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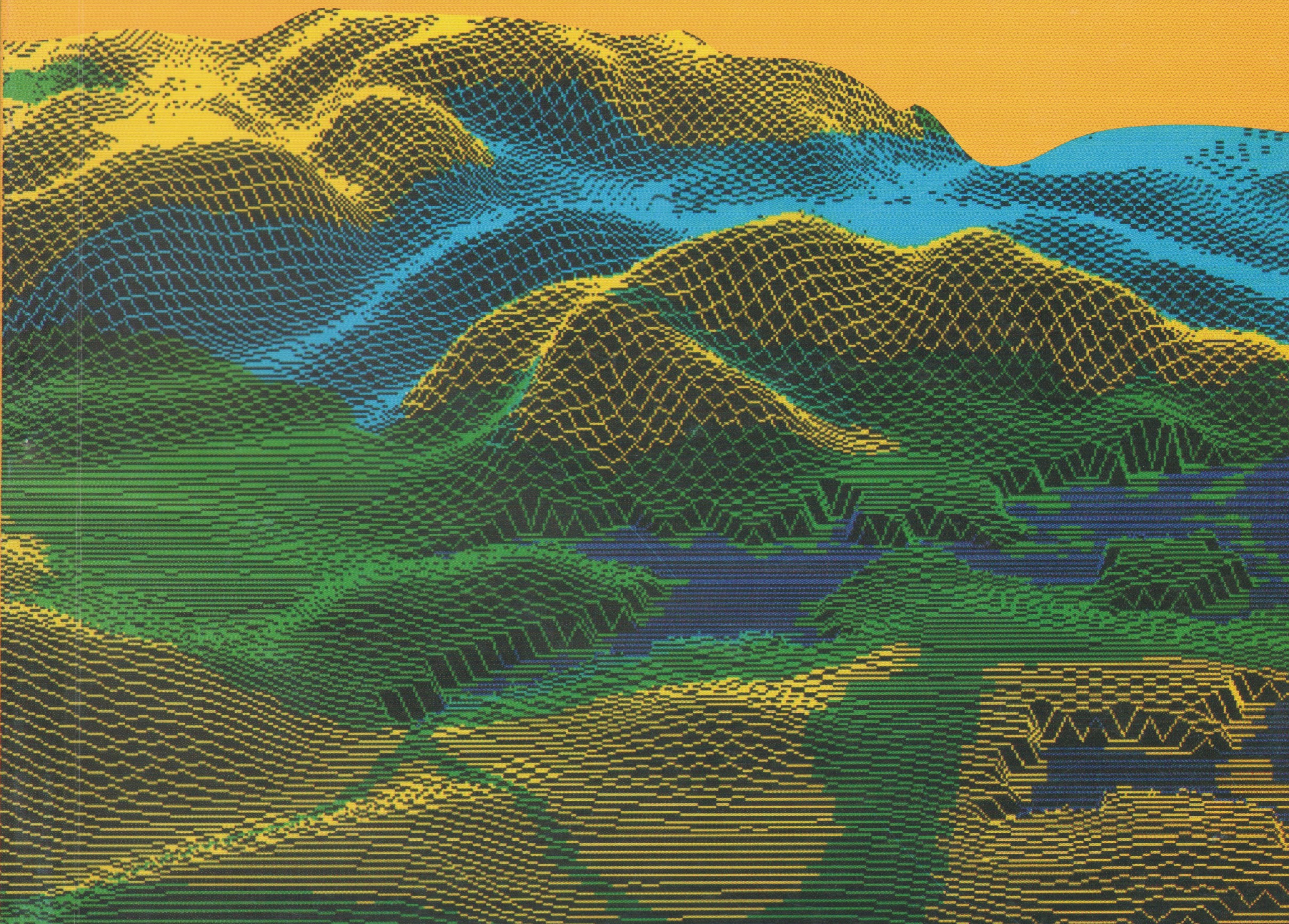

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Articles

Reports

Slovenian landscape with piedmont agriculture with typical driers

Photo: O. Mikulík

Illustration to B. Lampič's paper

Smoke blanket over Cracow

Photo: O. Mikulík

Illustration to K. Jarzyna's paper

AGRICULTURAL POLLUTION OF THE ENVIRONMENT IN SLOVENIA FROM THE ASPECT OF ENERGY AND NITRATE CONSUMPTIONS

Barbara LAMPIČ

Abstract:

Level of agricultural pollution of environment, in Slovenia reflected mostly in pollution of underground water with nitrates and pesticides, is presented in the article according to energetic intensity of agriculture. Agricultural pollution is irregular due to different orientation and intensity of agriculture, as well as to different sensitivity of particular landscapes. Pollution with nitrates is one of the most urgent pollution of Slovene underground waters, therefore with the nitrogen balances also surpluses of nitrogen of organic and mineral source are evaluated additionally and are the basis for determination of pollution of underground water with nitrates, which is also proved by the analysis of the same. Analysis of agricultural pollution of four main landscape types (gravel plains, tertiary hilly areas, mountainous areas, karst areas), as well as of Slovenia as a whole, is presented with determination of energetic intensity of agriculture with surpluses of nitrogen.

Shrnutí

Zemědělské znečišťování životního prostředí ve Slovinsku z pohledu energetické náročnosti a spotřeby nitrátů

Stupeň zemědělského znečištění životního prostředí, který se ve Slovinsku nejvíce odráží ve znečišťování podzemních vody dusičnany a pesticidy, je v příspěvku prezentován na základě energetické intenzity zemědělství. Stupeň zemědělského znečištění závisí jednak na orientaci a intenzitě zemědělství, jednak na rozličných typech krajiny. Znečištění dusičnany patří k nejzávažnějším znečištěním slovinských podzemních vod. Byl proveden rozbor energetické intenzity zemědělství a přebytků dusíku organického i minerálního původu v patnácti modelových územích, který byl doplněn chemickými analýzami obsahu dusičnanů v podzemních vodách. Na základě těchto kroků pak byla zpracovaná analýza zemědělského znečišťování všech čtyř hlavních krajinných typů Slovinska (štěrkové roviny, terciérní pahorkatiny, horské oblasti, krasové oblasti) i Slovinska jako celku.

***Key words**: agricultural pollution of environment, energetic intensity of agriculture, structure of agricultural inputs, nitrogen balance, surpluses of nitrogen, nitrates, Slovenia*

1. Introduction

From year 1990 researches in agrarian pollution of environment are being executed in Slovenia in accordance with the method of energetic intensity of agriculture (Slesser, 1975). This problem is also the topic of the present article. More than 20 researches were executed up till now according to this methodology (Radinja, 1996, Rejec Brancelj, 1999) which were determining the level of energetic intensity for particular settlements or regions.

In the present research, which is based on fieldwork (inquiry, collection of water samples), in Slovenian 15 Sloven regions 556 farms in 111 settlements on in total 5.843 ha of cultivable areas, which presents 1.2 % of all cultivable areas in Slovenia, are researched. Methodology of Slesser is complemented also with the nitrate analysis and analysis of water quality, first of all underground water.

Surface of Slovenia occupies only 20.000 km2 but nevertheless pollution of environment varies due to significant landscape variety, which results in different intensity of agriculture.

In year 1997, the average level of agricultural pollution of environment amounted to 38 GJ/ha of cultivable areas, which exceeds Sesslers permissible level of 15 GJ/ha - by 2.5 times, but there were great regional differences, from 12 GJ/ha which occurred in the region with the least intensive agriculture, to 69 GJ/ha in the region with the most intensive agriculture. Pollution is structurally combined of five basic inputs, the biggest share of which represents electrical energy with 45 %, liquid fuels with 20 %, organic fertilizers with a little less than 20 % and mineral fertilizers with less than 15 %. Pesticides are representing less than one percent of all inputs.

Electric energy which contributes withe the biggest share is not environmentally disputable, however inputs of organic and mineral fertilizers as well as pesticides are the biggest burden for the environment.

In Slovenia as a whole, the pollution of environment, excluding electrical energy, amounts to 20 GJ/ha of cultivable land, however if only three most environmentally burdening inputs are taken into account, this number amounts to 13 GJ/ha odd.

Nitrates in underground water of gravel plains which are the most intensive agricultural areas, are seriously threatening the quality of drinking water, therefore inputs of organic and mineral nitrogen are evaluated separately. With the balance between inputs and consumption surpluses are determined, which are on average much lower than in European countries with the most intensive agriculture, nevertheless being on average 95 kg/ha they are very close to the border of 100 kg/ha where nitrogen is being leached into the underground water. Regional differences are of bigger concern, regarding that in the regions with the least surpluses of nitrogen they amount to less than 13 kg/ha but in those with the biggest surpluses they amount to 222 kg/ha.

Water analyses also represent importance of the stated surpluses for the pollution of environment when agricultural pollution is first of all reflected in underground water polluted by nitrates.

2. Methods for determination of agricultural pollution of environment

Due to insufficient official statistic data for particular regions and due to big landscape variety of Slovenia the method of sampling was applied in some typical regions selected in each of five macroregions (Map 1). Using this method all basic landscape types and different agricultural systems were included.

Most areas were selected in Subalpine (5) and Subpannonian Slovenia (6). Agriculture in both regions is intensive, and they are composed of two elements, in Subalpine Slovenia of plains and mountains and in Subpannonian Slovenia of plains and hills. One unit was selected in Alpine as well as in Submediterranean Slovenia, regarding that extensive agriculture is prevalent in the first region which is not overpolluted yet, and in Submediterranean Slovenia a smaller but explicitly intensive region, oriented to fruit and vine growing, was selected. Two regions were selected in Dinaric-Karst Slovenia with specific water outflow.

Regarding landscape types (gravel plains, Tertiary hilly areas, mountain areas, karst areas) most selected regions are situated on gravel plains, due to the most favourable natural conditions for farming and the biggest pollution of environment, and at the same time due to the biggest reserves of drinking water. Its self-cleaning capabilities are in this landscape type much lower because of underground water. Regarding traditional forms of environmental degradation, first of all soil erosion (Radinja, 1993), plains are considered as the most safe type of landscape. However they are exposed to contemporary forms of agricultural degradation which could be defined as chemical degradation of environment.

Tertiary hilly areas as a landscape type with varying relief are characterized by a delicate natural balance which is even more unstable because of considerable wetness. Rocks which are soft and poorly resistant as well as extended cultivation, which had in many places replaced forest with its function of soil holding, are the reasons for prevalent mechanic degradation (soil erosion, denudation, landslides), however new forms of pollution appeared recently (chemical inputs).

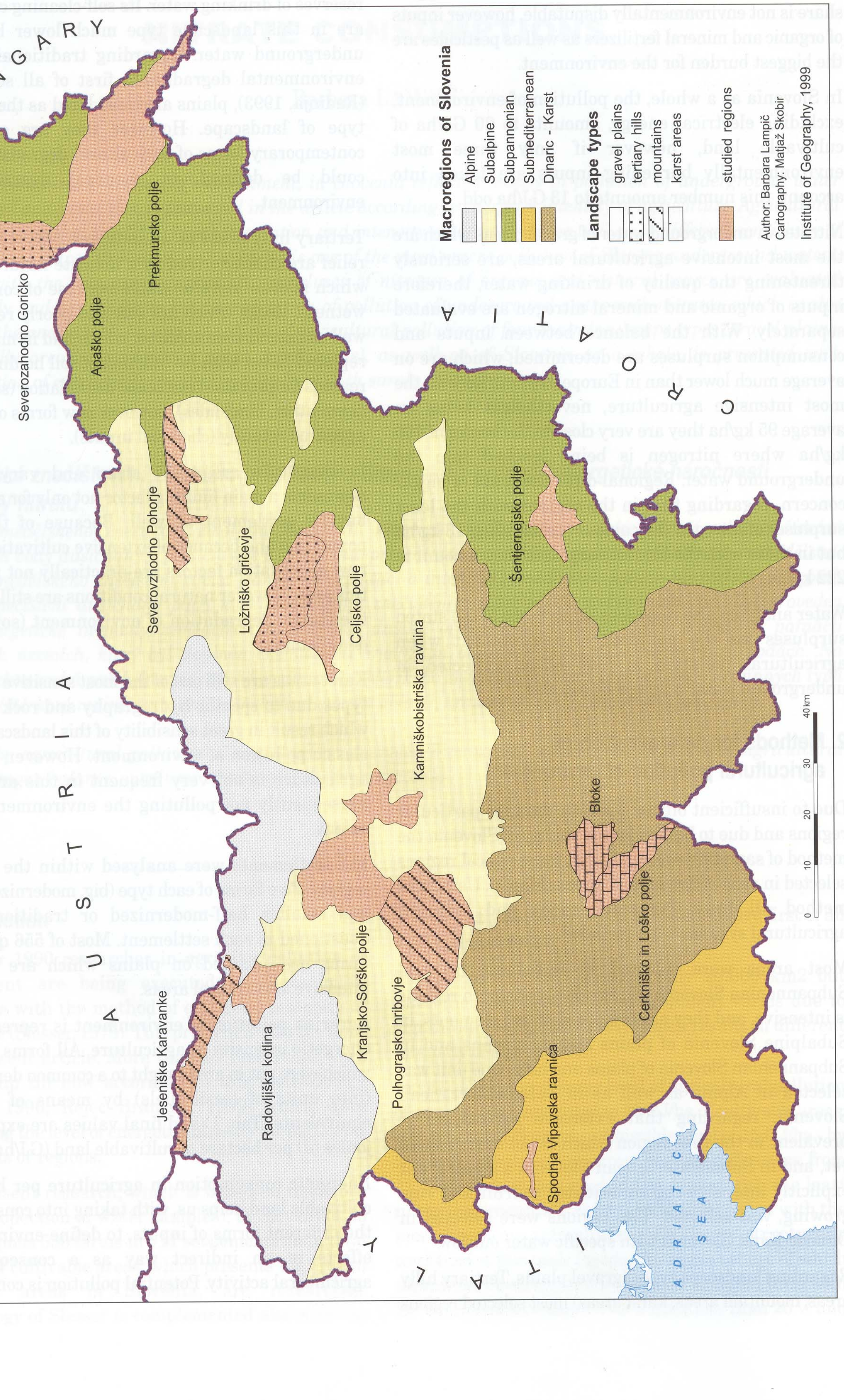
In mountain areas the steep and varying relief represents a main limiting factor not only for agriculture but for settlement as well. Because of the sparse population and because of extensive cultivation of land, new degradation factors are practically not present in this area, however natural conditions are still a cause to the classic degradation of environment (soil erosion, denudation).

Karst areas are still one of the most sensitive landscape types due to specific hydrography and rock structure which result in great sensibility of this landscape type to classic pollution of environment. However, extensive agriculture is not very frequent in this area and is consequently not polluting the environment to such extent.

111 settlements were analysed within the sampling regions. Five farms of each type (big, modernized, middle and smaller, half-modernized or traditional) were questioned in each settlement. Most of 556 questioned farms are situated on plains which are the most intensive agricultural areas.

Agrarian pollution of environment is represented by energetic intensity of agriculture. All forms of energy which were put in are brought to a common denominator (into units of fossil fuels) by means of energetic equivalents (Tab. 1) and final values are expressed in joules (J) per hectare of cultivable land (GJ/ha).

Energetic consumption in agriculture per hectare of cultivable land helps us, with taking into consideration the different forms of inputs, to define environmental effects in an indirect way as a consequence of agricultural activity. Potential pollution is considered a



Map 1 OVERVIEW OF STUDIED REGIONS IN SLOVENIA IN THE MAIN MACROREGIONS

starting point while actual effects are examined through the pollution of water, with nitrates in the first place.

It was taken into account by evaluation and interpretation of the results that the energetic and environmental weights of single inputs are differing considerably, with pesticides in the first place. Energetic value of the same is almost negligible however their ecological weight is much bigger, which is proven by their reminders in underground water as well as in soil and in cultural plants.

which supplements the method of energetic equivalents. Surpluses of nitrogen can be determined on two levels, with gross balance of nitrogen and with net balance (Schleef, Kleinhanss, 1994). Net balance offers a more detailed information on determination of environment pollution with nitrogen, since besides the inputs of nitrogen with mineral and organic fertilizers, it is also the deposition of nitrogen from the atmosphere that is taken into account, and by losses of nitrogen besides uptake of harvested crops also losses of nitrogen (ammonium) into the atmosphere is taken into account.

Tab. 1:*Energy equivalents (GER) of agricultural inputs*

ENERGETIC EQUIVALENTS OF STANDARD AGRICULTURAL INPUTS		
(DIRECT INPUT OF ENERGY ONLY)		
ITEM	UNIT	GER/UNIT (MJ/UNIT)
manure-cattle	1 kg	0.38
manure-pig	1 kg	0.45
manure-poultry	1 kg	1.90
manure-horse	1 kg	0.53
manure-sheep	1 kg	0.15
cattle liquid manure-urine	1 m^3	183
cattle slurry	1 m^3	344
pig liquid manure-urine	1 m	210
pig slurry	1 m^3	458
potassium	1 kg	9.6
phosphorus	1 kg	14
nitrogen	1 kg	67
urea	1 kg	30.8
pesticides	1 kg	110
petrol	1 l	42.1
diesel oil	1 l	45.8
electrical energy	1 kWh	14
corn mixtures	1 kg	14
strong fodder	1 kg	10.8

Sources: Slesser, 1975, Radinja, 1991, Lampič, 1995, 1999

Pollution of the environment with nitrates, of waters in the first place, represents one of the biggest problems which occurs mostly as the consequence of agriculture. Surpluses of nitrogen are the main problem which are determined on the basis of its balances (Matičič, 1996), Average input of nitrogen from the atmosphere amounts in Slovenia to 17 kg/ha (Matičič, 1996).

Determination of areas sensitive to nitrates with the balance of nitrogen is already executed in many

European countries however only few researches of this kind are represented in Slovenia, actually only experimental evaluation of the kind was made in year 1991 on the basis of rough statistical data.

Intensity of agriculture and conclusions about its effects can be further determined also regarding actual consumption of organic and mineral fertilizers, pesticides and liquid fuels per hectare of cultivable areas. Besides all this actual consequences of agrarian pollution of environment were determined also with application of direct methods, meaning with analyses of surface and underground water which were executed in years 1996 and 1997 in four regions with the most intensive agriculture and with plenty of underground water, comparing with the analyses of Hydrometeorological institute of the Republic of Slovenia. Using these methods a connection between the agricultural pollution and the pollution of underground water was determined.

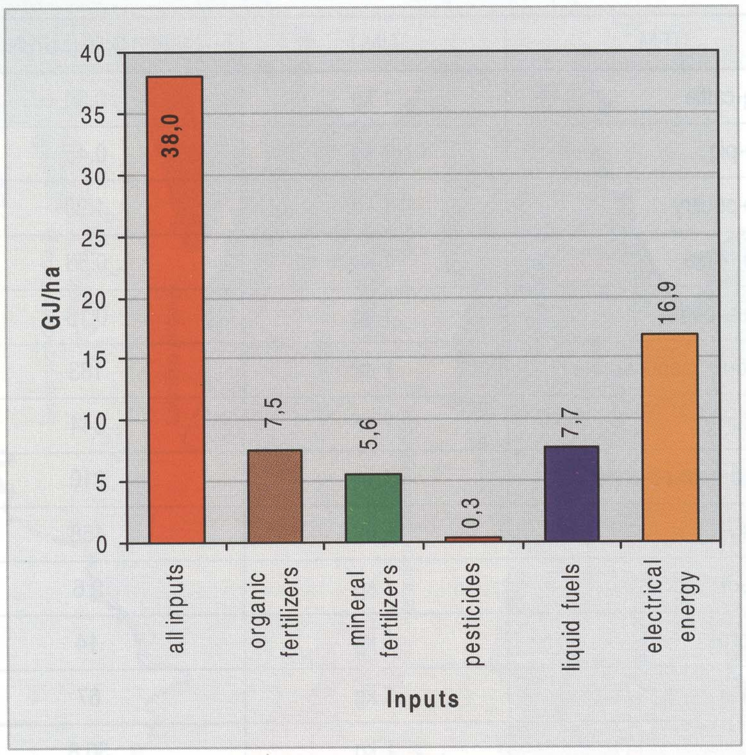
3. Energetic intensity of agriculture and structure of energetic inputs

Energetic intensity of agriculture represents a synthetic indicator of its pollution of environment. With energetic (not environmental) weight of single inputs a potential possibility of agricultural pollution is being determined, however with analyses of the structure of inputs also potentially the most troublesome kind of pollution could be determined. Slesser's admissible border of energetic intensity of agriculture, where pollution does not spread into the surroundings yet, amounts to 15 GJ/ha of cultivable land.

Researches which were in the beginning taking place on single farms and later on settlements indicate that the intensity of Slovenian agriculture can not be negligible any more for its environment (Map 2).

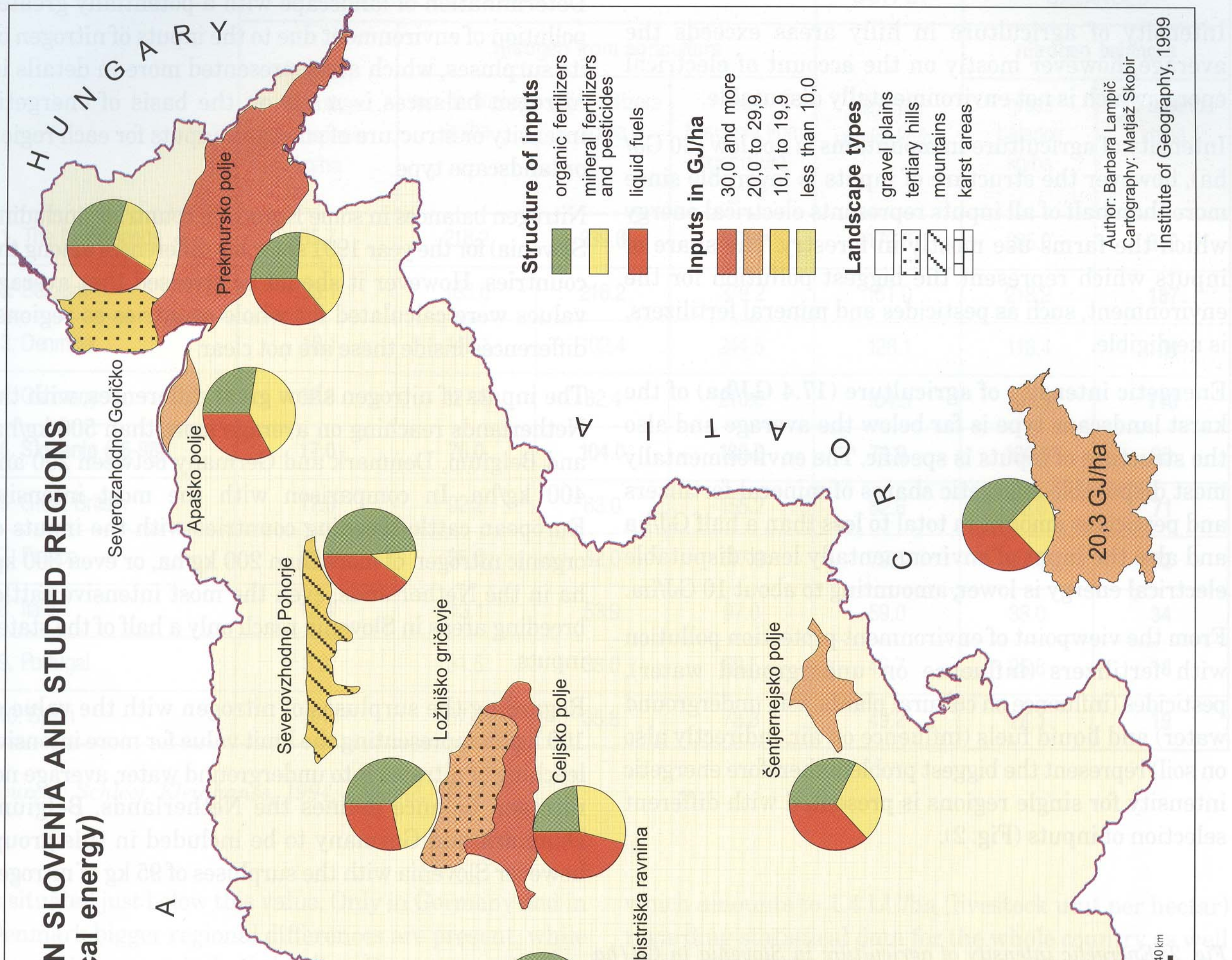
Regarding five main forms of input (stable manure with slurry, mineral fertilizers, pesticides, liquid fuels, electrical energy) average energetic intensity of agriculture amounts in Slovenia as a whole to 38 GJ/ha which exceeds Slesser's admissible border for pollution by more than two times. Nevertheless, structure of inputs is environmentally very satisfactory (Fig. 1).

Fig. 1: Intensity of agriculture in Slovenia in GJ/ha and structure of inputs (Lampič, 1999)



In twelve of the fifteen selected regions electrical energy represents the biggest share with on average 44,5 % of inputs, organic fertilizers and liquid fuels represent 20 % of inputs and mineral fertilizers represent only less than 15 % of all inputs. The fact that the share of mineral fertilizers is lower in comparison to organic fertilizers indicates that the proportion of fertilizers in the environment is satisfactory which is very significant for Slovenian agriculture with developed cattle breeding and polycultural agriculture. In the contrary, energetic share of environmentally very troublesome input of pesticides, amounts to less than 1 %.

Regarding single landscape types their circumstances are rather different. Energetic intensity of agriculture is biggest on gravel plains (46.5 GJ/ha) and the structure of the inputs is at the same time least favorable due to



Map 2: ENERGETIC INTENSITY OF AGRICULTURE IN SLOVENIA AND STUDIED REGIONS (inputs without fodder additions and electrical energy)

bigger share of mineral fertilizers and pesticides which are environmentally most burdening inputs.

Intensity of agriculture in hilly areas exceeds the average, however mostly on the account of electrical energy which is not environmentally disputable.

Intensity of agriculture in mountains is not low (30 GJ/ha), however the structure of inputs is favorable since more than half of all inputs represents electrical energy which the farms use mostly in forestry. The share of inputs which represent the biggest pollution for the environment, such as pesticides and mineral fertilizers, is negligible.

Energetic intensity of agriculture (17.4 GJ/ha) of the karst landscape type is far below the average and also the structure of inputs is specific. The environmentally most disputable energetic shares of mineral fertilizers and pesticides amount in total to less than a half GJ/ha and also the input of environmentally least disputable electrical energy is lower, amounting to about 10 GJ/ha.

From the viewpoint of environment protection pollution with fertilizers (influence on underground water), pesticides (influence on cultural plants, soil, underground water) and liquid fuels (influence on air, indirectly also on soil) represent the biggest problem therefore energetic intensity for single regions is presented with different selection of inputs (Fig. 2).

