UNDP/GEF Danube Regional Project

Policies for the Control of Agricultural Point and Non-point Sources of Pollution & Pilot Projects on Agricultural Pollution Reduction (Project Outputs 1.2 and 1.3)

INTERIM INVENTORY:

Agricultural Non-Point Source Pollution by Nitrogen and Phosphorus in the Danube River Catchment (by Country)

Revised Version
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Prepared using final project data supplied (May 2003) by the Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin

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Danube Regional Project - Project RER/01/G32

”Policies for the control of agricultural point and non-point sources of pollution”
and “Pilot project on agricultural pollution reduction”
(Project Outputs 1.2 and 1.3)

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INTRODUCTION

The data presented in this inventory are derived from the final results of the project entitled "Harmonised Inventory of Point and Diffuse Emissions of Nitrogen and Phosphorus in the Danube Basin" undertaken by the Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin[1].

This project aimed to determine and calculate the annual nutrient emissions into the Danube river for the period 1998 to 2000 by applying the so-called **MONERIS** (Modelling Nutrient Emissions in River Systems) mathematical model to the 388 sub-basins of the Danube river.

The MONERIS-emission model was originally developed by IGB for estimating point source and non-point source nutrient emissions into the surface waters of river basins in Germany. It is GIS-based and uses extensive statistical data to estimate total nutrient emissions into the Danube river system via 7 main pathways (see Figure 1):

1. discharges from point sources

2. diffuse nutrient inputs into surface waters via:

    - atmospheric deposition
    - groundwater
    - tile drainage
    - paved urban areas
    - soil erosion
    - surface run-off

Estimations of Agricultural Non-Point Source Pollution

Within the MONERIS model there are 4 main nutrient emission pathways influenced significantly by agriculture – namely, losses via:

- groundwater
- tile drainage
- soil erosion
- surface run-off

One of the main factors determining the size of nutrient losses via these pathways is the nutrient surplus (i.e. positive nutrient balance) of agricultural topsoil. Nutrient balances for the Danube river catchment were prepared by IGB using the standard OECD soil surface nitrogen balance methodology with crop and livestock data supplied by national consultants for selected countries. Where these data were not available, figures from the OECD and FAO databases were used.

[1] This project was funded by the German Federal Environmental Agency

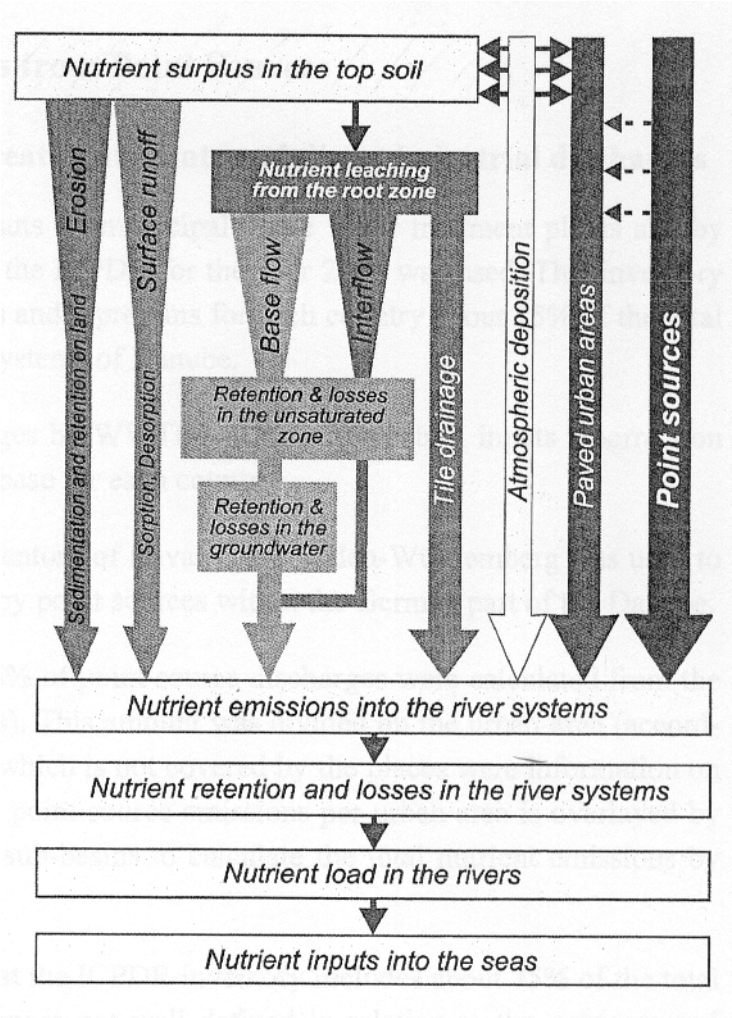

Figure 1: Pathways and processes in MONERIS

The total contribution of agricultural non-point source pollution to nutrient emissions into the Danube river is estimated by IGB as the **sum of losses** via Surface Run-off, Erosion, Tile Drainage and Groundwater **less** Background losses.

