Republic of Serbia
Ministry of Science and Environmental Protection
Environmental Protection Agency

ENVIRONMENT IN SERBIA

an indicator-based review

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CONTENTS

PREFACE

Reliable information on impacts of the socio-economic growth on environment, ecosystems and, consequently, on public health is essential for framing and implementing sound and effective environmental policy measures and legislation. Therefore, the Serbian Government established in 2004 the Environmental Protection Agency, within the Ministry of Science and Environmental Protection. Serbian Environmental Protection Agency (SEPA) is dedicated to providing environmental information to policy-makers and the public, in order to support environment improvement in Serbia.

Cooperating with relevant Serbian authorities, Universities and Scientific Institutions, SEPA permanently upgrades the national data bank that contains information on all environmental components in Serbia.

The Agency uses the central data bank to publish periodic reports on the environment in Serbia. Reports are directed to decision makers (Republic Government and Republic Parliament), to international institutions, first of all to the European Environment Agency (EEA) and to the widest spectrum of public clients.

Reports that are directed to Republic Government represent a valuable tool for developing, adopting, implementing and evaluating environmental policy.

Since 2004, SEPA started to cooperate with EIONET (European Information and Observation NETwork), a partnership network of the EEA in order to fulfil reporting obligations that countries have towards international organisations. Contribution of Serbia in development of pan-European environmental data bank was symbolic in 2004. However, in 2006 Serbia achieved significant progress in cooperation with EIONET and EEA.

Harmonizing reporting obligations with EIONET standards (an indicator-based approach), SEPA prepared this document in order to describe the current state and trends of environmental variability in Serbia, and to assess a progress in legal and economic mechanisms that are focused to environment improvement and, consequently, to advancement of life quality of Serbian inhabitants

Branko Karadžić,
Director

Republic of Serbia
Ministry of Science and Environmental Protection
Environmental Protection Agency

INTRODUCTION

Continuous growth of human population, which is associated with both the urbanisation and development of the economy branches (mining, energy supply, industry, transport) generates a series of ecological problems at *local, regional* or *global* levels (EEA, 1998, 2003, 2005). Most important among them involve:

- climate changes
- depletion of stratospheric ozone (causing increased levels of ultraviolet radiation)
- loss of biological diversity
- risk of nuclear accidents
- acidification of water and land ecosystems
- increased levels of tropospheric ozone and other photochemical oxidants
- water, air and soil pollution
- waste generation
- risk of accidents in chemical industries

Efficient policy of natural resource management enables maximum economic growth with minimum degradation of the environment. Reliable data on both socio/economic growth and trends of environmental variability may help in developing, implementing and evaluating environmental policy, which is aimed at the lessening of the “economy-versus-ecology” conflict. Hence both national and international legislation specify obligations on

- monitoring (continuous and systematic surveillance of parameters that indicate air, water, soil and biodiversity quality) and
- periodic reporting,

in order to assess and to control human impacts on environment.

In 2004 the Serbian Government established the Environmental Protection Agency, within the Ministry of Science and Environmental Protection. Main priority of the Serbian Environmental Protection Agency (SEPA) is to collect and to process the data on all environmental components in Serbia, and to disseminate reliable information to policy makers and to widest spectrum of public. The Agency has developed a system for data acquisition and processing that includes:

- a server operating system,
- a set of databases,
- an Intranet/Internet server,
- a programme package for creating dynamic Internet/Intranet stations and dynamic client applications.

Using this system, the Agency permanently upgrades the central data bank that integrates all ecology-related information into a single functional unit. *National Data Bank* was developed as a result of intensive cooperation of Agency with a number of other organisations, such as: the Ministry of Science and Environmental Protection – Environmental Protection Directorate; Ministry of Agriculture, Forestry and Water Management; Ministry of Energy and Mining; Ministry of Health, Ministry of Capital

Investment; Ministry of Trade, Tourism and Services; Republic Hydrometeorological Service; Statistical Office of the Republic of Serbia; Institute for Nature Conservation of Serbia; Institute for Health Protection “Dr Milan Jovanović Batut”; Serbian Chamber of Commerce; Secretariat for Environmental Protection and Sustainable Development of the Autonomous Province (AP) of Vojvodina; Secretariat for Agriculture, Forestry and Water Management of AP Vojvodina; Recycling Agency; Kragujevac Health Protection Institute; Novi Sad Institute of Public Health; Niš Health Protection Institute; Belgrade Health Protection Institute; Health Protection Institutes in Vranje, Kraljevo, Kruševac, Leskovac, Pančevo, Pirot, Požarevac, Subotica, Užice, Šabac and Čačak; Institute of Soil Science; Faculty of Biology and Faculty of Forestry, University of Belgrade; Faculties of Natural Sciences, Universities of Kragujevac and Niš; Belgrade Institute of Forestry, Institute for Biological Research “Dr Siniša Stanković”; Institute of Architecture and Regional & Urban planning of Serbia; Faculty of Agriculture - Institute of Lowland Forestry and Environment, University of Novi Sad; Faculty of Agriculture, University of Belgrade; Faculty of Natural Sciences, Department of Biology and Ecology, University of Novi Sad.

The Agency uses the central data bank to issue periodic reports on the environment in Serbia. Reports are directed to decision makers (Republic Government and Republic Parliament), International institutions (first of all to EEA) and to widest spectrum of public clients. The mechanism of SEPA functioning is presented in Figure 1.

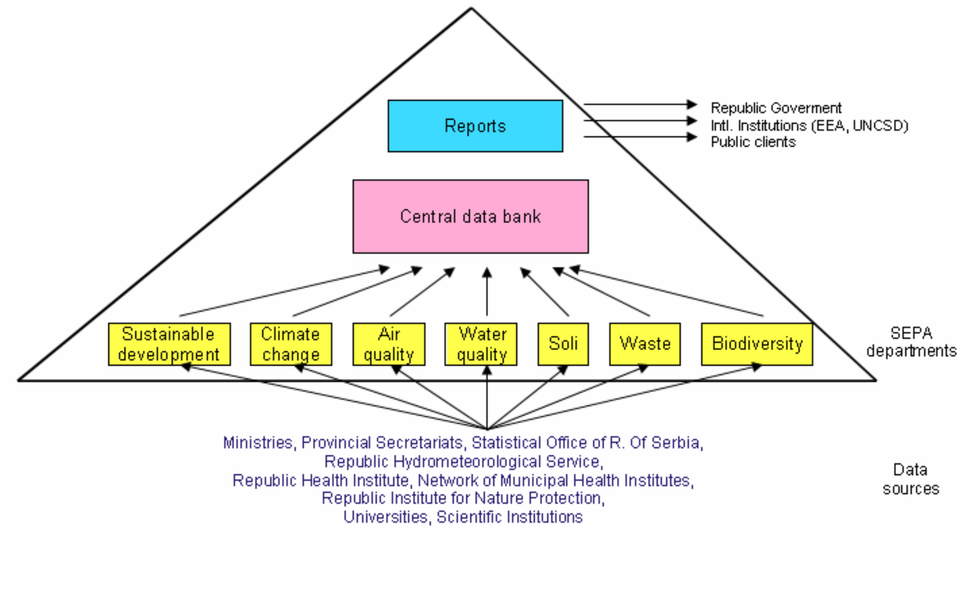


Figure 1

Concept of the SEPA functioning

Reports that are directed to Republic Government represent a valuable tool for developing, adopting, implementing and evaluating environmental policy. SEPA prepared two State of environment reports that cover period from 2003 to 2005.

Any environmental problem is local, but at the same time it has a regional dimension. Therefore, European Commission established the European Environment Agency (EEA), which propagates information to policy-makers and the public, in order to support measurable improvements in Europe's environment. Since 2004, SEPA started to cooperate with EIONET (European Information and Observation NETwork), a partnership network of EEA, in order to fulfil reporting obligations that countries have towards international organisations. Contribution of Serbia in development of pan-

European environmental data bank was symbolic in 2004. However, in 2006 Serbia achieved significant progress in cooperation with EIONET and EEA (Figure 2).

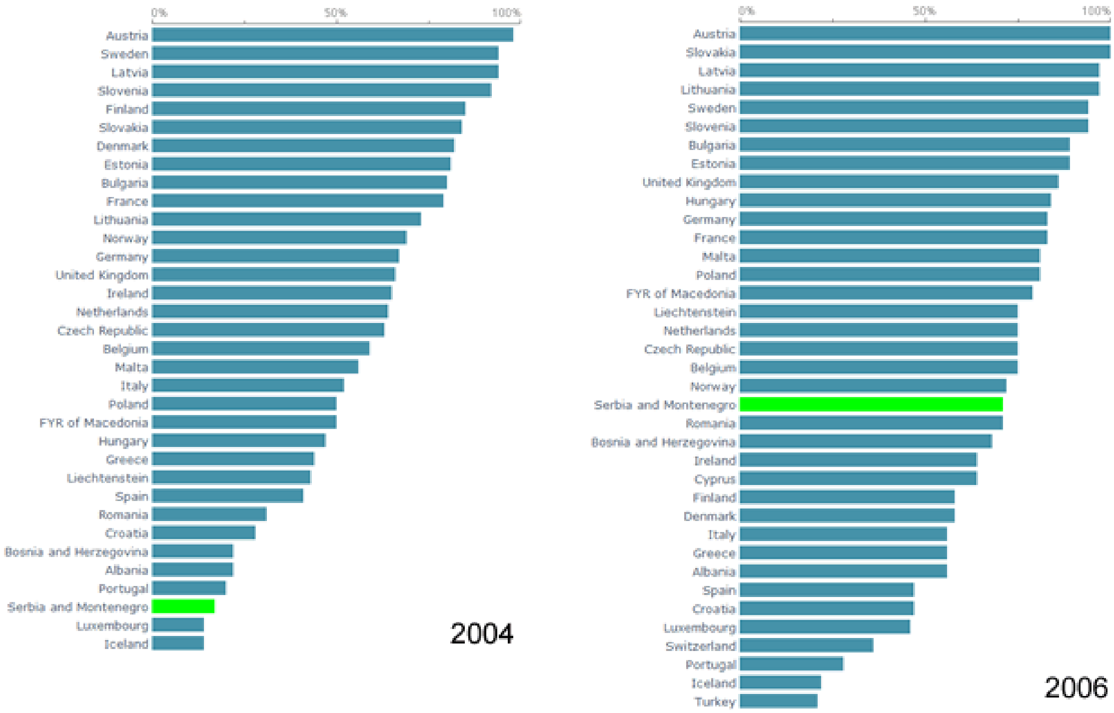


Figure 2

European countries ranked by their contribution to the EIONET data flows process. Source: http://www.eionet.europa.eu/dataflows/pdf2006

Harmonizing reporting obligations with EIONET standards (an indicator-based approach), SEPA prepared this report in order to:

- describe current state and trends of environmental variability in Serbia,
- identify the effects of socio-economic development on the environment, and
- assess a progress in legal and economic mechanisms that are focused to environment improvement in Serbia

An indicator is a measure that can be used to illustrate trends and progress over time. This report is based on the internationally accepted Core Set of Indicators (EEA, 2005).