4. Inputs of nitrogen and their surpluses

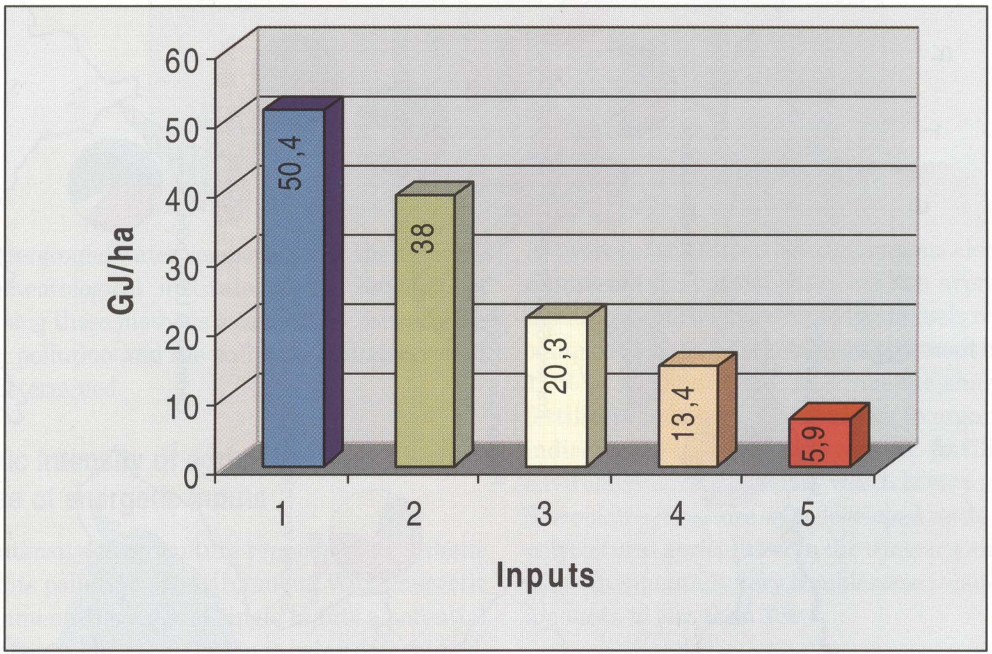
Determination of landscape with a potentially greater pollution of environment due to the inputs of nitrogen or its surpluses, which are represented more in details in nitrogen balances is made on the basis of energetic intensity or structure of energetic inputs for each region or landscape type.

Nitrogen balances in some European countries (including Slovenia) for the year 1991 show big differences among the countries. However it should be stressed that average values were calculated for whole countries so regional differences inside these are not clear.

The inputs of nitrogen show great differences, with the Netherlands reaching on average more than 500 kg/ha, and Belgium, Denmark and Germany between 200 and 400 kg/ha. In comparison with the most intensive European cattle-breeding countries with the inputs of organic nitrogen of more than 200 kg/ha, or even 300 kg/ha in the Netherlands, even the most intensive cattle-breeding areas in Slovenia reach only a half of the stated inputs.

Regarding the surpluses of nitrogen with the value of 100 kg/ha representing the limit value for more intensive leaching of nitrates into underground water, average net nitrogen balance defines the Netherlands, Belgium, Denmark and Germany to be included in this group, however Slovenia with the surpluses of 95 kg of nitrogen

Fig. 2: Energetic intensity of agriculture in Slovenia in GJ/ha



(Lampič, 1999)
1 - all inputs
2 - inputs without fodder additions
3 - inputs without fodder additions and electrical energy
4 - only inputs of organic fertilizers, mineral fertilizers and pesticides
5 - only inputs of mineral fertilizers and pesticides

Tab. 2: Nitrogen balances in some European countries and in Slovenia

COUNTRY	INPUT				OUTPUT	BALANCES	
		nitrogen from agriculture				nitrogen balances	
	nitrogen from the atmosphere kg/ha	min. fertilizers kg/ha	org. fertilizers kg/ha	total N-supply from agriculture kg/ha	nitrogen uptake kg/ha	gross balance kg/ha	net balance kg/ha
1. The Netherlands	35.7	218.2	339.6	557.8	172.8	385.0	**319**
2. Belgium	33.1	163.0	216.2	379.2	161.0	218.2	**187**
3. Denmark	18.1	142.1	102.4	244.5	128.1	116.4	**104**
4. Germany	32.0	127.6	82.4	210.0	104.5	105.5	**113**
5. Slovenia (96-98)	**17.0**	**76.0**	**104.0**	**180.0**	**71.0**	**109.0**	**95**
6. Great Britain	17.6	92.2	63.0	155.2	82.6	72.6	**71**
7. France	20.1	95.0	52.0	147.0	79.5	67.5	**72**
8. Italy	12.4	43.1	53.9	97.0	59.0	38.0	**34**
9. Portugal	3.9	31.5	38.0	69.5	43.7	25.8	**18**
10. Spain	6.1	37.5	35.8	73.3	49.2	24.1	**19**

Sources: Schleef, Kleinhanss, 1994, Lampič, 1999

is situated just below this value. Only in Germany and in Denmark bigger regional differences are present, while the environment in both leading European countries regarding the surpluses of nitrogen is almost in whole sensitive on nitrates.

In the structure of nitrogen inputs in Slovenia nitrogen of organic source is prevailing (104 kg/ha) meanwhile amounts of nitrogen of mineral source are ranged substantially lower also in comparison with most European countries, amounting only to 76 kg/ha. From the environmental point of view such proportion is satisfactory because of in average low density of cattle which amounts to 1.4 LU/ha (livestock unit per hectar) regarding statistical data for the whole country as well as the research and does not exceed the limit values (2.5 LU/ha) in any analysed region.

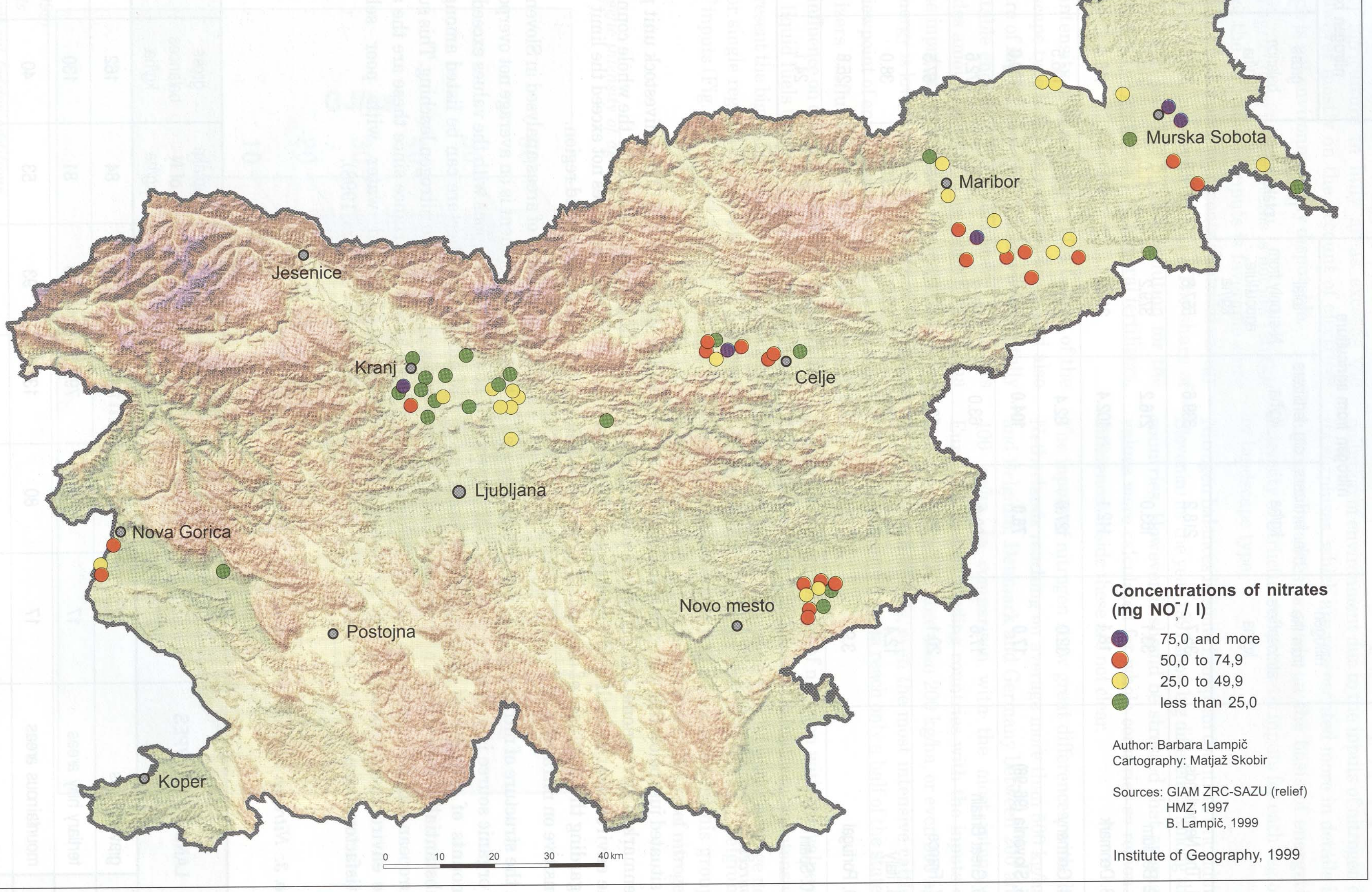
Nitrogen balances of areas analysed in Slovenia indicate that the environment is on average not overpolluted yet, however some regions with the values exceeding 100 kg of nitrogen per hectare can be listed among so called areas vulnerable to nitrogen leaching. This surplus is of even bigger importance since these are the areas with low underground water with poor self-cleaning capabilities (Brečko, 1998).

Tab. 3: Nitrogen balances for landscape types of Slovenia in year 1997

LANDSCAPE TYPES		N from the atmosphere kg/ha	organic N kg/ha	mineral N kg/ha	total N-supply kg/ha	uptake of N kg/ha	gross balances kg/ha	net balances kg/ha
1	gravel plains	17	126	120	246	84	162	**132**
2	tertiary hilly areas	17	132	79	211	81	130	**108**
3	mountainous areas	17	80	13	93	53	40	**33**
4	karst areas	17	63	6	69	43	26	**24**

(Lampič, 1999)

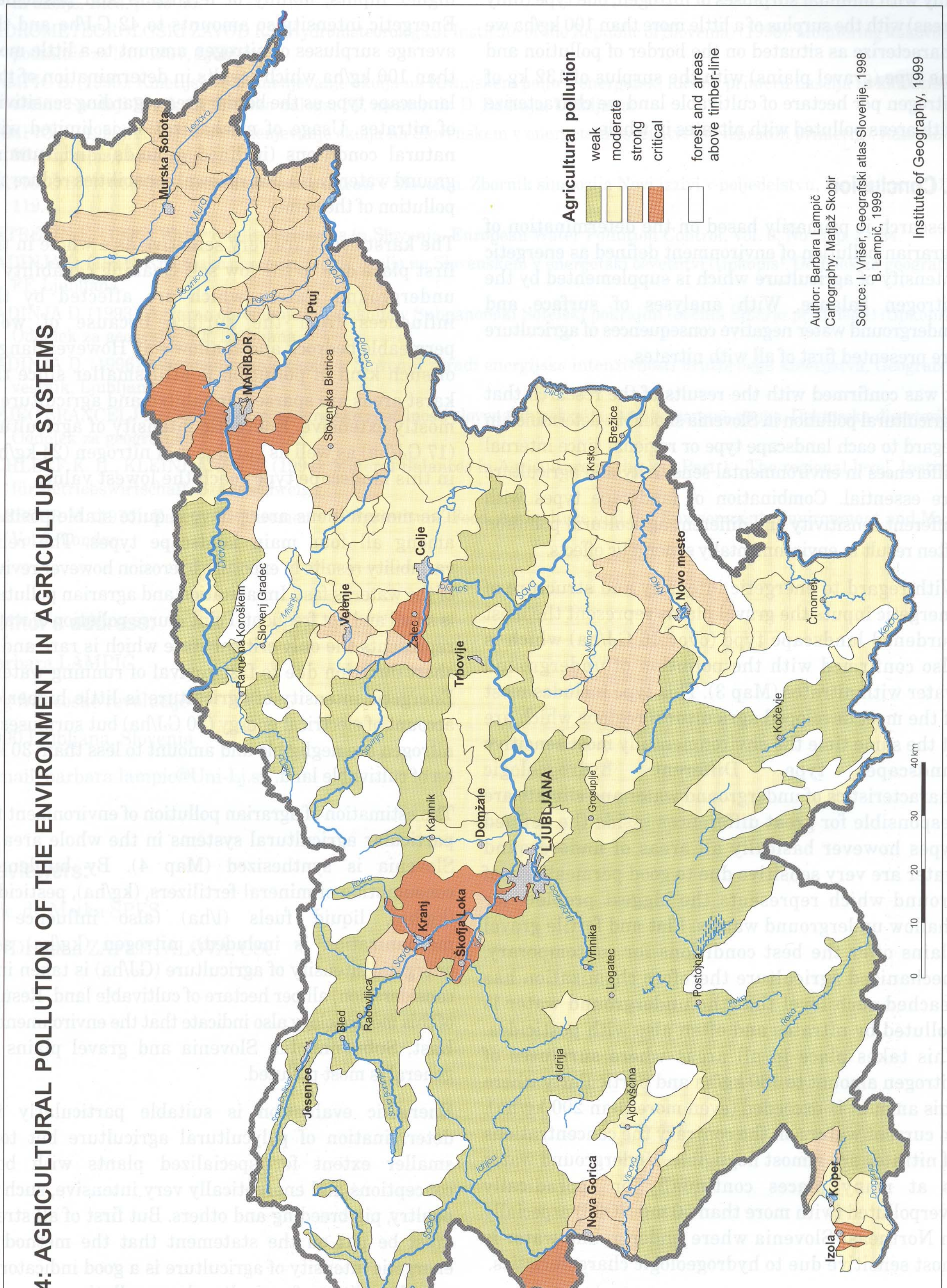
Map 3: POLLUTION OF UNDERGROUND WATER WITH NITRATES IN SLOVENIA (Autumn, 1997)



Author: Barbara Lampič
Cartography: Matjaž Skobir

Sources: GIAM ZRC-SAZU (relief)
HMZ, 1997
B. Lampič, 1999

Institute of Geography, 1999



Map 4: AGRICULTURAL POLLUTION OF THE ENVIRONMENT IN AGRICULTURAL SYSTEMS

Agricultural pollution

🟩	weak
🟨	moderate
🟧	strong
🟥	critical
☐	forest and areas above timber-line

Author: Barbara Lampič
Cartography: Matjaž Skobir

Source: I. Vrišer, Geografski atlas Slovenije, 1998
B. Lampič, 1999

Institute of Geography, 1999

Regarding the four main landscape types we characterize two of them (mountains and karst areas) only with minimal surpluses of nitrogen, one type (hilly areas) with the surplus of a little more than 100 kg/ha we characterize as situated on the border of pollution and one type (gravel plains) with the surplus of 132 kg of nitrogen per hectare of cultivable land we characterize with areas polluted with nitrates in whole.

5. Conclusion

Research is primarily based on the determination of agrarian pollution of environment defined as energetic intensity of agriculture which is supplemented by the nitrogen balance. With analyses of surface and underground water negative consequences of agriculture are presented first of all with nitrates.

It was confirmed with the results of the research that agricultural pollution in Slovenia should be determined in regard to each landscape type or regional since internal differences in environmental sensitivity and agriculture are essential. Combination of landscape types with different sensitivity and different agricultural pollution often result in environmentally synergetic effects.

With regard to energetic intensity and structure of energetic inputs the gravel plains represent the most burdened landscape type (over 46 GJ/ha) which is also confirmed with the pollution of underground water with nitrates (Map 3). This type includes most of the most developed agricultural regions which are at the same time the environmentally most sensitive landscape type. Different hydrogeologic characteristics of underground water and climate are responsible for great differences inside the defined types however basically all areas of underground water are very sensitive due to good permeability of ground which represents the biggest problem for shallow underground waters. Flat and fertile gravel plains offer the best conditions for contemporary, mechanized agriculture therefore chemization has reached such level that the underground water is polluted by nitrates and often also with pesticides. This takes place in all areas where surpluses of nitrogen amount to 130 kg/ha and particularly where this amount is exceeded (even more than 200 kg/ha). In current waters on the contrary the concentrations of nitrates are almost negligible. Underground water is at many places continually or sporadically overpolluted (with more than 50 mg NO3/l) especially in Northeast Slovenia where underground water is most sensitive due to hydrogeologic characteristics.

The tertiary hilly areas represent the second highly sensitive landscape type due to the varying relief and soft rocks which are the subject to strong erosion. Natural balance is nowadays threatened by higher and higher inputs, mainly of fertilizers and pesticides. Energetic intensity so amounts to 42 GJ/ha and the average surpluses of nitrogen amount to a little more than 100 kg/ha which results in determination of this landscape type as the border area regarding sensitivity of nitrates. Usage of mechanization is limited with natural conditions (inclined grounds) and running ground waters with fast renewal capabilities reduce the pollution of the same.

The karst areas are very sensitive as a whole in the first place due to the low self-cleaning capability of underground waters which are affected by the influences from the surface because of well-permeable bedrock and shallow soil. However danger of such kind of pollution is still smaller since the karst areas are sparsely inhabited and agriculture is mostly extensive. Energetic intensity of agriculture (17 GJ/ha) as well as surpluses of nitrogen (24 kg/ha) in this landscape type reach the lowest value.

The mountainous areas have a quite stable position among all four main landscape types. The relief variability results in exposure to erosion however revival of the water is fast. Inhabitation and agrarian pollution is small and not frequent. Point source pollution of water represents the only critical state which is rare and of short duration due to fast revival of running waters. Energetic intensity of agriculture is little higher on account of electrical energy (30 GJ/ha) but surpluses of nitrogen are negligible and amount to less than 30 kg/ha of cultivable land.

The estimation of agrarian pollution of environment for particular agricultural systems in the whole area of Slovenia is synthesized (Map 4). By burdening consumption of mineral fertilizers, (kg/ha), pesticides (kg/ha), liquid fuels (l/ha) (also influence of mechanization is included), nitrogen (kg/ha) and energetic intensity of agriculture (GJ/ha) is taken into consideration, all per hectare of cultivable land. Results of this methodology also indicate that the environment of East, Subpannonian Slovenia and gravel plains in general is most polluted.

Energetic evaluation is suitable particularly for determination of polycultural agriculture but to a smaller extent for specialized plants with bold conceptions and energetically very intensive, such as poultry, pig breeding and others. But first of all stress must be put on the statement that the method of energetic intensity of agriculture is a good indicator of actual condition of agricultural overpollution.

References

BREČKO V. (1998): Pokrajinska občutljivost območij podtalnic v Sloveniji z vidika kmetijstva. Zbornik posveta Kmetijstvo in okolje, Bled, p. 49-55.

HIDROMETEOROLOŠKI ZAVOD RS (Hydrometeorological Institute of the Republic of Slovenia) (1998): Monitoring kakovosti podtalnic za leto 1997, Ljubljana.

LAMPIČ B. (1995): Kmetijsko obremenjevanje okolja na Kranjskem polju v energetski luči na primeru naselja in katastrske občine Spodnji Brnik. Diplomska naloga, FF, mentor dr. D. Radinja, Ljubljana.

LAMPIČ B. (1999): Agrarno obremenjevanje okolja na Slovenskem v energetski osvetlitvi (na izbranih primerih). Raziskava IG, (tipkopis), Ljubljana.

MATIČIČ B. (1996): Onesnaževanje voda z nitrati v Sloveniji. Zbornik simpozija Novi izzivi v poljedelstvu, Ljubljana, p. 111-119.

PETREŠIN E. (1996): Water quality problems in Slovenia. European Water Pollution Control, Vol. 6, No. 3, p. 31-34.

RADINJA D. (1991): Kmetijsko obremenjevanje okolja na Slovenskem v energetski osvetlitvi (tipkopis). Oddelek za geografijo FF, Ljubljana.

RADINJA D. (1993): Agrarno obremenjevanje okolja v Subpanonski Sotelski pokrajini (občina Šmarje pri Jelšah) (tipkopis). Oddelek za geografijo FF, Ljubljana.

RADINJA D. (1996): Obremenjevanje okolja v Sloveniji zaradi energijske intenzivnosti družbenega kmetijstva. Geografski vestnik, Ljubljana.

REJEC BRANCELJ I. (1999): Agrarnogeografske značilnosti slovenskih pokrajin z vidika varstva okolja. Doktorska disertacija, Oddelek za geografijo FF, Ljubljana.

SCHLEEF K. H., KLEINHANSS W. (1994): Mineral Balances in Agriculture in the EU, Part 1 - The regional level. Institut für Betriebswirtschaft, Braunschweig.

SLESSER M. (1975): Energy Requirements of Agriculture, Food, Agriculture and the Environment. Environment and Man, Vol 2, London.

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REGIONAL ASPECTS OF RESULTS OF THE 1999 PRESIDENTIAL ELECTIONS IN SLOVAKIA

Peter MARIOT

Abstract

Presidential elections by the plebiscite were held in Slovakia first time in May 1999. Inhabitants of the Slovak Republic (SR) confirmed their concern in a cooperation at choosing the head of the state by their relatively high participation in the presidential elections, which was comparable with that recorded at the Parliament elections. An indirect proportionality was retained between the electoral attendance and the number of inhabitants in the municipality with the lowest attendance being recorded in towns with the population over 20 thousand inhabitants. In the first round of the elections none of 9 candidates received absolute majority of votes. Electoral results of candidates who received more than 2.5% of votes in the 1st round are illustrated in Figs. 1 to 5. Two candidates with the highest votes (R. Schuster and V. Mečiar) passed to the 2nd round in which the victory belonged to R. Schuster. The regions decisive for their preferences were formed as early as during the 1st round. The region with the higher support for R. Schuster is situated at the southern border of the Slovak Republic. V. Mečiar dominated mainly in the western half of Slovakia (Orava, Kysuce, central Váh R. basin, upper Nitra district). In the 2nd round of the presidential elections these regions of the conclusive preference were added some marginal areas in which a candidate with the absolute majority of votes from the 1st round could not be found.

The brief analysis of the results from the first presidential elections in Slovakia held in May 1999 can be concluded in the following statements: 1) The Slovak voters assumed a positive attitude to the election of the president of the Slovak Republic by plebiscite; 2) The Slovak voters employed political criteria at the election of the head of the state; 3) The regions of support for the presidential candidates who passed to the 2nd round were identical with the regions of increased political preferences reached by the coalition and opposition parties represented by R. Schuster and V. Mečiar, resp. in the Parliamentary elections to the National Council of the Slovak Republic in 1998; 4) The centres of support to the candidates for the 2nd round were formed as early as during the 1st round of the elections; 5) The dominant position of the candidate who won in the 1st round was further strengthened in the 2nd round of the elections; 6) The elections of the president of the Slovak Republic were held in a non-standard, complex political situation which will apparently not be typical of the presidential elections in the Slovak Republic after the year 2004. This is why any generalization derived from the results in 1999 can only be of informative character.

Shrnutí

Regionální výsledky prezidentských voleb na Slovensku v roce 1999

V květnu 1999 se na Slovensku uskutečnily poprvé volby prezidenta formou plebiscitu. Obyvatelé Slovenské republiky potvrdili poměrně vysokou volební účastí, srovnatelnou s účastí na parlamentních volbách, zájem spolupracovat při výběru hlavy státu. Přitom se zachovala nepřímá úměra mezi volební účastí a počtem obyvatel obce, když nejnižší účast byla zaznamenána v městech s více než 20 000 obyvateli. V 1. kole voleb nezískal žádný z 9 kandidátů nadpoloviční většinu hlasů. Volební výsledky kandidátů, kteří získali v 1. kole více než 2,5 % hlasů, znázorňují obr. 1 – 5. Do druhého kola postoupili dva kandidáti s nejvyšším podílem hlasů (R. Schuster a V. Mečiar), kde pak zvítězil R. Schuster. Regiony jejich hlavní podpory se vytvořily už v 1. kole. Oblast vyšší podpory R. Schustera leží při jižních hranicích Slovenska. V. Mečiar dominoval hlavně v západní polovině Slovenska (Orava, Kysuce, střední Pováží, horní Ponitří). Ve 2. kole přibyly k těmto regionům preference některých okrajových oblastí, v nichž se na základě výsledků 1. kola nedal určit kandidát s absolutní převahou hlasů.

Stručná analýza výsledků voleb umožňuje konstatovat, že: 1) slovenští voliči zaujali kladný postoj k volbě prezidenta Slovenské republiky plebiscitem; 2) voliči uplatnili při volbě hlavy státu politická kritéria; 3) regiony podpory kandidátů, kteří postoupili do 2. kola, byly shodné s regiony zvýšených politických preferencí, které dosáhly v parlamentních volbách do Národní rady Slovenské republiky 1998 koaliční strany (reprezentované R. Schustrem), respektive opoziční strany (reprezentované V. Mečiarem); 4) hlavní oblasti podpory kandidátů 2. kola se zformovaly už v 1. kole voleb; 5) dominantní pozice kandidáta, který zvítězil v 1. kole, se ve 2. kole voleb posílila;

6) volby prezidenta se uskutečnily v nestandartní, složité politické situaci, která zřejmě nebude typická pro další prezidentské volby po roce 2004. Proto mají zobecnění, odvozená z výsledků prezidentských voleb 1999, zatím jen informativní charakter.

***Key words**: political geography, presidental elections, Slovakia*

1. Introduction

In the course of a comparatively short time of ten years several studies appeared in the Slovak geographical literature, which contributed to more detailed knowledge of the relation of the inhabitants of Slovak Republic (SR) to democratic elections. Authors of those studies highlighted the specific features of territorial structure of the political preferences of population and laid down the foundations of political geography in Slovakia (Brunn, Vlčková, 1994, Krivý, 1999, Krivý, Feglová, Balko, 1996, Mariot, 1994 a,b, 1995, 1997 a,b, 1998, 1999 a,b, Vlčková, 1997). For the purpose they used the results of elections to the Slovak Parliament (The Slovak National Council in the years 1990, 1992 or The National Council the SR in the years 1994, 1998). Our article should enrich the database characterizing the territorial structure of political preferences of the voter of Slovakia with an analysis of results from presidential elections in the SR, which consisted of two rounds and took place in the second half of May 1999.

The first elections of the president of the SR, which were organized in the form of a plebiscite were the result of a complicated political situation in Slovakia after 1990 and, above all, after January 1st 1993, when Slovakia joined for the first time in its history sovereign states of the world. A key moment of this process was perhaps the abdication of the President of the Czecho-Slovak Federal Republic (CSFR), Václav Havel three days after the Declaration of Sovereignty of the Slovak Republic by the Slovak National Council (as to January 1st, 1993). Elections of the first Slovak president were held shortly after at the Slovak National Council, which chose Michal Kováč for the office (from February 15, 1993 to March 2, 1998).

After his term finished, the lack of agreement among the top representatives of the Slovak politics manifested in discrepancies and caused that from the early March 1998 to the end of May 1999 the office of the head of the state was vacant. This situation was convenient for the former coalition (Movement for Democratic Slovakia - MDS, Slovak National Party - SNP, Association of Workers of Slovakia - AWS), as the execution of the president's office was taken over, pursuing the provisions of the corresponding law of the Constitution of the SR, by the Prime Minister V. Mečiar. Parliamentary elections which took place in autumn 1998 helped the former opposition (Party of the Democratic Left - PDL, Party of Hungarian Coalition - PHC, Party of Civil Understanding - PCU) to take over the power and to present new dimensions for the solution of the vacant presidential office. In spring 1999 the Chairman of the National Council of the SR announced the direct elections of the president of the SR by plebiscite for May 15th 1999, which meant an end to the period of often purposeless discussions on the manner of elections of the president of the SR. Any candidate who would obtain absolute majority of valid votes of qualified voters (citizens of the SR who would be 18 years old on the day of elections resident in the territory of the SR) could be elected in accord with this decision. If none of presidential candidates obtained absolute majority in the firs round, the second round would take place with two candidates who obtained the highest number of votes in the first round. The winner of the second round would hold the office of the president for five years.