The final estimates of agricultural non-point source nutrient emissions from IGB are presented country-by-country on the following pages. One of the principal limitations to the accuracy of these estimates is the calculation of nutrient surpluses in the top soil – for example, the estimated nitrogen balance for each country is also shown on the following pages together with a comment on the limitations of the data sources used.

SUMMARY DATA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Agricultural Non-Point Source Pollution Losses of:

	Nitrogen (N) tonnes N year^{-1}	**Phosphorus (P)** tonnes P year^{-1}
Germany	75,553	1,561
Austria	28,900	1,947
Czech Republic	16,314	841
Slovakia	16,702	1,340
Hungary	8,700	1,639
Slovenia	10,629	349
Croatia	14,886	646
Bosnia & Herzegovina	7,332	963
Serbia & Montenegro	10,487	1,528
Romania	68,366	4,862
Bulgaria	18,197	1,379
Moldova	2,113	501
Ukraine	13,976	770
Other	388	33
TOTAL	**292,543**	**18,359**

GERMANY

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	56,633	km^2
Agricultural Area[2]	32,839	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	3,063		101	
+ "Erosion"	1,280		1,366	
+ "Tile Drainage"	7,509		30	
+ "Groundwater"	83,081		632	
- "Background"	19,380		568	
= Total Agriculture	**75,553**	**23.0***	**1,561**	**0.5***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **90.9** kg N ha^{-1} agricultural land

Comments Estimated nutrient surpluses for agricultural top soil in Germany were taken for the period 1950 – 1995 from Behrendt *et al.* (2000)[3]

[2] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[3] Behrendt, H., Huber, P., Kornmilch, M., Opitz, D., Schmoll, O., Scholz, G. & Uebe, R. (2000). Nutrient balances of German river basins. UBA-Texte 23/200. Umweltbundesamt (UBA), Berlin

AUSTRIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	80,853	km^2
Agricultural Area[4]	29,639	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	15,775		342	
+ "Erosion"	2,327		2,736	
+ "Tile Drainage"	3,373		17	
+ "Groundwater"	37,085		568	
- "Background"	29,660		1,716	
= Total Agriculture	**28,900**	**9.8***	**1,947**	**0.7***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **44.0** kg N ha^{-1} agricultural land

Comments For Austria, top soil nutrient surpluses were calculated on a district level for 1999 by IGB according to the standard OECD methodology[5] and based upon statistical data provided by national consultants

[4] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[5] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

CZECH REPUBLIC

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	21,692	km^2
Agricultural Area[6]	13,054	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	90		2	
+ "Erosion"	1,069		814	
+ "Tile Drainage"	8,056		23	
+ "Groundwater"	10,288		58	
- "Background"	3,189		56	
= Total Agriculture	**16,314**	**12.5***	**841**	**0.6***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **46.8** kg N ha^{-1} agricultural land

Comments For the Czech Republic, nutrient surpluses were calculated for 1995 on a district basis and for 1950 – 1995 on a country basis according to the standard OECD methodology[7] by the *Research Institute of Plant Production (VURV)*

[6] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[7] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

SLOVAKIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	47,213	km^2
Agricultural Area[8]	23,890	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	584		23	
+ "Erosion"	1,505		1,276	
+ "Tile Drainage"	6,089		44	
+ "Groundwater"	17,176		209	
- "Background"	8,652		212	
= Total Agriculture	**16,702**	**7.0***	**1,340**	**0.6***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **23.9** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Slovakia was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[9] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[8] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[9] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

HUNGARY

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	92,767	km^2
Agricultural Area[10]	66,400	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	40		1	
+ "Erosion"	1,272		1,419	
+ "Tile Drainage"	5,817		50	
+ "Groundwater"	5,651		319	
- "Background"	4,080		150	
= Total Agriculture	**8,700**	**1.3***	**1,639**	**0.2***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **21.9** kg N ha^{-1} agricultural land

Comments For Hungary, top soil nutrient surpluses were calculated on a district level for 1999 by IGB according to the standard OECD methodology[11] and based upon statistical data provided by national consultants

[10] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[11] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

SLOVENIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	16,408	km^2
Agricultural Area[12]	6,153	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	954		34	
+ "Erosion"	371		331	
+ "Tile Drainage"	811		4	
+ "Groundwater"	14,788		201	
- "Background"	6,295		221	
= Total Agriculture	**10,629**	**17.3***	**349**	**0.6***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **73.6** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Slovenia was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[13] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[12] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[13] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

CROATIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	34,629	km^2
Agricultural Area[14]	18,011	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	733		31	
+ "Erosion"	802		575	
+ "Tile Drainage"	3,504		20	
+ "Groundwater"	17,515		251	
- "Background"	7,668		231	
= Total Agriculture	**14,886**	**8.3***	**646**	**0.4***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **39.2** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Croatia was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[15] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[14] Total area of agricultural land (derived from adjusted IGBP land use data) within the national territory that forms part of the Danube catchment

[15] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

BOSNIA-HERZEGOVINA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	37,597	km^2
Agricultural Area[16]	13,778	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	907		39	
+ "Erosion"	1,247		939	
+ "Tile Drainage"	687		9	
+ "Groundwater"	15,616		323	
- "Background"	11,125		347	
= Total Agriculture	**7,332**	**5.3***	**963**	**0.7***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **15.9** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Bosnia-Herzegovina was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[17] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[16] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[17] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

SERBIA & MONTENEGRO

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	88,495	km^2
Agricultural Area[18]	46,686	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	1,000		42	
+ "Erosion"	1,922		1,450	
+ "Tile Drainage"	2,710		32	
+ "Groundwater"	19,220		384	
- "Background"	14,365		380	
= Total Agriculture	**10,487**	**2.2***	**1,528**	**0.3***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **11.9** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Serbia & Montenegro was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[19] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[18] Total area of agricultural land (derived from adjusted IGBP land use data) within the national territory that forms part of the Danube catchment

[19] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

ROMANIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	222,332	km^2
Agricultural Area[20]	112,931	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	3,360		136	
+ "Erosion"	4,956		4,611	
+ "Tile Drainage"	22,388		137	
+ "Groundwater"	75,173		1,146	
- "Background"	37,511		1,168	
= Total Agriculture	**68,366**	**6.1***	**4,862**	**0.4***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **21.5** kg N ha^{-1} agricultural land

Comments For Romania, top soil nutrient surpluses were calculated on a district level for 1999 by IGB according to the standard OECD methodology[21] and based upon statistical data provided by national consultants

[20] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[21] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

BULGARIA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	55,193	km^2
Agricultural Area[22]	35,946	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	723		19	
+ "Erosion"	1,392		1,346	
+ "Tile Drainage"	2,450		16	
+ "Groundwater"	23,477		227	
- "Background"	9,845		229	
= Total Agriculture	**18,197**	**5.1***	**1,379**	**0.4***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **16.8** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Bulgaria was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[23] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[22] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment

[23] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

MOLDOVA

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	12,326	km^2
Agricultural Area[24]	11,474	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	0		0	
+ "Erosion"	567		485	
+ "Tile Drainage"	1,494		8	
+ "Groundwater"	298		19	
- "Background"	245		12	
= Total Agriculture	**2,113**	**1.8***	**501**	**0.4***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **19.1** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Moldova was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[25] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[24] Total area of agricultural land (derived from adjusted IGBP land use data) within the national territory that forms part of the Danube catchment

[25] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

UKRAINE

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	33,926	km^2
Agricultural Area[26]	19,433	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	1,580		52	
+ "Erosion"	973		664	
+ "Tile Drainage"	2,066		17	
+ "Groundwater"	19,077		339	
- "Background"	9,720		302	
= Total Agriculture	**13,976**	**7.2***	**770**	**0.4***

* calculated on the basis of the total area of agricultural land within the Danube catchment

Estimated N Balance **15.7** kg N ha^{-1} agricultural land

Comments The soil surface nutrient balance for Ukraine was calculated on a country basis for the period 1961 – 2000 according to the OECD methodology[27] based on data from FAO Statistics (i.e. FAOStat 98 for the period 1961 – 1998 and the FAO website for the period 1999 – 2000)

[26] Total area of agricultural land (derived from adjusted IGBP land use data) within the national territory that forms part of the Danube catchment

[27] OECD (2001). *OECD National Soil Surface Nitrogen Balances: Explanatory Notes* (March) – available from: www.oecd.org/agr/env/indicators.htm

OTHER

Data provided by IGB, Berlin – results from MONERIS model (May 2003)

Catchment Area	2,823	km^2
Agricultural Area[28]	296	km^2

Loss	**Nitrogen (N)**		**Phosphorus (P)**	
	t N yr^{-1}	kg N ha^{-1} yr^{-1}	t P yr^{-1}	kg P ha^{-1} yr^{-1}
"Surface Run-off"	1,114		23	
+ "Erosion"	121		159	
+ "Tile Drainage"	10		0	
+ "Groundwater"	493		12	
- "Background"	1,350		161	
= Total Agriculture	**388**	**13.1***	**33**	**1.1***

* calculated on the basis of the total area of agricultural land within the Danube catchment

[28] Total area of agricultural land (derived from CORINE land cover data) within the national territory that forms part of the Danube catchment