SOCIO ECONOMIC GROWTH

DEMOGRAPHY
URBANISATION
ECONOMIC DEVELOPMENT
ENERGY
MINING
INDUSTRY
TRANSPORT
TOURISM
AGRICULTURE
FORESTRY
ENVIRONMENTAL MANAGEMENT

DEMOGRAPHY

The size of human (or any other) population depends on four demographic processes - births, deaths, immigration and emigration. Data collected in periodic surveys provide a basis for demographic statistics (per capita births and deaths, migration rates, age structure and sex ratio) that can be used for modelling and prediction of population dynamics. Periodic population censuses in Serbia were performed in 1921, 1931, 1948, 1953, 1961, 1971, 1981, 1991 and 2002. The results of the 1991 census were incomplete for Kosovo and Metohija due to a refusal of ethnic Albanian population to take part in it. On the other hand, the 2002 population census was not carried out at all in the territory of Kosovo and Metohija. According to available data (Statistical Office of Serbia), Serbia (excluding Kosovo and Metohija) had 7,576,837 inhabitants in 1991 and 7,498,001 in 2002. The Yugoslav Survey (http://www.yusurvey.co.yu) has put the estimated figure of Serbian inhabitants on January 1st, 2006 to 7,395,600, which is 83,000 less than 15 years earlier (1991) and 131,000 less than five years earlier (2001). In the 1991-2006 period, the total population of Central Serbia decreased by more than 206,000 or 3.7%, while that of Vojvodina increased by 23,700 owing solely to the arrival of refugees during disintegration of the former Yugoslavia and armed clashes in Croatia and Bosnia and Herzegovina between 1991 and 1996.

With the outbreak of war in the former Socialist Federal Republic of Yugoslavia (SFRY), Serbia faced a serious problem of incoming refugees for the first time since the Second World War. By the end of 1999, nearly 500,000 people had found refuge in the republic with no realistic possibility of returning home (http://www.srbija.sr.gov.yu). In April 2001, the Serbian Commissariat for Refugees, in cooperation with the UNHCR, carried out a new registration of refugees and other persons who had fled to Serbia during the war. A preliminary analysis of the data collected in July 2001 shows that 451,980 persons were registered in Serbia. Of that population, 377,731 have a refugee status, while 72,249 do not meet all required conditions to be given such status under international law. Most of the refugees are from Croatia (about 63%), while the percentage of those from Bosnia and Herzegovina has declined to 36%.

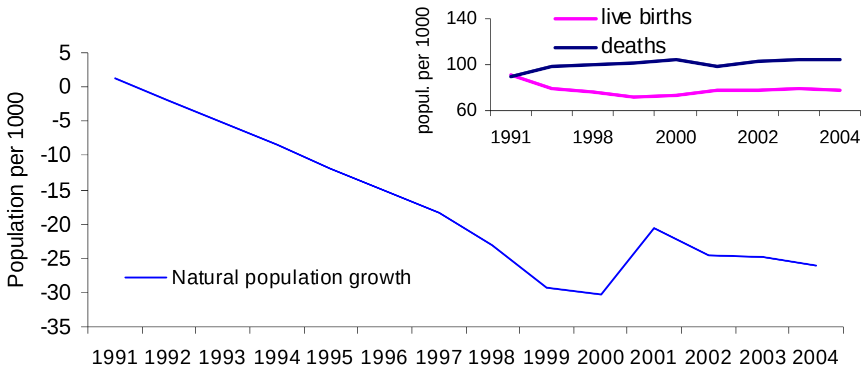


Figure 3

Parameters of population dynamics

The size and share of urban population in Serbia have been growing continuously over decades. In the 1991-2002 intercensal period, its share in the overall population increased from 54.6% to 56.4% (source: Yugoslav Survey http://www.yusurvey.co.yu).

Depopulation trend in Serbia is a consequence of the negative natural population growth. Natural population growth has been negative since 1992. In 2005, the difference between the number of deaths and live births reached 34,591 (-4.7‰), which is 14,018 more than in 2001. All districts in Serbia, with exception of several southern districts (Raška, Pčinja, and those in Kosovo and Metohija), have negative growth rates.

Figure 4

Serbian districts with negative (red) and positive rates (gray) of population growth. Only several southern districts (Raška, Pčinja, and those in Kosovo and Metohija) have positive growth rates

Over the 2001-2005 period, employment had a tendency of decline and unemployment was rising. In December 2005, 990.700 persons were registered as seeking employment, which was a 2.1% increase against the same month of 2004. According to data presented by the National Employment Service, the unemployment rate recorded in December 2005 was 29.2%, or 27.2% of actively unemployed persons.

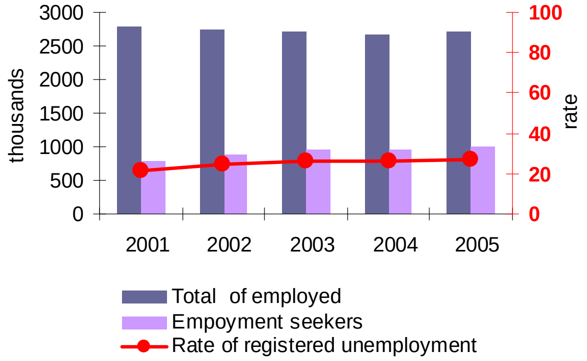


Figure 5

Unemployment trend in Serbia. Data for Kosovo and Metohija are missing.

Over 75% of the unemployed had been seeking job for more than one year, 33% of whom between one and three years and 42% for over three years. (Report on the Transition Process in Serbia and Montenegro, G17 Institute, 2004).

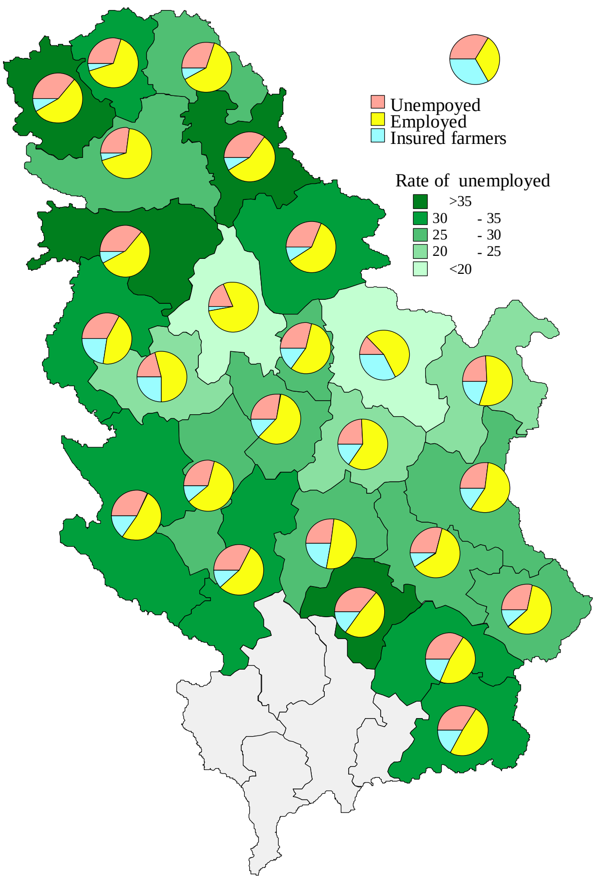


Figure 6

Employment rates in Serbian districts (Data source: National Employment Service, December 2005). Data for Kosovo and Metohija is missing

According to available statistics, the standard of living was on the rise in the 2001-2004 period, with 11.1% growth of earnings in real terms (exceeding a 9.3% growth of gross domestic product in real terms), while real growth of average pensions was 7% in 2004.

URBANISATION

Serbian territory covers 88,361 km². Within this territory there are 4,706 (data for Kosovo and Metohija are missing) human settlements (Statistical Office of Serbia, webrzs.statserb.sr.gov.yu).

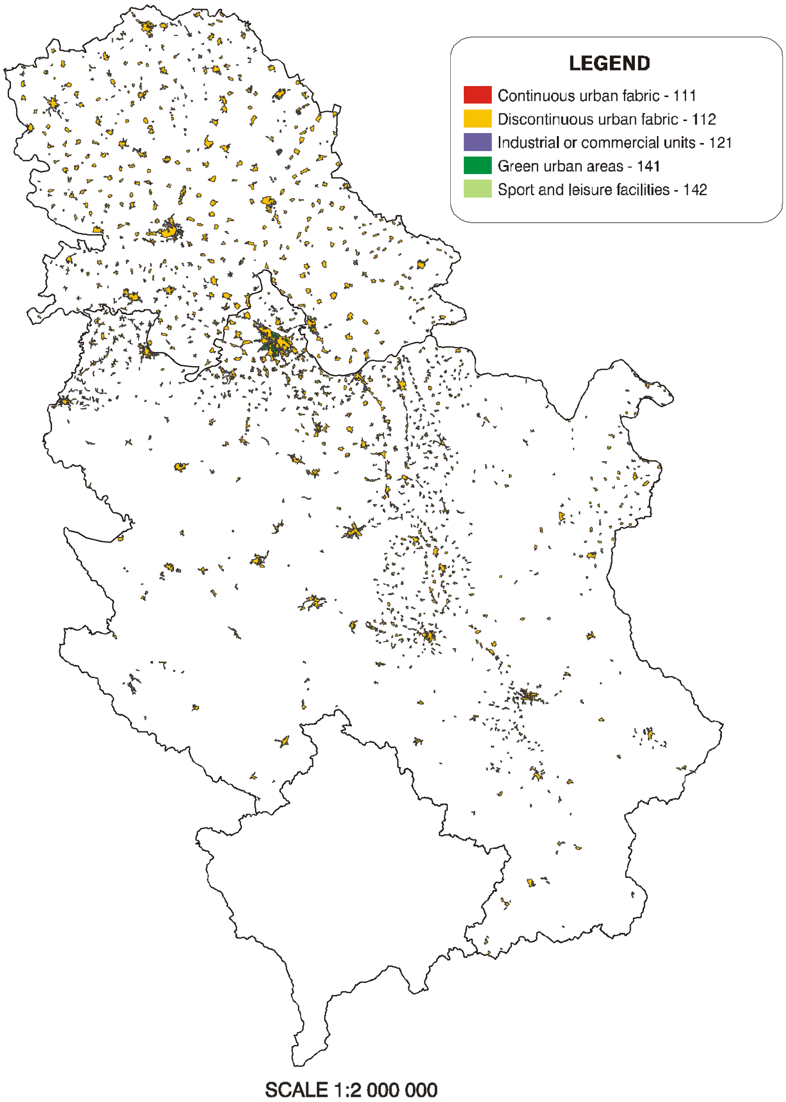


Figure 7

Distribution of (sub)urban settlements in Serbia (2000). Data for Kosovo and Metohija are missing.

