably used when a high level of certainty of outcome, or little flexibility regarding the timing or nature of the outcome is required. EU environmental legislation is often drafted in a way that explicitly or implicitly requires member states to implement it using regulatory instruments.

The appearance of global environmental problems, the economic globalisation and the emergence of the sustainable development paradigm have led to a remarkable transformation in the role of economics in environmental policymaking.
On the single instrument level a comparison of single instruments regarding the achievements of the predefined political aims under the constraint of cost minimisation is performed.

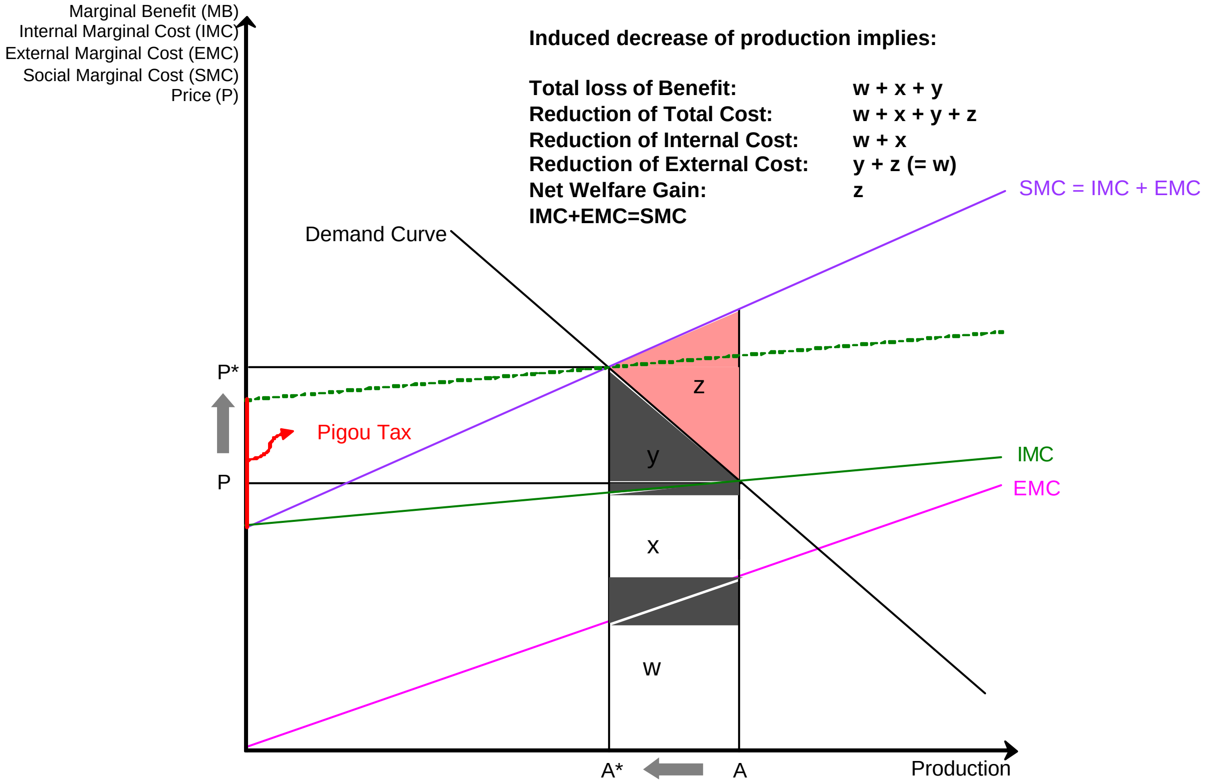
From the viewpoint of economists environmental pollution is the outcome of **negative external effects**. External effects are positive or negative consequences resulting from activities (consumption or production) of a subject that concern a third party but are not monetarily expressed, i. e. they are not monetarily assessed by the market. They lead to a difference between private and social benefit or costs respectively.
The main reason why external effects, causing environmental problems, are not regulated by the market is that environmental goods, like clean air or clean water, have traditionally been defined as unlimited, i. e. as free goods. Additionally nobody can be excluded from the use of these goods, wherefore they are also called collective goods. This creates a incentive to use the goods without joining the costs for their installation.

The solution of the economist to environmental problems therefore consists in internalising the negative external effects or more precisely the costs they generate, which are called external costs or social costs. Internalisation in this concern means that the “polluter pays” principle comes unexceptional into force. This however will only be possible if the society and their pursued policy support this task. In other words, environmental policy has to warrant that the internalisation takes place, so that the resulting market failure is overcome. It can be done by a new kind of environmental policy instruments, the so called **economic instruments**. They affect the costs and revenue of the economic actors, with the purpose of influencing their decisions, pressing for an efficient management of environmental resources. These instruments in contrast to command and control instruments, leave actors free to respond certain stimuli in a way they themselves think most beneficial.

Economic instruments for example are: environmental charges or taxes on emissions or products, tax differentiation (higher taxes on polluting activities), deposit-refund systems, tradable permits as well as subsidies.
It took a long time before economic instruments began to be implemented to a significant extent in industrialised economies; this delay has probably been costly. The main purpose of economic instruments is to achieve an effective integration between economic and environmental policies. In fact, this is a key element of sustainable development.
On the level of single instruments like the construction and improvement of wastewater management plants or the public spending to reach a reduction of nutrients by cutting down the fertiliser use in agriculture, the cost efficiency of the instruments is from the viewpoint of economy the main criterion. The principal idea is to show, how a given level of benefit can be achieved at the minimum cost or how a maximum of benefit can be achieved at some given level of cost. The use of instruments providing a preferably high cost efficiency should be preferred.

Economic impacts of policy instruments

The occurrence of externalities leading to market failure was recognised rather early. Already in 1912 Arthur Cecil Pigou made his famous distinction between private and social marginal products and costs. He developed the idea that governments can, via a mixture of taxes and subsidies, correct such market failures - or "internalise the externalities".



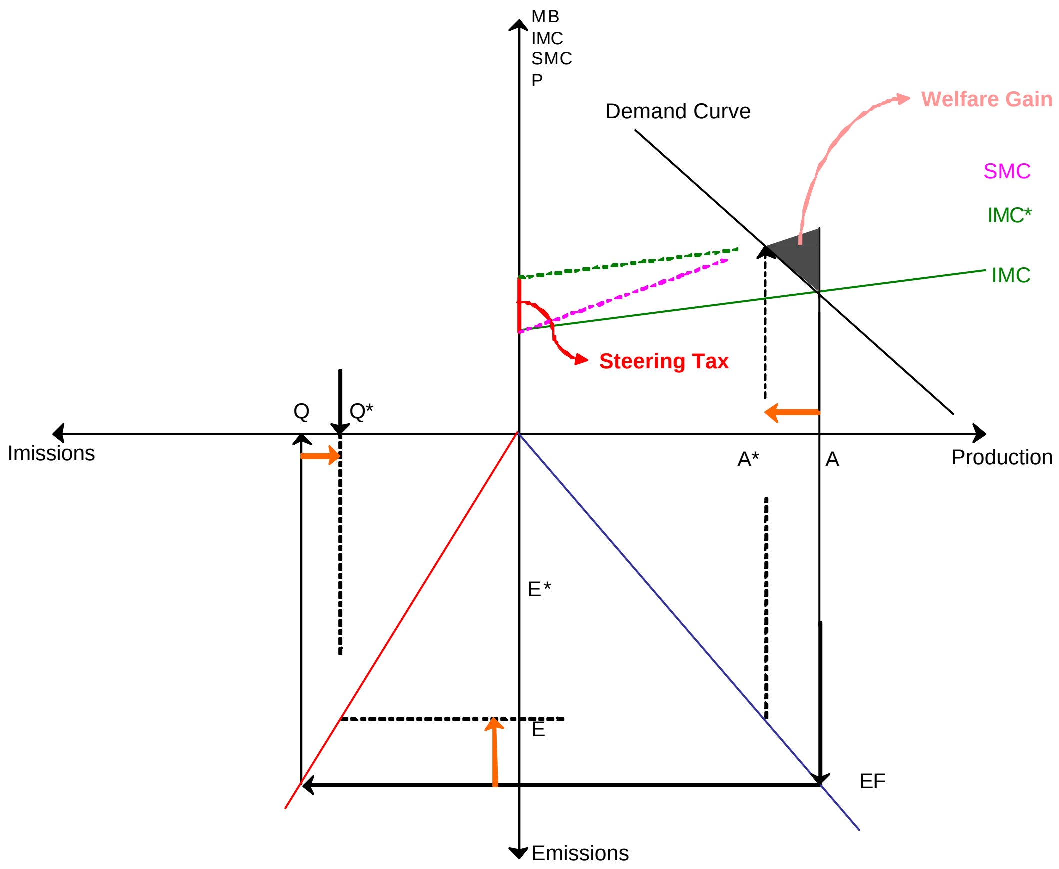
The different types of policy instruments designed to internalise external costs may be visualised with help of the 4-quadrant-diagram developed by ECOPLAN.
The first quadrant shows the correlation between costs/prices and the amount of production, e. g. the marginal social cost curve, the demand curve and the individual marginal cost curve. In the second quadrant the correlation between emissions and the level of production is shown, the emission curve is strongly related to the technology in use. The third quadrant contains the relation between emissions and imissions. The alteration of the imission function, is exclusively possible on a very narrow local level, mostly regarding noise emissions. Within the daNUbs project this is probably not an option. The fourth quadrant finally pictures the marginal damage function, which actually mirrors the marginal social cost function in quadrant one. Both functions are unknown in most of the cases.