2. The first round of presidential elections in the SR

The first round took place on May 15, 1999. Ten candidates complied with obligatory conditions and their results are presented in table 1. The voters gave invalid votes to M. Kováč, who gave up the candidature in the course of the pre-electoral period. The following table presents main subjects which supported election of the particular candidates:

From the point of view of differences in the intensity of regional support in the first round of the Slovak presidential elections the participating candidates can be classified into three groups:

1) candidates supported by a minimum number of voters in the whole territory of the SR
2) candidates supported by a small percentage of voters with little differences in the intensity of support
3) candidates supported by a considerable proportion of voters with big differences in the intensity of support.

Tab. 1 Results of the first round of presidential elections (May 15, 1999)

Candidate (year of birth)	Supporting subjects	No. of votes	%
Ján Demikát (1951)	National Alternative of Slovakia United Worker´s Party Party of National Understanding	4 537	0.15
Juraj Lazarčík (1949)	Communist Party of Slovakia	15 386	0.52
Vladimír Mečiar (1942)	Movement for Democratic Slovakia	1 097 956	37.23
Ivan Mjartan (1958)	independent candidate	105 903	3.59
Ján Slota (1953)	Slovak National Party	73 836	2.50
Rudolf Schuster (1934)	Party of Democratic Coalition Party of Hungarian Coalition	1 396 950	47.37
Juraj Švec (1938)	Democratic Union	24 077	0.81
Magda Vášáryová (1948)	Charta 99 Civil-Democratic Youth	134 635	6.60
Boris Zala	Movement of Our President	29 697	1.00
invalid votes		5 452	0.23
Total		2 948 402	100.00

The first group comprises four candidates (J. Demikát, J. Lazarčík, J. Švec, B. Zala) who obtained a minimum support of the voters (under 1 % of the total number of valid votes). This result is connected mainly with the fact that all of them had less than 3% of votes in more than 90% of settlements of the SR (Demikát in 98.5, Lazarčík in 92.9, Švec in 92.3 and Zala in 94.3 % of settlements). More than ten percent obtained were rare (Švec in two, Lazarčík in eight, Demikát and Zala in zero settlements). As the incidence of the minimum support of above mentioned candidates occurred in the whole territory of the SR, no regions of their preference were formed. We can only observe that J. Švec had higher support in urban environment while the three remaining candidates obtained higher support in rural area.

The second group comprises three candidates who obtained 2.5 to 6.6 % of votes: in the first round of presidential election J. Slota (Chairman of the SNP, deputy of the NC of the SR, Mayor of Žilina), I. Mjartan (ambassador of the SR in the Czech Republic in the years 1991-98, leader of the Co-ordination Council of the MDS during the pre-election campaign, left MDS after the elections, Magda Vášáryová (actress, ambassador of the CSFR in Austria, founder and chairwoman of the administrative council of the Slovak Society for Foreign Policy). These candidates obtained 2.5-6.6% of votes in the majority of settlements (Mjartan in 67.5 %, Vášáryová in 65.8 %, Slota in 60.6 % of settlements of the SR) However, less than 3% voted them in a comparatively large number of settlements of the SR (Slota was voted in 38.1 %, Mjartan in 33.0 %, Vášáryová in 28.3% of settlements of the SR) so that the differences in the rate of their support allow to suggest certain features of spatial differentiation of their political preferences.

Regions of political preference of M. Vášáryová (Fig. 1) can be comparatively easily identified. It is so mainly because the differences between the highest (30%) and lowest (0 %) proportion of votes which she obtained at the level of settlements reached 30 points (national average being 6.6%). Two areas can be determined in Slovakia where the voters manifested an increased support to M. Vášáryová. One of them represents a part of the western Slovakia consisting of the Záhorie districts (Malacky 11.2%, Senica 11.9%, Skalica 19.9%) and Carpathian districts of the SR (Pezinok 9.1%, Trnava 9.7%). The second area contains the districts of central part of the SR (Námestovo 6.6%, Dolný Kubín 9.2 %, Ružomberok 8.5%, Banská Bystrica 12.5%, Zvolen 8.7%, Krupina 6.6%). Apart from it the centres of higher concentration of votes for M. Vášáryová were the towns of western and central Slovakia. Thanks to the high absolute number of voters these towns contributed to the result reached by M. Vášáryová. In the majority of the settlements in the two provinces of eastern Slovakia the proportion of votes obtained by her did not exceed 3%.

Detailed research showed that the only 1999 woman candidate for the president of the SR got above-average

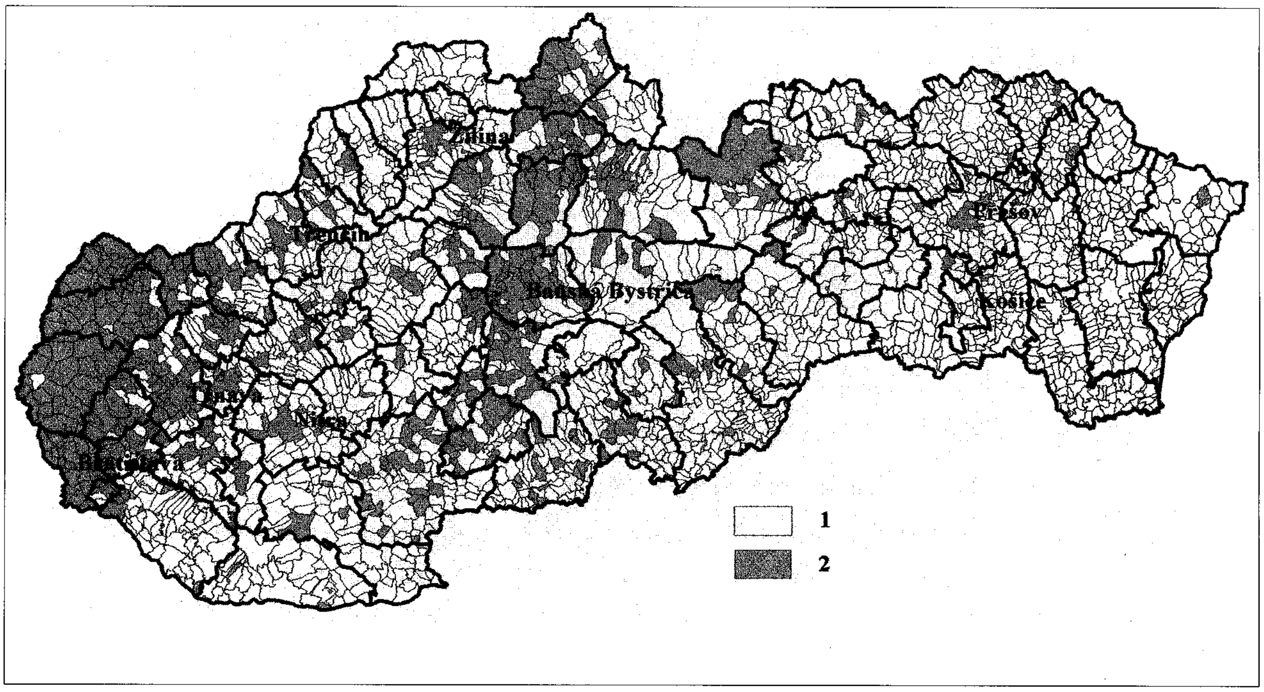


Fig. 1 Results of M. Vášáryová in the first round of the 1999 presidential elections. Share of votes: 1) 0.0 - 6.6 %, 2) 6.7 - 28.2 %

results from the voters of the PDC (16.9 % of voters of PDC voted her), with medium level education (8.4%), university education (12.9%) and urban population from the towns counting more than 10,000 inhabitants.

In spite of their different image and position in the Slovak political life, the structure of regional support for I. Mjartan and J. Slota was similar. Its typical trait is concentration of political preferences into the central part of Slovakia, its gradual diminishing while going to the west (less) or to the east (more) and an almost complete absence of voters in areas with higher number of the Hungarian population. The main supporting regions of I. Mjartan (Fig. 2) were the north and central parts of central Slovakia while he obtained more than 6% in districts of Orava and 5% in districts of Banská Bystrica, Brezno, Zvolen, and Poltár. He obtained highest votes from the voters of the PDL (8.3%) and SNP (8.1%). J. Slota was supported by the voters from the province of Žilina where he obtained 4.1% of votes (more than 5% of

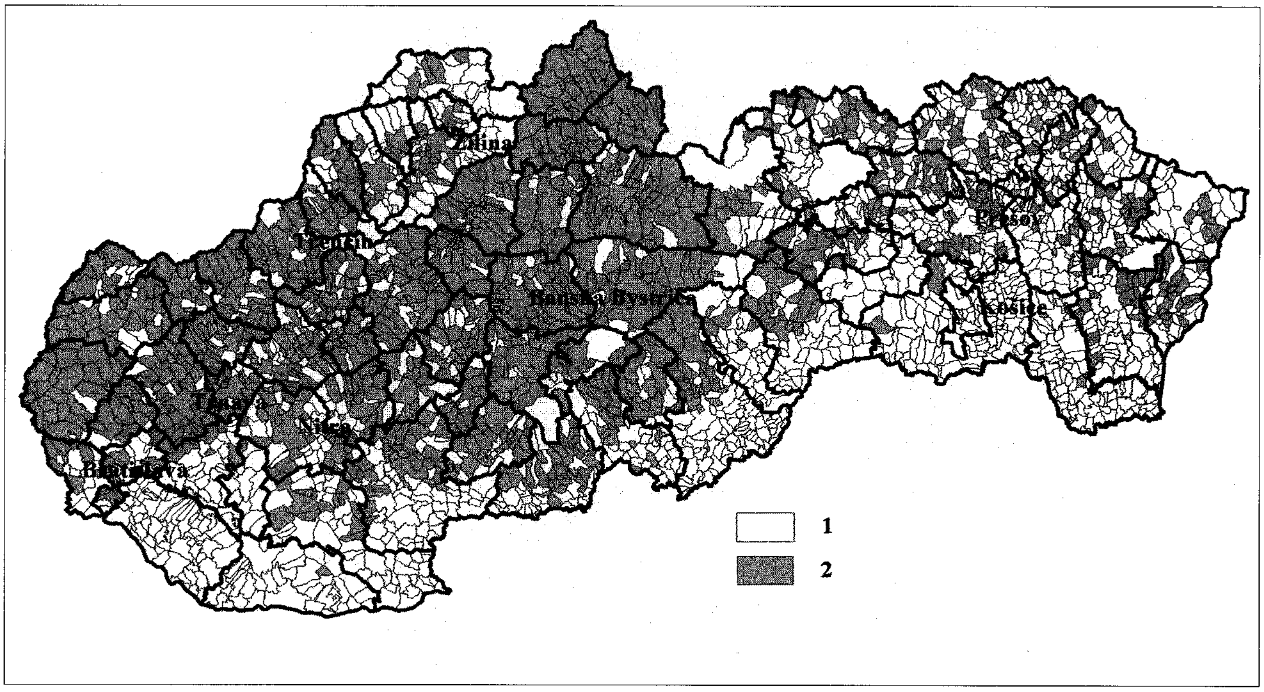
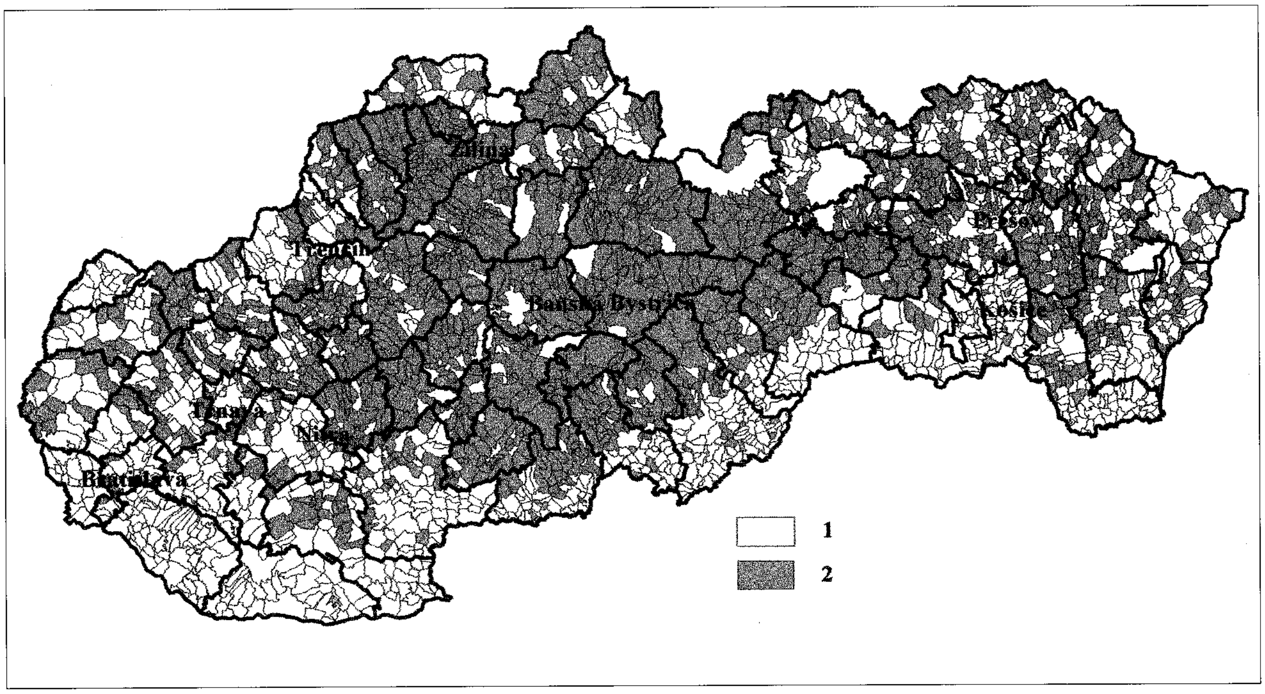


Fig. 2 Results of I. Mjartan in the first round of the 1999 presidential elections. Share of votes: 1) 0.0 - 3.9 %, 2) 4.0 - 19.2 %

votes in the districts of Bytča and Žilina). It is connected with the fact that as a head of the SNP he obtained the widest support (26.6%) among the sympathizers of the SNP who concentrate mainly in the environs of Žilina. On the contrary, J. Slota obtained an under-average support from the voters of other principal political parties in Slovakia (Fig. 3).

Fig. 3 Results of J. Slota in the first round of the 1999 presidential elections. Share of votes: 1) 0.0 - 2.5 %, 2) 2.6 - 28.0 %



The third group is represented by two candidates for the office of the president of the SR, who found a comparatively wide support in the whole territory of the SR though with great differences in its intensity (V. Mečiar and R. Schuster). These two candidates passed to the second round with a distinct advantage compared to the rest of the candidates while they obtained 84.5% of votes from all voters while only 2.63 % or 77,252 votes would have been sufficient for R. Schuster to obtain an absolute majority of vote.

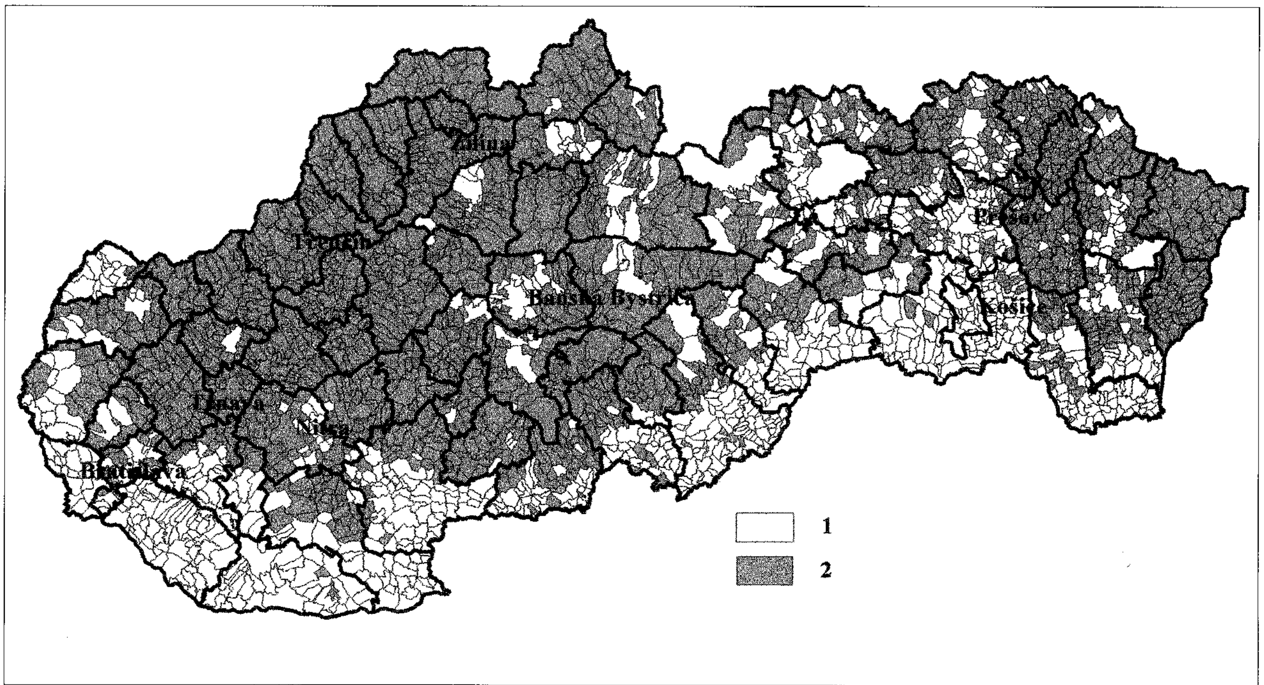
Vladimír Mečiar (born on 26th July 1942) used to be an employee of the District National Committee in Žiar nad Hronom from 1959. In the years 1967-68 he was the Chairman of the District Committee of the Czechoslovak Youth Union. He was recalled from the office and expelled from the Communist Party of Czechoslovakia after occupation of the Czechoslovak Socialist Republic by the troops of the Warsaw Pact in August 1968. He worked as a smelter in heavy industry (Heavy Industry Works in Dubnica nad Váhom). He finished external university studies at the Law Faculty of Comenius University in Bratislava in 1974. He became Minister of Interior and Environment of the SR in 1990, later Prime Minister of the SR and deputy for he Federal Assembly of the CSFR representing the movement Public Against Violence. He was recalled from the office of Prime Minister in 1991 to assume the office again after the 1992 elections to the Slovak National Council. He was recalled again in March 1994 and became Prime Minister for the third time after the 1994 elections. He has been the Chairman of the Movement for Democratic Slovakia (MDS) since the organization came into existence.

Rudolf Schuster (born on 4.1.1934) graduated from the Slovak Technical University in Bratislava. His first employment was with Agricultural Office in Košice, followed by East Slovakian Iron Works in Košice in 1974. He became the chairman of the East-Slovakia Province Office in the same years. He was elected Chairman of the Slovak National Council (SNC) in November 1989. In July 1990 he was appointed ambassador of the CSFR in Canada. In the years 1994-1999 he again assumed the office of the Mayor of Košice. The former member of the Communist Party of Slovakia he left the Party in the early 1990 and is a co-founder and chairman of the Party of Civil Understanding (PCU).

Contrary to the regional structure of preferences of the above mentioned candidates the spatial application of discrepancies in the rate of support to V. Mečiar or R. Schuster is much more closely related to the regions of support of the opposition or coalition group of parties active in the Slovak politics in mid-1999 (Mariot, 1999a,b). While the candidates for president of the first group practically represented only their persons and the candidates in the second group did not represent any defined (Vášáryová and Mjartan) or even exposed (Slota) political opinion, V. Mečiar and R. Schuster were protagonists of the fighting of the ruling coalition (Schuster) with the opposition (Mečiar).

This corresponded not only to the high rate of support, but also to the spatial picture of their preferences. It manifested in the electoral results to V. Mečiar, which practically copied the electoral results of the MDS in the 1998 parliamentary elections (Mariot, 1999a). R. Schuster entered the first presidential elections realized through plebiscite as a candidate who made use of the advantage that he was the only actual rival to V. Mečiar. Theoretically it was improbable that Schuster, as the main representative of the Party of Civil Understanding, which obtained 8.6% of votes in the 1998 parliamentary elections would win over V. Mečiar, whose movement obtained as much as 29.8% votes when the mandates to the National Council of the SR were distributed. But more by coincidence than by its own efforts Schuster found himself in a position when also representatives and voters of parties with higher (PDL, ChDM) or equal (PHC) intensity of electoral support to that of PCU in 1998 elections decided to give their support to him. The effort to prevent Mečiar to become the president of the SR united the sympathizers of these different political subjects. Thanks to it, Schuster obtained almost 85% of votes of his own party (PCU), 71.5 % of the voters of PDL, 73.6 % of votes of the voters of PDC and even 91.9% of voters of PHC in the first round of presidential elections.

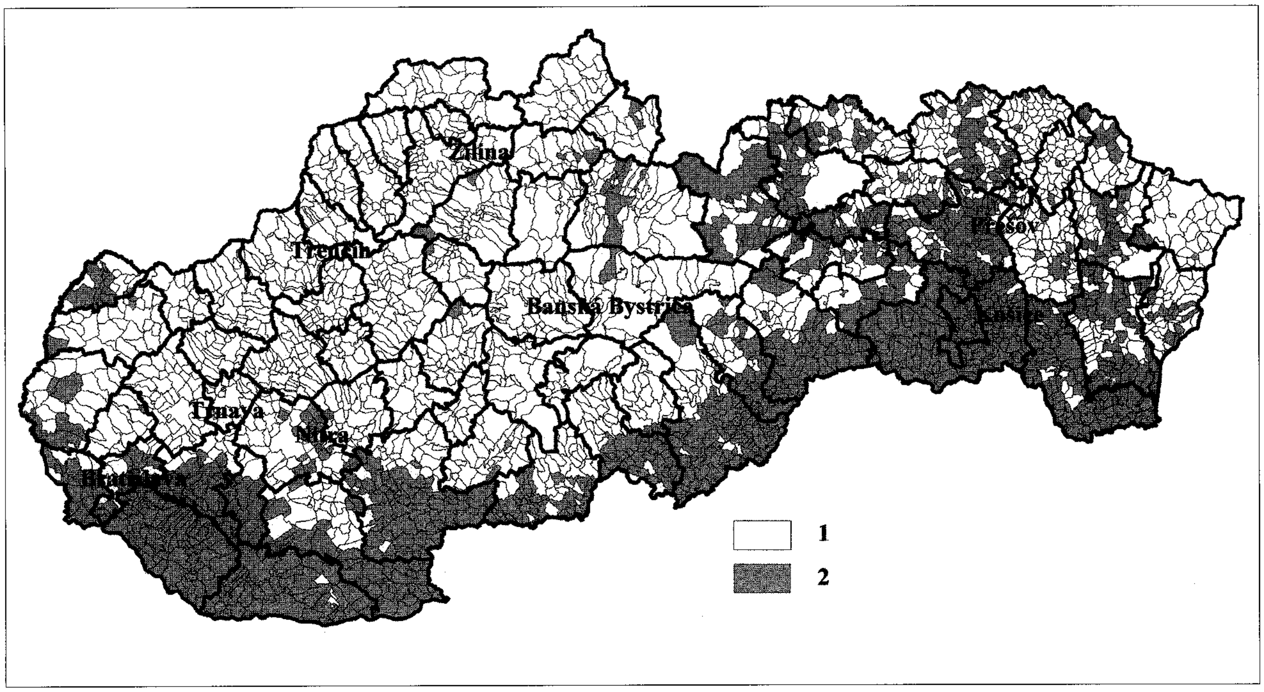
Fig. 4 Results of V. Mečiar in the first round of the 1999 presidential elections.
Share of votes: 1) 0.0 - 37.2 %, 2) 37.3 - 93.0 %



Such a distribution of political preferences contributed to the fact that already in the first round of the presidential elections the basic features of the territorial structure of support to their both top candidates were formed. The districts, in which one of the candidates obtained more than 50 % of votes in the first round became its fundamental elements. It was fairly presumable that in the case of an equal attendance of the population in the second round, each of the candidates would maintain his absolute dominance. As shows Fig. 1, R. Schuster obtained in the 1st round more than 50% of votes and a relative majority in 30 and 9 districts, respectively. V. Mečiar obtained absolute majority and relative majority of vote in 26 and 14 districts of the SR, resp.

The territorial differences in the intensity of political preferences to the two top candidates clearly manifested already in the first round. As supposed, V. Mečiar obtained a greater support than his rival in areas with the dominant preference of the MDS and SNP (Mariot, 1999a,b). The region with the largest area and the highest number of Mečiar's voters includes Orava, Kysuce, the middle part of the Váh basin and the upper part of the Nitra basin.V. Mečiar obtained a relative majority in the district Dolný Kubín (39.8%) and Piešťany (43.7%) and his absolute dominance (Fig. 4) in 20 other districts of this area confirmed already in the 1st round of the elections. Two additional regions join the area which has decisively influenced the position of the MDS and V. Mečiar in Slovakia. The smaller one of them, situated in central Slovakia, consists of the Detva and Poltár districts with only 32.3 thousand voters (while 57% of them voted Mečiar). The larger one is situated next to the north-eastern borders of the SR and consists

Fig. 5 Results of R. Schuster in the first round of the 1999 presidential elections. Share of votes: 1) 0.0 - 47.4 %, 2) 47.5 - 100 %



of the districts Svidník, Stropkov, Medzilaborce, Snina and Sobrance.

The area with prevailing preferences to R. Schuster spreads along the southern borders of the SR from Bratislava to the districts of Trebišov and Michalovce. It also reaches the region of Spiš, the belt of urban districts of Košice, Prešov, and Bardejov and the territory of district Humenné (Fig. 5). This area is more heterogeneous than the one dominated by V. Mečiar from the viewpoint of support to important political subjects in Slovakia. Its most marked part is the belt of intensive and stable support to the PHC occupying the territories of settlements with an elevated share of the Hungarian population, situated close to the southern frontier of the SR. Part of the territory of this areas with a marked representation of Slovak nationals is characterized by the heterogeneous structure of political preferences although the subjects of the present coalition prevail.

Besides the areas with the dominant support to one of the presidential candidates there are two major and two smaller regions in the territory of the SR, in which none of the two obtained an absolute majority of vote. One of them is a part of the south-western Slovakia (Záhorie region, districts Pezinok, Trnava and Piešťany) and the northern part of central Slovakia (Turiec, Liptov, upper and middle parts of the Hron basin). Districts of Nitra, Gelnica, Stará Ľubovňa, Sabinov and Vranov appear as comparatively separated regions of the above mentioned type.