Distribution of urban areas in Serbia is shown on Fig. 7, which was generated using the CORINE Land Cover database. As part of the CORINE (COoRdinated INformation on Environment) Programme, the European Environment Agency (EEA) has initiated the Land Cover Project (EEA Multi-annual Work Programme 1998 2002, project 1.3.5.) in order to create an inventory of landscape classes using satellite images. In cooperation with the Topic Centre on Land Cover, the company Evrogeomatica processed a set of satellite images and created a database on land use classes in Serbia for the period of 1990-2000. Map 1 clearly indicates that the areas of Vojvodina and large river basins (the Sava, Danube and Velika Morava) are exposed to heaviest urbanisation pressures.

Data on the housing conditions indicate a slight improvement of some parameters, such as the number of housing units, utility installation, housing area per tenant, etc. In 2004, 99.9% of the housing units were equipped with electrical installation, 89.6% with plumbing pipes, 83.3% with sewage pipes, while 26.2% of units had central heating installation.

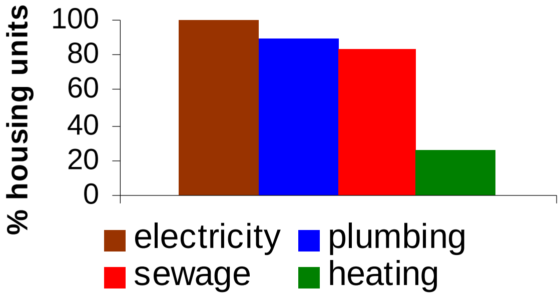


Figure 8

Housing conditions in Serbia

The use of solid fuels is high as some 40% of the households still use them. Poor quality of tap water is a special concern as some 30% of water samples collected from the waterworks fall short of the required bacteriological and physico-chemical standards. This percentage goes to as far as 50% or so in rural areas.

Problems in implementing environment protection measures in the area of spatial and urban planning and housing refer to: a lack of clearly defined national policy of spatial planning and development; lack of high-quality spatial and urban plans; unsatisfactory inter-departmental and inter-sector cooperation; insufficient training of local government divisions and their weak financial capacity for implementing the duties stemming from legislation and planning.

ECONOMIC DEVELOPMENT

At the end of 2000, Serbia embarked upon a process of transition towards market economy, which led to a significant economic growth. Macroeconomic activity from 2001 until 2005 was characterized by introduction of a sustainable macroeconomic stability and sustainable and stable economic growth. Economic development since 1997 is reflected in gross domestic product (GDP) and GDP per capita figures in dollar currency (using the World Bank methodology) as provided by the Statistical Office of Serbia.

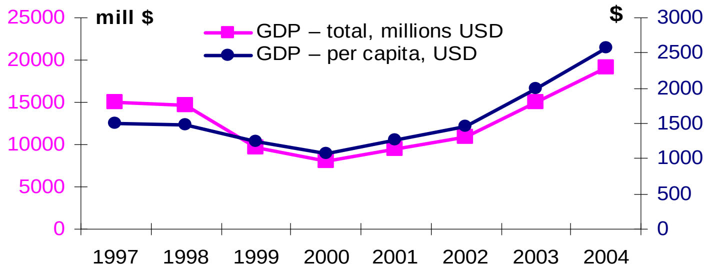


Figure 9

Indicators of economic growth in the Republic of Serbia

GDP (gross domestic product) growth in real terms in 2004 and 2005 has been estimated at 9.3% and 6.5%, respectively. Average inflation rate, measured in terms of growing retail prices, was reduced from 91.8% in 2001 to 10.1% in 2004, while it was 16.5% in 2005.

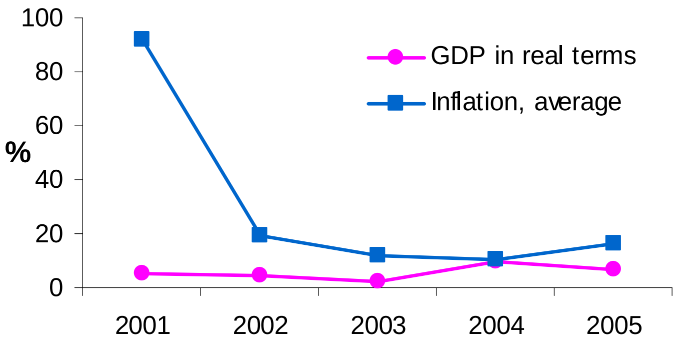


Figure 10

Gross domestic product and inflation in the Republic of Serbia

In 2005, the process of rectifying a disparity in prices in the energy industry and public utilities continued. Price rise in that area causes a decrease in electricity and water consumption, and leads to more rational consumption of the resources and lower emissions of pollutants. According to the Statistical Office of Serbia, public utility prices rose 45.1%, household electricity 6.6%, coal price 20.9% and liquid fuels and mazut (a heavy, low quality fuel oil) 23.1%, compared to prices in December 2004.

Relationship between economic policy and environmental protection

According European Union statistics, the EU-25 in 2001 allocated around 1.8% of their GDP for the protection of the environment (funds for prevention, reduction and elimination of pollution or some other type of environmental degradation). Those included investments by the public sector, specialized producers and the industry:

- Public sector (government, competent institutions and agencies at central and local levels) set aside 0.6% of the GDP
- Specialized producers (public and private enterprises involved in the management of wastes and wastewaters) provided 0.8% of the GDP
- Industry (mining, industries, electrical power supply, water management sector, etc.) invested 0.4% of the GDP.

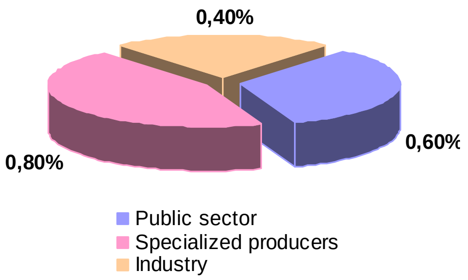


Figure 11

Environmental protection expenditure (EPE) as % of GDP, EU-25 2001, Eurostat estimate

Preliminary estimates (Directorate for Environmental protection, 2005) show that annual cost of degradation of the environment in Serbian economy is between 4.4% (conservative scenario) and 13.1% (maximum scenario) GDP. A bulk of this burden is assessed to be caused by air pollution (53% of total expenses), water pollution (22%) and waste management (11%).

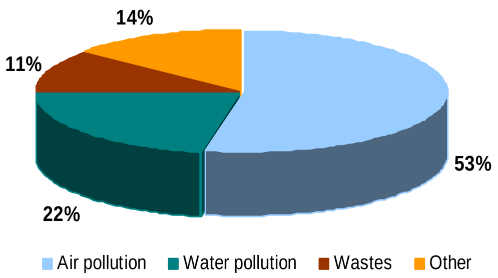


Figure 12

Structure of estimated annual losses caused by degradation of the environment

Environmental protection expenditure has been considerably below EU average and lags behind other transition economies. Under a functional classification of consolidated public expenditure, environmental protection expenditure accounted for 0.3% GDP in the 2001-2003 period and 0.4% in 2004, while the estimates for 2005 are 0.3%.

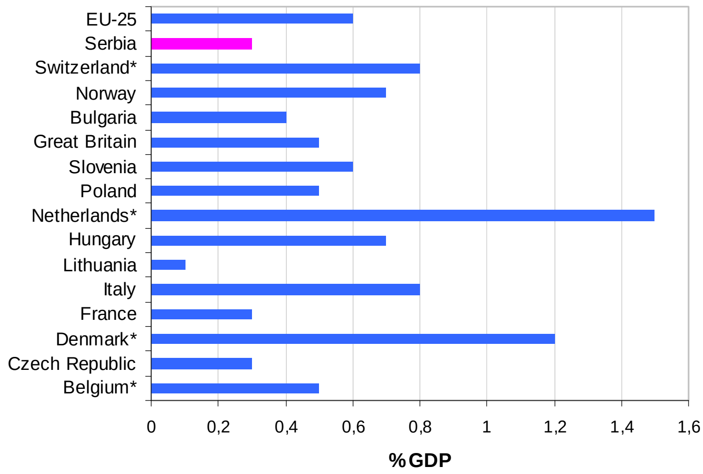


Figure 13

*Comparative survey of public sector expenditure for environmental protection in GDP % in 2002. Data marked with * refer to 2001*

Weighing the estimated cost of degradation of the environment against investments in environmental protection, it becomes clear that the cost by far exceeds investments made to improve environmental quality in Serbia.

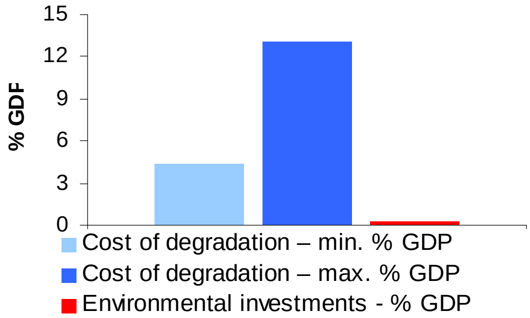


Figure 14

Estimated annual costs of degradation of the environment and investments in environmental protection in 2005

According to projections stated in the *Memorandum on Budget and Economic and Fiscal Policy* in 2006, allocations for environmental protection in the 2006-2008 period were planned to be 0.4% GDP annually. On the other hand, based on the *National Programme of Environmental Protection in Serbia* and a projected annual economic growth of 5% GDP, the environmental investments are expected to grow from 0.3% GDP in 2005 to 1.2% in 2009 and further on to 2.4% in 2014. These two projections differ considerably as a result of inadequate treatment of environmental protection under the existing economic policy on the one hand and possibly owing to different methodologies employed.

ENERGY

Serbia is not rich in energy resources. With the current level of production, which provides for only 25% of the country's needs, Serbia (excluding Kosovo) is expected to exhaust its coal supplies within the next 55 years, and oil and gas within 20 years. Current hydroelectric power capacity is 10,200 GWh per annum, while potential capacity has been estimated at 14,200 GWh per annum.