An achievement of the aim to improve environmental quality can be obtained by:

1. (Environmental-)Standard-Price Approach

The standard-price approach seeks to internalise external costs despite the fact that the marginal external cost function is unknown. This might be done by determining a:

STEERING TAX: starting from a politically aimed environmental standard (e. g. level of imission) Q*, the tolerable level of emissions E* as well as the level of production A* are determined. Subsequently a tax having a magnitude to warrant the required decrease in production is implemented.



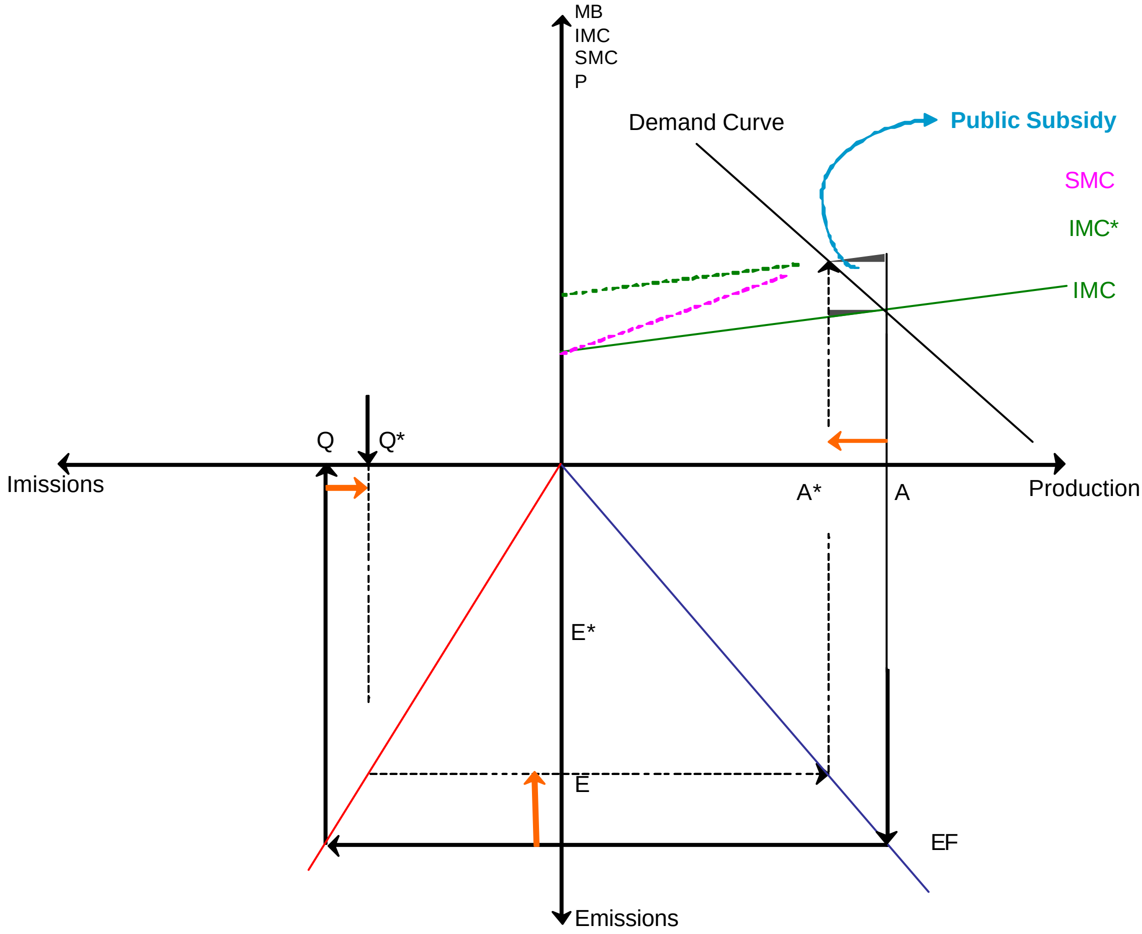
The polluter has to pay the external costs arising from his production (i. e. internalising external costs). This meets “polluter pays” principle.

SELECTED EXAMPLES:

- Water effluent charges
- Charge on the use of fertiliser

SUBSIDIY per unit of production in case the producer does not produce this unit. The same process used to determine the magnitude of the tax can be used to identify the magnitude of a subsidy per unit of production to be paid to individual producers in order to make them feeling a financial loss in case of not reducing production.

The financial burden of achieving the optimal solution is carried not by the individual producer, but by the commonality. Therefore this instrument is based on the “principle of the common burden”.



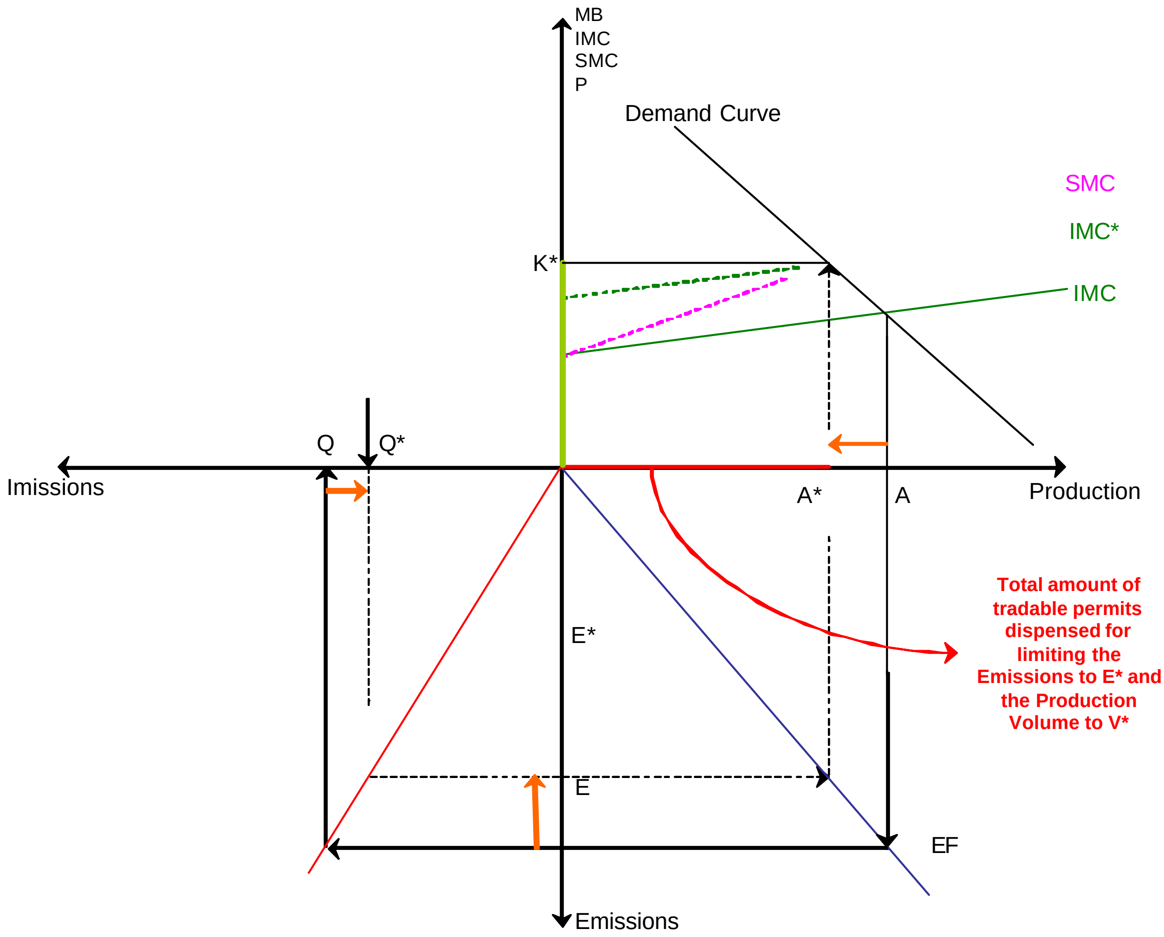
SELECTED EXAMPLES:

- Subsidy for the reduction of the livestock
- Subsidy for the reduction of fertiliser use
- Subsidy for the expansion of fallow land area

2. Tradeable Permits to Produce

Starting also from a desired imission level Q*, this approach limits the amount of production to a level A* which warrants a tolerable total emission level E* by admitting a total amount of emissions for which tradeable permits are issued by the public authorities.