3. The second round of the presidential elections

The second round of the presidential elections was held two weeks after the first one (May 29, 1999). The candidates who obtained the highest number of votes in the first round: Rudolf Schuster and Vladimír Mečiar were the protagonists of the round. They obtained the following results:

Tab. 2: Electoral results of R. Schuster and V. Mečiar in the 1st and 2nd rounds

	1st round		2nd round		Difference	
Schuster	1 396 950	(47.37%)	1 727 481	(57.18%)	330 531	(9.8%)
Mečiar	1 097 956	(37.23%)	1 293 642	(42.82%)	195 686	(10.6%)

3.1 Attendance

The Slovak voters adopted a roughly similar attitude to the direct elections of their president carried out in May 1999 as to that to the Parliamentary elections in the years 1994 or 1998. This can be proved by their

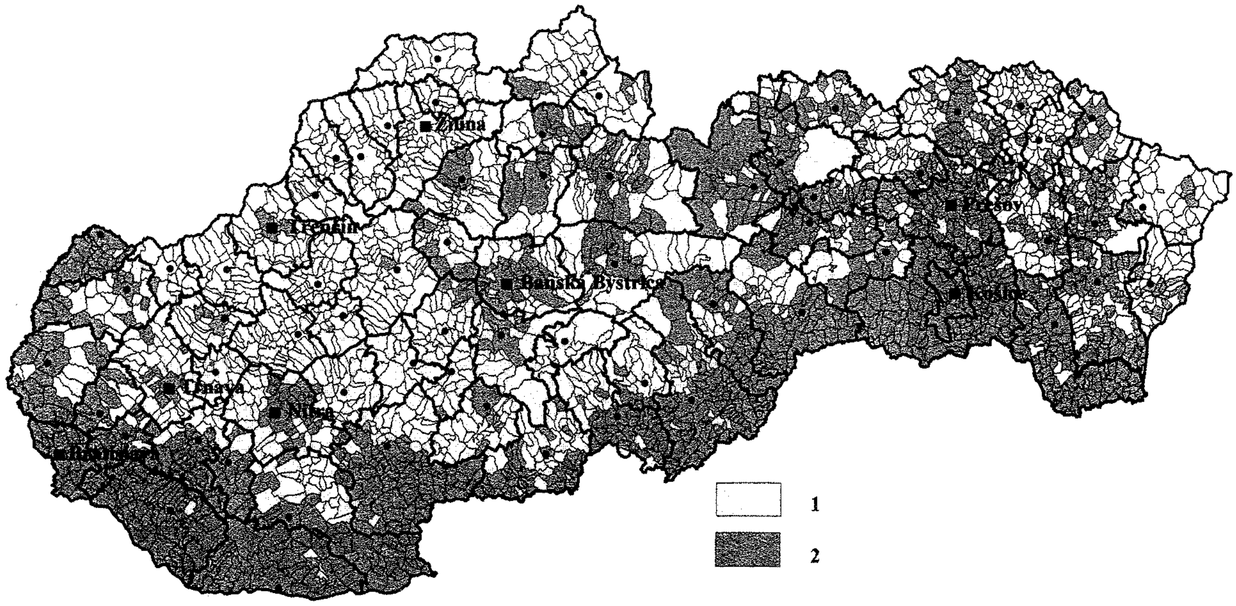
Tab. 3 Comparison of the electoral attendance by size groups of settlements (%).

Population number	Electoral attendance			
	1994	1998	1 st round 99	2 nd round 99
15 - 199	88.4	89.2	84.3	84.0
200 - 499	85.8	88.3	81.6	81.7
500 - 999	83.2	86.7	78.7	79.2
1 000 - 1 999	81.2	86.0	77.1	77.7
2 000 - 4 999	78.3	84.1	74.2	75.1
5 000 - 9 999	75.2	84.2	73.4	74.8
10 000 - 19 999	71.8	82.8	70.6	70.7
20 000 - 49 999	71.9	82.4	70.4	71.8
50 000 - 99 999	72.8	83.6	72.4	72.2
100 000 and more	62.8	82.7	70.5	72.0

attendance and its intensity in different groups of settlements of the SR. An indirect proportionality between the size of the settlements and the attendance of population appeared the same as in the past parliamentary elections. The highest attendance was that of inhabitants from the smallest settlements and the lowest attendance is typical for the population of large towns as proved by the data in table 3.

The data included in table 2 document some particularities of the relation of population from different size groups of the settlements of SR to elections. In the first place it is the high electoral attendance of the population from small rural settlements (population below 1,000) and its nature is stable in spite of a slightly dropping trend. In contrast, towns with the population over 10,000 had an average attendance of the population by 5 or 10% lower than in the smallest settlements. Also, the difference between the attendance of the population from settlements of different sizes in the 1998 parliamentary elections and the attendance in the presidential election held eight months later is interesting. Also, this comparison shows the small settlements as a group with the more stable rate of political preferences. Appurtenance to a certain size

Fig. 6 Results of R. Schuster in the second round of the 1999 presidential elections.
Share of votes: 1) 5.24 - 49.9 %, 2) 50.0 -100 %



group of settlements was the decisive factor which controlled the rate of electoral attendance of the population regardless of the existing regions for preference of the individual political subjects in the whole territory of the SR. Only the region supporting the PHC constitutes an exception as the electoral attendance of the population from all size groups of settlements exceeded the national average.

Tab. 4: Structure of dominating support to R. Schuster and V. Mečiar in the second round of elections

Rudolf Schuster		Vladimír Mečiar	
large towns	73.6 %	rural settlements	55.6 %
medium large towns	56.2 %	population in productive age	58.0 %
small towns	55.1 %	farmers	61.7 %
younger part of productive population	61.6 %	workers	58.1 %
older part of productive population	57.4 %	unemployed	52.5 %
students	66.6 %	persons with basic education	54.7 %
employees	66.6 %		
businessmen and managers	67.3 %		
persons with medium level education	62.9 %		
persons with university education	70.5 %		
women	55.6 %		
men	51.2 %		

3.2 Structure of electoral preferences

The situation on the Slovak political scene manifested also in the second round of the presidential elections. Sympathizers with the coalition parties voted for R. Schuster (95.3 % of voters of PDC, 84.8% of voters of PDL, 99% of voters of PHC, 93.6% of voters of PCU) while the voters from the opposition parties gave their votes to V. Mečiar (95% of voters of MDS, 80.2% of voters of SNP). Table 4 presents the structure of preferences for both candidates in terms of other aspects.

3.3 Regions of electoral preferences

Results of the second round of the 1999 presidential elections confirmed the presumption that the basic features of the territorial structure of support to both main candidates from the 1st round would be maintained. In the second round both candidates obtained higher share of votes than in the 1st round in all districts of the SR (Schuster by on average 9.8%, Mečiar by on average 5.6%). They maintained this dominance in all districts in which they obtained the absolute majority of vote in the first round. Essentially, also the spatial features of relative dominance of one of the candidates were also maintained in the second round. Changes appeared only in four districts where a small difference existed between the share of votes for both candidates (2.3%). R. Schuster won in three districts in which Mečiar relatively led in the first round (Senica, Pezinok, Dolný Kubín) and Mečiar won in one district (Medzilaborce).

Consequently, the crucial regions of preference for the individual candidates were the areas mentioned in evaluation of the results of the 1st round. However, it is also possible to specify the situation in the regions where neither of the candidates obtained the absolute majority of vote in the first round. After accepting the results of the second round the south-western region of Slovakia can be divided into two parts. Its western part (Záhorie and Pezinok district) inclines to the southern boundary part of Slovakia characterized by supporting R. Schuster. Its eastern part (districts of Trnava, Piešťany) inclines to the area of central part of the Váh basin with dominating support to V. Mečiar. The ratio of electoral preference became also more distinct in the northern part of central Slovakia after the second round, when the voters from the districts Dolný Kubín, Martin and Banská Bystrica univocally voted for R. Schuster and the voters from Turčianske Teplice, Ružomberok, Liptovský Mikuláš and Brezno preferred V. Mečiar. Fig. 6 brings a detailed view of the regional preferences for R. Schuster. It shows the ballot results at the level of settlements, which confirm the reflections on districts with dominant position of one candidate or district, in which positions of both candidates were more balanced.

4. Conclusion

The first presidential elections in Slovakia by plebiscite allow for widening the database of information about the population's behaviour in the SR. Some of the new pieces of information hold generally, other temporarily.

In the first place, we can say that the Slovak voters assumed a positive attitude to the challenge of their constitutional body, which gave them an opportunity to decide elections of the president. The relatively high attendance in both rounds of the presidential elections (73.8 and 75.5%), comparable to the attendance at previous parliamentary elections (75.6%) proves it.

The 1999 presidential elections also confirmed that the Slovak voters applied the political criteria in the case of election of the head of the state. This is why the independent candidates who did not represent any political party, movement or group obtained only 12.8% of votes. In contrast, the two representatives of the main political subjects obtained votes from 84.6% of voters already in the first round.

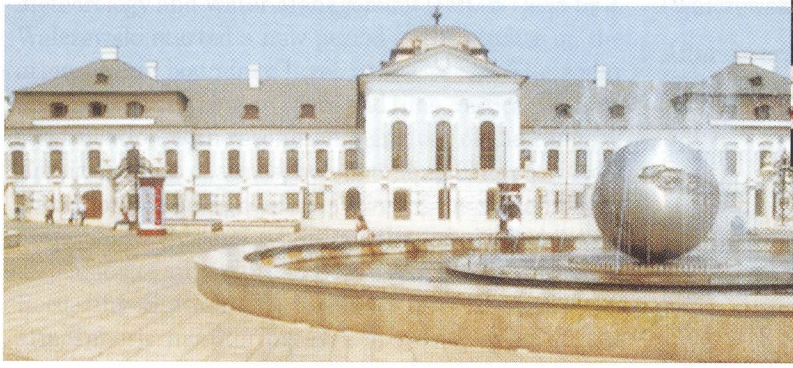
The above-mentioned facts also hold for the result of the presidential elections related to the spatial structure of electoral preferences of the individual candidates.The regions of increased support to candidates who passed to the second round are almost identical with the regions of increased political preferences of coalition or opposition in Slovakia. Regions of increased support to R. Schuster have a very complicated inner structure determined by alternation of the dominant position of a particular coalition partner (PDL, PHC, ChdM, and other). It is hardly to be expected that the similar agreement of the common support of various political subjects will occur again in the next presidential elections. The future task of R.Schuster in the next elections will be obviously decided by the rate of his success in the office.

The comparison of the results from the first and second rounds of elections suggests that the crucial regions of support to both candidates entering the second round formed in the first round. The dominance of the leading candidate in such regions increased in the second round. Apart from them there are also regions where none of the candidate dominated and there is a small difference between the share of votes of the first two candidates. In these regions the order of candidates might have changed in the second round.

In the conclusion we can observe that the first plebiscite in the SR took place in a non-standard, complex political situation and consequently the validity of generalization derived from their results is limited. Only the next presidential elections (foreseen for spring 2004) will bring some general conclusions characterizing the attitude of the Slovak voters to the elections of their head of the state.

Rudolf Schuster, President of the Slovak Republic 1999 - 2004

Bratislava - Prezidential palace



References

BRUNN, S. D., VLČKOVÁ, V. (1994): Parties, candidates and competitive regions in the 1992 Slovak National Council elections. Geografický časopis, Bratislava, 46, p. 231-246.

KRIVÝ, V. (1999): Územné celky a skupiny obcí v parlamentných voľbách 1998. Sociológia 31, Bratislava, p. 51-77.

KRIVÝ,V., FEGLOVÁ,V., BALKO, D. (1996): Slovensko a jeho regióny, sociokultúrne súvislosti volebného správania. Nadácia Média, Bratislava, 414 pp.

KTO? PREČO?, AKO? (1999). Ed.:Bútora M., Mesežnikov, G., Bútorová, Z., Inštitút pre verejné otázky, Bratislava, 311 pp.

MARIOT, P. (1994a): Voľby do SNR v roku 1992 a ich porovnanie s voľbami v roku 1990. Geographica Slovaca 7, Bratislava, p.103-110.

MARIOT, P. (1994b): Spatial aspects of the 1994 elections for the National Council of the Slovac Republic Moravian Geographical Reports, Brno, 4, p. 52-60.

MARIOT, P. (1995): Stability and similarity of voting preference in Slovakia. Acta Univ. Belii, Banská Bystrica, Geographical Studies, Banská Bystrica, 1, p. 76-80.

MARIOT, P. (1997a): Regióny volebnej preferencie na západnom Slovensku. Geographia Slovaka, Bratislava,12, p. 99-105.

MARIOT, P. (1997b): Slovak Republik Nationalities-Religiousness-Electoral Preferences. Foldrajzi Értesíto, Budapešť, 3-4, p. 183-189.

MARIOT, P. (1998): Stadt-Umland-Forschungen im Raum Bratislava. Arbeitsmaterialen zur Raumordnung und Raumplannung, Bayreuth, 166, p. 127-136.

MARIOT, P. (1999a): Three levels of territorial differantation of political preferences in the territory of the SR. Geographica Slovenica, Ljubljana, 31, p. 223-229.

MARIOT, P. (1999b): Regionálne aspekty neúčasti na voľbách do NR SR 1994. Folia Geographica , Prešov, 3, p. 144-149.

MARIOT, P. (1999): Štruktúra volebných preferencií obyvateľov najväčších miest Slovenska. Geografický časopis, Bratislava, 51, p. 153-175.

VLČKOVÁ, V. (1997): Geografické aspekty výsledkov volieb do SNR a Národnej rady SR (1990-1992-1994). Elita, Bratislava, 76 pp.

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ON APPLICATION OF ACOUSTIC SOUNDING METHOD TO THE STUDIES ON THE ATMOSPHERIC BOUNDARY LAYER OVER CRACOW - CONTRIBUTION TO MONITORING OF A LARGE CITY SANITARY STATE

Krzysztof JARZYNA

Abstract

In Cracow sounding of the atmospheric boundary layer by a sodar has been carried out since 1979. Because of its high temporal and spatial resolution the sodar technique has been widely used in the investigations on thermal stratification of the atmosphere. Moreoever, this technique is also practised in monitoring air pollution dispersion in 850 000 inhabitant Cracow. In this paper, the studies dealing with usage of the sodar for examination of diurnal and annual courses of processes in the atmospheric boundary layer over Cracow and their meteorological conditioning are reviewed. Possibilities of practical application of the study results have been emphasised.

Shrnutí

Využití metody akustické sondáže při průzkumu mezní vrstvy atmosféry nad Krakovem - příspěvek k monitorování čistoty ovzduší velkého města

V Krakově je už od roku 1979 prováděna sondáž mezní vrstvy atmosféry pomocí sodáru. Poněvadž tato technika se vyznačuje vysokou rozlišovací schopností a to nejen časovou, ale také prostorovou, proto je často využívaná při průzkumu teplotního zvrstvení atmosféry. Využívaná je rovněž k monitorování podmínek rozptylu škodlivin v ovzduší Krakova, města s více než 850 tisíci obyvatel. Tento článek obsahuje přehled výzkumných prací věnovaných využití sodaru při průzkumu denního a ročního průběhu procesů v mezní vrstvě atmosféry nad Krakovem v závislosti na meteorologických podmínkach. Jsou rovněž naznačeny možnosti využití výsledků tohoto průzkumu v praxi.

Key words: *acoustic sounding, thermal stratification, atmospheric boundary layer, Poland*

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1. Introduction

Construction of the Polish sodar "SAMOS" in 1978, i.e. over 20 years ago, by the team of the Institute of Meteorology and Water Management (IMGW) lead by J. Walczewski started a new period in the studies on the atmospheric boundary layer over Cracow. The sodar allowed for analysing, in space and time, vertical thermal stratification with resolution being out of the range of classic methods of atmosphere sounding. This provided a frame for a thorough examination of the variability of atmospheric thermal conditions that are important for dispersion of air pollution. Because of that, the Central Recording Station (? - 50o04'35", ? - 19o59'27") of atmospheric monitoring system was founded in the Department of Atmosphere Remote Sensing lead by Prof. J. Walczewski in 1990. This station provides records allowing for a current evaluation of air pollution dispersion over Cracow as well as for its forecasting (Walczewski, 1994a, 1997).

After several improvements the above mentioned sodar, allows for sounding the atmosphere to the height of 1000 m. To perform the latter the sodar uses a beam of acoustic waves emitted directly upward. The signal from the sodar is scattered by thermal inhomogeneities of the atmosphere and the sodar records a reflected acoustic echo. The height at which the scattering occurs is proportional to a period between the signal emission and the recording of the acoustic echo. An interval of the signal repetition is 6 s which guarantees a quasicontinuous sounding. The outcome is a sodar image (sodar records). By comparison with the results obtained by classic methods, the characteristic forms of acoustic echoes occurring on the sodar images may be related to thermal stratification of the lower atmosphere. It allows to study, i.a. convection and temperature inversion phenomena occurring in the atmospheric boundary layer. Raw sodar images are manually encoded as numerical series describing properties of the sodar echo in hourly intervals. Technical aspects of the sodar technique were described by Walczewski (1999).

2. Application of sodar data for the atmospheric boundary layer studies

Sodar observations that have been carried out since 1979 allowed to collect in Cracow a 20 year long data series being the longest in this part of Europe. Unfortunately, the usage of the entire data set is difficult at present, because the data originating from sounding by various versions of the sodar are not comparable. Yet, attempts to make the Cracow sodar data base uniform are in progress. Despite the difficulties mentioned above these data form a basis for numerous studies on the atmospheric boundary layer. Results of these studies were published many times. An overview of all papers published until 1998 was compiled by Walczewski (1999).

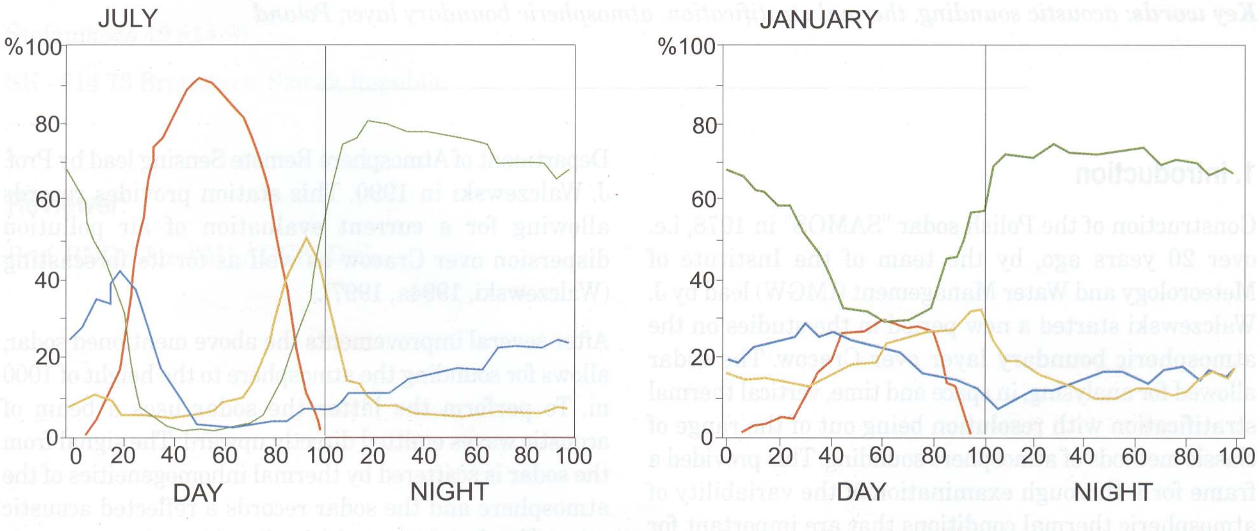
The purpose of this work is to summarise a part of these studies related to climatological aspects of investigations of the atmospheric boundary layer over Cracow. A special emphasis is put on studies devoted to characteristics of the diurnal and annual courses of the processes in the atmospheric boundary layer and to their meteorological conditioning. Outcomes for the air monitoring system resulting from the studies have also been shown.

2.1 Functioning of the atmospheric boundary layer over Cracow

The first analyses of sodar records confirmed a soundness of the "classic" model of a diurnal course of processes in the atmospheric boundary layer which presumes convection predominating during the day and the ground temperature inversion at night (Walczewski, 1980 and 1984). It was stated that the "classic" model is better demonstrable in a warm season when the convection is observed more often (Walczewski, 1994b) - (Fig. 1).

Convection occurs much more rarely in cold season months. Yet, ground and raised inversions of air temperatures are more frequent. It limits a vertical air exchange and in conjunction with the lowland location of Cracow and intensified pollution emission contributes to degradation of the aero-sanitary state. Later the discussed model was added more details owing to the analysis of changes in the thermal structure of the atmospheric boundary layer after sun rise in the period of a so called "morning transition" (Walczewski, 1994c, Walczewski and Stasiak, 1995, Godłowska and Walczewski, 1998). At that moment, transformation of the ground temperature inversion into the raised inversion was usually observed, under which convection cell developed. Strong vertical air circulation associated

Fig. 1: Diurnal frequency of particular types of the sodar echo (%) in the atmospheric boundary layer over Cracow in January and July in 1980-1992



— - echoes of convection cells, ... -.echoes of ground temperature inversions, ... - echoes of raised temperature inversions, ... - echo-less structures

(Source: Walczewski, 1994b)

with convection cause air pollution emitted at night by high sources flow downward to the ground. This results in morning maxima of air pollution imission. Walczewski (1994c) classified the morning transitions according to their conditioning of air pollution dispersion.

Some characteristic deviations from this classic model were also noticed. These are: nocturnal occurrence of featureless structures corresponding to the neutral stability of the atmosphere and presence of ground inversion layers during the day (Walczewski, 1981, 1984 and 1985). The latter phenomenon, significantly degrading the aerosanitary conditions of Cracow, was analysed in details. These analyses allowed to precise the term "days with temperature inversion". According to the accepted definition these are days when the lower inversion layer occurs continually or with a maximum 3 hour gap in the time span from 5:00 to 17:00 GMT (or longer). However, a free convection must not develop during this gap. Such conditions were observed in 1991-1997 in cold seasons (November-February). In winter months of 1997 such conditions occurred in half of the days when the sodar observations were performed (Dębicka, 1999).

2.2 Regularities in diurnal and annual thermal stratification in the atmospheric boundary layer over Cracow

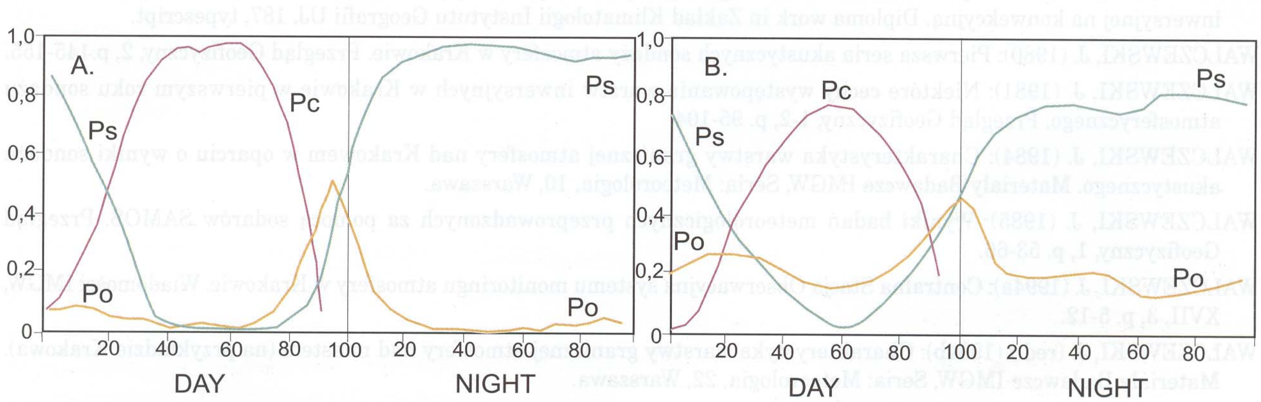
The sodar data base set up in Cracow in the mid-1980s allowed for initiation of the studies on meteorological conditioning of changes in thermal stratification of the atmospheric boundary layer. Under these studies, particular characteristics of the sodar echo were compared with the magnitudes of meteorological elements measured at the ground and with synoptic conditions affecting the weather in Cracow. Unfortunately, it often happened that under similar synoptic conditions a high variability in forms of the sodar echo was observed there (Wójtowicz, 1986). Therefore, it was impossible to develop a prognostic model of the changes in the thermal stratification in the atmospheric boundary layer over Cracow. The performed analyses allowed for drawing some general conclusions only, most of which refer to the influence of meteorological conditions on the frequency of occurrence of the characteristic structures of the sodar echo.

The classic model of the annual course of the thermal stratification in the atmospheric boundary layer over Cracow was observed most often under radiation weather conditions. Such weather is characterised by high contrasts in day and night air temperatures, low cloudiness and relatively high insolation. The weather of this type was observed most often under conditions of high pressure systems, especially with stagnating air or with an inflow of cold air masses over the warmer ground surface (Cholewa, 1990, Cacak, 1991). As a result, at that time the nocturnal ground temperature inversions predominated under which the convection processes leading to disappearance of the inversion layer (Walczewski, 1994c, Godłowska and Walczewski, 1998) were developing after the sun rise (Fig. 2).

The moment of the "morning transition" was usually slightly delayed with respect to the sun rise and fairly coincided in time with the change in sign of the vertical gradient of the air temperature at the ground as well as with the morning increase in wind speed and air temperature fluctuation (Walczewski, 1995, Stasiak, 1996). Such weather might sometimes be responsible for the morning maxima of air pollution imission.

On the other hand, daily ground and raised air temperature inversions were observed most often during

Fig. 2: Probability of diurnal occurrence of three basic types of the atmospheric stability in the atmospheric boundary layer over Cracow in warm season (March-September) in relation to the pressure system; data for 1980-1987



A - high pressure situation with stagnant air masses, B - low pressure situation with inflow of air masses from N and NW, Pc - probability of unstable stability of the atmosphere (echoes of convection cells and echoes of raised temperature inversions occurring independently during the day, Po - probability of neutral stability of the atmosphere, (echo-less structures), Ps - probability of stable stability of the atmosphere (echoes of ground temperature inversions and echoes of raised temperature inversions occurring independently at night). Source: Starzec - Molenda (1988) the high cloudiness typical of low pressure systems (Wójtowicz, 1986). Unfortunately, an unambiguous determination of conditions controlling the multi-diurnal ground air temperature inversions has not been possible yet. The weather of low pressure system also favoured the occurrence of featureless structures corresponding to the neutral stability of the atmosphere as seen on the sodar records. The occurrence of the above mentioned structures resulted in the limited convection taking place during the day and temperature inversions at night in 1980-1987 (Fig. 2).

3. Topics of the sodar studies in the future

In the studies on the dynamics of the changes in thermal stratification of the atmospheric boundary layers over Cracow numerous problems, especially those related to meteorological conditioning, are still unsolved. This makes an interesting field for further studies in this domain. The studies of this type should be based not only on the analysis of the frequency of particular types of the sodar echo but they should also take into account the height characteristics of the echo. According to the author the following aspects should also be considered:

- annual changes in physical properties of air masses affecting the weather in Poland,
- variable dynamics of synoptic conditions that decide to what degree the local weather is affected by these conditions,
- complex influences due to local meteorological conditions,
- inertia of the atmospheric boundary layer system which reacts with a delay to changes in the meteorological conditions,
- peculiarity of the thermal regime of a large city such as Cracow as well as the influence of a diversified relief.

The picture of processes occuring in the atmospheric boundary layer may be updated in the future owing to the comparison of the sodar data with results of sounding of the dust layer by lidar (atmospheric laser). A helpful tool seems to be the Doppler sodar allowing for studying the vertical wind profile as well as a deflection of wind direction with height.

References

CACAK, D. (1991): Porównanie charakterystyk ech sodarowych i stanów pogody dla wybranych miesięcy okresu 1980-1987 w Krakowie. Diploma work in Zakład Klimatologii Instytutu Geografii UJ, 153, typescript.

CHOLEWA, B. (1990): Związek między częstotliwością występowania warstw inwersyjnych nad Krakowem a temperaturą powietrza, usłonecznieniem i zachmurzeniem. Diploma work in Zakład Klimatologii Instytutu Geografii UJ, 151, typescript.

DĘBICKA, K. (1999): Częstotliwość występowania dni z całodziennymi inwersjami w Krakowie. Wiadomości IMGW, XXII, 3, p. 99-105.

GODŁOWSKA, J. - WALCZEWSKI, J. (1998): Próba określenia uwarunkowań porannych przemian struktury warstwy granicznej. Wiadomości IMGW, XXI, 1, p. 49-60.

STARZEC-MOLENDA, T. (1988): Uwzględnienie typów pogody w modelu empirycznym opisującym występowanie stanów równowagi atmosfery w Krakowie na podstawie danych sodarowych. Diploma work in Zakład Klimatologii Instytutu Geografii UJ, 141, typescript.