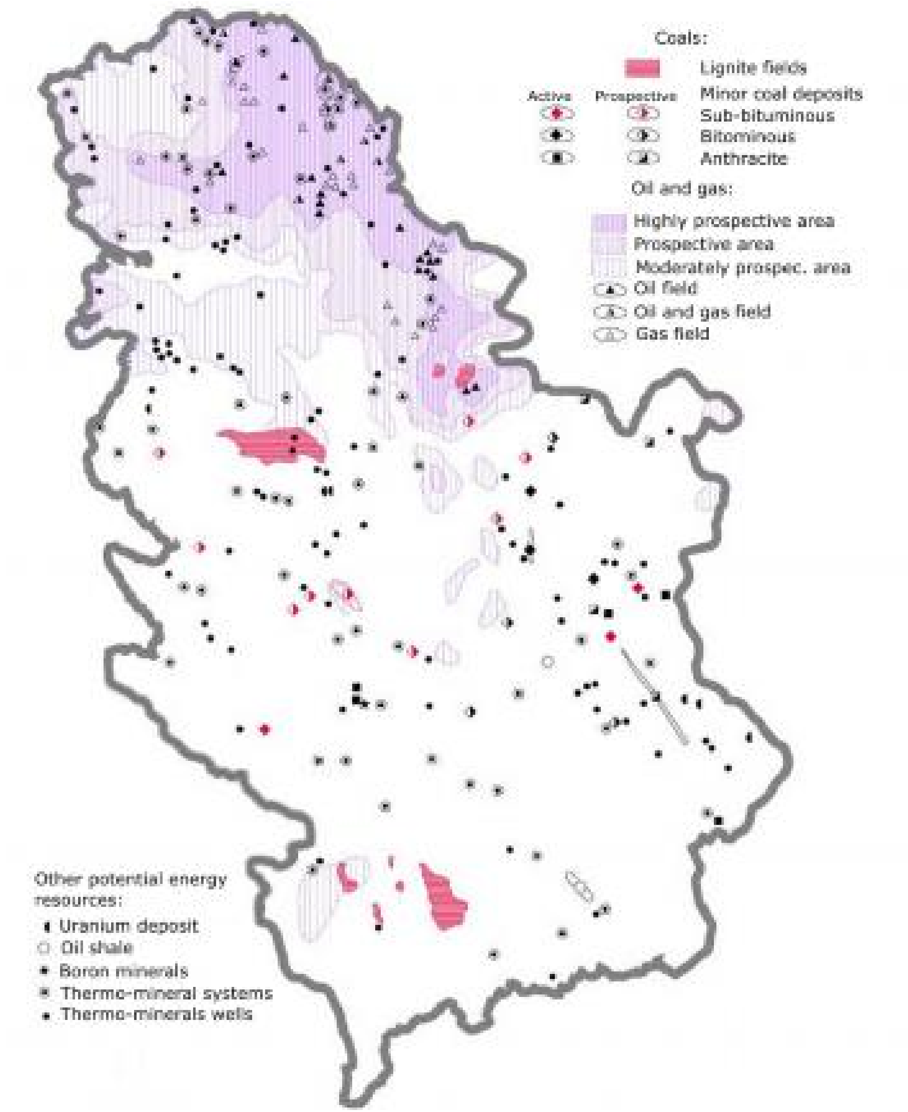


Figure 15

Exploitation of energy resources in Serbia (source: Institute of Architecture and Regional & Urban Planning of Serbia)

The potentials of other, renewable energy resources, including biomass, small hydroelectric power plants, geothermal, wind and solar energy are very significant and exceed 3.8 Mtoe. Some 63% (2.4 Mtoe) of the potential renewable energy resources described lie in the utilization of biomass (wooden and agricultural biomass). Energy potential of the existing geothermal springs in Serbia is nearly 0.2 Mtoe, and that of small hydroelectric power plants 0.4 Mtoe. There are 50 city heating plants in Serbia with total heat energy capacity of 6,597 MW. The main characteristics of Serbia's heating plants are low operating readiness due to insufficient maintenance and outdated equipment, financial exhaustion and an inability to perform urgent intervention on sources and grids. Heating is poor and there is a need for additional capacity.

The Electric Power Industry of Serbia (EPS) encompasses coal mines, electric power sources (hydroelectric power plants, thermal power plants, heating plants) and grid distribution systems. From 1975 to 1990, 450 million US dollars was invested in the EPS on an annual basis (a total of 7.5 billion US dollars). Between 1990 and 2000, less than 10% of the planned funds were invested in repairs and maintenance each year, so that construction of new power plants is urgently needed.

The overall economic situation, technological outdatedness and depreciation of the energy and production capacities, as well as the structure of available energy resources, such as they were inherited from an earlier decade, have caused a significant deterioration of economic effectiveness and power consumption efficiency in Serbia.

According to data of Ministry of Mining and Energy, over the 1990-2005 period, the production of primary energy varied perceptibly. In 2005, it was 13% lower than in 1990. Dependence on inputs after a decline in early 1990s continued to grow, reaching 37.22% in 2003.

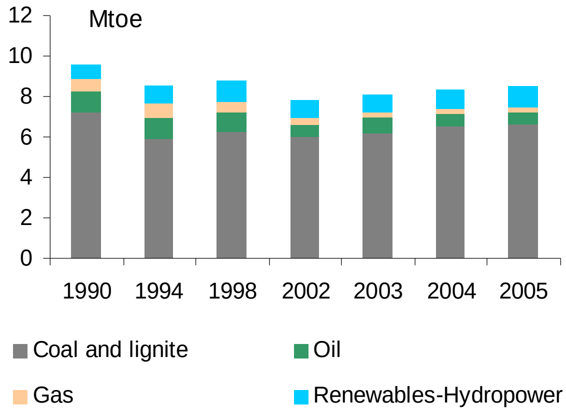


Figure 16

Final energy production

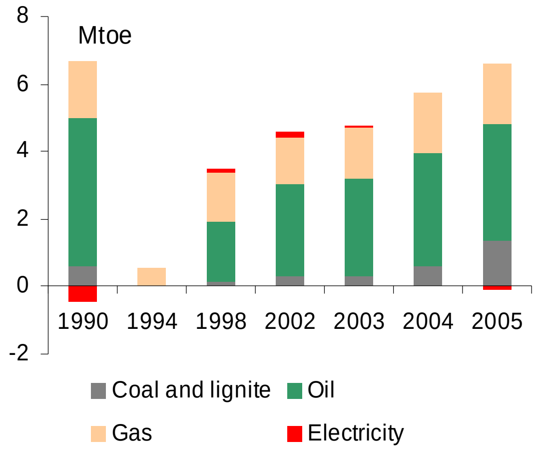


Figure 17

Energy imports

The 1990-2005 period was characterized by reduced energy consumption by 6% and a predominant use of fossil fuels (coal, oil and gas). However, a trend of slow reduction of fossil fuel consumption is perceptible as their share decreased from 97.9% to 93.6% and the energy consumption from renewable resources (hydroelectric power plants) increased from 4.7% to 6.9%. These changes, even though limited, alleviate the effect that energy industry has on the environment. Over the same period, EU-25 member-states increased energy consumption by 11%, while decreasing fossil fuel consumption from 82.6% to 79.3% and increasing energy consumption from renewable resources from 4.4% to 6.0%.

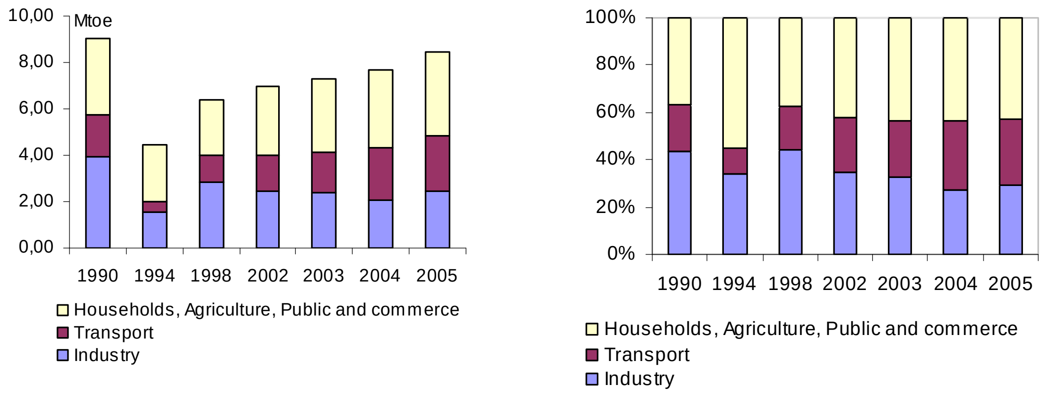


Figure 18

Left: Final energy consumption by sector (1000 TOE); Right: Shares % aggregated (source: Ministry of Mining and Energy)

Over the 1990-2005 period, the structure of energy consumption changed significantly. The highest increase in energy consumption was achieved in the transport sector - 29.5%, slightly lower in the sectors of households, agriculture, public and commerce – 10.4%, while a decline of 36.7% was recorded in the industrial sector. Considering all facts, it is evident that a drop in industrial production was the primary cause of such decrease in energy consumption in Serbia.

Even though electricity prices rose nearly four-fold, the consumption of energy for heating decreased by no more than some 25%. The reason for this lies most probably in insufficient coverage of long-distance central heating systems, so that, regardless of prices, the population continued to use electricity for heating.

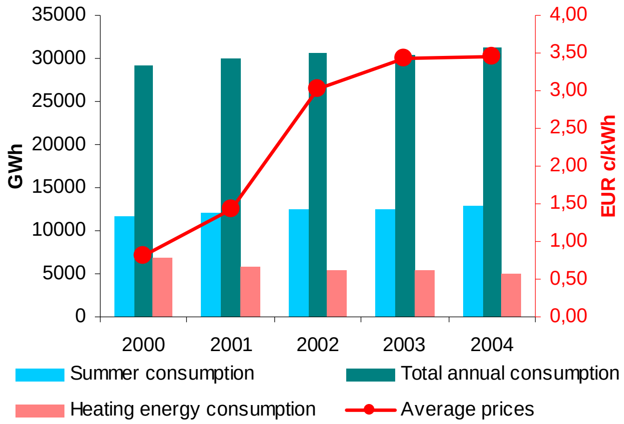


Figure 19

Electricity consumption and average electricity prices

Hydropower is the most important source of renewable energy in Serbia. The share of renewable energy resources in overall energy consumption in the 1990-2005 period increased by only 2.2% and it is still at a low level of 6.9%.

The White Paper for a Community Strategy and Action Plan (COM(97) 599 final), which provides a framework for Member States action to develop renewable energy and sets an indicative target to increase the share of renewable energy in total energy consumption (GIEC) in the EU15 to 12 % by 2010.

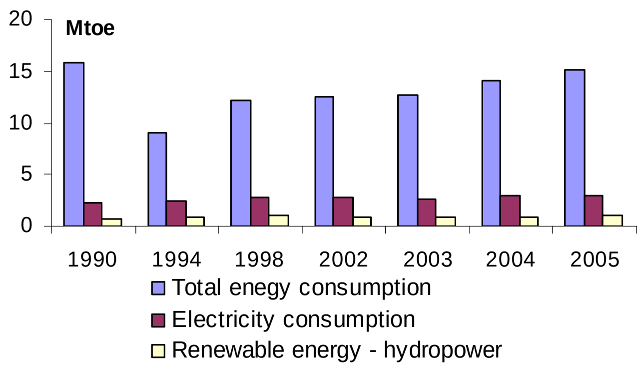
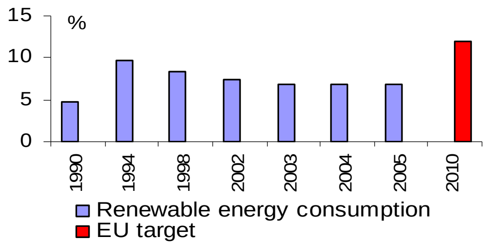


Figure 20

Total energy and electricity consumption and renewable energy (source: Ministry of Mining and Energy)

Specific targets have been set for the share of renewable fuel (biofuels) in transport to achieve 5.75 % by 2010 (Directive 2003/30/EC), and for the share of renewables in gross electricity consumption to reach 21 % by 2010 (Directive 2001/77/EC).The original EU Directive on the promotion of electricity from renewable energy sources in the internal electricity market (2001/77/EC) sets an indicative target of 22.1 % of gross EU-15's electricity consumption from renewable sources by 2010. For the new Member States, national indicative targets are included in the Accession Treaty: the 22.1 % target set initially for EU-15 for 2010 becomes 21 % for EU-25. However, in Serbia energy consumption from hydroelectric power resources has risen from 32% in 1990 to 34.2% in 2005. As the EU intends to achieve 21% of renewable energy resources in the overall electricity consumption, Serbia has already exceeded that goal.