The tradeable permits give the permission to the holders to produce a certain amount, implying the emission of a specific amount of a substance within a predefined time frame. After the emission occurred, or the time frame elapsed, the permits expire. The certificates are traded at the stock market, their market value represents the scarcity of the commodity.



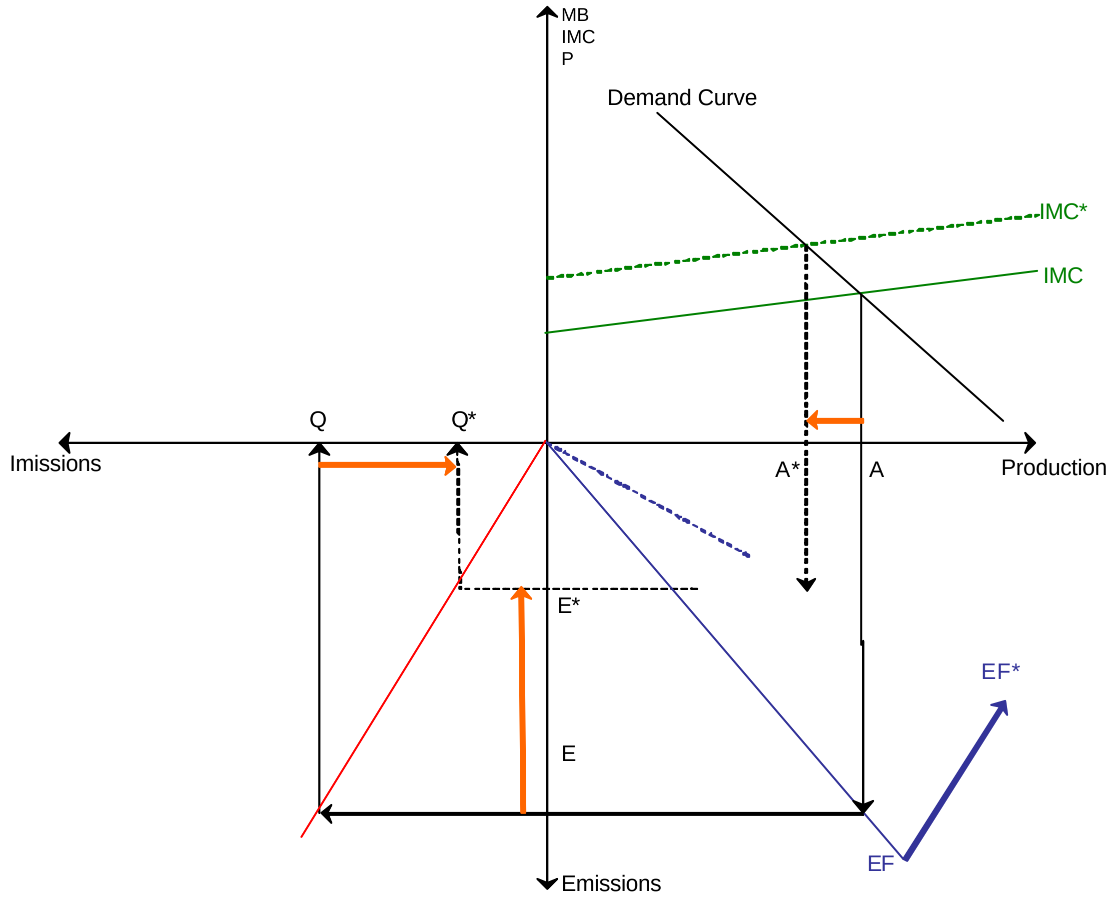
SELECTED EXAMPLES:

- Tradeable permits for nutrient emissions could be implemented in the same way as for instance for greenhouse emissions

3. Command and Control rule regarding the Technology used

Instruments of this type seek to alter the emission-function. This is generally done by stipulating the use of a (new or enhanced) technology or by stipulating technological change (improvement) of existing technology accompanied a simultaneously cut down on limiting values or the introduction of new technical standards.

The change in existing technology as well as the introduction of new technology turns the function for emissions from EF to EF*. This change in technology causes costs for the individuals, what relocates their individual marginal cost curve (IMC to IMC*) and results a decrease in production (A to A*), Emissions (E to E*) and the level of imissions (Q to Q*).



SELECTED EXAMPLES:

- Compulsory use of a N an P removal technology in wastewater treatment plants
- Technological modification of waste waster treating plants in order to achieve new and lower limiting values

The scenario level

On the scenario level bundles of instruments are analysed in order to investigate their usability to reach the predefined political aims at minimal costs. On the scenario level the cost effective use of bundles of instruments is not necessarily limited on a national economy.

Within the daNUbs project the selection of appropriate bundles of instruments to achieve the aims of future nutrient development within different sectors, established in the daNUbs scenarios is an important task. The fact that 13 countries (Austria, Bosnia&Herzegovina, Bulgaria, Czech Republic, Germany, Hungary, Moldova, Romania, Serbia&Montenegro, Slovak Republic, Slovenia, Ukraine) with considerable differences regarding their economic, ecological, social and population development levels, as well as regarding their legislation in general and environmental legislation in particular complicate this challenge.

The macro economic level

The macro economic level represents the level where the output of the scenarios in term of changing macro economic indicators like GDP, value added, employment, consumer prices, etc.
In fact the analysis of the macroeconomic implications of the considered scenarios requires a simulation model, whose development would exceed the scope of the daNUbs project by far. Additionally the knowledge of the mathematical relationship of the production level and the respective nutrient level within the single economic sectors is an elementary precondition. In order of being able to do this time series of reliable data regarding the sectoral outputs as well as of the respective nutrient emission amounts are indispensable for all countries under investigation. Considering that many of those countries have differences in their national accounting methodology so that specific economic sectors may comprise different economic activities, it becomes obvious how time consuming this kind of analysis can be.
Therefore macro economic results within the daNUbs project can only be obtained at a limited degree.

The supra-national level

In order to enhancing the ecological status of the Black Sea concerning nutrient loads carried along by the river Danube it is indispensable that all the countries of the Danube River Basin feel constrained to achieving this task. The question to address on this level concerns the distribution of burdens for the establishment of a ecologically justifiable level of nutrients in the Danube River and the Black Sea.
One possible strategy to think of, could be the implementation of a uniform standard for every country. For instance the yearly amount of nutrients discharged into the Danube River by each single country could be limited in a way that the total of the annually emitted amount by all countries does not exceed the ecological justifiable amount, which may be introduced into the Black Sea without damaging the marine ecosystems. In this case each country would have to find its own solution to solve the problem and thus comply to the standard. The aspect that suitable management strategies also fit the constraint of being cost minimal is not considered in this strategy.
An other possibility is the use of optimisation methodology and the development of a strategy, which distributes the burdens between the countries according to the amount of nutrients emitted and the individual costs for reduction under the main requirement that the reduction is done in a cost minimal way for the entirety of all countries in the Danube River Basin. In that case the total area of the Danube River Basin is considered as one economic area.

Challenges for Sustainable Nutrient Management in the Danube River Basin (DRB) with Special Reference to Human Nutrition and Agriculture

Klaus Isermann, Renate Isermann

Bureau of Sustainable Agriculture-BSA (BNLA), Heinrich-von-Kleist-Str.4, 67374 Hanhofen, Germany

1. Background, scientific innovation and relevance

The „nutrition" system includes agriculture with plant and animal nutrition, human nutrition and waste as well as waste water management with its 7 actors agriculture, feed industry, households, food industry, waste and waste water management, trade and policy (esp. of human nutrition, agriculture, waste and waste water management and environment). Its emissions of reactive compounds (C, N, P and S) cause essentially not only eutrophication – like here as a transboundary pressure in the DRB and the Black Sea - but as „new types"of environmental problems also acidification, climate change, stratospheric ozone depletion and lack of biodiversity. Their impacts are mostly linked synergistic due to both the multifunctionality of reactive C, N as well as S compounds and their exchange between pedosphere, biosphere, hydrosphere and atmosphere. In light of the non-sustainability of the nutrition system in the so called developed countries with their destructive affluence and nutrient surpluses especially of C (fossil energy), N and P there is looming a special challenge considering not only ecological and economical problems but also social pressures and repercussions. There is a need to adapt and to react in all nutrition sectors simultaneously.