STASIAK, M. (1996): Zmiany elementów meteorologicznych podczas porannej przemiany struktury warstwy granicznej z inwersyjnej na konwekcyjną. Diploma work in Zakład Klimatologii Instytutu Geografii UJ, 187, typescript.

WALCZEWSKI, J. (1980): Pierwsza seria akustycznych sondaży atmosfery w Krakowie. Przegląd Geofizyczny, 2, p.145-155.

WALCZEWSKI, J. (1981): Niektóre cechy występowania warstw inwersyjnych w Krakowie w pierwszym roku sondażu atmosferycznego. Przegląd Geofizyczny, 1-2, p. 95-104.

WALCZEWSKI, J. (1984): Charakterystyka warstwy granicznej atmosfery nad Krakowem w oparciu o wyniki sondażu akustycznego. Materiały Badawcze IMGW, Seria: Meteorologia, 10, Warszawa.

WALCZEWSKI, J. (1985): Wyniki badań meteorologicznych przeprowadzonych za pomocą sodarów SAMOS. Przegląd Geofizyczny, 1, p. 53-66.

WALCZEWSKI, J. (1994a): Centralna Stacja Obserwacyjna systemu monitoringu atmosfery w Krakowie. Wiadomości IMGW, XVII, 3, p. 5-12.

WALCZEWSKI, J. (red.) (1994b): Charakterystyka warstwy granicznej atmosfery nad miastem (na przykładzie Krakowa). Materiały Badawcze IMGW, Seria: Meteorologia, 22, Warszawa.

WALCZEWSKI, J. (1994c): Problem prognozowania porannej ewolucji warstwy granicznej przy prognozowaniu porannych maksimów imisji. Wiadomości IMGW, XVII, 3, p. 81-90.

WALCZEWSKI, J. (1995): Zmienność niektórych elementów meteorologicznych mierzonych na powierzchni ziemi podczas pojawiania się i zaniku struktur konwekcyjnych w warstwie granicznej na podstawie obserwacji w Krakowie. Wiadomości IMGW, XVIII, 3-4, p. 81-100.

WALCZEWSKI, J. (1997): Wskaźnik meteorologiczny określający prawdopodobieństwo wzrostu zanieczyszczenia powietrza w okresie zimowym. Wiadomości IMGW, XX,1, p. 38-43.

WALCZEWSKI, J. (1999): 20 lat polskiego sodaru. Wiadomości IMGW, XXII, 3, p. 5-21.

WALCZEWSKI, J. - STASIAK, M. (1995): Przebieg roczny występowania typów porannych przemian w warstwie granicznej - obserwacje sodarowe w Krakowie w roku 1994. Wiadomości IMGW, XVIII, 3-4, p. 67-80.

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LANDSCAPE, SETTLEMENT AND FLOODS IN THE HANUŠOVICE/JINDŘICHOV MODEL REGION (NORTHERN MORAVIA)

Antonín VAISHAR, Pavlína HLAVINKOVÁ, Zdeněk MÁČKA

Abstract

The model region is situated in the piedmont of the Hrubý Jeseník Mts. and Králický Sněžník Mts. upstream the Morava River and its tributaries Branná and Krupá. Flood hazards in the region issue from the location on the contact between the erosional and transport parts of the watershed, and from the drainage pattern configuration. Characteristic are flash floods with a minimum time space between the actual precipitation fall and the onset of the flood wave. In the last 150 years, the centre of settlement shows a principal shift from the protected locations at higher altitudes to the inundation areas. In July 1997, the intensive rainfalls resulted in a whole-area run-off from steep slopes and in a dramatic rise of all water courses, which represented a considerably destructive potential, multiplied by coinciding flood waves of individual streams. The historical memory of flood jeopardy returned to the region. A return of the settlement to the original locations would be hardly realistic, however. The technical protection should consist in the construction of a system of polders on all three rivers. The issue of accepting the flood risk has to face a psychological barrier of the relying on the patronizing role of the state.

Shrnutí:

Krajina, osídlení a povodně v modelovém regionu Hanušovice/Jindřichovice

Modelová oblast se nachází v podhůří Hrubého Jeseníku a Králického Sněžníku na horním toku řeky Moravy a jejích přítoků Branné a Krupé. Rizika povodní v této oblasti vyplývají z umístění na styku erozní a transportní části povodí a z konfigurace říční sítě. Charakteristické jsou náhlé povodně (flash floods) s minimální dobou mezi spadnutím srážek a nástupem povodňové vlny. V uplynulých 150 letech byl pozorován zásadní přesun těžiště osídlení z vyšších chráněných poloh do inundačních území. V červenci 1997 došlo v důsledku intenzivních srážek k plošnému odtoku z příkrých svahů a k rychlému nárůstu hladin všech vodních toků. Výsledkem byl značný ničivý potenciál, znásobený souběhem povodňových vln jednotlivých toků. Historická paměť pocitu ohrožení se do regionu vrátila. Návrat osídlení do původních poloh je však málo reálný. Technická ochrana by měla spočívat ve vybudování systému poldrů na všech třech řekách. Problém akceptování rizika povodní naráží na psychologickou bariéru, spočívající ve spoléhání na protektorskou úlohu státu.

Key words: *Floods, settlement, landscape, Morava River, Czech Republic*

Introduction

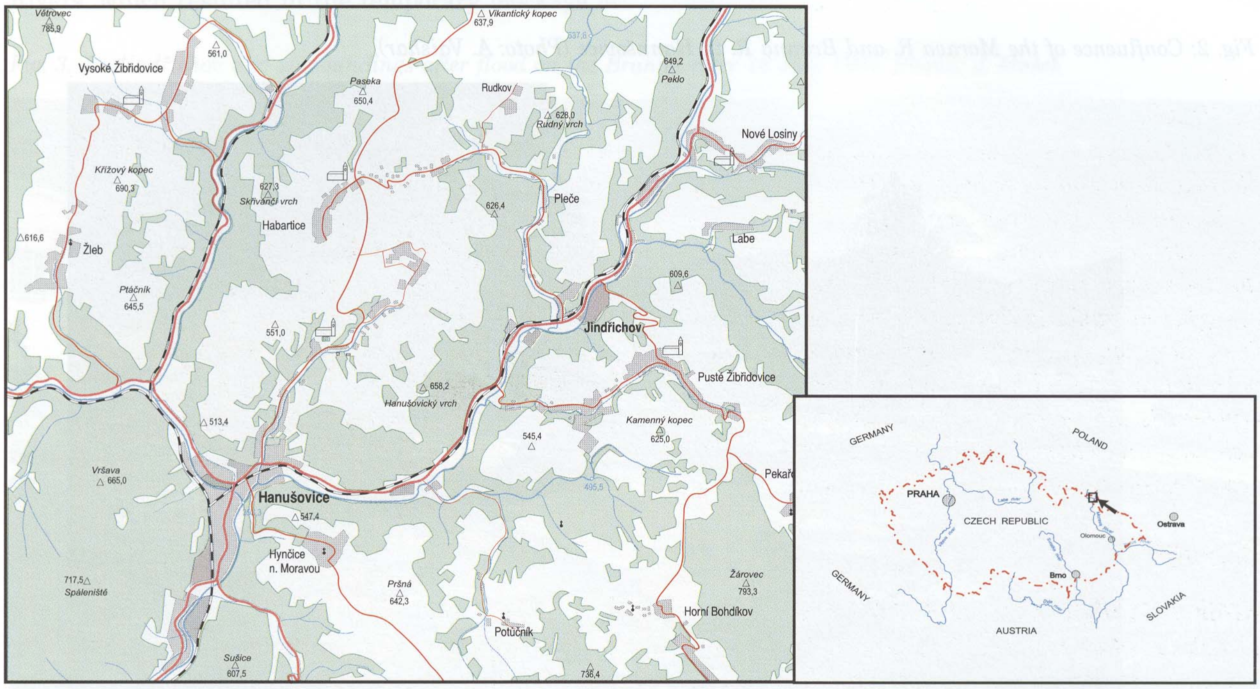
In the summer of 1997 the central Europe suffered under the influence of extremely heavy and long-lasting rains with extreme floods which had disastrous consequences in many countries. The region most afflicted in the Czech Republic were the watersheds of the Morava and Odra Rivers.

Institute of Geonics, CR Academy of Sciences was granted a financial support from the Grant Agency of the Czech Academy of Sciences (No. IAA3086903) for the project "Floods, Landscape and People in the Watershed of the Morava River" which studies the long-term consequences of floods. The consequences show both in the landscape and natural environment themselves and in the modification of the development of the economic and social systems as well as in the psychological condition of the population from the affected regions.

In order to evaluate the consequences in the vast area of the Morava R. watershed (21 145 km^2) as precisely as possible, there were 4 model regions chosen for the project. Each of them represents to a certain extent the situation in the given region and is characteristic not only by the different course of the flood, but also by different consequences.

The presented model region (Hanušovice/Jindřichov) is situated upstream the Morava R. and its tributaries Krupá and Branná (Šumperk district). The course and consequences of floods in mountain regions are studied on the example of this model region - in spring areas and on upper reaches of big rivers (Morava, Opava, Odra and Bečva) affected by the flood. As to possible remedial measures and prevention of new floods, the situation is further complicated by the fact that a major part of the Jeseníky Mts. and Králický Sněžník Mts. is subjected to a special regime of nature conservation (the Jeseníky Mts. protected landscape; the Králický Sněžník Mts. national nature reserve).

Fig. 1: Model region of the Hanušovice / Jindřichov and its localization in the Czech Republic



Relief as a factor of flood origination, course and consequences

Relief is an important factor acting in the process of origination, course and resulting effects of the flood. Of a number of possible causes of river floods, in the natural conditions of our country it is the intensive rainfall activity. Relief is then one of a complex of factors of the fluevial system (watershed), which define the way of transformation of the precipitation water fallen on the watershed surface and how will the rainfalls affect the river discharge. Relief influences the rise of flood discharges especially by the parameters of watershed shape, geological structure, river pattern arrangement and riverbed morphology.

Wider surroundings of the Hanušovice/Jindřichov model region is situated in the upper part of the Morava R. watershed, at places where its collecting channels leave the territory of the upland relief type of the Králický Sněžník Mts., Rychlebské hory (Mts.) and Hrubý Jeseník Mts. and enter the territory of the upland relief type of the Hanušovická vrchovina (upland). According to the basic schematic division of the watershed into the erosion area, transport area and accumulation area, the model region is to be found on the contact between the erosion and transport parts of the watershed. The stream section in the watershed source upland area up to the confluence of the Morava, Krupá and Branná near Hanušovice, and the partial watershed of the Desná R. can be denoted as the erosion area, the stream section in the upland terrain from Hanušovice up to the confluence with the Desná R. near Postřelmov can be denoted as the transport area, and the longest section in the hilly land relief of the Outer Carpathian Depressions up to the confluence with the Danube R. can be denoted as the accumulation area.

From this point of view the model region is situated in an unfavourable location succeptible to floods with a short time between the precipitation fall and the onset of the flood wave (flash floods) and with a complicated possibility of alarm system employment. The risk issues from the windward effect of high mountain ranges which constitute a barrier to the movement of atmospheric masses, which -under unfavourable circulation conditions- results in orographically induced intensive rainfalls. Another potential risk based on the presence of the vast and high mountain ranges is the sudden melting of snow cover, combined possibly with the rainfalls, and occasional summer rainstorms. Another risk given by the location on the edge of the source erosion part of the watershed is a considerable degree of terrain erosional articulation (high value of valley and drainage patterns density), narrow and deep valleys without developed fluvial plains, and a large gradient of streams. These factors condition a great effectiveness of water and sediment transportation from the valley patterns to the lower parts of the watershed, resulting in a high speed of the flood wave passage and in a considerably great erosion and transport power of the water courses. These are subsidized in the erosion part of the watershed with a huge amount of sedimentary materials from the steep and long-stretching slopes of mountain valleys. The material is being displaced in the streambed mainly during the floods and is deposited at places where the stream looses a part of its energy, i.e. often at the mouth where the tributary opens into a water course of higher order. All this indicates that the volume of the material displaced by the flood is considerable in the model region and that the damage due to the deposition may be high.

Another factor unfavourable for the model region is the arrangement of the drainage pattern. The town of Hanušovice is situated on an important hydrographic joint at the contact of three rivers - Morava, Krupá and Branná. In the case of simultaneous precipitations in watersheds of all three rivers, there is a convergence of flood waves and a jump multiplication of stream energy exactly at places where the town is located. The discharge multiplication is attended by a certain decrease in the gradient of the Morava R. which enters on the confluence into a wider valley with a more pronounced fluvial plain. Here the erosional and accumulation effects of a considerably powerful stream transforming and displacing its bed and depositing at the same time a considerable amount of fluvial sedimentary materials on the surface of the fluvial plain sum up. An interesting fact found out on the basis of an analysis of the stream magnitude M (sensu Shreve, 1966), which informs about the number of stream collection channels and is a good approximation of its discharge where the hydrological measurements are missing is a finding that a main stream here is not the Morava River (M=83) but the Krupá River (M=142). From this point of view, the Branná River is an equivalent stream (M=83). It can be assumed that the Morava R. won the status of the major water course in the past thanks to its greater length (by ca. 3.5 km) or simply via a social consensus. The difference among the three watersheds is also obvious from the groundplan of the drainage pattern: the Morava R. has a feather typer of the drainage pattern with short branches, the Krupá and Branná Rivers have drainage pattern groundplans of an arboreal type.

Fig. 2: Confluence of the Morava R. and Branná R. in Hanušovice (Photo: A. Vaishar).

Historical information on floods in the region

The history of floods in the territory of present Šumperk and Jeseník Districts was studied by Polách and Gába (1998). Although their survey may not be complete, it apparently succeeded in capturing all most important floods since the end of the 16th century. The history of floods in the region of the Jeseníky Mts. and their piedmont is relatively rich but the region of Hanušovice/ Jindřichov is not mentioned too frequently in the disastrous records before the end of the 19th century. The very first military mapping of 1768 mentions abundant spring and autumn floods on the Krupá and Branná Rivers, which resulted in the temporary blockage of roads leading through their valleys due to flooded communications and destroyed bridges. Nevertheless, the settlement of these valleys was low at those times and this is perhaps the reason why -unlike in Šumperk and seats in the Desná R. watershed- neither human victims nor serious damages on property are mentioned.

Records mentioning damaged railway tracks constructed in the region begin to appear from the end of the 19th century. The railway traffic between Šumperk - Hanušovice was stopped in 1883 due to the overflowing Morava R., perhaps for the first time. In 1903, the railway was damaged by the overflowing Krupá R. which also destroyed the regulated riverbed. In July 1907, the Morava R. inundated Hanušovice and Holba, damaging the railway track from Hanušovice to Králíky and Staré Město. In August 1913, the coinciding floods on the Morava R. and Krupá R. damaged a railway bridge in Hanušovice and the sluice-gates of the local weaving mill. The railway operation between Hanušovice and Staré Město was once again discontinued due to a flood in 1919. One of the most severe disasters was the flood resulting from a cloud-burst on 1 June 1921 when the paper mill in Jindřichov and the whole valley up to Hanušovice suffered great losses due to the overflowing Branná R. The situation repeated in June 1927 with the greatest damage at Potůčník where the water took away a bridge and an oil-shop, and again in Hanušovice. The flood in September 1938 was possibly the last one at which (quite unusually at that time) Czech and German rescue teams cooperated, being helped by the local population in Hanušovice and at other places of the District.

Fig. 3, 4 : Jindřichov and surroundings after flood on the Branná river 16 July 1997. Photos: J. Mašek

In the period of building socialism, the floods were standing outside the centre of attention and were sometimes mentioned only in district newspapers. A cloud-burst in Hanušovice caused a great damage in August 1951. In July 1965, the Branná R. water table rised by about a meter after a torrential rain and hails, the flood taking down bridges, roads and minor

Fig. 4

structures. The August of 1977 was the rainiest August in the last hundred years. The floods also affected the watersheds of the Morava and Krupá Rivers. A number of roads and railways connecting Hanušovice with the rest of the world were blocked. Another flood with considerable material damages on private and public buildings, communications and farm animals occurred in July 1984 due to a storm at the high air temperature. The Hanušovice region was one of the most afflicted. And the next great disaster was the flood of 1997 (Fig. 3, 4).

Although the floods affected the model region regularly, it appears that the damages have been gradually increasing. The very first thing to matter was in fact only the temporary valley blockage as viewed from the point of possible military operations, later it was the damage on railways, motorways and bridges, and eventually the most serious impact was seen in the damage on buildings and properties. This development naturally relates immediately with the developing settlement in the region.

Region settlement in the middle 19th century

Let us assume that the Hanušovice/Jindřichov region includes all seats that form the present municipalities of Hanušovice and Jindřichov. These are as follows: Hynčice nad Moravou, Potůčník, Vysoké Žibřidovice and their local parts integrated with Hanušovice, and Habartice, Nové Losiny, Pusté Žibřidovice and their local parts integrated with Jindřichov. The census by seats has been in use in Czechia since 1850 or 1869; however, the results are not always comparable with the present structure of seats.

At those times, the structure of seats in our region was as follows: Hanušovice had mere 635 inhabitants in 1850. Nevertheless, the then Hanušovice stretched over a distance of 6 km from the confluence of the Morava R. with the Branná R. up the valley of the Hanušovický potok (Brook), i.e. at a considerably higher altitude than the today's core of the town. In place of the today's core of Hanušovice there was a village of Holba with about 300 inhabitants. It was exactly in the middle of the 19th century when a principal change occurred, Hanušovice began to grow rapidly and the town centre of gravity began to be shifted below the Morava-Branná confluence to an altitude of about 400 meters, i.e. into locations immediately endangered by floods.

Hynčice nad Moravou, in a side valley at the medium altitude of 527 m, had altogether 313 inhabitants in 1850. The village of Potůčník in another side valley at the mean altitude of 526 m has no records about its population from 1850 and the records of 1869 speak of 259 inhabitants. This means that the community ranked with small seats as early as at that time. Vysoké Žibřidovice (altitude 577 m) situated in one of side valley shooting from the Krupá R. valley was the largest seat in the territory of the present Hanušovice with 1156 inhabitants in 1850, of whom a part (about 300 persons) lived in the community Žleb, localized in a side valley emanating from the Morava R. valley at the altitude of 564 m.

Jindřichov (altitude 460 m) situated right in the Branná R. valley did not exist in 1850. It was as late as after 1862 that a group of houses was built around a paper mill. Jindřichov became municipality only in 1949. Habartice is situated on an upland plateau at the mean altitude of 590 m and its population was 697 in 1850. The village included a small community of Rudkov pod Rudným vrchem (altitude 628 m) which soon lost administrative independence, however, and a community of Pleče with 164 inhabitants in 1869 the location of which was less safe in terms of floods regarding its altitude (490 m) and the vicinity of the larger brook Stařič. It seems, nevertheless, that it is assumed that it was in fact the brook which became the very impuls to found the settlement around the hammer-mill belonging to the local family of manor.

Pusté Žibřidovice was a considerably larger seat, stretching along the long mountain hollow from the Branná R. and along the motorway from Hanušovice to Velké Losiny. Its mean altitude is 557 m and the population was 980 persons in 1850, of whom a part (257 persons in 1869) lived in the even higher situated community of Pekařov (altitude 680 m).

The largest seat in the territory of our region was Nové Losiny at the mean altitude of 585 m, which had 1326 inhabitants in 1850, of whom a part (279 persons in 1869) lived in the community Labe at an altitude of 590 m and in the village Josefová. Nové Losiny is situated in the valley of the Losinský potok (Brook) and along a mountain motorway from Jindřichov to Loučná nad Desnou.

Should we summarize the distribution of the settlement in the region in the middle 19th century we arrive at a conclusion that an absolute majority of the then 5.5

Fig. 5: A majority of the original cores of municipalicites in the model region are situated at higher altitudes (Church in Nové Losiny) (Photo: P. Hlavinková).

thousand inhabitants used to live at altitudes over 500 m, outside the reach of the expected major flood waves on the rivers Morava, Branná and Krupá. Only a small percentage of the population living in Holba and perhaps also in Pleče (i.e. less than 10% of the total population in the region) was exposed to an increased flood risk. The fact is that it was also the minor water courses flowing through the side valleys that could have overflown. Nevertheless, the probability was low and a possible flood would have affected only a small portion of the buildings anyhow. It is obvious from the localization of churches and a number of other buildings that their builders sought more protected locations even in the relatively well protected side valleys. If there was any protection against the floods, it was usually by erecting dikes along the natural riverbed.

Settlement development in the 2nd half of the 19th century

The 2nd half of the 19th century is first of all characteristic by a rapid growth of Hanušovice. The Vienna Flax and Hemp Society classified the local region as one of best to grow these crops in the monarchy of those times and established in the territory of present Hanušovice a flax adjustment shop in 1852. A flax spinning mill with a subsidiary at the neighbouring Holba was built in Hanušovice by E. Oberleithner - entrepreneur from Šumperk in 1857. In the 70s of the 19th century the two works had 800 employees. An important pre-requisite for a further growth became the railway connection between Šternberk - Šumperk - Hanušovice - Králíky in 1873. In 1874, a brewery came into existence at Holba, which was at its time the third biggest brewery in Moravia. Before the end of the 19th century, the industrial structure was extended with three minor plants manufacturing agricultural machines and equipments, a big steam sawmill of the Lichtenstein manor, a small chemical factory, a tannery, a soda water work, and the existing railway network was expanded to include Frývaldov. It is possible to say that in 1999 the industrial structure of Hanušovice was in principle completed and the traditional agricultural production withdrawn into the background. In 1900, the total population was 2241 persons, of whom 892 inhabitants lived at Holba which was at that time still a separate community. In the place of the todays's Jindřichov there was a paper mill established in 1862 and later expanded into a cellulose factory. In the year 1900, the colony at the paper mill had 333 residents.

All this indicates that the developing industry and railway brought the concentration of inhabitants to the lower locations, and partly right into the floodplain below the confluence of the three rivers. However, this did not occur to the detriment of the communities situated in higher locations. In these, the numbers of inhabitants increased in Hynčice, Potůčník, Pleče and Pusté Žibřidovice, and decreased in other communities.. The second largest settlements after Hanušovice were Nové Losiny (1191 inhabitants), Pusté Žibřidovice (1109 inhabitants) and Vysoké Žibřidovice (997 inhabitants). The total population of the region increased for the period 1850-1900 up to 7164 persons. It seems that the rural settlement in the higher locations remained more or less unchanged so far while the surplus population developing due to the demographic revolution left into the valley to work in the industry.

Yet, it is obvious that it was exactly the second half of the 19th century when a decisive change occurred in the distribution of inhabitants in relation to the flood danger. In 1900, some 40% of the population lived within more or less endangered areas. It would be interesting to know how the then (German) inhabitants and entrepreneurs perceived the flood danger and what were their solutions. Owners of industrial works probably included the flood risk in their business plans while factory workers did not have a greater choice. It seems that the first buildings located in the fluvial plains were shrinking from the river -similarly as in the case of Hanušovice- as far as to the margin of a distant slope and that it was only the buildings constructed later that got gradually closer to the river.

Settlement development in the 1st half of the 20th century

The population turn-over in the first half of the 20th century and particularly the resulting situation around the year 1950 were among other also influenced by the fact that the population in the region before World War II consisted mainly of German nationals. After the constitution of Czechoslovakia in 1918, the region was newly inhabited by a number of Czech civil servants and their families who settled especially in Hanušovice. According to our findings, they were offered land properties right in the Morava R. floodplain below the confluence with the Branná R., i.e. in the most endangered part of the town the reason being both the fact that the higher and more protected locations were already engaged and probably also the fact that the price of properties in the inundation area was lower. Although the traffic and industrial structure of the town recorded only an insignificant further development (railway to Staré Město from 1905, cannery), the number of inhabitants before the end of the year 1930 increased to 3954.

The entire increase of population generally concentrated in Hanušovice while other seats -with the exception of Pleče- began to loose the inhabitants. It seems that in consequence of increasing yields the agriculture in the region began to leave the highest altitudes and started to move down in more favourable locations. In 1930, there were 8042 inhabitants in the region, which is by nearly 1.5 thousand more than in 1900. Nevertheless, the rural seats as a whole lost about 200 inhabitants. The proportion of those who lived in the potential inundation areas exceeded a half.

Essential changes occurred after the evacuation of German population which has never been compensated for in terms of its numbers. In 1950, the region had a total population of 4428 inhabitants, i.e. 55% of the population in 1930. With the exception of Jindřichov, all seats lost ; a relatively greatest shrinkage of population was recorded in Potůčník (82%), Nové Losiny (60%), Pusté Žibřidovice (54%), etc. Hanušovice lost 35% of its population, Pleče 38%. Jindřichov recorded a population increase. This means that the most severe population losses were recorded in the highest situated seats whilst the least losses were in the lowest situated seats. The proportion of inhabitants endangered by floods increased to two thirds. German inhabitants from the higher situated villages left while newcomers settled preferrably in the valleys. We can say that a specific feature of the region under study was the evacuation of a major part of the German population, which put the seats from higher locations on the same level as small and very small villages in a conclusive way, thus becoming a basis for an earlier or later loss of their administrative independence and a further economic decline. The shift of the population from the protected higher altitudes into the fluvial plains of the main rivers Morava and Branná was to its greater part completed in the first half of the 20th century.

Settlement development in the 2nd half of the 20th century

The second half of the 20th century is typical of centrally steered economy which in the sphere of settlement consisted particularly in the implementation of a so called system of centres. The sense was to ensure the greatest possible concentration of the population and its activities into pre-determined central municipalities in order to improve efficiency of operating costs for the functioning settlement. This is why the central municipalities became also centres of a so called complex house building. The house building was usually localized according the principle of the cheapest and fastest construction, i.e. right into the floodplain. The individual house building was also directed into these centres by means of a number of government tools. The situation was similar in the concentration of industrial plants and enterprises. Agricultural works merged into a state farm managing the area of 8000 ha. A majority of industrial works were incorporated into national enterprises residing elsewhere. The end of the 50s was the beginning of closing down some small facilities such as the sawmill and dairy.

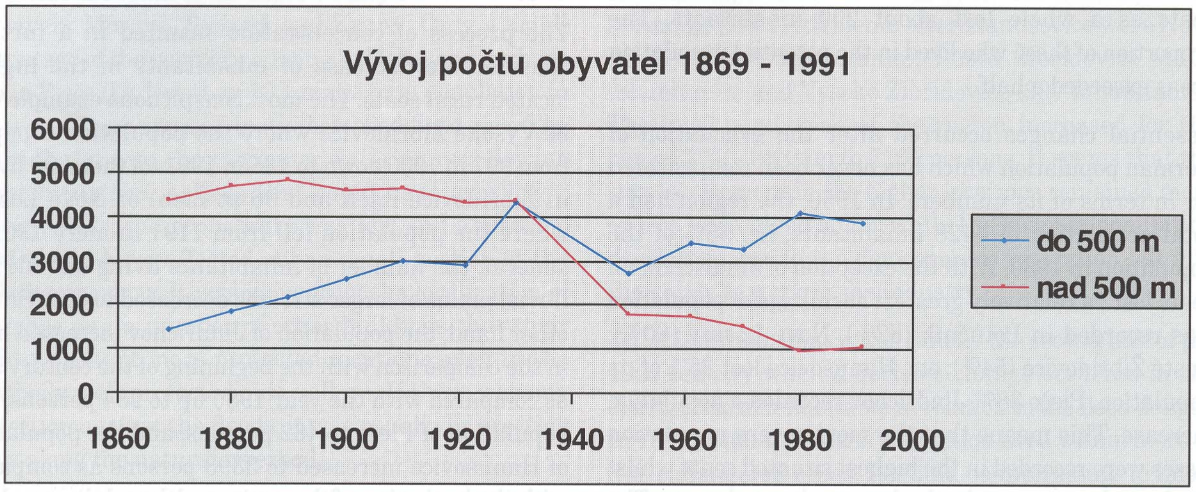
The process of concentration resulted in a further considerable decrease of inhabitants in the higher located rural seats. The most conspicuous example can be Vysoké Žibřidovice where the population dropped from 997 in 1900 down to 135 in 1991 (of these, 99 living in Žibřidovice itself and 36 at Žleb) or Nové Losiny where the population fell from 1191 to mere 190. In general, the number of inhabitants living outside the fluvial plains of larger streams decreased to 881. On the other hand, the population of Jindřichov increased both in the comparison with the beginning of the century and as compared with the year 1930 up to 234 persons, the population of Pleče to 462 persons, and the population of Hanušovice increased to 3393 persons as compared with the beginning of the century although its numbers did not reach the figures of 1930 any more. The total population in the microregion fell to 4970 persons (5029 in 1998) with the proportion of residents living in the seats located in the fluvial plains of the major streams exceeding 80%. The statement cannot be too much changed by the fact that a slight decrease in the number of inhabitants living in the lower locations was recorded in the 80s of the 20th century - along with an increase in the number of inhabitants living in the higher locations.