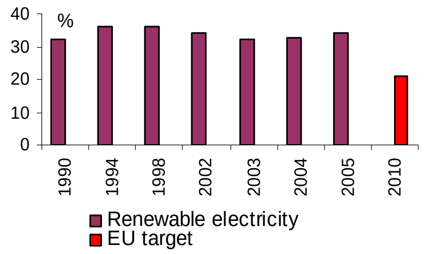


Figure 21

Left: Contribution of renewable energy in total energy consumption; Right: Contribution of renewable electricity in gross electricity consumption

Effects on the environment

Environmental pollution is possible in almost all sectors of energy industry: sector of coals (from production to consumption); production, transmission and distribution of electricity; sector of crude oil and gas (from prospecting to exploitation and, especially, to processing and transportation of oil and oil derivatives).

The most evident effects of thermoelectric power plants on the environment include:
- air pollution with suspended particles, SO_2, NO_x and O_3
- contribution to the greenhouse effect by CO_2 emissions
- risk of accidents on ash landfills
- soil degradation in areas surrounding thermoelectric power plants
- pollution of surface and underground waters
- increase in water temperatures caused by releases of cooling waters from thermoelectric power plants directly into rivers.

Detriments to the environment caused by hydroelectric power plants include:
- changed regime of alluvium depositing in the reservoir area and downstream
- activation of existing and excitation of potential land-slides
- changed regime of underground waters in river bank areas
- submersion of fertile soil
- change of microclimate
- negative effect on biological diversity, primarily ichthyofauna
- change in seismic activity

"*The Strategy of Development of the Energy Sector*" determined a new energy policy within the ongoing reform of the energy sector in Serbia. The main objectives of Serbia's new energy policy, viewed from the aspect of environmental protection, are:
- reliable domestic production and stable supplies of energy products from the existing energy resources with improved technological and operational characteristics
- harmonized operation and development of entire energy industry with the needs of the consumption sector and development of relevant sectors of the economy
- efficient production and rational, cost- and energy-efficient utilization of primary energy resources aimed at improving the volume and structure of high-quality energy resources consumption and more efficient protection of the environment.

MINING

Mining is the cornerstone of Serbia's industry and, consequently, of Serbian economy in general. The mining comprises four extraction sectors: coal; crude oil and gas; metal ores; other ores and stones.

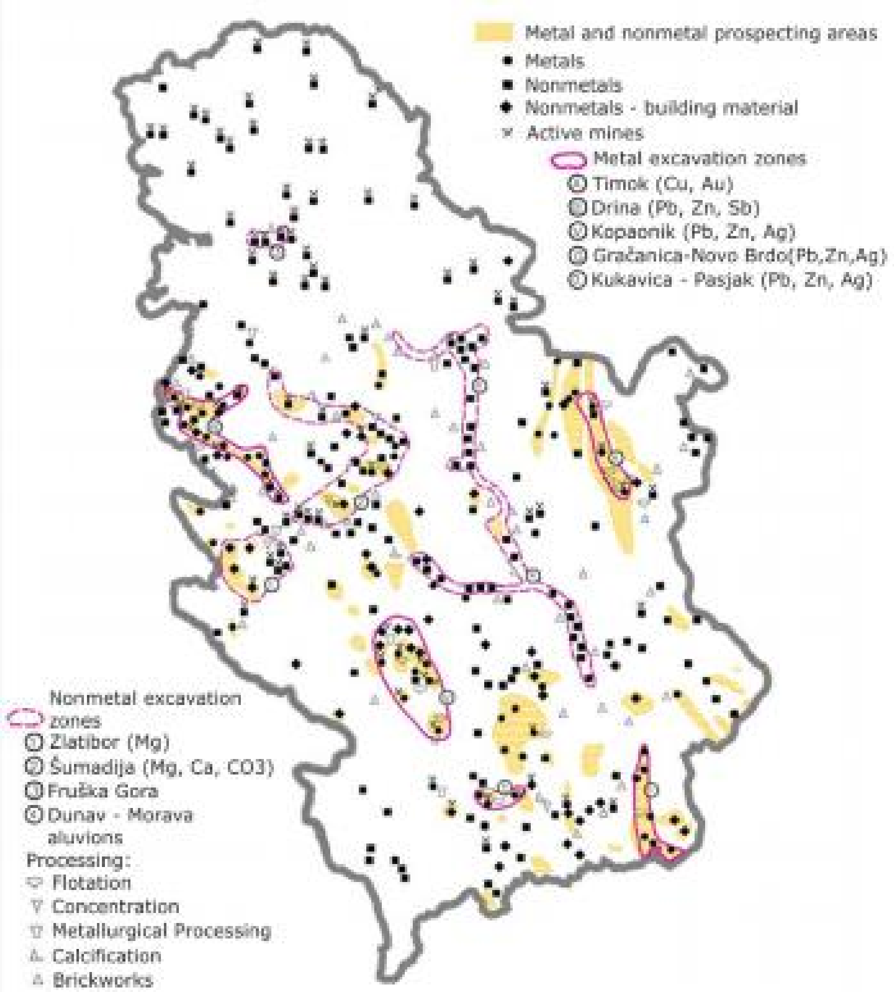


Figure 22

Excavation of mineral raw materials in Serbia (source: Institute of Architecture and Regional & Urban Planning of Serbia)

Low-caloric coals, the lignites, which are mined at Kolubara and Kostolac, provide 65% of electricity in Serbia. Significantly, available data shows that one Kolubara excavation site alone - Field D, provides 32% of electricity in Serbia. The average content of sulphur in those lignites is below 3%.

Despite the general trend of industrial production in Serbia, production of building material is still a significant and profitable segment of industry that has been continuously developing (20% growth in the year 2000) and is based primarily on mineral materials, i.e. on mining. The main producers of building material are the cement factories in Beočin, Kosjerić and Novi Popovac, brick factories in Kikinda, Novi Bečej, Novi Pazar, Ruma, and Kanjiža. Excavation of technical and building stone is also a profitable mining sector, with sites near Ub, in Topola, Jelen Do, and Aranđelovac. Private sector initiative is most prominent in this sector through exploitation of non-metals and building materials.

The Bor Mining and metallurgical complex produces copper ore and precious metals in quantities that are significant on a regional level. The most important copper-mining sites are Bor, Veliki Krivelj, Cerovo, Majdanpek and Jama Bor. Secondary precious metal refining is also substantial.

Exploitation of industrial minerals in Serbia will soon be of great consequence. Highly profitable projects are planned that are partly based on estimated and partly on confirmed reserves of boron minerals, phosphates, zeolites, granite alluviums, ilmenite, zircon, etc. Foreign companies are especially interested in exploitation of industrial materials.

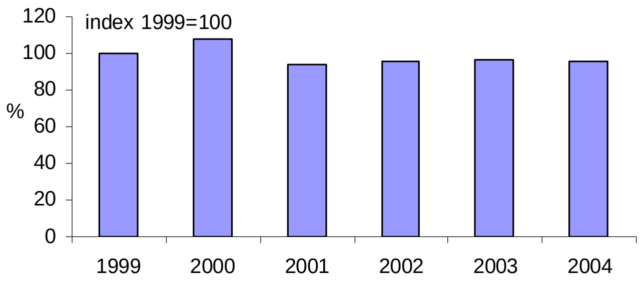


Figure 23

Mining production compared to 1999 output

According to the Ministry of Energy and Mining, nine out of ten requests for mineral prospecting are made for underground water, which clearly points at their significance. The main commercial mineral water producers are successful companies such as Knjaz Miloš, Rosa, Leda, Bivoda, Palanački kiseljak etc.

Mining production trends over the 1999-2004 period show a slight decline, reaching in 2004 around 96% of the 1999 production.

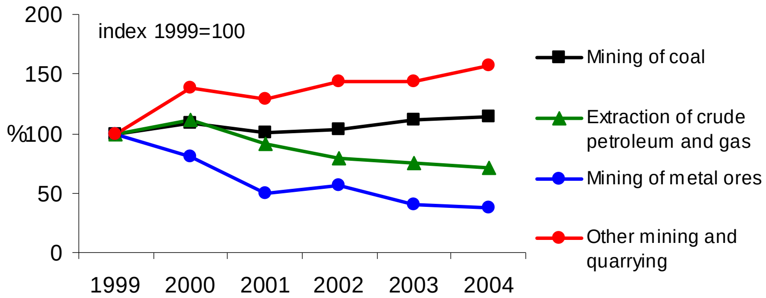


Figure 24

Structure of mining production (source: Statistical Office of Serbia)

Production within mining sectors shows a rising trend in the extraction of coal and other ores and stones, and a declining trend for metal ores, oil and gas.

The mining areas in Serbia have been under massive exploitation for many years. Billions of tons of ore and tailings have been excavated. It is noteworthy that the amounts of overburden exceed coals by multifold.

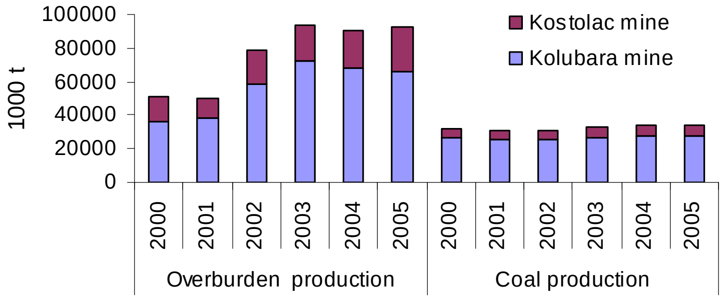


Figure 25

Coal and overburden production (source: Ministry of Mining and Energy)

Effects on the environment

Intensive mining of mineral ores has caused exhaustion of non-renewable natural resources and pollution of water, air and soil, and significant deterioration and degradation of soils. Most of the terrain has been degraded by surface mining of copper and coal. Large areas are covered with tailings and fly ash deposits. Such deposits in Serbia have been estimated to contain:

- around 170 million tons of fly ash from thermoelectric power plants
- between 1.4 and 1.7 billion tons of tailings from overburden
- around 700 million tons of flotation and separation tailings

Around 10,000 hectares of land have been degraded by surface mining and tailing ponds in the major mining complexes. Of that area, less than 20% has been under natural (by spontaneous succession of vegetation) and artificial recultivation. Some 1,700 hectares of land degraded by lignite mining had been ameliorated by 1991, but soil improvement was brought to a halt in 1992.