2. Aims

In this respect there is a need not only for agriculture and /or waste and waste water management to reduce merely the nutrient inputs into groundwater and surface waters only with technical measures resting so-called "unavoidable" but time after not tolerable C, N, P emissions. Including also human nutrition, there are needs for integrated cause - and source-oriented as well as sufficient C, N, P (S) emission reductions based on the critical loads and levels of the (nearly) natural terrestrial, aquatic and atmospheric ecosystems of about 70-90% in the so-called developed countries. These countries are characterized by (relative) high Gross Domestic Products (GDP) but in reality - including also their negative effects of environmental damages and irreversible exploitation of raw materials (i.e. fossil energy→ fertilizer-N, phosphorus) - considerable lower Net Domestic Products (NDP) and increases.

3. Methods

In order to demonstrate sustainable/unsustainable situations it is important to compare complete nutrient balances based on healthy/unhealthy human nutrition with input/output data of the corresponding (eco-)systems. On the basis of (non-) optimised organic matter (SOM) from terrestrial and subhydric soils [i.e. also nutrient stocks in inland waters (rivers, lakes, groundwater) estuaries and coastal waters] the comparison should include the (net-) immobilisation and the (net-) mineralization of C, N, P and S.

4. Results and conclusions

4.1 The main measures and indicators for sustainable and non sustainable nutrition and its individual objectives are shown in Table 1 (I – IV/IV):

4.1.1 I/IV**: beginning with** general objectives for the total (eco)system nutrition

4.1.2 II-IV/IV**:** Sectoral objectives are shown for**:**

4.1.2.1 II/IV Human nutrition and Agriculture

In spite of about 80% of the reactive C, N, P, S emissions of the nutrition system are in agriculture and off them also about 80% are caused (in-)directly by animal production starting point for all mitigation options and strategies is not the output of feed and food or the production of the agricultural sector but cause oriented a healthy human nutrition especially with animal food: **Basis for comparisons is the Body Mass Index [BMI=Body weight (kg) / square of body height (m^2)].**

4.1.2.2 II/IV Crop and animal production of agriculture

4.1.2.3 IV/IV Waste and waste water management

4.2 Special references to human nutrition

The costs for unhealthy human nutrition (morbidity) also in respect do the overfed and overweight populations are tremendous i.e. in Germany of about 77 Mrd. € corresponding to about 35% of the total health costs and responsible to about 80% of mortality. On the other hand an intolerable overproduction of animals and feed (with imported feed 100% of plant production) corresponds to this overeating, contributing to a degree of about 80% of the reactive C, N, P and S of the nutrition system, resulting e.g. in environmental damages with additional costs of 50 milliards € per year in Germany alone.

The recommended and generally relevant reference values for dietary intake/consumption of energy and nutritious matters [protein, fat, carbohydrates, dietary, fibre (alcohol)] and for net meat are shown in Table 2 in comparison with their average dietary intake/consumption i.e. in Germany 1993 and in Western Germany (1985/89).Distinction is made especially in respect to sex, pregnancy and nursing, age, abnormal weight (BMI > 22(24) and physical activity level (PAL). On the basis of these reference values for dietary intake of energy, nutritious matters and phosphorus the generally relevant optimal need oriented average capita specific dietary animal and plant food intake with 18 (groups of) nutritive is calculated by BNLA. The given reference values for the intake/consumption of energy, protein and fat (with portions of animal food of about 19, 38 and 48 % respectively) and those values for net meat consumption of 23.4 kg per capita and year represent the maximum of a tolerable animal production of the corresponding capita specific animal stock of 50 kg live weight per capita and year. This is equivalent to 0.1 live stock units (LSU) or Gross Weight Units (GWU) per capita and year. **Compared with these needs the animal production i.e. in the EU (15) or in Germany can be reduced of about 58 and 41% respectively with a decline of cropping and fodder area of about 20% and corresponding reductions of reactive C, N, P, S emissions. In contrast realistic need oriented healthy human nutrition will reduce N and P excretion and input into the waste and waste water sector of only about 15 and 4% respectively and not realistic need adapted human nutrition will reduce it of about 31 and 41% respectively. Comparable calculations are made by BNLA actually for the individual countries of the Danube River Basin for the years 1988-1990 and 1998-2000**

respectively with special reference to human nutrition with animal food and livestock manure nutrient production.

The ecological component “consistency” of sustainable nutrition can therefore nearly be achieved by mitigation measures safeguarding its social component “sufficiency”, mostly cost-saving and cost-effective. These proposed mitigation measures of a sustainable life style should be flanked by individual technical mitigation measures in “small steps” aiming to reduce all the reactive C, N, P and S sufficiently. In this respect there is a need for N-, P and C-directives also as parts of a reformed EU-WFD (2000). These measures should be accompanied by adequate prices for biomass products and especially for food and feed. The products must not necessarily be cheap but worth their prices. That way the “efficiency” of a sustainable overall nutrition as economical component can best be achieved.

4.3 Special references to agriculture

Plant as well as animal production of the agricultural sector must use the best available organic soil matter (SOM) conditions shown e.g. for arable European farming in Table 3. The data shown originates from 26 long-term field trials in Western Europe. The figures suggest mainly that the optimum for organic soil matter conditions must be maintained by use of 2 t reproduction-efficient organic substance (ROS) per ha and year, equivalent to 2 t of dry matter (10 t raw mass) from stable or liquid manure produced from a maximum of 1 gross weight unit (GWU) [one such life stock unit (LSU)] delivering 500 kg live weight (LW).

Therefore the main key factor for a sustainable human nutrition is an *animal amount* (production) from 0.1 GWU/LWU per capita and year (equivalent to 50 kg of life stock weight per capita and year), with a corresponding human consumption. This can be achieved with an *animal density* between 0.4 and 1.0 GWU/LSU per ha agricultural land sufficiently supplied with SOM and main nutrients (C, N, P, S, Mg, Ca).

The implementation of this key factor can be not sufficiently realized by educational and advisory measures but in the main by tax levy both for animal products according environmental sustainability and not tolerable nutrient surpluses of agriculture (i.e. > 50 kg N$^{\cdot}$ ha aa$^{-1\cdot}$ yr^{-}). They must be accompanied by an optimisation of foreign trade and corresponding protection from not tolerable imports and exports of food and feed and by soil analysis respectively.

4.4 The instruments and measures for an (un-)sustainable total (eco-)system nutrition shown here, are essential parts for the scenarios and prognoses dealing with the sustainable nutrient management in the Danube catchment of the EU-RP-5-Program “daNUbs” (2/2001-1/2005) [EVK1-CT-2000-00051] shown as an overview in Table 4.

5. References

Isermann, K, Isermann, R and M. Zessner (2004): daNUbs nutrition scenarios: Agriculture-Human nutrition - waste and waste water. Fourth Black Sea International Conference “Environmental Protection Technologies for coastal areas”, 9-11 June, 2004, Varna, Bulgaria (in preparation)

Tab. 1:Sustainable and non sustainable main measures and indicators for the total (eco-)system „nutrition“ (human nutrition - agriculture with plant and animal nutrition – municipal waste and waste water management) from the viewpoint of its nutrients balances and in the background of corresponding scenarios and prognoses with special reference causing eutrophication of terrestrial and aquatic (nearly) natural ecosystems

(I / IV)

Objectives	Main measures and indicators: Sustainable	Main measures and indicators: Non sustainable
A) General objectives		
1. Goals	**Aims** ▪ Economical (=>Efficiency), ecological (=> Consistency) and social (=>Sufficiency) aspects are equally significant ▪ Obligatory (levels, loads, time scales)	**Targets** ▪ Preference of single aspects of economical, ecological or social criterions respectively ▪ Not obligatory (levels, loads, time scales)
2. Sectors involved	**Multisectorial:** Simultaneously the total (eco-)system “nutrition” with human nutrition, agriculture (plant and animal nutrition), waste and waste water management	**Singlesectorial:** Only 1, i.e. agriculture, extremely: Only plant production
3. Priority of food consumption in human nutrition	**Sufficient and healthy food (and consequently feed) consumption** and accordingly production in agriculture determines primarily sustainability	**Not tolerable affluence and unhealthy consumption of food (and consequently feed) in human nutrition** and accordingly overproduction in agriculture determines primarily non sustainability
4. Environmental problems regarded	**Simultaneously eutrophication, acidification, climate change and ozone depelation with their interrelations caused by reactive C, N, P and S compounds**	**Only i.e. eutrophication (of aquatic) ecosystems with N and P (Si)**
5. Emission /Immission reductions	▪ **Cause-oriented emission reductions at the source** (human nutrition) and subsequent aimed emission reductions in agriculture as well in waste and waste water management ▪ **Sufficiently:** accordingly to the critical levels and loads of the (nearly) natural ecosystems ▪ **“Natural « Attenuation** esp. In (nearly) natural ecosystems (pedosphere, hydrosphere, atmosphere) like decomposition, conversion and dilution of C, N, P, S respectively **intentionally not utilised => Correct terms: Short time accumulation; C, N, P, S-Retardation,-Delay and Remobilisation**	▪ **Not cause-oriented: immission reductions at the sinks (end of the pipe) =>i.e.“natural” attenuation** ▪ **Insufficiently:** i.e. only critical levels and no critical loads (i.e. EU-Nitrate-Directive (1992): 50 mg $NO_3^- l^{-1}$) ▪ **“Natural” Attenuation intentionally utilised** (i.e. EU-Nitrate Directive (1992): high loads with low levels of N and P; New harmful C, N (P) S compounds and emissions like NO_3^- => NH_4^+, NH_3, N_2O, NO, N_2 (losses!), SO_4^{2-}, CH_4, $(CH_3)_2$ S, COS **=>Wrong terms: C, N, P, “Retention” or “Sequestration”** re /I