We do not assume the danger of flood being the sole reason to the former settlement of the higher situated areas. An important role was doubtlessly played also by the way of subsistence and by the issue of safety. It can be anticipated that in some periods of time the river valleys were passed by rushing armies or marauding hordes rather than the flood waves. Under these circumstances the location in marginal altitudes was advantageous. However, in the middle 19th century the safety issues were formulated in a different way and the forces of production and production relations exhibited rapid changes. The risk of floods became a less important matter and disappeared from the minds of the residents.

The fact is, however, that in the case of extensive floods it is also the population living outside the direct reach of the flood wave, which is affected indirectly by being cut off the communications and suffering from malfunctioning supplies, disturbance of technical networks, damaged or destroyed working places, etc. The man of present time is much more depending on external supplies of energy and information and on the cooperation with other places than was the man in the past. Nevertheless, these indirect damages are usually of only temporary character and little important as compared with the direct jeopardy to lives and property.

The historical awareness of flood danger has probably got close to zero both in general terms due to the conviction that technical measures help to face

Fig. 6: Population development 1869-1991 (up to 500 m; above 500 m)



anything, and in specific terms due to the exchange of the population in the region after World War II. A conclusive dominance won the conviction that the control of floods is a matter of government and the citizen is not obliged to get involved. This opinion did not change even in the short period of transformation to marhet economy since the market tools -among other in the relation to property value, housing market, household insurance against natural disasters, etc. could not get developed yet. The sense of responsibility of municipalities and citizens for civil defense and the feel of appurtenance within the municipalities decreased. This was the situation when the flood arrived in 1997.

Landscape and its use in connection with floods in the Hanušovice-Jindřichov model region

The landscape development since the last census was studied on the basis of data on the land use structure. It is generally assumed that the course and to a considerable extent also the consequences of the floods in 1997 were contributed to by intensive and vast

Tab. 1: Cadaster structure of Jindřichov (ha)

Cadastral area		TOTAL	Rural	Forest	Water	Built-up	Other	Houses	Plots
Situation to 1 January 1990	Habartice	934.4716	513.4884	353.4924	3.7169	4.2232	59.5507	44	1636
	Labe	350.2717	118.8487	210.4534	0.5029	1.1912	18.7755	8	619
	N.Losiny	2303.3463	349.6324	1856.5198	4.7756	4.49,3	78.4573	80	1896
	Pekařov	337.5212	144.4385	167.9937	1.5583	0.7219	22.8088	9	479
	Pleče	291.8506	115.1721	125.2428	9.2259	4.0016	38.2082	92	991
	P.Žibřidovice	841.4304	460.9918	291.1850	12.8370	10.3289	66.0877	109	1522
	Sklená	111.8474	13.4055	93.6937	0.3142	1.1912	18.7755	0	86
	Jindřichov	5170.7392	1715.9774	3098.5808	32.9308	23.448	302.6637	342	7229
Situation to 1 January 1997	Habartice	934.4716	514.0503	352.9820	3.9987	3.9368	59.5038	42	1637
	Labe	350.2717	114.6051	214.3837	0.5029	1.1912	19.5888	8	616
	N. Losiny	2303.3463	350.9138	1867.0797	4.7765	4.5090	76.0673	73	1887
	Pekařov	337.5212	144.3222	167.9937	1.5583	0.7219	22.9251	6	474
	Pleče	291.8609	112.2916	129.0708	8.9278	4.2139	37.3568	94	1030
	P.Žibřidovice	841.4304	461.2609	291.5582	11.4894	10.5231	66.5988	109	1574
	Sklená	111.8474	13.1984	93.9146	0.2992	0	4.4352	0	81
	Jindřichov	5170.7495	1710.6423	3116.9827	31.5528	25.0959	286.4758	332	7299
Situation to 5 June 2000	Habartice	934.4716	515.6809	352.9801	3.9987	3.9456	57.8663	43	1608
	Labe	350.2717	115.3919	215.8037	0.4684	1.1912	17.4165	8	598
	N. Losiny	2303.3816	366.8235	1864.6091	4.6115	4.4842	62.8533	76	1829
	Pekařov	337.5212	145.4595	167.9020	1.6902	0.7272	21.7423	7	476
	Pleče	291.8609	113.3108	128.9924	8.8454	4.2760	36.4363	92	1025
	P.Žibřidovice	841.4377	463.5128	291.7075	10.2086	10.5959	65.4129	111	1643
	Sklená	111.8474	13.4084	93.9146	0.2992	0	4.2252	0	78
	Jindřichov	5170.7921	1733.5878	3115.9094	30.122	25.2201	265.9528	337	7257

Tab. 2: Rural (agricultural) land structure in Jindřichov (ha)

Cadastral area		Arable	Gardens	Orchards	Hops	Vineyards	Meadows	Pastures
Situation to 1 January 1990	Habartice	306.0159	3.5508	0	0	0	16.7205	187.2012
	Labe	21.1193	0.2060	0	0	0	6.8633	90.6595
	N. Losiny	38.9713	3.5655	0	0	0	24.9474	282.1482
	Pekařov	7.6645	0.4462	0	0	0	0.4626	135.8652
	Pleče	45.8660	5.0205	0	0	0	13.9188	50.3668
	P.Žibřidovice	142.3460	5.3336	1.0673	0	0	28.0409	284.2040
	Sklená	0	0	0	0	0	0	13.4055
	Jindřichov	561.983	18.1226	1.0673	0	0	90.9535	1043.8504
Situation to 1 January 1997	Habartice	305.7711	3.6259	0	0	0	16.9621	187.6912
	Labe	21.1193	0.2066	0	0	0	6.8633	86.4159
	N. Losiny	28.5588	3.6205	0	0	0	24.8525	293.8820
	Pekařov	1.7055	0.4462	0	0	0	0.4626	141.7079
	Pleče	33.8153	5.0164	0	0	0	14.1841	59.2758
	P.Žibřidovice	114.6248	5.3355	1.0673	0	0	38.3228	301.9105
	Sklená	0	0	0	0	0	0	13.1984
	Jindřichov	505.5948	18.2511	1.0673	0	0	101.6474	1084.0817
Situation to 5 June 2000	Habartice	306.5366	3.6259	0	0	0	17.7992	187.7192
	Labe	21.7021	0.2066	0	0	0	6.8629	86.6203
	N. Losiny	13.2126	3.6388	0	0	0	25.5583	324.4138
	Pekařov	1.7055	0.4462	0	0	0	0.4626	142.8452
	Pleče	32.5936	4.9946	0	0	0	14.3383	61.3843
	P.Žibřidovice	124.7370	5.3312	1.0461	0	0	39.7271	292.6714
	Sklená	0	0	0	0	0	0	13.4084
	Jindřichov	500.4874	18.2433	1.0461	0	0	104.7484	1109.0626

anthropogenic interventions in the landscape. It was the pronounced changes in the use of the piedmont and mountain landscape of the Hanušovice-Jindřichov model region-the landscape which could previously cope with the destructive force of floods with no greater consequences-, which as a final result reflected in the impaired retention capacity of the landscape and hence in the course of the floods itself. We have on our minds the gradual urbanization of the narrow valley floodplain of the Morava R. and its tributaries - Krupá R. and Branná R., the whole-area transformation of the entire landscape due to the intensive agricultural large-scale production, regulation of water courses, damage to forest stands, building up of the valley floodplain with the seat and traffic infrastructure, etc.

To evaluate the development of landscape use in the last 10 years we can use several information sources such as statistic data about the structure of land use within particular cadasters, topographic maps, aerial photographs and last but not least the field survey itself. Similarly as in other cases of geographic research, the most objective information on the actual and topical

Tab. 3: Cadaster structure of Hanušovice (ha)

Cadastral area		TOTAL	Rural	Forest	Water	Built-up	Other	Houses	Plots
Situation to 1 January 1990	Hanušovice	1400.5260	514.5601	701.5057	16.8317	26.9365	140.6866	435	3180
	Hynčice nad Moravou	485.8203	277.3890	171.6553	3.2112	4.5573	29.0075	29	547
	Potůčník	276.6455	132.3180	122.0000	0.8402	1.3604	20.1269	7	730
	V.Žibřidovice	897.5237	511.8292	287.4006	4.6227	4.3328	89.3384	42	1916
	Žleb	620.5110	308.0234	270.7790	4.3457	2.2410	35.1219	14	1065
	Hanušovice	3681.0265	1744.1197	1553.3406	29.8515	39.428	314.2813	527	7438
Situation to 1 January 1997	Hanušovice	1400.6409	514.5363	702.3195	17.0579	27.6802	139.0470	458	3571
	Hynčice n.M.	485.8203	277.3805	171.1425	3.1462	4.5404	29.6107	30	581
	Potůčník	276.6463	132.1818	121.8950	0.8402	1.3675	20.3618	9	737
	V.Žibřidovice	897.5161	511.1205	286.7503	4.8093	4.3873	90.4487	39	1832
	Žleb	620.5110	308.0242	271.6859	4.3457	2.2010	34.2542	17	1021
	Hanušovice	3681.1346	1743.2433	1553.7932	30.1993	40.1764	313.7224	553	7742
Situation to 5 June 2000	Hanušovice	1400.6312	512.0301	703.7745	16.7702	28.0699	139.9865	470	3619
	Hynčice n.M.	485.8203	277.5125	171.1691	3.2320	4.4980	29.4087	30	608
	Potůčník	276.6582	131.2683	122.9043	0.7702	1.3789	20.3365	9	725
	VŽibřidovice	897.6169	513.1271	286.9781	4.8093	4.3873	88.3151	41	1800
	Žleb	620.5110	308.0869	271.3001	4.3457	2.1687	34.6096	16	1035
	Hanušovice	3681.2376	1742.0249	1556.1261	29.9274	40.5028	312.6564	566	7787

condition in the landscape use can be obtained only by a combination of these resources.

It follows from the following tables on the cadaster structure and rural (agricultural) land structure in the model region (Tabs. 1-4) that conspicuous changes in the use of particular plots occurred during the first half of the 90s due to the process of transformation rather than in the consequence of floods.

Tab. 4: Rural (agricultural) land structure in Hanušovice (ha)

Cadastral area		Arable	Gardens	Orchards	Hops	Vineyards	Meadows	Pastures
Situation to 1 January 1990	Hanušovice	210.5751	31.9211	0	0	0	36.6405	235.4234
	Hynčice n.M.	161.2848	2.0452	0	0	0	12.3739	101.6851
	Potůčník	6.6198	1.0834	0	0	0	7.2393	117.3763
	V.Žibřidovice	217.2672	0.6890	0	0	0	48.6019	245.2703
	Žleb	201.8160	0.7243	0	0	0	26.3474	79.1357
	Hanušovice	797.5629	36.463	0	0	0	131.203	778.8908
Situation to 1 January 1997	Hanušovice	208.7478	32.0837	0	0	0	36.2063	237.4985
	Hynčice n.M.	99.3058	2.0273	0	0	0	12.4487	163.5987
	Potůčník	1.5990	1.0834	0	0	0	7.2017	122.2977
	V.Žibřidovice	101.5954	4.6109	0	0	0	44.7676	360.1466
	Žleb	142.2167	0.3891	0	0	0	26.4332	138.9852
	Hanušovice	553.4647	40.1944	0	0	0	127.0575	1022.5267
Situation to 5 June 2000	Hanušovice	210.5197	30.7717	0	0	0	32.7885	237.9502
	Hynčice n.M.	111.4758	2.0397	0	0	0	12.5520	151.4450
	Potůčník	1.3982	1.1007	0	0	0	7.2838	121.4856
	V.Žibřidovice	101.9935	4.6109	0	0	0	44.6843	361.8384
	Žleb	142.2475	0.3891	0	0	0	26.4636	138.9867
	Hanušovice	567.6347	38.9121	0	0	0	123.7722	1011.7059

The available data indicate that the first half of the 90s saw a shrinkage of rural land and increasing forest land in the majority of local areas in the Hanušovice-Jindřichov model region. Within the rural land, a certain proportion of arable land or meadows were changed into pastures this being given particularly by the transformation of agricultural production, low competitiveness of particular agricultural cooperatives, restitutions, restricted subsidies, etc. Forestation and grassing both represent a positive trend from the viewpoint of flood prevention although their effect can be only partial in the case of extensive flood disasters.

Fig. 7: The present use of the landscape in the surroundings of the integrated seat of Žleby is dominated by mountain pastures and meadows (Photo: P. Hlavinková)

After 1997, we can see a reverse trend in several cases, when pastures are being transformed into arable land once again. Only time will show whether this phenomenon is a new developmental trend or whether its character is only temporary. The fact is, anyhow, that the agricultural production in this area, specialized mainly in rearing cattle, has been still surviving at the present time and not recording losses only thanks to government subsidies.

From the viewpoint of landscape use in the Hanušovice-Jindřichov model region, there was a change in using the valley floor of all local streams in the watershed of the Horní Morava R., which occurred in connexion with the summer flood of 1997. The reason was the own force of the flood or -in other words- the force of a mass of flood water which re-modelled the mentioned valley bottoms of these water courses and caused great material losses.

The traffic infrastructure was changed both in terms of its location and extent: the communications were displaced and enlarged, new bridges and protective dikes were built, etc. The flood of 1997 to a certain extent also relates with the reduction of meadows in the region, whose greater part -used for agricultural production- was situated on the valley floors of local streams. As shown by aerial photographs and field research itself, the valley floors were to a greater deal re-modelled during the floods due to the erosional activity of the flowing water and the meadows damaged.

The seats situated in the valley floors -particularly Hanušovice and Jindřichov- also recorded certain changes in the structure and area of built-up and other plots. The knowledge is based on authors' own field research since no statistic data exist today on the structure of these areas in the period before the flood and this is why there is nothing which the contemporary data could be compared with.

The fact is, however, that the material damages on the seat and traffic infrastructure were eliminated very quickly; new houses were built, bridges, motorways and damaged railways repaired so that the losses were compensated for and the present condition of the built-up and other plots approximately corresponds with that before the flood.

Partial conclusions

The above data and facts led us to formulate the following conclusions:

1. In the course of the last 150 years we are witnesses to an absolutely principal change in the distribution of population. In this period of time, the ratio of people living in protected and endangered locations nearly turned into its opposite.
2. These changes started in the period of industrialization, extensive urbanization and demographic revolution, and continued in the period between the wars being further accentuated in this region by the circumstances concerning the evacuation of the German population and accomplished in the period of centrally planned economy.
3. In the comparison with the year 1850, the present number of inhabitants in the region is lower which indicates that a reason to the concentration could not be the increased pressure for space due to the growing population but only and exclusively the change in land use.
4. In addition to climatic changes which we consider not sufficiently demonstrated, the region exhibits all other causes of increasing potential flood damages defined in the UN strategy for the beginning of the third millennium in order to reduce the risk of natural disasters: the mass transfer of the population into endangered areas, the growing value of facilities and buildings located in inundation areas, and in terms of flood prevention the improper land use.

Strategy of area protection against floods

There are three basic strategies to protect the territory and the population against floods. The first of them is to bring the people and their activities to a distance from water, the second one consists in preventing water from flooding areas in which it could disturb people's lives, and the third one is the art of living with floods.

The first strategy is a return to building houses outside the inundation areas. This strategy cannot be employed generally in the whole area but can be taken into account when building new houses, production facilities or infrastructure. What comes into consideration is a building in more protected locations of existing centres Hanušovice and Jindřichov, or an attempt at a rehabilitation and return to higher locations in integrated seats, possibly also in the old Hanušovice.

In reality the strategy is employed at minimum. There are several barriers of which the most important one is a lack of funds to launch new structures. Another barrier is the continuing relying upon the protective function of the state. If the building finds itself within the compact housing area of the seat, the state or the municipality are obliged to provide its protection. The fact that during the extreme flood of 1997 the state or the municipality could not do so does not seem to disquiet anybody. This is why a new dwelling house was recently put into operation in Sportovní Street in Hanušovice, which is situated right in the inundation zone and other two buildings were erected by entrepreneurs in an inundation zone on the

Fig. 8: The original seats at higher locations do not miss charms but infrastructure (Photo: P. Hlavinková)

southern limits of the town. A great problem of the possible rehabilitation of at least some integrated seats is the disconsolate condition of their infrastructure starting with traffic, technical networks, and ending with services. Any larger construction work in these protected locations would call for considerable preliminary investments which could pay back only on the condition that the interest in building is high. Up to now, there is only one new house built in such a location in the whole region (in the old Hanušovice).

Jindřichov has a relatively suitable area within the protected zone in the locality of Kosmákov, which is well funded and sufficient enough at a very low interest in new building.

Fig. 9: A private house built in the Morava R. inundation zone in Hanušovice after the flood of 1997 (Photo: A. Vaishar)

Another possible strategy is the employment of technical measures which are inomissible with respect to the condition of the settlement in the upstream inundation areas. In this sphere, there is a conflict of several conceptions. The company Povodí Moravy, a.s. advocates for waterworks in Hanušovice, which would protect the town of Hanušovice from the side of the Morava and Krupá rivers and -along with other hydrological works- could contribute to the protection of other seats downstream the Morava R. This plan is opposed by a union of municipalities under the leadership of the mayor of Hanušovice, which includes the following municipalities: Hanušovice, Králíky, Malá Morava, Staré Město, Jindřichov, Branná, Ostružná, Bohdíkov and Ruda nad Moravou. The union of municipalities, including all three watersheds (Morava, Krupá and Branná) prefers the solution of flood situations by means of polders located on the particular water courses. These principal measures should be combined with a system of other measures such as dikes, higher capacity of streams, improved retention capacity of the landscape, etc.

As far as the social context of these technical measures is concerned, a statement can be made that the period of central decision-making about interventions in the landscape has ended. Any such a measure must count with the participation of citizens and representatives of local authorities as well as other entities. Their opinions might and might not be rational. Lands that must be used, buildings that must be rehabilitated - they all have their owners and it is necessary that their concerns are taken into account as well as the compensations for entities whose economic or non-economic activity is going to be restricted or impacted by the technical measures. On the other hand, all entities providing their opinion to the technical measures should be aware of their own responsibility for the future and their opinions should therefore include proposals of realistic alternative solutions. This should be a basis on which all different opinions and conceptions should be negotiated. It is also necessary to consider the fact that the interventions in the landscape can bring good solutions to the situation of some inhabitants and entities, and at the same time bad solutions for other. In these cases it is good to start speaking of compensations. Nevertheless, not even the very best site and planning measures forced in without the consent or even against the will of involved entities do not have any chance to be implemented.

In the concrete case of the Hanušovice-Jindřichov model region the union of municipalities actually focused on the entire watershed of the upper Morava R. and its main tributaries, and there are efforts to expand it up to the confluence of the Morava R. with the Desná R. If all municipalities in this section of the Morava R. or their absolute majority arrived at a common agreement and if they are prepared to take responsibility for this opinion, their standpoint should have a high priority - naturally also regarding the towns and villages downstream the river.

It is obvious that a flood similar to that of 1997 or even greater can affect the Hanušovice-Jindřichov region again and that the technical measures can only reduce its future consequences. This is a core of the third strategy: to master the flood consequences with as minor losses on lives and properties as possible. A key problem in this respect is to clearly define responsibilities of citizens (owners of immovables), municipalities and state. There are still justifiable fears that this part of the whole issue is still considerably weak despite the warning experience from the floods of 1997.

The division of responsibilities between the citizens and municipalities should theoretically be based on Law No. 100/99 which defines an obligation to elaborate flood plans for all owners (users) of real estates. Regular updating of these plans would then bring a periodical renewal of knowledge of citizens. A training of the situation is not considered necessary due to the recent "live" experience, similarly as a preparation of substitute accommodation and supplies to evacuated persons since these problems were satisfactorily mastered during the flood of 1997 in conditions of entire improvisation and failure of the state.

The municipality would then work out the general flood prevention and protection plan. This would help to differentiate between the responsibility of citizen and municipality with the citizen being primarily responsible for his(her) own situation, and the municipality being responsible for the general coordination and assistance to citizens in cases where the situation grows beyond their own possibilities. The citizen's responsibility would be then accentuated by the linkage with insurance conditions in which a citizen who would deliberately ignore the flood control measures would loose the right of claiming insurance coverage.

However, the information gained in the field provides a space for certain fears. Our citizens have the relying on the state rooted deeply in and it is also the age and educational structures that raise fears if the old citizens can be able to work out the flood control plans and implement them in the case of danger. In our opinion, the necessity of training the flood situations should not be underestimated since the behaviour of some individuals in the case of acute danger can be entirely different from the theoretical knowledge and elaborated plans. It also seems that regarding the development of economic situation in the region (unemployment, late payment of wages), a certain part of citizens lost their life motivation and could be passive in the case of danger.

Conclusion

Research projects in this and other model regions point out some general features of the flood-landscape-people relations. The very first thing to bear in mind is that floods are natural phenomena which have been modelling the landscape for thousand and thousand years. From this point of view the floods cannot be considered negative phenomena.

The flood damages and adverse consequences of floods can be to a great extent affected by man and its reasonable landscape management. Regarding the long-term development in the last 150 years, the human activities in the landscape were distributed in such a way which -together with new methods of landscape use- creates an increased hazard of floods in a number of regions and localities. These changes are not reversible in real time and at realistic cost.

In the effort to minimize the flood consequences the responsibilities of individuals and state or municipalities should be clearly defined and separated.

It appears that it is human minds in which the flood consequences dwell longest. It is therefore necessary to pay an increased attention to the research of psychological and social aspects of natural disasters even in our conditions.

References

HLAVINKOVÁ, P., KIRCHNER, K., LACINA, J., ŠKRABALOVÁ, J., VAISHAR, A. (1999): Modelové oblasti. (Model areas.) In: Vaishar, A. (ed.): Povodně, krajina a lidé v povodí řeky Moravy. Volume I, Regiograph Brno, p. 16-32.

HORÁK, P. (1998): Studie protipovodňové ochrany okresu Šumperk [Research report]. (A flood control study for the Šumperk district.) Výzkumný ústav vodohospodářský T.G. Masaryka Brno, 57 pp.

MELZER, M., SCHULZ, J. et al. (1993): Vlastivěda šumperského okresu. (Local history and geography of the Šumperk district.) Okresní vlastivědné muzeum Šumperk, 585 pp.

MUNZAR, J., ONDRÁČEK, S., TÁBORSKÁ, J. (1997): Disastrous Floods in Moravia and Silesia in July 1997. Moravian Geographical Reports 5, No. 5, p. 44-59.

POLÁCH, D., GÁBA, Z. (1998): Historie povodní na šumperském a jesenickém okrese. (History of floods in the Šumperk and Jeseník districts.) Northern Moravia Vol. 75. Okresní vlastivědné muzeum Šumperk, p. 3-29.

Retrospektivní lexikon obcí ČSSR 1850-1970 (1978). (Retrospective encyclopaedia of municipalities in the Czechoslovak Socialist Republic 1850-1970 (1978)., Part 1, Vol. 2. Federal Bureau of Statistics Prague, p. 681-1184.

SHREVE, R.L. (1966): Statistical law of stream numbers. Journal of Geology, Vol. 75, p. 175-186.

VAISHAR, A., LACINA, J., ONDRÁČEK, S. (1999): Floods in the Morava River Basin in 1997 and Their Consequences for the Social System. Moravian Geographical Reports 7, No. 2, p. 2-11.

VAISHAR, A. (2000): Povodně a osídlení. (Floods and settlement.) In: Mikulík, O. and Mariot, P. (eds.): Aktuální aspekty teritoriální struktury ČR a SR. (Topical aspects of territorial structure of the Czech and Slovak Republics.) Regiograph Brno, p. 113-123.

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FLOODS IN CENTRAL EUROPE AFTER THE EXCEEDINGLY SEVERE WINTER SEASON 1829/1830

Jan MUNZAR

Abstract

The winter 1829/1830 is the most severe and up to these times unsurpassed winter since the beginning of air temperature measurements not only in the territory of the Czech Republic (since 1775 according to the Prague-Klementinum station), but also in a number of other countries in central Europe. Extraordinary were also the ice phenomena on water courses and lakes and the snow conditions. Unusually severe floods occurred towards the end of the winter, which are documented in the paper for territories of the present Austria, Czech Republic, Germany and Poland. A particular attention is paid to the watershed of the Morava River (left-hand tributary of the Danube R.), to the supraregional context of the floods and to the resulting flood losses.

Shrnutí

Povodně ve střední Evropě po mimořádně tuhé zimě 1829/30

Zima 1829/30 je dodnes nepřekonanou nejtužší zimou od počátku měření teploty vzduchu nejen na území České republiky (podle stanice v Praze-Klementinu od roku 1775), nýbrž i v řadě dalších zemí střední Evropy. Mimořádné byly i sněhové poměry a ledové jevy na tocích a jezerech. V jejím závěru se vyskytly neobvykle silné povodně, které jsou v článku dokumentovány pro území dnešního Rakouska, České republiky, Německa a Polska. Zvláštní pozornost je věnována povodí řeky Moravy (levostranného přítoku Dunaje), nadregionálním souvislostem, popř. škodám, které povodně způsobily.