Air pollution occurs in mining areas as a consequence of increased levels of dust raised by excavation, intensive transportation, etc. Water pollution in mining areas occurs primarily through erosion of unprotected tailing ponds. Surface and underground waters have been polluted several times by accidental outbreaks of flotation dams and spilling over of more than 100 million tons of flotation tailings.

Continued mining without adequate preventive measures would lead to:

- air and water pollution caused by tailings and surface excavation
- lowering of the levels of underground waters
- degradation and contamination of soil
- increased risks of accidents at tailings ponds
- soil and water pollution caused by drilling mud from oil wells.

Such pressures on the environment may in some cases be dramatic (degradation of entire regions, deterioration of soils, etc.).

INDUSTRY

Unfavourable economic situation in the industrial sector over the past decade comes as a result of economic sanctions in the past. The country's isolation and dramatic loss of traditional markets and business partners have caused industrial production to sustain a sudden drop of some 60% in the early 1990s.

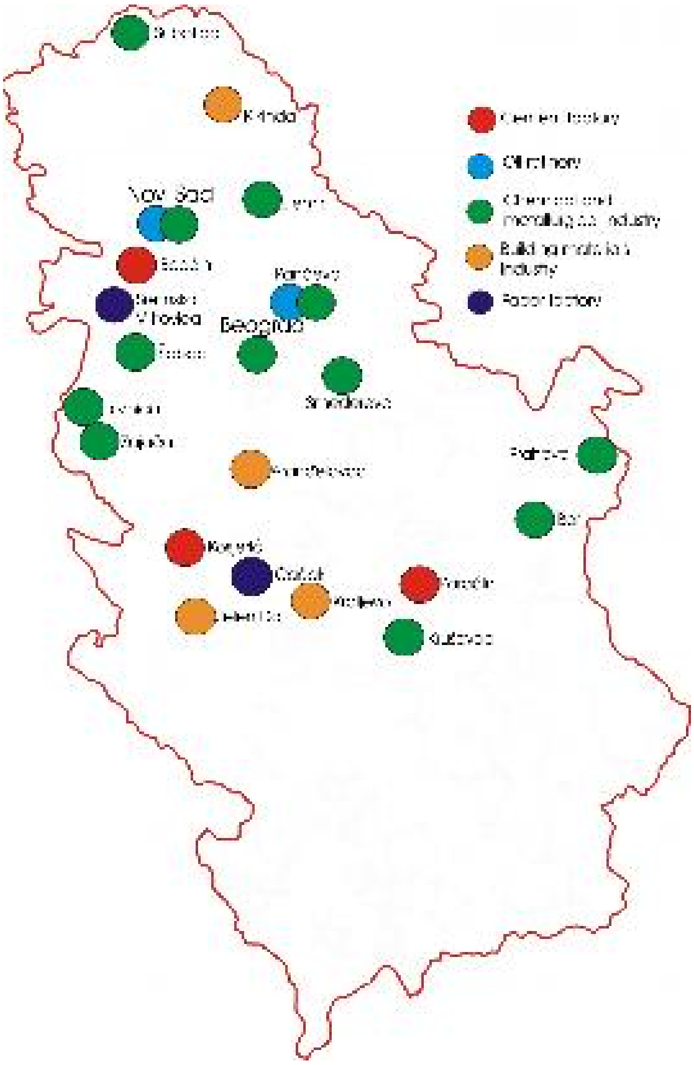


Figure 26

Main industrial centres in Serbia

After the Privatisation Law was adopted in June 2001, conditions were created for implementing economic reforms in the productive branches of the economy. Some other steps that have been taken so far (in solving the outstanding internal and foreign debts, and providing funds for energy imports), as well as those that will be taken in the future, contribute to a gradual recovery of the industrial sector and its easier adaptation to new economic conditions. However, industrial production is still far below the 1990 output as it still does not reach 50% of that year's level. According to the Statistical Office of Serbia, the share of industrial output in the gross domestic product (firm prices in 2002) was 21.4% in 2004.

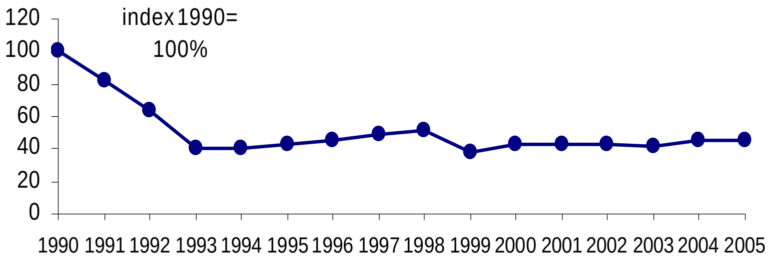


Figure 27

Industrial production compared to 1990

Industry includes three sectors: mining of ores and stones; processing industry; production and distribution of electricity, gas and water. In the overall industrial production in 2005, the processing industry participated with 75.4%, electricity generation and distribution with 18.3% and mining of ores and stone with 6.3%.

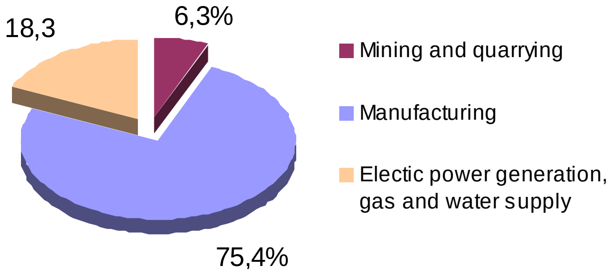


Figure 28

Structure of industrial production in Serbia in 2005 (source: Statistical Office of Serbia)

Industry is a major energy consumer as it accounts for around 45-30% of the overall consumption of secondary energy. However, a slow trend of increase in energy efficiency has been observed over the past years and, besides its economic benefits, it also has favourable effects on the environment.

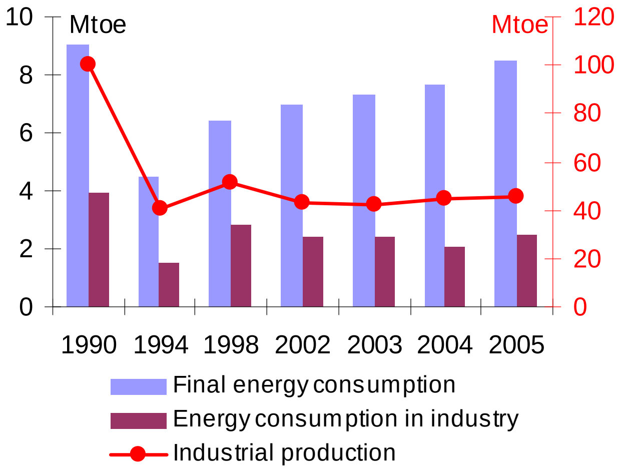


Figure 29

Energy consumption in the industrial sector

Effects on the environment

In earlier decades, Serbian economic structure had been characterized by a high degree of industrialization, controlled prices and unrational management of natural resources, which has led to exhaustion of natural resources, great amounts of waste and high levels of industrial pollution.

As the country moved to a market-oriented type of economy, a new problem arose regarding environmental protection – responsibility for the environment in a process of privatization. Damage caused to the environment by activities before a company has been privatized is treated as a preceding liability.

Industrial development is accompanied by a series of detrimental effects, some of which are:

- increased industrial emissions of SO_2, NO_x, volatile organic compounds, polycyclic aromatic hydrocarbons and other pollutants in the locations of Bor, Šabac, Pančevo, Novi Sad, Smederevo, etc.
- contamination of soil and ground- and underground waters with hazardous materials in Bor, Pančevo, Novi Sad, Smederevo, Belgrade, Kragujevac, etc.
- most of the industrial wastewater is being released without appropriate treatment
- contamination of soil, ground- and underground waters.

Outdated technology, low energy and raw material-efficiency, loose technological discipline and a high level of waste generation are the factors that greatly add up to the pollution and degradation of the environment. Lacking facilities for reduction of pollution is a general concern (most particularly wastewater treatment facilities, scrubbers and facilities for desulphurization of fumes). Some industrial facilities (such as iron and steel works, metallurgical and chemical industries, etc.) used to have the basic pollution-reducing installations but most of them have not been in use for the past 15 years. Nearly 90% of industrial wastewater is therefore being released without appropriate treatment.

A solution to these problems is seen in implementing a set of laws relevant to the environment, which were adopted at the end of 2004 (Law on Integrated Prevention and Control of Environmental Pollution, Law on Evaluation of Effects on the Environment, Law on Strategic Evaluation of Effects on the Environment, Law on Environmental Protection) and various regulations that were either adopted in 2005 or are still under preparation.

The Serbian Chamber of Commerce in 2002 organized a registry of business and other organizations holding certificates on compliance with appropriate standards of the JUS ISO 14001 and ISO 14001 series. Their data show that 16 companies, including 14 companies engaged in processing industry, have introduced systems of management of environmental protection that is coordinated with the JUS ISO 14001, while ISO 14001 standard has been incorporated in standards of environmental protection management of 19 industrial companies, 16 of which fall under the jurisdiction of the Ministry of the Economy.

TRANSPORT

Serbia's greatest comparative advantage is its geographic position as a natural transportation hub in South-East Europe. Serbia is also a link between South-Eastern, Central and Western Europe as two important European corridors pass through the country: Corridor X running from Austria, passing through Serbia and branching off into Greece and Bulgaria; and Corridor VII, the largest waterway in Europe.

There are about 18,000 km of primary roads in Serbia and about 30,000 km of local roads. Network density is 43.9 km/100 km². According to the Statistical Office of Serbia (http://webrzs.statserb.sr.gov.yu), the number of passenger cars has been on a steady increase since 1999 (Figure 30). Approximately 12,000 vehicles are in function, of which 2,544 intercity buses, 7,261 trucks and 1,385 trailers. Some 59% of the buses and 37% trucks do not meet relevant EU technical standards (http://www.srbija.sr.gov.yu).

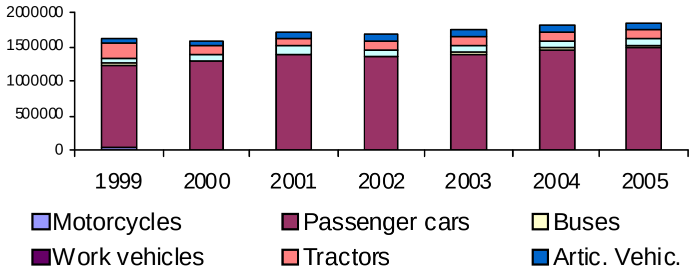


Figure 30

Number of registered cars and vehicles in Serbia

The number of registered vehicles in 2005 was around 1.9 million. The age of vehicles causes concern both regarding traffic safety and environmental risks. In 2004 and 2005, 40.1% and 36.2 % of the vehicles, respectively, aged over 15 years, excluding passenger car estimates, while merely 6.8 % and 11.5 % were less than three years old. Data on the vehicle stock by category of certificate (excluding passenger cars) shows that 84.5 % of the vehicles had no certificate in 2004, and 77.5 % in 2005.