Objectives	Main measures and indicators: Sustainable	Main measures and indicators: Non sustainable
B) Sectoral objectives		
1. Human nutrition [capita^{-1}d^{-1}]	**Optimisation: Need oriented and healthy (esp. of animal) food consumption** [DGE2000/Cancer Aid 2000, Office of Technology Assessment of the German Parliament 2002]	**Maximation: Demand-oriented affluence and unhealthy (esp. of animal) food consumption** of i.e. in Germany [DGE 2000]=>too much (animal) fat and protein / sugar
Energy [kcal]	2013 (100)	2295 (114)
Protein [g]	46 (100)	77 (166)
Fat [g]	70 (100)	94 (136)
Carbohydrates [g]	275 (100)	257 (93)
Free sugar [g]	[WHO: 0] 67 (100)	73 (109)
Meat [Net] [g]	[WHO: 0] 72 (100)	129 (180)
=> Measures:	Differentiated taxation and repayment to agriculture,=>food worth its price, objective recommendations and education	Subsidies for food production and consumption (often without production limits)=> cheap food; Non objective recommendations and education
2. Agriculture	**Integrated need oriented plant and animal production with optimised (=>minimized) imported feed (Cereals, soy etc.)** ▪ **Products worth their prices economically, ecologically and socially** i.e. taxation and repayment to agriculture=>**Increase of product prices** ▪ **Optimisation of foreign trade with food and feed** ▪ **Minimising overall nutrient surpluses (C,N,P,K,S)** i.e. by taxation and repayment i.e. max. 50(15-50) kg N ha AA^{-1} yr^{-1} ▪ Changeover from conventional and organic to **sustainable farming** ▪ **Re-wetting of original wetlands** depends on the amounts of the emissions of CH_4? CO_2 ?,N_2O?, P? ▪ **Optimisation of the intensity of capital goods,** i.e fertilizers => **Deintensivation**	**Desintegrated demand and too high affluence oriented plant and animal production with high amounts of imported feed (Cereals, soy etc.)** ▪ **By subsidies (dumping) cheap products not worth their prices => Decrease of product prices** ▪ **Maximisation of foreign trade with food and feed** (“increased competition” => WTO) ▪ **Reducing only N surpluses in sensible water protection zones** according to insufficient levels (50 mg $NO_3^- l^{-1}$) and neglecting critical loads for surface waters (i.e. EU-Nitrate Directive 1991) ▪ Changeover partly from **conventional** only to **organic farming** (i.e. Germany to 20%) ▪ **Drainage of original wetlands** depends on the amounts of the emissions of CH_4? ,CO_2?, N_2O?, P ? ▪ **Minimisation of the intensity of capital goods,** like fertilizers => **Extensivation** **Re0484/II**

(III / IV)

Objectives	<u>Main</u> measures and indicators	
	Sustainable **Need oriented**	**Non sustainable** **Demand oriented**
2.1 Crop production (food and feed) **=> Specific measures esp. in Plant nutrition**	▪ **Optimal crop rotations** (leaf/root crops, with high nutrient output and efficiency, intercropping, no fallow and set-aside, changes from arable to grazed=> cutted grassland=> afforestation ▪ **Minimum tillage**=> low erosion and surface runoff ▪ **Optimisation of mineral fertilizer and organic manure input** (economically, ecologically and socially) ▪ **Optimal nutrient (C,N, P,K, S) supplies of the soils** ▪ **Best available techniques applied** ▪ etc.	▪ **Non optimal crop rotation** (too many root crops, vegetables with low nutrient output and efficiency, no intercropping , fallow, set-aside, change from grassland to arable land, etc.) ▪ **Maximum tillage**=>high erosion and surface runoff ▪ **Minimization of mineral fertilizer and organic manure input** (quota fixing, licenses, high prices by taxation, etc.) ▪ **Too high nutrient (C, N, P, K, S) supplies are tolerated**, esp. in regions with too high animal densities ▪ **Only present actual techniques applied** ▪ etc.
2.2 Animal production **=> Specific measures esp. in Animal nutrition**	**Need oriented** ▪ **Optimal densities and amounts of animals**: - in total: Max 0,1 GWU · capita^{-1} · yr^{-1} - farm level: Max. 1,0 (0,4-1,0) GWU · ha with nutrients supply able AA^{-1} · yr^{-1} ▪ **More efficient animal nutrition** by reducing nutrient (protein) surpluses and by feed additives (amino acids, enzymes, minerals) ▪ **Best available techniques (BAT) applied** especially for housings, storage and spreading of animal manure ▪ **Sufficient use of progress in animal breeding and husbandry** ▪ **Ethical aspects are included => Agri<u>culture</u>** ▪ etc	**Demand oriented** ▪ **Too high densities and amounts of animals**: - in total: up to 1.0 GWU · capita^{-1} · yr^{-1} - farm level: > 10.0 GWU · ha AA^{-1} · yr^{-1} are subsidised (i.e. Germany) ▪ **Animal nutrition: Using additionally antibiotics** ▪ **Only present actual techniques applied** ▪ **Insufficient use of progress in animal breeding and husbandry** ▪ **Ethical aspects are excluded => Agro <u>industry</u>** ▪ etc. re0484/III

(IV / IV)

Objectives	<u>Main</u> measures and indicators	
	Sustainable ("ecological") sanitation	**Non sustainable ("conventional") sanitation**
3. Waste and waste water management	**…With optimal capacities, esp. of wwtp´s**	**…With not tolerable (over)capacities, esp. of wwtp´s**
=> Measures	▪ **Minimising N and P (P-free detergents) inputs** ▪ **C, N, P elimination by assimilation** ▪ **Separation of substances (esp. in rural districts)** **- urine (yellow water): hygenisation=> fertilizer (N,P,K)** **- faeces (brown water):composting=> biogas, soil improvement (C, P)** **- showers, washing etc. (grey water): Biol. treatment => Reuse, irrigation (P,K), ground water recharge** ▪ **Minimising the inputs of Xenobiotics and other harmful substances =>** ▪ **Minimising incineration and deposition (a.o. "land fill") of sewage sludge (and bio compost)=>** ▪ **Optimisation of the recycling of safe sewage sludge (and bio compost) to agriculture (relevant for C, N, P)** **=> recycling beats disposal**	▪ **Avoidable N and P inputs** ▪ **N elimination by (de-)nitrification (losses!)** ▪ **No separation of urine, faeces, showers etc.** ▪ **Too high inputs of Xenobiotics and other harmful substances=>** ▪ **Incineration and disposal of sewage sludge (and bio composts) in high amounts** ▪ **Minimisation of the recycling of (safe) sewage sludge (and bio compost) to agriculture (relevant for C, N, P)** **=> Linear end-of-pipe technology** **Re0484/IV**

Tab. 2: Recommended average reference values for dietary intake/consumption of energy, nutritious matters [protein, fat, carbohydrates, dietary fibre (alcohol)] and for net meat of males and females [individually differing in respect to sex, pregnancy and nursing, age, abnormal weight (BMI > 22/24) and physical activity level (PAL)] in comparison with their average dietary intake/consumption i.e. in Germany 1993 and in Western Germany (1985/89)