Key words: *winter severity , the 1829/1830 winter season , extreme air temperatures , snow cover , ice phenomena, floods in February/March 1830, Czech Lands, Europe*

1. Introduction

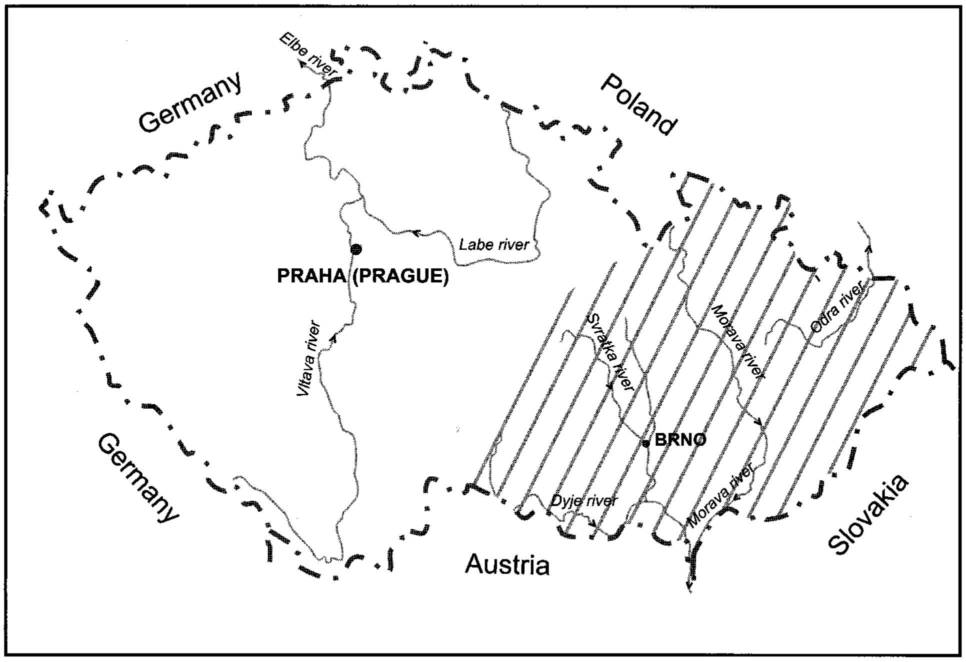
An analysis of severe winters according to the secular series of air temperatures measured by the Prague-Klementinum station (50°05' N, 14°25' E, altitude 202 m) for the period 1775-2000 revealed that the winter season of 1829/1930 is the hitherto unsurpassed coldest extreme recorded in the territory of the Czech Republic. The extraordinary character of this winter season was confirmed also from other European countries (Kakos-Munzar, 2000).

Towards the end of the winter -at the turn of February and March 1830- a disastrous flood occurred on the Danube R., which among other damages put into a serious jeopardy the royal seat of Vienna (Sartori, 1830-1832) and resulted in enormous losses. Records from the Czech Lands speak of great floods in the watersheds of the Vltava R.and lower Elbe R. occurring at this time (Kotyza et al., 1995). It was therefore only logical to presume analogical extremes occurring in the watershed of the Morava R. (Fig. 1), left-hand tributary of the Danube R., where more systematic information about historical floods before the year 1900 are still missing. This was the reason for the author to contribute to the documentation or even reconstruction of the winter season in question and the following floods in this region and in the neighbouring countries of central Europe within the grant project "Floods, landscape and people in the watershed of the Morava River" (Vaishar, 1998). Attention was also paid to the investigation of the chain of supraregional circumstances and to a brief summary of flood damages.

2. The winter season 1829/1830 in central Europe

The course of this record winter can be briefly elucidated by means of the observations and measurements made by the secular station in Prague-Klementinum, which can be considered representative for a major part of the Czech territory. The first night frosts occurred as early as on 21 and 23 October and then in a short period from 1 to 3 November 1829. The main part of winter season itself started on 13 November 1829 and lasted until 8 February 1830. There were no thaws during the entire period only 11 days with a mild afternoon warm up above zero (Hlaváč, 1966). The winter season 1829/1830 had a total of 95 days with the daily average air temperature

Figure 1: Centre of the area under study - The Czech Republic and its eastern part consisting of its historical lands Moravia and "Czech" Silesia; from the hydrological point of view the basins of the Morava River and the Odra River (Munzar-Drápela, 1999).



below 0°C; of these 79 days were ice days (with the maximum temperature lower than 0°C).

The frosts culminated between 26 January and 4 February 1830 when the daily minima dropped below -20°C and even below -25°C in a two-day period (30-31 January). Although the main winter season ended on 8 February, the average daily temperatures still ranged around zero after a short and vague thaw. Since the minimum temperatures were keeping below zero from 12 to 26 Frebruary, there was no occasional thaw to reduce the snow cover. A pronounced thaw arrived as late as during the last two days in February and on 1 March 1830, which raised an unusual flood on the Vltava R. in Prague.

Latin glosses in the Klementinum diary indicate that the Vltava River in Prague was covered with ice at the night from 2 to 3 December 1829 and the ice thickness on 7 December reached 14 inches, i.e. over 35 cm. The entry from 20 January reports the ice thickness of 1 1/2 Viennese foot, i.e. about 47 cm. The entry under the date of 10 February 1830 speaks of the ice thickness ranging between 2 and 2 1/2 feet, i.e. between 63 and 79 cm. The Vltava River not only became a big skating place but also a "temporary ice bridge" for both pedestrians and carriages at the time when the Lesser Town and the Old Town of Prague were connected with a single stone bridge only.

It is much more difficult to trace back the snow cover characteristics for Bohemia and Moravia (Munzar-Drápela, 1999) because the systematic measurements were started as late as towards the end of the 19th century. The station in Prague-Klementinum recorded the first snow on 2 November 1829. After snowing the whole evening and night of 29 December 1829, the snow cover height was estimated at 2 feet, i.e. about 60 cm (Observationes, 1829).

A chronicle from Dolánky near Turnov (altitude 264 m) in northern Bohemia reports that frosts and snow arrived as early as in October 1829 and a severe winter started on 2 November with snow. There was so much snow that people had to shovel roads as late as on the St. Joseph's day [19 March 1830] because carriages could not get through (Kutnar, 1941). In Rumburk (altitude 387 m), the snow cover in the open space was 2 Viennese feet and 1 1/2 inch, i.e. about 67 cm towards the end of January (Observationes, 1830).

There is an entry in Valašské Klobouky (altitude 390 m) in eastern Moravia that the winter started on 1 November 1829 with snow and frost and the ice cover on a local brook was 4 inches thick, i.e. about 10 cm on 24 November. An entry from Kroměříž mentions that the date of the first frost was 19 November 1829. There was so much snow here that people could sledge until 10 March 1830 when its generous treat arrived before 1 January 1830. The problems with snow, with road clearance and cleaning of roofs nearly breaking under the weight of snow lasted for weeks; snowbreaks were reported from forests. Snow had to be shovelled as late as in the week from 13 to 20 March 1830 in which a big thaw occurred (Munzar, 2000a).

Table 1

Station	Average temperatures of months (°C)			Average XII-II	Order of the winter	Observation since	Deviation from average(°C)
	XII	I	II				
Prague	-7.1	-8.3	-2.8	-6.1	1	1775	-6.2
Warsaw	-12.3	-10.1	-6.5	-9.6	1	1801	-
Cracow	-13.7	-11.4	-5.8	-10.3	1	1826	-8.4
Brno x)	-8.2	-9.8	-5.2	-7.7	-	1829	-
Vienna	-7.5	-8.6	-3.7	-6.6	1	1775	-6.4
Linz	-5.6	-8.5	-3.6	-5.9	1	1816	-5.1
Kremsmünster	-7.6	-10.0	-4.4	-7.3	1	1796	-5.8
Munich	-7.3	-9.5	-3.2	-6.7	-	1800	-
Basle	-5.2	-8.8	-2.3	-5.4	1	1755	-6.0
Geneva	-5.4	-7.2	-3.2	-5.3	-	-	-
Milan	-1.9	-3.9	-3.6	-3.1	-	1763	-4.8

x) Unstandard conditions;

Average air temperatures of three winter months in the winter season 1829/1830 and the winter quarter, the order of this winter season since the beginning of measurements on particular stations, and the deviation of average temperature of winter quarter from the long-term mean (according to Kakos-Munzar, 2000; Lindgrén et al., 1985; Pfister, 1999; Piotrowicz, 2000; Gisler, 1983).

In Židlochovice (altitude 190 m) in southern Moravia the frosts arrived as early as on 20 October 1829 and the ice and snow were on continually without any break from 1 November 1829 to mid-March 1830 with no single thaw occurring in this long period time. The snow cover was at an "ell height" [i.e. min. 60-80 cm] as long as 4 1/2 months with the lasting sled which occurs only rarely in this south-Moravian village and usually lasts only a few days (Eder, 1859).

Temperature characteristics of the extremely severe winter season of 1829/1830 for meteorological stations of central Europe are summarized on the basis of available sources in Tables 1 and 2. Regarding the mean air temperature of three successive winter months, this winter season is identically on the first place in the order of extremity with the coldest locality being Cracow (Tab. 1) where the deviation from the long-term average was -8.4°C. The extreme severity of the winter season 1829/1830 is also demonstrated in the survey of below-zero average daily temperature sums in the period from November to March (Tab. 2). Even this criterion shows that the coldest locality was the town of Cracow where as many as 111 days occurred during the winter season with the average daily temperature lower than 0°C (in Prague it was "only" 95 days), of which 87 were ice days on which the temperature did not rise above 0°C (in Prague it was "only" 79 days).

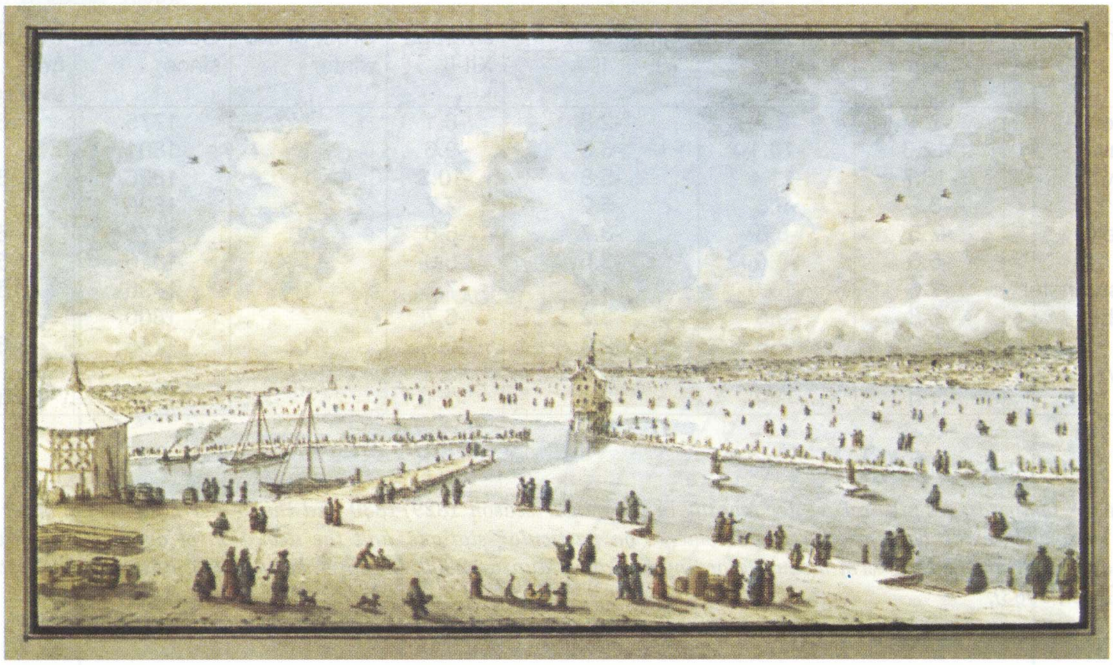
The lake in Zurich (Switzerland) was completely overfrozen only six times in the last 200 years: in 1830, 1880, 1891, 1895, 1929 and 1963. In the winter season under study, with the sum of below-zero daily temperature means being 561°C in Basle, it was bound in ice from 18 January to 15 March 1830, together with the Lake of Constance (Fig. 2), the Thunersee frozen in

Table 2

Station	Sum of below-zero daily temperature means XI-III [°C]	Order of the winter	Observation since the year
Cracow	1111	1	1826
Berlin	791	1	1766
Kremsmünster	766	1	1796
Munich	765	1	1781
Hohenpeissenberg	723	1	1781
Vienna	663	1	1775
Praha/Prague	638	1	1775
Frankfurt a/M	572	1	1826
Basle	561	1	1755

Sums of below-zero daily air temperature means from November 1829 to March 1830 for 9 stations in central Europe - the so called Hellmann's criterion - and the order of the winter season 1829/1830 since the beginning of temperature measurements (according to Kakos-Munzar, 2000; Piotrowicz, 2000).

Figure 2: A view of the frozen Lake of Constance from the dam in Constance in the year 1830. Coloured cut by Nicolaus Hug (1771-1852), Rosgartenmuseum Constance (Postcard).



its eastern half, the Wallensee frozen at some places, the Neuenburgersee and the Vierwaldstättersee partly frozen. In the most severe winter seasons of the 20th century the sums of below-zero daily temperature means according to Pfister /1985/ were "only" 453°C /1962/63/ and 398°C /1928/29/.

The demarcation of the European territory affected by the exceedingly bitter winter season can be -together with the tables- contributed by the fact that the winter season 1829/1830 was not included even among the first ten most severe winter seasons since the beginning of the measurements in the temperature series of northern-European stations in Trondheim, Vardo, Archangelsk and St. Petersburg (v. Rudloff, 1967). An observation diary from Prague even contains a note written in German that according to records from St. Petersburg originating from 16 January 1830 the mild winters [as this] are rare in this town. The air temperature did not fall lower than 5 to 6°C below zero for many days (Observationes, 1830). Analogical mild frosts were reported from Island where the temperatures were dropping only some 3 degrees below zero even on the coldest days, which made the cattle stay on pastures (Hydrolog. Dienst, 1908).

This is corroborated by maps of average air pressure distribution over Europe for December 1829 - February 1830, worked out by Ch. Pfister (1999). During these three months, there was a stable ridge of high pressure more or less continually occurring between Denmark and western Russia including Ukraine, which was demarcated by the isobar of 1020 hPa. Central Europe was situated on its southern to south-eastern edge with the prevailing mild north-eastern to south-eastern flow. At the same time, a stable cyclone (low) occurred over central Mediterranean, which was occasionally passed at higher levels by a warmer air flow with accompanying abundant snowing.

This exceptionally stable distribution of air pressure which was blocking the inflow of a warmer air from SW to W is convincingly documented by the processing of wind direction frequencies in Prague-Klementinum for the period of nearly three months, in which the minus average daily air temperatures occurred practically without any break. In the course of 87 days - from 14 November 1829 to 8 February 1830 - when the average air temperature "jumped" slightly above zero just in two days, the relative frequency of winds from the eastern quadrant was greatest (32%). On the other hand, the minimum frequency of winds was recorded from the western quadrant (2%) with calm being recorded in 21% of all cases (Kakos, 2000b).

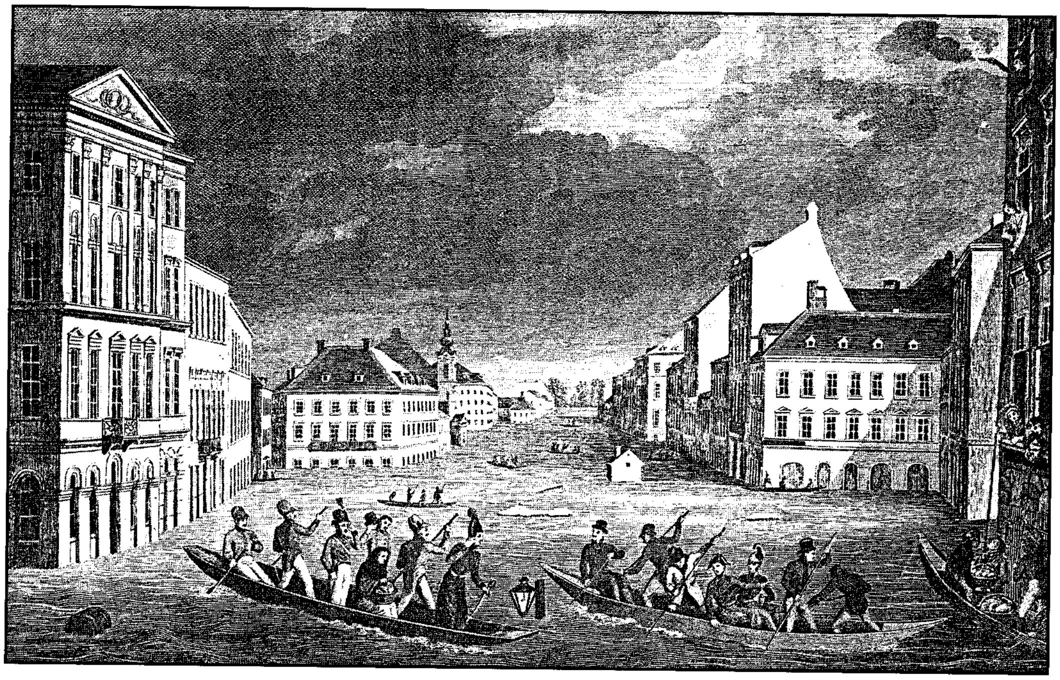
Situations with the south-western flow and daily air temperatures above zero started to partially make their way from the second February decade.

3. Floods after the severe winter season 1829/1830

3.1 Floods in Austria

According to Austrian sources very warm southern and western flows prevailed in higher atmosphere layers from 22 February 1830, which evoked thawing of a high snow cover in Upper Austria, Bavaria, Württemberg and

Figure 3: Archduke Franz Carl in the Jägerzeile street in Vienna during the flood in 1830 (Sartori, 1830-1832).



in the Tyrol. This is also confirmed by records from Hohenpeissenberg (altitude 983 m) where air temperatures above zero occurred steadily from the morning of 23 February to the night of 1 March 1830. The warmest days were those between 26 and 28 February when the air temperatures at 02.00 o'clock PM reached 8.8°C, 9.2°C and 10.1°C, resp. (Lamont, 1851). Pfister (1999) assumes that it was the föhn which arrived towards the end of February and together with other factors contributed to the thaw on lakes in the Alps - up to now still covered with ice.

The first rain in Linz arrived on 23 February 1830 (similarly as in Prague) and the water level of the Danube River, which got at many places frozen to its very bottom during the winter began to rapidly rise. An intensive thaw occurred during the last February days.

On 25 February 1830, an ice-drift occurred on the Danube near Linz at 06.00 o'clock PM with the water level being 7 feet (220 cm) beyond the minimum water level. The ice considerably damaged a bridge but there were no other serious losses. On 28 February the Danube

Figure 4: The front page of a Czech historical press about the disastrous flood in Vienna in 1830 with a picture of Noah's Ark.

Nowá pjſeň
o hrozné powodni v města Wjdně
w roku 1830.

Křeſťané rozmilj, poſlechněte nynj, ten ꝛc.

overflew its banks and water reached as far as the town of Linz through its main gate. The water level was still rising until the noon of 1 March.

On 28 February 1830, the water level measured on the Taborbrücke bridge in Vienna was 15 feet [474 cm]. The water flooded the Marchfeld but on the same day the Danube water level dropped by 3 feet [by more than 90 cm]. This was considered a good sign by inhabitants from the most jeopardized places of the Austrian royal seat and it was generally believed that the flood danger was over. However, the ice packs contributed to a sudden increase of the water level on the Taborbrücke by 5 feet [nearly 160 cm], occurring within a very short time (less than 5 minutes) before the midnight. At other places the water lines raised by even more than 7 feet [220 cm]. A "flash" flood reached the suburban town parts of Rossau, Leopoldstadt, Lichtenthal, Jägerzeile (Fig. 3) and Erdberg. The nightmare was further supported by a windstorm which made the rescue works difficult. (It was exactly the strong and warm wind that caused the rapid melting of the snow cover and this was the reason why the disaster arrived so fast.) The water level of the Danube River culminated on the Taborbrücke at 601 cm.

The flood arrived so quickly that it took by surprise ten thousands of inhabitants living in low-situated single-storeyed houses and staying in their beds at that time - unprepared and undefended. There was no time to rescue properties or basic personal belongings; it was bare lives that had to be rescued. Unexpectedly fierce streaming water with ice floes and drift turned all preventive measures in Vienna into nothing. The water severely damaged several bridges (most the above mentioned Taborbrücke), dikes, walls and wells which were flooded. Dangerous fires raised in the deserted houses left without guards, ignited by forgotten lights (candles, oil lamps). Hundreds of persons were saved from certain death, diseases and hunger thanks to the self-sacrificing help of courageous volunteers and generous donors.

Original records spoke of this apparently most tragic flood in Vienna to have taken the toll of several hundreds of human lives. This was also the tone of responses to the flood in the Czech Lands. For example, there is a passage in memoirs from the Turnov district in northern Bohemia that reads as follows: "That year, on the third day after St. Matthias [i.e. 27 February 1830] the ice on the Danube and Moldau (Vltava) rivers got in motion and a terrible, unheard-of flood with ice was raised that the Danube took bridges and houses in Vienna, and many hundreds of people and cattle got drowned. And whole villages were swept away with people and buildings." (Kutnar, 1941). There was a number of stall-keeper's songs composed about the disaster even in Czech (Fig. 4). The flood disaster in Vienna was also mentioned in the Moravian register from Valašské Klobouky (Zlín district) at the end of the entry about the severe winter of 1829/1830 and it reads as follows: "A great flood near Vienna on 1 March" (Munzar, 2000a). It was only later that an official list reported the number of tragically died Vienna inhabitants to be 74 (Sartori, 1832).

The Danube water level at the Taborbrücke remained unchanged from the late night hours of 28 February to 02.00 o'clock AM on 1 March 1830 and only then it began to fall. The water line on the Ferdinand Bridge on 1 March 1830 was 558 cm above zero on the water gauge. Water was

Figure 5: Royal Prince Archduke Ferdinand with his companion inspects the landscape on the Moravian Field short after the flood in 1830.

rushing into the lowest parts of Vienna also through channels. It remained standing at a height of 3 to 4 feet [95 - 125 cm] in Adlergasse, Roteturmstrasse, Fischmarkt and on Salzgries. The Danube returned back to its riverbed in Vienna as late as on 4 March 1830 (Fig. 5).

On 3 March 1830 a committee was nominated by Emperor Franz I, which organized a great charity campaign to help the flood victims; the campaign turned out a success with over 350 thousand guilders collected for the purpose. The most urgent repairs were made in a short time of four weeks and 50 000 persons immediately affected by the flood in Vienna were provided with the basic assistance.

Below Vienna, near the mouth of the Morava R. opening into the Danube, the water level began to rise as early as on 27 February 1830. The greatest danger to people living in seats alongside the lower Morava R., Hof and Marchegg, threatened at the daybreak of 3 March and the water level culminated with the simultaneous occurrence of a large number of flowing ice blocks. The local inhabitants were lucky in the fact that the Morava R. water level rise before its mouth resulted only from the swollen Danube and there was no interference of flood waves on the two rivers such as in the case of the Bečva R. and Morava R. near Troubky in July 1997 (Munzar-Ondráček-Táborská, 1997; Munzar-Ondráček, 2000). The water levels of most water courses in the Morava River watershed increased about 2 - 3 weeks later, presumably under the influence of another weather situation.

3.2 Floods in the territory of the Czech Republic

3.2.1 Floods in Bohemia

The upper reach of the Vltava River saw an ice drift in Český Krumlov at the night from 28 February to 1 March 1830. The flood from too fast snow melting exceeded at its culmination the water gauge mark from 1784 by two feet [63 cm]. This winter "flash" flood related according to Kakos (2000b) most probably to the occurrence of föhn in Austria since the southern corner of Bohemia experienced this dry falling wind most in the whole territory of the Czech Republic. This is why the culmination here was higher than that during the winter flood 46 years ago. There were 9 human lives lost during the flood. The ice destroyed 2 bridges, the flowing water took down 4 houses including farm buildings, 2 houses were taken away only partly and other 21 buildings were damaged to such an extent that they had to be taken down (Brün. Zeitung 1830, Kotyza et al., 1995).

On the Berounka R., left-hand tributary of the Vltava R. above the capital of Prague, the ice got loose on 26 February 1830 while the Vltava River itself remained ice-bound so that people could still pass between the Old Town of Prague and the Lesser Town along the "ice bridge". The major amount of ice passed through Prague on 27 February at 05.00 o'clock PM and the Vltava R. water level got swollen by 2 Viennese feet [over 60 cm]. A continuous thick layer of packed ice covered the whole river with water reaching to the height from 8 1/2 up to 9 feet [270-285 cm]; however, at 10 o'clock PM the water level decreased, similarly as in Vienna (see Chapter 3.1).

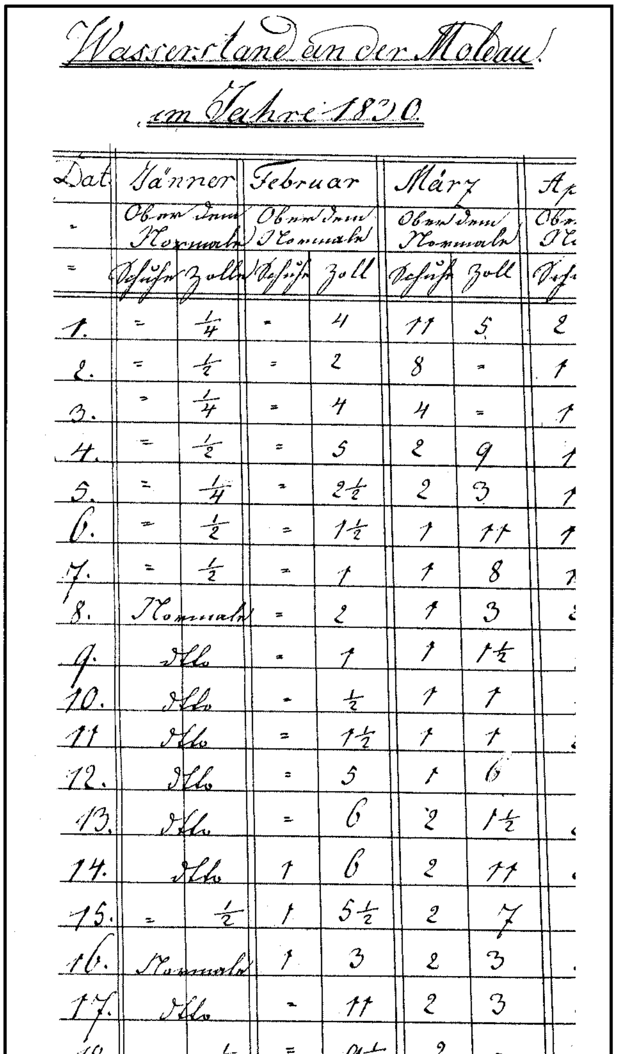
On 28 February 1830, Prague witnessed a passage of the "mountain ice" (which was most probably ice originating from the upper reaches of the Vltava R. and its tributaries) with the water level of 12 feet [380 cm]; at 05.30 o'clock PM on the same day the water level exhibited a further rise due to the ice. The highest water line of 2 fathoms, 1 foot and 3-4 inches [420 cm] was reached at 09.00 o'clock PM and the level was maintained until 11.00 o'clock PM; then the water began to fall. The culmination height was by 12-13 inches [30-35 cm] lower than during the flood from 26 June 1824 (Observationes, 1830). The culmination discharge was later estimated at 2840 m3.sec-1, which ranks the flood on the 7th place for the period from the beginning of hydrological observations in Prague in 1825, or on the 10th place in the order of floods for the period 1775-2000. Since 1825, this was the fourth greatest winter flood after the cases from the years 1845, 1862 and 1940 (Kakos, 2000), and more than a 20-year flood discharge for which the discharge in Prague is reported at 2490 m3.sec-1 (Hydrological characteristics 1996).

In the morning of 1 March 1830 the water level of the Vltava R. in Prague was by 5 inches lower and at 05.00 o'clock PM on the same day it further dropped by 7 inches; i.e. the water level fell by 1 feet - over 30 cm in the course of one day (Observationes, 1830). These glosses in the Klementinum diary unequivocally confirm the fact that the determination of time and culmination only by regular 1-day observations of the water level values on 1 March 1830 is inaccurate (Fig. 6).

On the Elbe R. near Litoměřice the ice got into motion on 28 February 1830 at 10.45 o'clock AM; at 12.00 o'clock AM it began to form layers near Lovosice and blocked the river up to Litoměřice. A repeated movement of ice masses occurred at 05.00 o'clock PM. At its passage, the ice damaged 3 central ice barriers and the central pillar of the bridge across the Elbe R. in Litoměřice. There the flood culminated on 2 March 1830 with the water gauge level being by 17 degrees and 8 inches above the normal, which was by half an ell lower than in 1799 and by 1 1/2 ell lower than in 1784, but higher than in the years 1821 and 1824 (Schreyer, 1965; Kotyza et al., 1995).