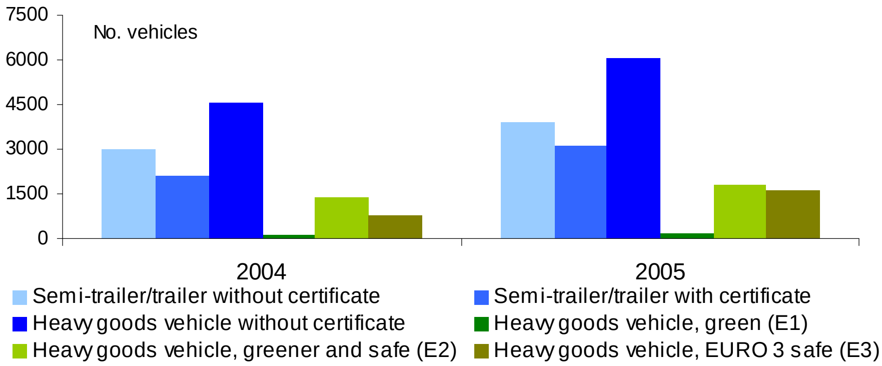


Figure 31

Vehicle stock (excluding passenger cars) according to category of certificate

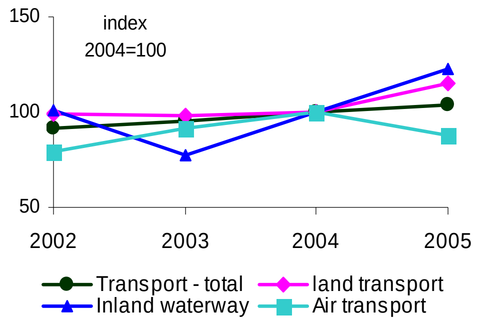
Total length of railway tracks is 3,808 km, of which 3,533 km are single-track and 275 km double-track. The main railway routes are:

- Belgrade-Resnik-Niš 246 km
- Belgrade-Majdanpek-Bor-Vražogrnac 300 km
- Lapovo-Kraljevo-Đeneral Janković border 372 km
- Niš-Kuršumlija-Kosovo Polje-Peć 284 km
- Belgrade-Novi Sad-Subotica border 200 km
- Belgrade-Zrenjanin-Kikinda border 210 km

Serbia has an outstanding potential for river transport. The River Danube, running for 580 kilometres through the Serbian territory, is a natural junction of Eastern, Central and Western Europe. There is also a 164 km long inter-state navigable passage on the River Tisa, and a domestic Danube-Tisa-Danube canal network totalling 600 km of waterways with a potential of becoming an international navigable route with a satisfactory level of use by all Danube basin countries. A stretch of approximately 207 km of the River Sava is used for river transport. The Serbian section of the Sava is planned to gain the status of international navigable route of sufficient category to attract interest from all neighbouring countries the river runs through [Slovenia, Croatia, Bosnia and Herzegovina (i.e. the Republic of Srpska) and Serbia]. As the River Morava has considerable length, plans have been made for it to link the Danube and the Aegean Sea at Thessalonica. Significant advantages and a comparatively well-developed network of internal navigable routes, as well as pier and port capacities and facilities in the Republic of Serbia constitute a good infrastructure basis for further development. These plans are compatible with the EU-defined policy of moving part of the transport sector to river and integrated transport.

There are two airports in Serbia: Belgrade and Niš. JAT Airways is the national air carrier.

After a regression period between 1990 and 2000, when the transport sector suffered a significant decline under economic sanctions and war devastation, the transport services have intensified since 2000, reaching a 13% increase in the volume of transport between 2002 and 2005 (Statistical Office of Serbia).



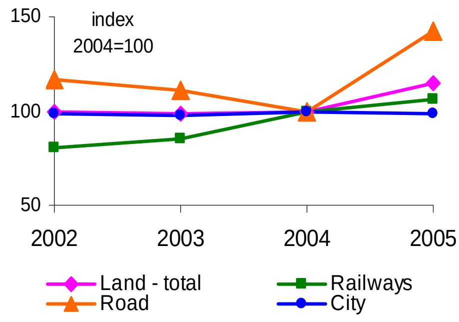


Figure 32

Left: Physical volume indices of Total transport; Right: Physical volume indices of Land transport

Effect on the environment

Development of the transport sector may have adverse effects on human health and the environment as it causes:

- diffuse (unlocalised) air pollution (increased concentrations of CO, NOx, volatile organic compounds, heavy metals, suspended particles and O_3)
- pollution caused by crude oil and derivatives on navigable waterways
- noise pollution

Technical inspection of vehicles is obligatory in one-year intervals for passenger cars and six-month for commercial vehicles. The existing legislation has not been harmonized with the effective EU legislation and implementation of legal provisions is unsatisfactory due to current economic difficulties and a problem of unclear jurisdiction among the relevant institutions.

No immediate steps to protect the environment have been taken in the area of river transport. Serbia has not yet signed the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) but a bylaw on transports of dangerous goods by waterways is underway. An Environmental Impact Assessment was given as part of the Master Plan and Feasibility Study for the Serbian Inland Waterway Transports Network and Ports within Project 2: Rehabilitation and Improvement of the Inland Navigable Waterway Network in Serbia.

It is noteworthy that in the area of railway transport, environmental protection activities are focusing on intensified efforts to introduce intermodal transport.

TOURISM

The main characteristics of Serbian territory, its beautiful nature and cultural heritage, provide a favourable basis for development of tourism industry. Tourist activities mostly focus on major cities, spas and mountains, and on tourism for specific interests (cultural and natural heritage, hunting, and fishing), countryside tourism and tourism on the main rivers (especially the Danube). The most frequently visited cities are Belgrade and Novi Sad.

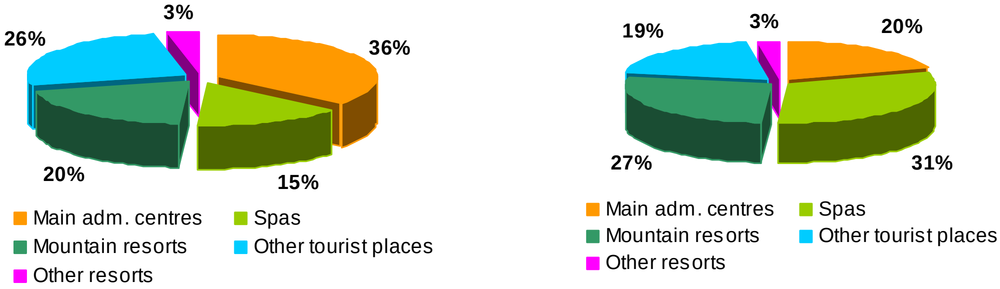


Figure 33

Tourist arrivals (left) and tourist nights (right) by destination category in 2005 (source: Ministry of Trade, Tourism and Services)

Over the past several years, there have been nearly two million arrivals annually and foreign tourists accounted for almost 25% of that number. Some 6.5 million nights were recorded in 2005, of which 5.5 million by domestic tourists. Compared to 2004 figures, there was a 16% rise in the number of foreign tourists (17% nights), while domestic tourism decreased slightly (3% in arrivals and 5% in nights).

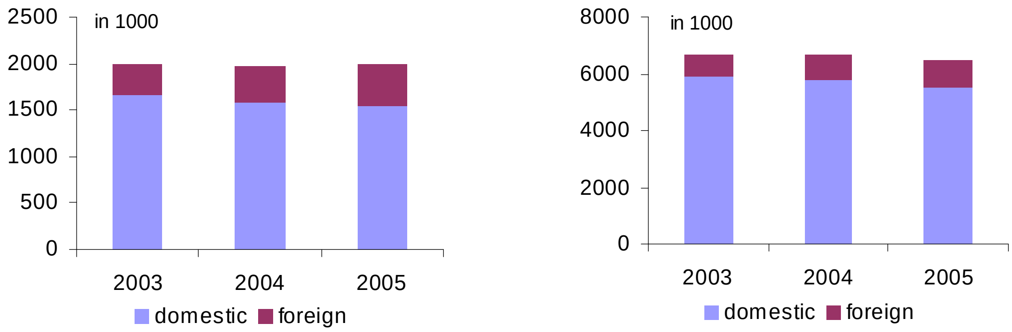


Figure 34

Tourist arrivals (left); Tourist nights (right) (source: Ministry of Trade, Tourism and Services)

The total number of beds in tourist facilities in the Republic of Serbia in 2005 was 86,731, of which hotels accounted for 36,538 and complementary facilities 38,511.

In 2005, foreign-exchange earnings from tourism were 304,149,000 US dollars, while foreign-exchange outflow in the same period was 245,387,000 US dollars. Compared to 2004, foreign-exchange earnings rose 38% and outflow 19%.

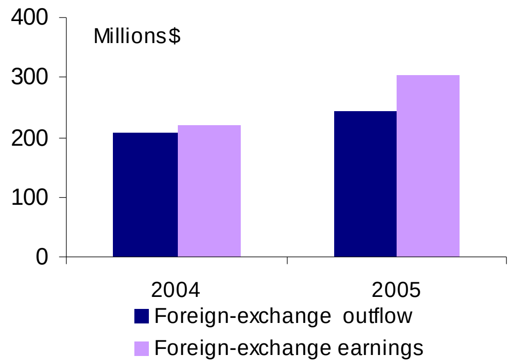


Figure 35

Foreign-exchange earnings and outflow in tourist trade (in millions of US dollars)

Effects on the environment

The data on tourist trade in Serbia presented here suggests that tourism is still not sufficiently developed to pose a significant threat to environment quality. Development of this sector must be based on simultaneous conservation and improvement of environment, since the best interest of the tourist trade as healthy environment is an important precondition for its successful operation. Negative effects of inadequate development of tourism involve: pressure on the environment, natural resources and biological diversity by inappropriate location or illegal construction of tourist facilities; release of untreated wastewaters; inadequate waste disposal; emissions of gases from traffic and boiler-rooms; noises from traffic and various tourist activities; unchecked and ecologically unacceptable development of tourist activities in conserved environments and other natural environments; disturbance of wild animals in their habitats by visiting tourists.

AGRICULTURE

Serbia has 5,734,000 ha of agricultural land (0.56 ha per capita), of which 4,867,000 ha are arable land, 1,006,473 ha pastures and 37,504 ha fish ponds. Farmland covers 70% of total surface area of Serbia, while 30% is woodland.

Cereals are grown on 2.453.374 ha of arable land, while 494.598 ha are reed-marshes and forage fish ponds, and industrial herbs are grown on 348.641 ha, vegetables on 300.484 ha, orchards on 256.887 ha, vineyards on 85.763 ha, nursery-gardens on 2.164 ha and meadows on 666.702 ha. Approximately 86.866 ha of Serbian territory are under forests.