Average dietary Intake/ Consumption (Average person: 41 years, 66 kg, expectancy: ♂ 74/ ♀ 81 □78 years)	Reference values [BMI< 22/24] (DGE 1996, 2000, 2001)	Germany 1993 (n= 38924) (DGE 2000) Units · capita[1]	Germany 1993 (n= 38924) (DGE 2000) % reference values	Western Germany (1985/89) DGE 1996) % reference values
1. Energy ($kcal \cdot d^{-1}$)	2100 (2013)	2295	**114**	99
2. Protein ($g \cdot d^{-1}$) (% Energy)	DGE 2001: 53 49 (46) 10-15	76,6 13	**145; 156 (166)**	**155**
3. Fat ($g \cdot d^{-1}$) (% Energy)	70 25 – max. 30	94,2 **36**	**136**	**127**
4. Carbohydrates ($g \cdot d^{-1}$) (% Energy) ….off them Disaccharides (% Energy)	275 55-60 (> 50) 67 10	257 **45** 73 **15**	**94** **109**	**83** n.d.
5. Dietary fibre ($g \cdot d^{-1}$)	30 (27,3)	20,1	**74**	**65**
6. [Alcohol] ($g \cdot d^{-1}$) (% energy)	(adults max: 15) -	13,1 **4**	-	-
7. Meat (Net)[1)] (without self production) 7.1 Intake (DGE) ($g \cdot d^{-1}$) ($g \cdot w^{-1}$) ($kg \cdot yr^{-1}$)	 64 (43-86) 6 x 75 = 450 (300-600) 23,4 (15,7-31,4)	 129 [75]900 46,9	**200 (327)**	n.d.
7.2 Consumption[1)] (BMELF) ($g \cdot d^{-1}$) ($g \cdot w^{-1}$) ($kg \cdot yr^{-1}$)	- - -	172 [100]1204 62,8	**268**	**286**

[1)] Meat without bones, wasted fat, industrial utilisation, feed, losses (ca. 67% of gross meat consumption) Re0527

Table 3: Optimum soil organic matter conditions (SOM or C_{org} □humus) of groundwater-remote sandy and loamy soils under common arable farming and average climatic conditions in Europe derived from 26 long-term field trials in Western Europe (Average yearly temperatures: 6- °C, average yearly precipitation: –800 mm)
(Körschens / , Schulz , Körschens and Schulz , Isermann and Isermann , a-b, Isermann und Körschens , Isermann 2002, 2003, Benbi et al. 2003; completed)

Individual parameters	*Respective optimum conditions of SOM*
1. Concentrations / Quantities 1.1 Total SOM	Total SOC= C_{org}: 0.7 % (sandy soil) up to 2.5% (black soil) dependent on the clay content (0.7-21%) Total SON= N_{org}: 0.07% (sandy soil) up to 0.25% (black soil) dependent on the clay content (0.7-21%)
1.2 Decomposable $SOM_{dec.}$ Hot water soluble SOM_{hws} (SOM thickness: 30 cm)	Decomposable SOC= C_{dec}: 0.4 (0.2-0.6)% □16 (8-24) $t \cdot ha^{-1}$ □C_{hwl}: 25-30 mg·100 g soil matter^{-1} Decomposable SON= N_{dec}: 0.04 (0.02-0.06) % □1.6 (0.8-2.4) $t \cdot ha^{-1}$
1.3 Mineralised SOM_{min} (e.g. Central Germany: 4% of SOM_{dec})	Mineralised SOC= C_{min}: 680 (320-960) $kg \cdot ha^{-1} \cdot a^{-1}$ Mineralised SON= N_{min}: 68 (32-96) $kg \cdot ha^{-1} \cdot a^{-1}$
2. Thickness **(tillage depth)**	<35 (e.g.: black soil) up to > 20 cm (e.g. sandy soil)
3. Qualities: 3.1 SOC/SON= C_{org}/N_{org} 3.2 SOC/SOS= C_{org} / S_{org} 3.3 SOC/SOP= C_{org} / P_{org}	 10/1 (> 8/1 up to < 12/1) 100/1 (> 70/1 up to < 140/1) 150/1 (> 100/1 up to < 200/1)
4. Types	raw humus → moder → mull
5. Maintenance of optimal SOM balance **(Mineralisation = Immobilisation)**	2 t reproduction-efficient organic susbtance (ROS) $\cdot ha^{-1} \cdot a^{-1}$ □stable manure / liquid manure of 2 t of dry matter / 10 t of raw mass from 1 gross weight unit (GWU) or 1 life weight heavy lifestock unit (LFU) of 500 kg life weight (LW) re0518

Tab. 4: Scenarios in the Danube Basin with corresponding C, N, P (and S) balances of the total system nutrition with Agriculture: Plant and Animal nutrition, Human nutrition and Waste as well as Waste Water Management Period: 2000- (2012) 2015 (G= Germany, A= Austria, CEE= Central and Eastern European EU)

Scenarios ➔ *with corresponding sustainable criterions*	**Agriculture:** **Plant and Animal nutrition** (also Feed Industry) ➔ Feed production and consumption, Food production	**Human nutrition** (also Food Industry) ➔ Food processing and consumption	**Waste and Waste Water Management** (Infrastructure Sewage, TP) ➔ Nutrient removal and recycling
Scenario1: **Business as usual (BAU)** **= Status quo** ➔ ***Weak efficiency,*** no further urbanisation	Situations like 1995-2000 (Consolidation) G+A: No change, subsidies	Situations like 1995-2000 (unhealthy nutrition, esp. G+A) G+A: No change CEE: No change	Situations like 1995-2000 G+A+ CEE: only operation and maintainance of existing infrastructure
Scenario 2: **Worst Case (WC)** **= Global Markets (GM)** ➔ ***Strong Efficiency*** Urbanisation	Export oriented, within EU and globally G+A: like 1995-2000 CEE: like 1989 Specialisation of plant and animal production (esp. CEE)	G+A: like 2000 CEE: like 1989	Sewerage: all settlements > 2000 pe Treatment: Carbon removal as minimum requirement (normal areas) Sludge: Incineration
Scenario 3: **Best Available Technique (BAT)** ➔ *Strong Efficiency* ***and Consistency*** Urbanisation like Scenario 2	Additionally reduction of nutrient emissions by BAT ➔ "Unavoidable" emissions resting G+A+CEE: better state than in 2000	G+A: like 2000 CEE: like 1989	Sewerage: all settlements > 2000 pe Treatment: nutrient removal as minimum requirement (sensitive areas) Sludge: 50% Incineration, 50% reuse

Tab. 4 Continued: Scenarios in the Danube Basin with corresponding C, N, P (and S) balances of the total system nutrition with Agriculture: Plant and Animal nutrition, Human nutrition and Waste as well as waste water Management Period: 2000- (2012) 2015 (G= Germany, A= Austria, CEE= Central and Eastern European EU)

Scenarios ➔ *with corresponding sustainable criterions*	**Agriculture:** **Plant and Animal nutrition** (also Feed Industry) ➔ Feed production and consumption, Food production	**Human nutrition** (also Food Industry) ➔ Food processing and consumption	**Waste and Waste Water Management** (Infrastructure Sewage, TP) ➔ Nutrient removal and recycling
*Efficiency + Consistency +**Sufficiency***	**S U S T A I N A B L E D E V E L O P M E N T**		
Scenario 4: **Sustainability / Green** **= Regional Markets (RM)** ➔ *Efficiency + Consistency +**Sufficiency*** Urbanisation lesser than Scenario 2+3	Need oriented feed and food production / Structural changes: Integrated need oriented plant and animal production G+A+CEE Optimised foreign trade with feed and food (imports and exports) ➔ Simultaneously economical, ecological and social optimisation	Healthy food consumption (esp.animal fat +protein/meat) Need oriented food consumption D+A+CEE	Sewerage: improved on site treatment and reuse Treatment: nutrient removal as minimum requirement (sensitive areas) Sludge: 20% Incineration, 80% reuse
Scenario 5: **Policy Scenario** **= Weak Sustainability** Urbanisation like Scenario 2	Expected situations according to the present and proclaimed (inter-)national laws and directives as well as intensions and their implementations regarding agriculture, Human nutrition and Waste as well as Waste Water Management(i.e. also intensions of ICPDR (2001/2005) for N and P emission reduction) Nitrate directive (1991) IPPC-directive (1996) UN/ECE (1999) + NEC/EU (2000)directives Agenda of Rio (1992) Agenda 2000 of the EU (1999) EU water framework directive (2000) National directives	Open declarations for food Recommendations for healthy nutrition	Sewerage: all settlements > 2000 pe Treatment: Carbon removal as minimum requirement (normal areas) and improved treatment if ambient water quality requires it. Sludge: 50% Incineration, 50% reuse
Scenario 6: **Consistency Black Sea (CBS)** Urbanisation like Scenario 2	**Nutrient management in the Danube Basin oriented on the critical levels and loads of the N and P inputs from the delta into the Black Sea: Critical nutrient loads and environmental limits for the Western Black Sea** *Based on tolerable natural loads of N, P and Si from the Danube Basin to the Black Sea sets of measures are combined in a way that this goal of tolerable emissions / immissions reach in a most cost effective way. The question is what are the minimum requirements in nutrient management (agriculture, human nutrition, waste water management) in the Danube Basin to reach prerequisites for a stable development of the Black Sea ecosystem.*		

Nutrients as a Transboundary Pressure in the DRB Summary of Interim Results from the daNUbs Project and further Perspectives

Helmut Kroiss

Institute for Water Quality and Waste Management, Vienna University of Technology, Karlsplatz 13, 1040 Wien, Austria (hkroiss@iwag.tuwien.ac.at)

Introductory remarks

The flows of the nutrients nitrogen (N) and phosphorus (P) play an important role in natural aquatic systems. Their effect on the development of aquatic life is only dominant, if N and/or P limit the growth of the plants and all other compounds necessary for primary production are abundant. In most of the aquatic environments which are markedly influenced by human activity we assume that at least one of the two nutrients controls the eutrophication process.