In the Elbe R. watershed above the confluence with the Vltava R. the floods were recorded considerably later. The ice at Turnov on the Jizera R., right-hand tributary of the Elbe R., got "loosened" on 19 March 1830 and caused great losses on mills and in towns. All footbridges

Figure 6: Observations of water level heights on the Vltava River in Prague at the beginning of 1830 (Observationes, 1830).



Wasserstand an der Moldau!
im Jahre 1830.

Dat.	Jänner		Februar		März		Ap
=	Oben dem Normale		Oben dem Normale		Oben dem Normale		Ob. N
=	Schuh	Zoll	Schuh	Zoll	Schuh	Zoll	Sch
1.	=	¼	=	4	11	5	2
2.	=	½	=	2	8	=	1
3.	=	¼	=	4	4	=	1
4.	=	½	=	5	2	9	1
5.	=	¼	=	2½	2	3	1
6.	=	½	=	1½	1	11	1
7.	=	½	=	1	1	8	1
8.	Normale		=	2	1	3	
9.	Dtto		=	1	1	1½	
10.	Dtto		=	½	1	1	
11	Dtto		=	1½	1	1	
12.	Dtto		=	5	1	6	
13.	Dtto		=	6	2	1½	
14.	Dtto		1	6	2	11	
15.	=	½	1	5½	2	7	
16.	Normale		1	3	2	3	
17.	Dtto		=	11	2	3	
18.	=	½	=	9½	2	=	
19.	Normale		=	9	2	4½	
20.	=	½	=	8	3	1	
21.	=	½	=	7	2	7½	
22.	=	½	=	6	2	5	
23.	=	1	=	4	2	3½	
24.	Normale		=	3	2	1	
25.	=	1	=	8	1	10	
26.	=	½	1	3	2	1	
27.	=	1¼	2	9	3	7	
28.	=	1½	7	=	3	4	
29.	=	½			2	8	
30.	=	½			2	5	
31.	=	3½			2	3	

and wooden bridges were taken away along with the bridge in Semily. In Turnov the bridge remained hanging on "just a couple of needles" (Kutnar, 1941). In Mladá Boleslav, the ice passing on the same day was two feet thick - over 60 cm.

3.2.2 Floods in Moravia

A huge ice movement was recorded on the Dyje River, right-hand tributary of the Morava R. springing in the territory of Austria (the Thaya R.) near Znojmo on 2 March 1830, which broke the dam below the weir at a width of several Viennese six feet [1 six foot = 1.896 m]. This corresponds well with the above mentioned culmination of the Morava River in the area around its mouth opening into the Danube "on the daybreak" of 3 March 1830. This flood on the Dyje River damaged a number of houses on the Břeclav estates: 19 in Břeclav (altitude 158 m), 6 in Stará Břeclav, 33 in Ladná (altitude 160 m), and 2 in Lanžhot (altitude 164 m). The official committee appraised the damage by means of the area of waterlogged walls; in the Břeclav estates the flood drenched a total of 1214 square six feet, i.e. 3945.5 m2 of walls. As a compensation, Prince Lichnowský made a donation of 715 guilders and 45 kreutzers which were meant for those of his serfs who suffered losses on dwelling and farm buildings. Land properties were excluded from the compensation because "they are being flooded nearly every spring without suffering any damage". The financial support should have been given out only to the serfs living in the Břeclav estates because it was said that the Lednice estates (altitude 173 m) were not at all affected by this spring flood (Munzar, 2000a).

In the watershed of the Švratka R., left-hand tributary of the Dyje R., the thawing started after 13 March 1830 and the rivers began to visibly swell. The flood danger in Tišnov (altitude 256 m) near Brno, and especially in its suburb Předklášteří, is dated from 15 to 21 March. However, no human losses were recorded thanks to the self-sacrificing work of rescue teams.

Of two rivers in Brno, the Svratka River and the Svitava River as its left-hand tributary the first one to overflow the banks on 15 March 1830 was the Svitava R. which flooded meadows and yards of several houses in the city limits. At night from 15 to 16 March 1830, the ice cracked in Brno on the Svratka River itself and a part of the town got flooded due to the swelling ice masses. The Svratka R. culminated at night from 18 to 19 March 1830 when the water level was higher by 7 feet [220 cm] than the water gauge mark from 15 March. The Svitava River culminated on 19 March 1830 at 11.00 o'clock AM and reached a record water level height "which did not occur in the previous years yet" (the actual value of the culmination water level is however unknown). Some suburbs of Brno were flooded totally, some only partly. In the Olomoucká street water stood up to 2 feet [60 cm].

Dams were damaged, several houses tumbled down, other were more or less damaged. The end of major rescue works dates back to the evening of 22 March 1830 (Anonymus, 1964).

On the Svratka River in Židlochovice (altitude 190 m), below the confluence with the Svitava R., the flood arrived after 17 March 1830 and the water level was "unheard-of high". All dams bursted and the whole surroundings became a big lake. Flooded houses in five villages had to be left by their inhabitants. Many walls fell down due to waterlogging and had to be rebuilt. The connection between three villages by means of common dry roads was disrupted and the only possible connection for three weeks was only across the water on boats (Eder, 1859).

On the Bečva River, left-hand tributary of the Morava R., the disastrous floods developed from the unusual amount of snow in 18 - 21 March 1830 and took down bridges and houses.

According to records from Kroměříž (altitude 201 m), a heavy thaw occurred on the Morava River itself before 20 March and the ice gradually began to loosen. The danger of flood began to threat the town between 21 and 27 March 1830 when the water dropped more than 2 feet [over 60 cm] by 26 March. The losses in Kroměříž included the damaged chain bridge, mill and water supply system. In the town surroundings three lakes were damaged (with the major cracks being 80 steps wide) and a part of the sawn rye was taken away with water. Should a new dam of the Křivý rybník (pond) have not resisted the flood, which was erected in 1828 as a protection against the overflowing of the Rusava R., left-hand tributary of the Morava R., the flood would have been much more dangerous in this region.

The latest date for the flood in the Morava River watershed - 22 March 1830 - was recorded in Týnec (altitude 173 m) to the north-east of Břeclav where a cottage was swept away and two houses damaged. Waterlogged walls reached 172 m2 and 34 500 bricks were needed to repair the damages (Munzar, 2000a). Because the village is situated on the Kyjovka R. and taking into account the local topography, it is assumed that the flood relates to the water from the Morava River, which overflew the riverbed.

It can therefore be estimated that the Morava River culminated at the mouth opening into the Danube thanks to the water whose greater part was originating from its own watershed approximately between 23 and 25 March 1830.

3.3 Floods in Germany

In Berlin, the air temperature raised above zero as late as in the last February pentad [25 February - 1 March 1830] while in the south-western Germany it was already between 10 and 14 February (v. Rudloff, 1967). The mountain station Hohenpeissenberg in Bavaria at an altitude of 983 m recorded the above-zero temperatures in the period 8-10 February and 17-18 February, and particularly between 23 February and 1 March 1830 (Lamont, 1851). In Freiburg i. Breisgau the snow cover reached the thickness of 40 cm towards the end of the winter season 1829/30 (v. Rudloff, 1967).

On the Rhine R. in Cologn the ice got into motion on 10 February 1830 evening with the water level height being 14 1/2 feet [nearly 460 cm]. Huge masses of ice driven by the river filled the riverbed so that the connection between some surrounding villages was cut off. On 11 February 1830 at 15.30 o'clock the Rhine water level reached the height of 20 feet [630 cm]. Nevertheless, this case is not being considered one of important historical floods in Cologn (Brün.Ztg. 1830, Pörtge-Deutsch, 2000). Similarly, on the Main R. in Würzburg the flood of 1830 is not mentioned among the nine greatest floods from the 14th century to the year 1909 (Pörtge-Deutsch, 2000).

According to high water gauge marks on the Pillnitz Chateau, the water on the Elbe R. in Dresden culminated on 2 March 1830 (i.e. on the same day as in Litoměřice - see Chapter 3.2.1) with the maximum discharge being estimated at 3950 m3.sec-1. In the context of local high water gauge marks from 1784-1940 the flood took the 6th place behind the cases from the years 1845, 1890, 1862, 1784 and 1876 (Fügner, 1995; Pörtge-Deutsch, 2000).

According to Zinke (1998) the water on the Saale R., left-hand tributary of the Elbe R., culminated on the water gauge in Halle-Trotha as early as on 27 February 1830 with the mark of 925 cm; according to Wiese (1953) it was later - on 2 March 1830, i.e. on the same day as the Elbe R. culminated in Dresden, and the water level was 945 cm high. In the list of 32 floods from the period 1585-1994 the big water took the 7th place as related to the above water gauge (Zinke, 1998). A comparison is then made by Kakos (1973) of data for culminations of winter floods on the Saale River according to Wiese (1953) with the corresponding cases on the Vltava River in Prague.

3.4 Floods in Poland

Also in Poland the brooks, streams and rivers got covered with a thick layer of ice during the unusually bitter winter season 1829/1830. On the Odra R. between the towns Wroclaw and Brzeg the thickness of ice reached about 65 cm which raised justified fears from the ice movement occurring in spring.

After a strong onset of the thaw on 28 February and 1 March 1830 the ice began to crack first on the left tributaries of the middle Odra R. - on the Luźycka Nysa R. near the town Zgorzelec (Görlitz), and on the Bóbr R. with its affluxes Kwisa and Kaczawa. However, on the Odra R. itself the ice was still holding on so firm on 1

March that the carriages could still pass on the ice roads below Wroclaw. Yet, on the very next day - 2 March - the ice began to crack also here near the banks and got into motion. At the same time, the ice was breaking also on other Odra River tributaries (e.g. Bystrzyca R.) and began to move away. Water levels of the Ślęza R. and Olawa R. got swollen. Adjacent areas were flooded, the flowing ice destroyed bridges and the ice packs had to be blasted in order to release the water flow. On 3 March the ice cracked on the Kłodzka Nysa R. and the ice packs developed too.

On 7 March 1830, the ice on the "old" Odra R. in Wroclaw began to move away with no damage after the ice heaps near the bridge in Psie Pole (today's neighbourhood of Wroclaw) had been destroyed by artillery fire. In the mean time the ice on the upper reach of Odra was remaining still.

Eventually, the ice on the Odra River broke on 16 March 1830 near the towns Racibórz, Brzeg and Olawa, and the ice movement began near Wroclaw on 17 March. The upper Odra R. got entirely free from the icy confinement in the course of the two following days. The unusually thick ice blocks (whose most frequent size ranged between 45 - 60 cm) endangered with their hardness everything that was standing in their way. Although they were blasted, great losses were recorded on mills, bridges and ice-aprons near the towns Brzeg and Wroclaw.

The water level height was in no way unusual when the ice was moving, it increased only later due to the steady snow melting. On 21 March 1830 the Odra River in Koźle reached 664 cm (i.e. nearly the same water level height as in 1826), records from Opole speak of 537 cm (about the same water level height as in 1829 and 1826). On the other hand, in Wroclaw the records from the spring 1830 spoke of the highest water mark since the very beginning of the hydrological measurements. The height of 743 cm reached on 22 March 1830 was the Odra R. water level measured in the past years, and then the river culminated here on 23 March 1830 with the water level of 753 cm (i.e. approximately on the same date when the Morava River culminated in the south of Moravia). Since the water gauge scale in Wroclaw did not count with such a high value to be ever reached, it had to be quickly extended "by several inches" [1 inch, Zoll = 2.6 cm] in order to be able to precisely measure the new record culmination.

The Odra River overflew the stone banks in Wroclaw and flooded a considerable part of the town - this time even the streets which were not put into danger in the past years. The affected parts of Wroclaw could only be reached on boats. Then the Odra R. water level was declining only slowly with the water gauge recording the height of 745 cm on 24 March, and only on 26 March 1830 the water dropped to 714 cm (Schles.Prov.Blätter 1830; Rospond, 1951).

As far as the Wisla R. watershed is concerned, there is no information to be found in the list of historical floods about a hydrological extreme in the spring of 1830 (Bielański, 1997). Nevertheless, the author of this paper succeeded in finding out that a harmful flood was recorded on the Wisla R. on 21-22 March 1830 in the vicinity of Cracow when the river got swollen due to ice packing and fifteen villages on the right bank of the river appeared under water from approximately Nowa Wies (today's parts of the Cracow neighbourhood of Zwierzyniec) up to Uscie solne (Brün.Ztg. 1830).

4. Conclusions

Notwithstanding the lack of suitable hydro-meteorological or other documentation the first elucidation succeeded in having provided a true picture of the course of the "ice" floods in central Europe towards the end of the winter season which was most severe since the beginning of the systematic air temperature measurements. The reconstruction suggested among other that:

- From the viewpoint of temporal occurrence of floods in the territory of the Czech Republic there is a clear weather divide separating in rough contours the south-western part of the country from the north-eastern part. The floods in the Elbe R. watershed below the confluence with the Vltava R. occurring between 28 February and 2 March 1830 were to a conclusive measure initiated by water originating from western and southern Bohemia. At the beginning of March the floods were also recorded on the Dyje River while in north-eastern Bohemia it was the Jizera River (right-hand tributary of the Elbe R.), the rivers Svratka, Svitava, Bečva and Morava in Moravia culminated as late as in the second half of March 1830.
- The flood culmination on the Vltava River in Prague occurred neither on 26 February (Kotyza et al., 1995) nor on 1 March (Novotný, 1963), but on 28 February 1830 evening between 21.00-23.00 o'clock (Observationes, 1830). This indicates that the Vltava River in Prague and the Danube in Vienna culminated practically at the same time.
- The Odra River in the Polish territory in Wroclaw culminated on 23 March 1830, i.e. at approximately the same time when the Morava River culminated in the south of Moravia.
- Floods on the Danube arrive at a long-term regime only in late spring and sometimes even as late as in summer because the snow cover at the higher altitudes of the Alps does not melt so early. In 1830, however, it was the enormously thick snow cover presumably at relatively lower altitudes that melted most rapidly. The air temperatures measured on the Hohenpeissenberg station at an altitude of nearly 1000 m from 23

February - rather high for this season of the year - give evidence that an intensive melting had to occur simultaneously at altitudes of at least 1500-2000 m. And because these places in the watershed of the Danube River were located at a short distance from Vienna the flood wave reached the city unexpectedly fast as compared with the previous experience. The thaw was further supported by the unusually strong and warm wind from the southern quadrant at night from 28 February to 1 March 1830.

- There are surprisingly at disposal less historical data available for a reconstruction of the conditioning weather situations in the spring of 1830 than were at a disposal of for example R. Glaser and H. Hagedorn (1990) for a reconstruction of conditions standing at the development of the flood disaster on the Main River after the winter season 1783/84, i.e. at the time of activities of the international meteorological network of the Mannheim Society (which also included the Prague-Klementinum station). This in spite of the fact that the two winter seasons - 1783/84 and 1829/30 - have undoubtedly a lot of common features, particularly the occurrence of disastrous floods towards their ends. However, there are good reasons to assume that in contrast to the floods in northern Bohemia and in a great part of the Moravian territory the floods in the territory of Austria, in south-western and central Bohemia and on the south-western edge of Moravia (Znojmo) occurred under different weather situations.
- The study of causal links between the snow cover water reserve at the end of winter and the subsequent discharges for the prognosis of floods in Czech Lands is possible only since the end of the 19th century when the systematic measurement of unneccesary hydro-meteorological parameters were launched. From this point of view the year 1830 belongs in the pre-instrumental era as far as the quantification of snow cover heights is concerned. The relation between the average below-zero monthly temperature deviations in Prague-Klementinum during the severe winter seasons and the culmination discharges of ten cases of winter floods on the Vltava River in Prague -including that of 1829/30- were in detail studied by V. Kakos (1974) in connexion with possibilities of the hydro-meteorological prediction of emergency run-off situations.
- The impact of floods into the socio-economic sphere is documented in the first elucidation, which is being neglected in the hydro-meteorological studies. A very serious complication from the viewpoint of these impacts are the ice phenomena occurring on the water courses during winter floods. Similarly as in Prague on the Vltava River, the Danube in Vienna swelled at first due to various ice blockages, etc. Then its water level even recorded a drop which is a great sell-out for the population since it offers a false relief that the flood danger is over. Another greater culmination arrived within 12-24 hours with the ice phenomena taking already a considerably lesser share in the magnitude of the culmination wave. This is also confirmed by an analogue - the detailed measurements of Vltava River water level height in Prague towards the end of March 1845 during one of the greatest floods at all on the Czech and Saxonian Elbe R. (Kakos-Kulasová, 1995).

References

ANONYMUS (1964): Die grossen Überschwemmungen in den Jahren 1827, 1830, 1840 u. 1845. Brünner Heimatbote (Heidelberg),16, p. 124-128.

BIELAŃSKI, A.K. (1997): Materialy do historii powodzi w dorzeczu górnej Wisly, edit. J. Fiszer. Politechnika Krakowska, Kraków 118 pp.

BRÁZDIL, R. (1998): The history of floods on the rivers Elbe and Vltava in Bohemia. Erfurter Geographische Studien, 7, p. 93-98.

Brünner Zeitung (Brno), Vol. 1829-1830.

EDER, J. (1859): Chronik der Orte Seelowitz etc. Brünn, p. 158.

FÜGNER, D. (1995): Hochwasserkatastrophen in Sachsen. Taucha, p. 14.

GISLER, O. (1983): Die meteorologische Beobachtungen von Schaffhausen (1794-1845) und Zürich (1767-1802) nebst einige Betrachtungen über historische Niederschlagsreihe. Physische Geographie (Zürich), Vol. 12, 184 pp.

HLAVÁČ, V. (1966): Wie waren die Winter in Mittelböhmen während der letzten 190 Jahren. In: Meteorologie - Ergebnisse der Konferenz über Meteorologie in Liblice bei Prag 13.-bis 16 Oktober 1964, p. 395-401. Academia Praha

Hydrologické charakteristiky vybraných vodoměrných stanic České republiky. Český hydrometeorologický ústav Praha 1996, 134 pp.

Hydrologischer Dienst in Österreich (1908): Der Schutz der Reichshauptstadt und Residenzstadt Wien gegen die Hochfluten des Donaustrom. Beiträge zur Hydrographie Österreichs, IX, Wien, 130 pp.

KAKOS, V. (1973): Zusammenhang zwischen Überschwemmungen in Prag an der Moldau und in Trotha an der Saale. Manuscript, 4 pp. + 4 Tabs.

KAKOS, V. (1974): Možnosti hydrometeorologických předpovědí havarijních odtokových situací. In: Sborník prací Hydrometeorologického ústavu, 21, p. 55-85. Praha

KAKOS, V. (1990): Fluctuations in the frequency of floods on the Vltava river in Prague in relation to meteorological observations at Prague-Klementinum. In: Brázdil, R., ed.: Climatic change in the historical and the instrumental periods, Masaryk University Brno, p. 319-322.

KAKOS, V. (2000a): Povodně na Vltavě v Praze s kulminačním průtokem Qk = 2490 m3.sec-1 a větším. Prague, Manuscript.

KAKOS, V. (2000b): Personal communication

KAKOS, V.-KULASOVÁ, B. (1995): Povodeň v březnu 1845 v povodí českého Labe. In: Sborník "Povodňová ochrana na Labi", p. 24-55. Český hydrometeorologický ústav Praha etc.

KAKOS, V. - MUNZAR, J. (2000): The winter of 1829/30 - the most severe in Central Europe since the beginning of the measurement of air temperature (in Czech-English summary). Meteorologické zprávy (Praha), Vol. 53, No. 4, p. 103-108.

KOTYZA, O. - CVRK, F. - PAŽOUREK, V. (1995): Historické povodně na dolním Labi a Vltavě. Okresní muzeum Děčín, 169 pp.

KUTNAR, F. ed. (1941): Paměti sedláka Josefa Dlaska. Melantrich Praha, p. 42-43.

LAMONT, J. (1851): Beobachtungen des meteorologischen Observatoriums auf dem Hohenpeissenberg von 1792-1850. München, 788 pp.

LINDGRÉN, S. et al. (1985): Winter 1788-89 - The Lagoon of Venice freezes over. Meteorologische Rundschau, 38, p. 112-118.

MUNZAR, J. (1998): Historical floods in Bohemia and Moravia on the example of the year 1598. Moravian Geographical Review (Brno), Vol. 6, No. 2, p. 50-58.

MUNZAR, J. (2000a): Rešerše k historickým povodním na Moravě před rokem 1900. Brno, Manuscript.

MUNZAR, J. (2000b): Selected historical floods in Moravia in the preinstrumental era in Central-European context. Paper for the conference "Images and reconstructions of weather and climate over the last millennium, Cracow, 20-22 September 2000.

MUNZAR, J. - DRÁPELA, M.V. (1999): Czechia = Bohemia + Moravia + Silesia. Moravian Geographical Reports (Brno), Vol. 7, No. 2, p. 58-60.

MUNZAR, J. - ONDRÁČEK, S. (2000): Floods in July 1997 - The most destructive natural disaster in the territory of the Czech Republic not only in the 20th century. Erfurter Geographische Studien (in print).

MUNZAR, J. - ONDRÁČEK, S. - TÁBORSKÁ, J. (1997): Disastrous floods in Moravia and Silesia in July 1997. Moravian Geographical Reports (Brno), Vol. 5, No. 2, p. 44-59.

Nowá pjseň o hrozné powodni u města Wjdně w roku 1830. Knihovna Národního muzea v Praze.

NOVOTNÝ, J. (1963): Dvě stoleté řady průtokové na českých řekách. Sborník prací Hydrometeorologického ústavu, Vol. 2, 116 pp. Praha

Observationes meteorologicae habita ad Observatorium Regium Pragense Anno 1829, 1830. Archiv Akademie věd České republiky Praha.

PFISTER, CH. (1985): Klimageschichte der Schweiz 1525-1860. 2nd ed., Vol. I. Verlag P. Haupt Bern etc.

PFISTER, CH. (1999): Wetternachhersage. 500 Jahre Klimavariationen und Naturkatastrophen (1496-1995). Verlag P. Haupt Bern etc., 304 pp.

PIOTROWICZ, K. (2000): Termika zim w Krakowie, Pradze i Lwowe od schylku Malej epoki lodowej do konca XX stulecia. Praca doktorska, Instytut geografii UJ Kraków, 182 pp.

PÖRTGE,K.-H. - DEUTSCH, M. (2000): Hochwasser in Vergangenheit und Gegenwart. In: Entwicklung der Umwelt seit der letzen Eiszeit, Rundgesprache der Kommussion für Ökologie, Bd. 18, p. 134-151. Verlag Dr. F. Pfeil, München.

ROSPOND, S. (1951): Slownik nazw geograficznych Polski zachodniej i pólnocznej. Vol. II, PTG Wroclaw-Warszawa.

RUDLOFF, H.v. (1967): Die Schwankungen und Pendelungen des Klimas in Europa seit dem Beginn der regelmässigen Instrumentenbeobachtungen (1670). F.Vieweg u. Sohn, Braunschweig, 370 pp.

SARTORI, F. (1830, 1832): Beschreibung der unerhörter Ueberschwemmung der Donau im Erzherzogthum Oesterreich under der Enns im Jahre 1830. 2 Vols., Wien.

Schlesische Provinzial Blätter (Wroclaw), Vol. 90-91, 1829-1830.

VAISHAR, A. et al. (1998): Floods, landscape and people in the Morava river basin. Grant project of the CR AS Grant Agency No. A3086903. Brno, Institute of Geonics ASCR.

WACHA, G. ed. (1964): Die Tagebücher Franz de Paula Haslingers, 2. Teil (1818-1833). Witterung und Klima von Linz, Anhang-Band 2, Stadtmuseum Linz, p. 417-472.

WIESE, H. (1953): Klimarhytmen und Schwankungen in ihrer Auswirkung auf die Wasseführung. Abhandl.d.Meteorol.u.Hydrol.Dienstes der DDR, Nr. 21, Bd. III. Akademische Verlag Berlin, 44 pp.

ZINKE, G. (1998): Die Erfassung von Hochwasserereignissen an Saale, Unstrut und Werra mittels Spezialbefliegung. In: Pörtge, K.H.-Deutsch, M. eds., Aktuelle und historische Hochwasserereignisse, Erfurter Geogr. Studien, 7, p. 54.

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RNDr. Vilibald KAKOS

Professor Miroslav HAVRLANT (75)

When you meet Prof. Havrlant on official business or privately, you do not believe he celebrated already his 75th birthday on 5 March 2000 at full physical and mental freshness when his "round" anniversary passed "not before long"(Moravian Geographical Reports, Vol.3, 1995, No. 1/2, p. 90). The prominent Czech geographer is always in a good humour and actively cooperates with the Institute of Geonics AS CR both as a member of the Institute's Scientific Board and in research projects.

We wish Prof. Havrlant for his way towards the next anniversary good health and sunny weather with no disturbing fronts of personal discomfort and we are looking forward to further fruitful cooperation with him.

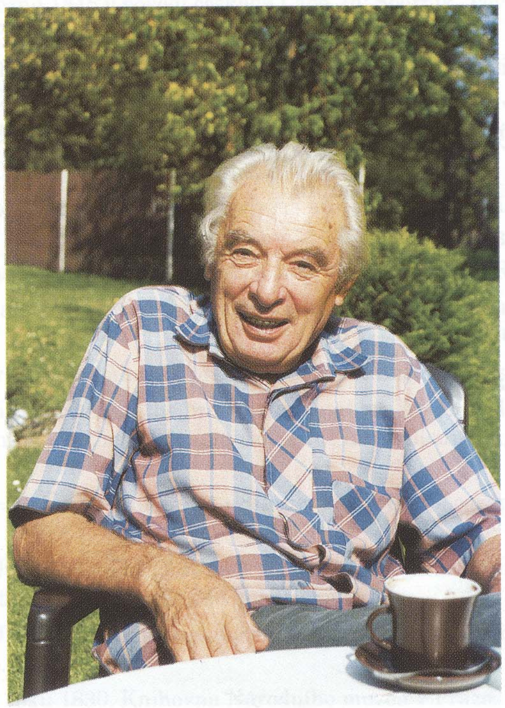

Photo: O. Mikulík

Professor Jaromír DEMEK (70)

A Conference "Relief and Landscape" was held at the Department of Geography, Faculty of Paedagogics, Masaryk University in Brno on 27 September 2000 on the occasion of an important life anniversary of Professor Demek (born 14 August 1930). His general scientific profile was outlined in the opening paper. Then the audience listened with interest to the contribution of Prof. Demek "Physical geography and global changes of environment". The successful conference also included a presentation of 17 posters with new pieces of knowledge and methods in the field of geomorphology, Prof. Demek's line of specialization.

The editorial board of Moravian Geographical Reports is pleased to have been entrusted with the publication of two stimulating papers by Prof. Demek and J. Kopecký as co-author in the past years (MGR No. 2/1996, MGR No. 2/1998). We wish the person celebrating the anniversary all the best and believe that he will find some time for a cooperation with the Moravian Geographical Reports also in the future.

Editorial Board

Hanušovice - aerial photograph (Postcard)

Railway bridge in Hanušovice after flood in July 1997

Photo: Z. Gába Jr.

Illustrations to A. Vaishar's, P. Hlavinková's and Z. Máčka's paper

Parts of picturesque Alpine valleys in Slovenia used for agriculture and recreation

Photo: O. Mikulík

Illustration to B. Lampič's paper