Natural environments without human influence have a continuous flow of nutrients through the aquatic system (e.g. a River Basin including the coastal waters) coming from diffused sources and ending up in sediments (N and P) or in the air (N). Human activity changes the flows of nutrients and increases the potential development of primary production (algae) and the food chain making use of this nutritional potential.

- The mass flow (kg/year) to an aquatic system represents (only) a potential for algae production in rivers and sea.
- The **use of this potential** for primary production **is limited by the concentration of one** essential **nutrient** necessary for growth or by the climatic conditions.
- The **ratio of nutrients (esp. N/P)** and the specific climatic and geologic background of the catchment (water chemistry) **influences the competition between the species and the development of the foodchain.**
- Additional anthropogenic influence on growth and species beyond nutrient emissions can be:
  - Fishery (e.g. overfishing)
  - Import of “foreign” species (e.g. Mnemiopsis leydii)
  - Waste water discharges containing other “nutrients” or inhibitors

Data interpretation

The basic data for all considerations regarding the role of nutrients are concentrations in the water.
The most reliable data are those for dissolved (inorganic) nutrients. The measured value is already the result of the following processes and their related history:

- Natural nutrient input
- Anthropogenic input
- Primary production (sunlight and other climatic conditions)
- Release of nutrients from breakdown of organic solids (including denitrification)
- Transport phenomena including intermediate storage

- “final” storage in sediments (e.g. deep sea)

All these processes are subject to strong variations over time (day, season, year, decades) and are strongly influenced by specific local and regional conditions.

There are much less reliable data on particulate nutrient compounds. Their interpretation is even more difficult than for the dissolved compounds.

The basic consequence of these statements is that the interpretation of measured concentrations without using models is very limited and can be misleading. DWQ model includes a great part of the influencing processes and the related mass flows using the flow data.

Specific local and regional conditions

We can distinguish between natural conditions and anthropogenic influences. Natural conditions are characterised by the fact that we cannot influence them.

Natural conditions:
- Geology
- Morphology (e.g. slope)
- Climate (temperature, precipitation, wind, latitude)

Anthropogenic influences:
- Agriculture
  - Crops
  - Volume of production
  - Animal production (volume and density)
  - Practice (fertilizing, manure handling)
- Water and waste water management (municipal, industrial, storage)
- Air pollution (incineration, traffic)

Using the information about the natural conditions and knowing the relation between the natural conditions, the anthropogenic influences and their effect on the nutrient fluxes different scenarios can be developed which include economical, political and technological tools. After an assessment of the different scenarios a decision has to be made for the implementation of one of the strategies. The monitoring results during and after implementation are introduced in a new assessment for improved performance or change of strategy.

Assessment of the actual state

Western Black Sea Coastal Area (WBSC)
The actual state of the WBSC can be characterised as follows:
- Strong improvement during the last years
- Climatic conditions during the last years have been favourable for this development
- Fish population still not recovered

Indicators for this improvement are:
- Anaerobic conditions in the sediments (anoxia) have nearly disappeared

- Number of macrobenthic species in the WBSC has markedly increased
- Algae growth is phosphorus limited (in summer, in winter probably light limited)
- Rare algae blooms (similar to the 1960ies)

<u>Nutrient transport from catchment to Black Sea</u>

Actual situation

- P discharge to WBSC has decreased by about 50% compared to the early 1990ies, the situation is comparable to the 1960ies
- N discharge has markedly decreased, probably by about 30%, data consistency makes problems
- There is a slow trend towards lower nutrient loads from Germany and Austria
- A strong decrease in nutrient emissions has taken place in the Eastern Danubian Countries (EDC), but an increase can be anticipated due to an increasing use of market fertilizers

The main causes for this positive development are:

- Economic crisis in EDC countries since 1989
- Change of agriculture from economically driven production to nutritional survival of the population, closure of the large animal production plants and of fertilizer industry (market fertilizer application close to zero)
- Use of P free detergents in D, A, and increasingly in EDC
- N and P removal at municipal treatment plants in D, A, CZ
- Improved agricultural practice

Models

The MONERIS model and the DWQ-model are suitable to describe the consequences of these changes in the catchment for N and P discharge to Black Sea with adequate accuracy for strategic decisions, not for adequate description local and regional peculiarities.

Drivers

The main driving forces for N and P **discharge to the Black Sea** are (actual state):
Anthropogenic drivers:

- Agriculture
- Wastewater management (Sewerage, wastewater treatment)
- Air pollution by the traffic with NO_X

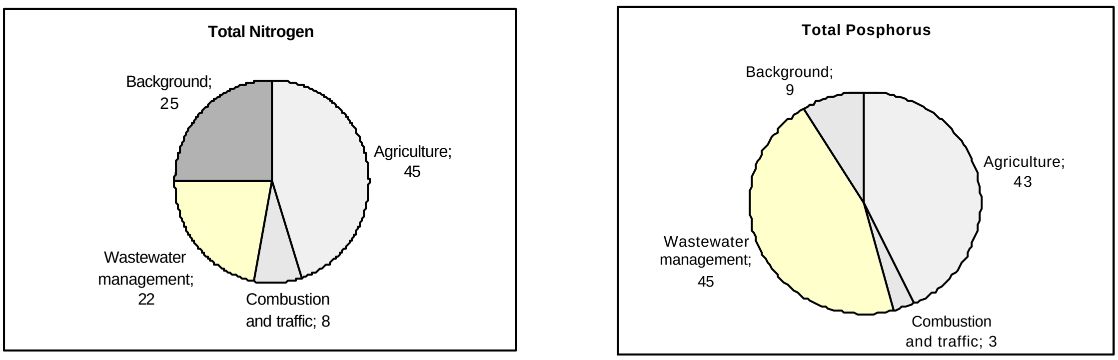


Fig.: sources of nutrient emissions 1998-2000 into the Danube

Driving forces for **N, P emissions to water system** in agriculture:

a: Anthropogenic

- Fertilizer management in plant production
- Production of animal protein and fat (milk, meat, eggs)
- Soil quality management, erosion abatement, etc.
- Economic competitiveness of agricultural products

b: Natural

- Soil geology
- Precipitation (amount, distribution)
- Climatic conditions
- Slope
- Residence time in groundwater

Driving forces for **transport and losses:**

- Denitrification potential mainly from source to medium size rivers with strong emphasis on processes in soil and ground water (residence time) and interaction between ground and river water (littoral areas).
- Large rivers (including wetlands along these rivers and the delta) have only little influence on N transport and loss.
- Erosion together with overfertilisation strongly contributes to transport of particulate nutrient loads, their role for eutrophication is included in DWQM, but is still not very well understood. The role of particulate nutrient loads in the Black Sea Coastal Area may depend on the easily accessible nutrient loads as primary eutrophication potential. In case of anoxia at the sea bottom, nutrient release from the sediments represents an unpredictable additional potential for eutrophication.

Conclusions

The modelling and understanding of the nutrient transport and of their effect on the Western Black Sea allows the following conclusions:

- The Danube is the main contributor to eutrophication phenomena in WBSC.
- Nutrient characterisations in Danube river will probably meet good status requirements.
- The actual status of WBSC is close to “good” (except fish population).
- The climatic conditions during the last years were very favourable for WBSC.
- Eutrophication in WBSC is actually phosphorus limited and the N/P ratio is “good”.
- Economic crises and decrease of soluble P by P free detergents and P removal at treatment plants (A, D,CZ) were the main drivers for the improvements in WBSC.
- Agriculture is the main driver for nitrogen emission to water systems and the transboundary transport. For phosphorus point sources are essential too.
- The regional contribution of agriculture to the transboundary transport to WBSC strongly depends on
    - Kind and size of production
    - Geologic, morphologic and climatic condition
    - Agricultural practice

- The actual data as well as historic records reveal important inconsistencies, which result in difficult calculation and validation problems for the models.
- The data basis for the models has to be improved in the future in order to improve accuracy of modelling results.
- The models are based on strong differing time scale and spatial relevance; from hours (DWQM, DDM) to at least 5 years (MONERIS) to ground water with detention times of > 20 years. The anthropogenic changes in the whole river basin are superposed by the variability of climatic conditions (precipitation, wind, temperature).
- The establishment of a clear correlation between measures taken and the response in the status of Danube and WBSC needs long term reliable monitoring adapted to the questions to be answered.

Economic development and anticipated pressures for nutrient management in Danube Basin

Diffuse sources development by agricultural activity:

- Increase of agricultural production in EDC
- Increase of area specific production in EDC
- Return to fertilizer management as before 1989
- Increased and centralized meat (animal protein and fat) production

Point sources:

- Reconstruction of fertilizer production plants without adequate nutrient discharge control
- Reconstruction of animal production industries without strong nutrient control
- Return to P containing washing powders
- Sewerage development without adequate wastewater treatment (P and N-removal)
- Industrial development without adequate nutrient discharging control for their wastewaters and NO_X emissions
- Neglect of continuous and effective education in good agricultural practice along with adequate facility development for manure management

General remarks

Climatic conditions (including climate change) can lead to increase the pressure.

A great variety of economic and political tools to influence on the emissions and to avoid pressure on the environment are available.

Nutrient management needs a long lasting strategy for sustainable development with a prospective of about 30 years for stable success.

Clarifications of papers as outcomes of discussion and working groups

Discussions carried out within working group II

1) “Upper reaches are critical areas for management”
We recommend to talk about “small rivers” instead of “upper” rivers. In these rivers retention is much higher – caused by denitrifications in the river sediments. For retention the flow, flood plains as well as reservoirs are important. The river structure is very important for the rentention. From retention point of view a natural river is more efficient than a strongly canalized river.

2) The Gabcikovo and the Iron Gate reservoir have two completely different retention systems:
Iron Gate: if flow velocity decreases, sedimentation takes place in the reservoir. This happens mainly during low flow and mean flow conditions. The retention time of water in the Iron Gate is between several days to weeks. The Danube within the Iron Gate is like a river flowing on a lake, this means there is some kind of stratification.
Is it possible that anoxic conditions occur in the reservoir? Will be there a P-release? Can a flushing effect be observed during high flow conditions?
Are the sediments within the reservoir a P-reserve for the future??

Gabcikovo: retention only during flood conditions as former river stretches are dotated with water resulting in a deposition of sediments in the river bed and the flood plains.

In the middle and lower Danube there is no correlation betweeen discharge and P-concentration in the surface water.
In the Danubs Vienna there was observed a correlation during a flood event project.

The operation of the Iron gate influences the flow below.

How deep is the reservoir of Iron Gate? Estimates are between 32 and 70 m. Per year about 35000 kt of sediments are deposited. In regard to the volume of about 2.5 km3 in about 100 years a equlibrium could be reached. A rough estimation will be given in the daNUbs project.

Satellite images indicate that the Danube is not the only influence to the Western Black Sea but also the Dnjepr and the Dnjestr contribute significant loads to the Black Sea.
The images shown depict a situation with wind from a southern directions- as a result everything moves north. The Danube is the main disposer. The Dnjepr/Bug plays a certain role, the Dnjestr is negligible (recently a transboundary diagnostic analysis was completed for the Dnjepr river).
The distribution of Chlorophyll very much depends on wind conditions.
The north western area is a much more shallow area. The impact of mixing by various currents and rims is not given to that extent.
The Dnjepr is strongly dammed. Therefore the flow is controlled. Furthermore there is a liman at the mouth of the river influencing the distribution of the discharge. In the Dnjepr a pulse release could be expected under extreme conditions. But: how can we properly sample these extreme events??

Other researchers in the Danube Basin and elsewhere reveal the same retention for N (e.g. in the EROS project)

Policy can react faster in the reduction of P . It makes sense to reduce the limiting factor. The reduction on N would be more expensive.
There is a strong priority to reduce P (resp. to keep it low)

In the very shallow limans/lagoons the satellite images can not be used. As the signals are influenced e.g. by the bottom.

Questions distributed:

Climate change could release a considerable amount of N due to an increased mineralisation in the soils in the winter time.

The Danube Delta is not relevant for nutrient retention as only a small amount of water enters the Delta. The restoration of the Delta could increase the importance of the Delta for nutrient retention. But it is not expected to be become of high importance. Wetlands are only efficient if a relatively low amount of water is discharged and the residence time is long.

The role of stocks in the river systems including the sediments:
Sedimentation takes place in the reservoirs and during low flow conditions also in the riverbed itself.

The characteristics of P transport shows a different characteristics in the Danube upstream of the Iron gate and downstream.
Upstream: a transformation of P dissolved to P adsorbed can be observed. Furthermore there is transport during high flow conditions and sedimentation during low flow conditions.
For N no significant changes during high flow conditions could be observed. N remains dissolved (not adsorbed)

The annual cycle on N-concentrations in river systems is dominated by denitrification and not by biological incorporation.

For the Zala river there is some indication that P-remobilisation during summer time takes place.

The accuracy of calculations of nutrient transportation is strongly influenced by the accuracy of data. Main discrepancies are due to different analytical methods.
In the TNMN data the laboratories have to be inside a deviation of 20
% (except low concentrations: absolute deviations are given)
We have to be careful by subtracting two concentrations. in both values a certain error is given – the errors have to be summed up.

The ICPDR provides a load calculation assessment from 2000 onwards.

The correspondence of algae growth to light conditions is very important. The content of organic C, humic acids, suspended solids as well as algea itself influence light conditions. If

perfect data on this is available only about 50% of the reality can be described. this means that the accuracy never can be better than 50%.
The weakest point in load calculation is quality control. Therefore an increase of the sampling frequency does not make sense.

The improvement in the Black Sea goes into the right direction. However we should be careful to draw to strong conclusions.

ICPDR – UNDP/GEF workshop

Nutrients as a Transboundary Pressure in the DRB

26-27 January 2004, Sofia

Questions for working group discussion Session II

working group A: Regional Differences of Sources, Pathways and Storage for Nutrients in the DRB (drivers and pressures)

Chair: Horst Behrendt, rapporteur: Matthias Zessner

- What are the dominant point and diffuse sources for the nutrient emissions into the Danube river system? Where are the hot spots for these sour ces?
- How do natural conditions (climate, hydrology, geology and soils) influence the nutrient emissions on a short, mean and long term run?
- To what extend does population's lifestyle and the economic situation/ economic development (e.g. waste water manage ment, agriculture, nutrition) influences the nutrient emissions? What were the changes of the nutrient emissions and loads in the last decades? What could be the possible changes for the future?
- What is the role of stocks of nutrients in the catchment (soils, groundwater)? How do we have to consider them for the development of scenarios?
- What is the accuracy of the nutrient emissions calculations and which data improvements and model developments are necessary to increase the accuracy of results?

working group B: Danube River as Conveyer Belt for Nutrients and their Impacts on Western Black Sea (state and impact)

Chair : Jos von Gils, rapporteur : Christoph Lampert

- Which causes and conditions (e.g. hydrological events, climate) influence the transport of nutrients from the catchment to the Sea? To what extend does the Danube delta retain nutrients?

- What is the role of nutrient stocks in the river system including the river sediment?
- What is the accuracy of calculations of nutrient transport in the Danube river and which data improvements and model developments are necessary to improve accuracy and reliability of the information?
- Which relations exist between the nutrient loads from the Danube Basin and the quality of the Black Sea (coastal area)? What indicators or criteria can we use to express the state of the Shelf in relation to the Danube nutrient loads? What are the consequences of P-, N-reduction and Si-reduction in the Danube for the Black Sea ecosystem? What is the limiting nutrient(P or N) for the primary productivity in the Black Sea and consequently should have the priority for reduction in the rivers? What is the role of nutrient stocks in the coastal area?
- What is the accuracy of calculations of effects of nutrients discharges on the Black Sea ecosystem and which data improvements and model developments are necessary to improve accuracy and reliability of the information?

working group C: Socio-economic development in the DRB and its Impact on Future Nutrient Management (impact and response)

Chair: Wilfried Schönbäck, rapporteur: Helmut Kroiss

- What economical development of different Danubian countries can be expected?
- How will the economical development of Danubian Countries influence the development of nutrient loads in the Danube and the Black Sea?
- What data, information and analytical tools are missing?
- Which economic and policy instruments should be considered as area for future intervention to manage nutrient emissions in the Danube Basin?