Serbia's irrigation system covers 180,000 ha. Yet only 30,000 ha of cultivated land are actually irrigated, which means that irrigation is minimal in Serbia. As a result, potentials for high production of sugar beet, sunflower, soybean, vegetables and fodder are not being fully exploited.

Livestock production focuses mainly on cattle breeding, while fields and gardens cover most of the farmland. There is an evident neglect of the potentials that meadows, pastures and fields have in terms of intensive and efficient livestock production.

Rural transport infrastructure is underdeveloped, and agricultural machinery and equipment are generally in poor condition. Average tractor age is 12 years, while combine harvesters are 15 years old on the average.

Mineral fertilizer consumption is 36 kg/ha. The use of agrochemicals is fairly low and kept in check, and there is a highly organized system of regular veterinary, phytosanitary and sanitary inspections.

Cereals and fodder crops are grown on most of Serbia's agricultural land (Figure 36). Over the 1990-2005 period, areas under cereal crops decreased substantially, while a slight upward trend occurred with areas cultivated with fodder crops. The number of fruit trees also dropped significantly over the period.

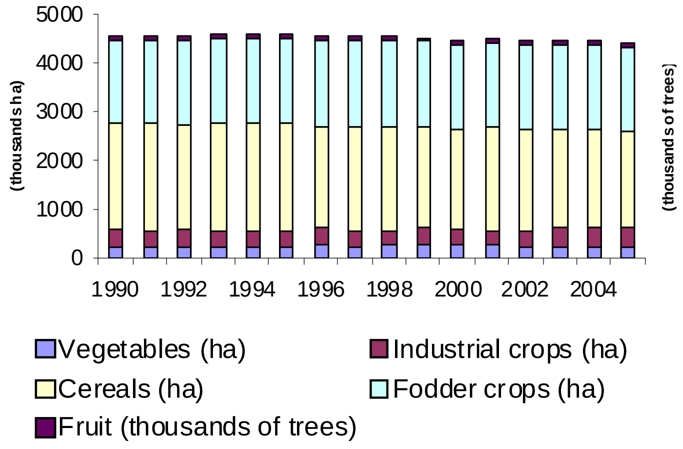


Figure 36

Structure and size of main agricultural crops (per ha and number of trees) in Serbia

Most of the areas under fodder plants in Serbia are meadows and pastures and their size has not changed significantly over a long period. Alfalfa (lucerne) and clover are also grown on large areas of land.

Despite evident oscillation, agricultural areas under maize and wheat crops generally show a dwindling trend (Figure 37). Other *cereals* (barley, oats, and rye) are grown on much smaller areas.

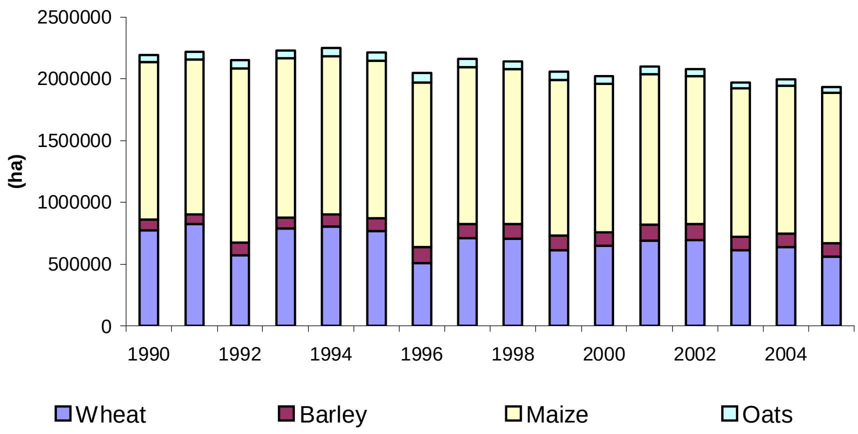


Figure 37

Area under cereals in Serbia

Sunflower, sugar beet and soybean are the main *industrial crops* in Serbia (Figure 38). Over the 1990-2005 period, a significant rise was recorded in areas under soybean crop, while area under sugar beet was reduced.

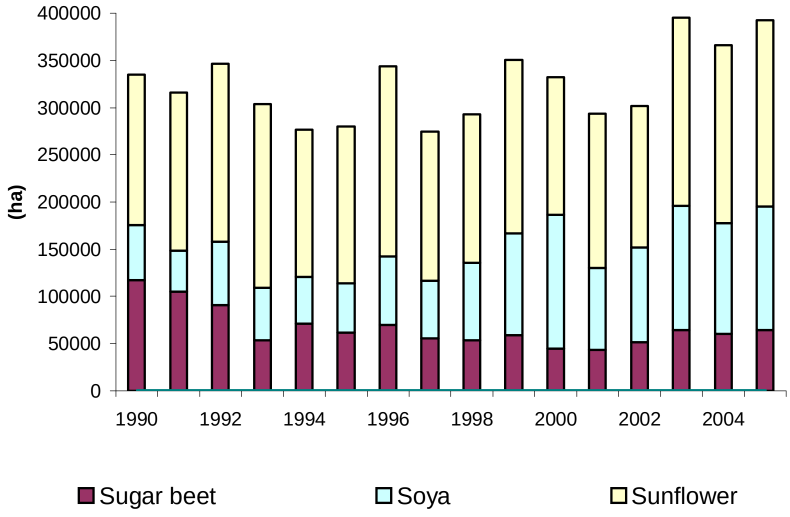


Figure 38

Area under industrial crops in Serbia

Tomato accounts for the largest area under *vegetable crops* in Serbia.

Plum is the main *fruit crop* grown in Serbia but the number of plum trees has been on a steady decrease over the 1990-2005 period (Figure 39). Most other fruit trees have also declined in numbers in that period, the apple being the only exception to such trend.

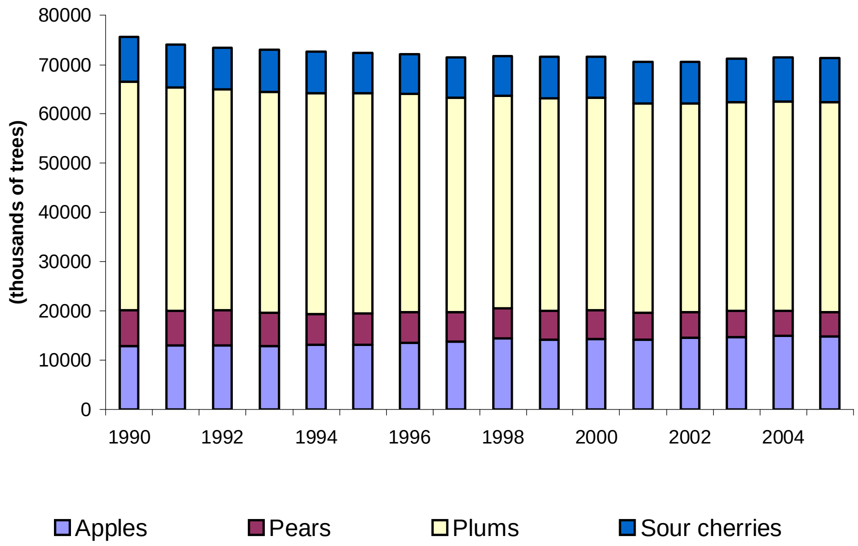


Figure 39

Fruit crops in Serbia – number of trees

Animal husbandry is a significant economic resource in Serbia, primarily cattle and pig breeding (Figure 40). However, their numbers decreased considerably in 1990-2005.

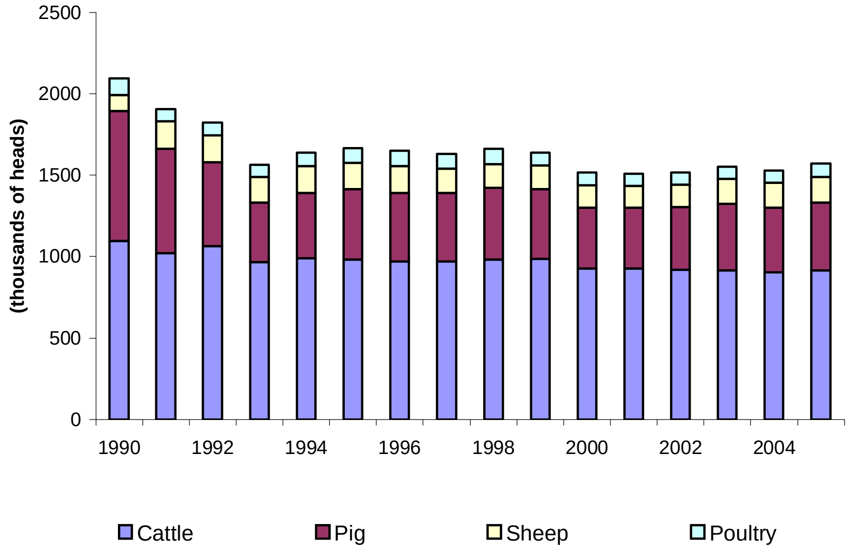


Figure 40

Number of heads in 1990-2005

Consumption of fertilizers

There are no reliable data on fertilizers' consumption in Serbia, although the production trend in the period 2000 – 2005 (Fig. 41) indicates increase in consumption. As opposed to Serbia, in 15 EU countries in the period 1990 – 2001, there was decrease of nitrogen (N) consumption in mineral fertilizers of 12%. There is no simple correlation between this data and effects on environment, due to synergistic effects of other factors (manure consumption, crops, arable land and farm management).

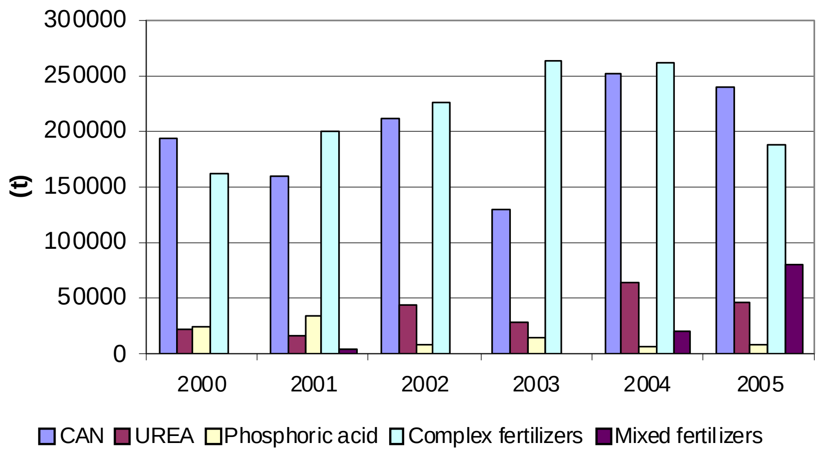


Figure 41

Production trend of fertilizers in Serbia

Consumption of plant protection chemicals

Degree of damages in environment depends on the quantity of active matter, but also on its quality. Existing data on consumption can not be correlated to increased risk on environment due to various factors: application of the chemical by farmers, changes of the active substance and its degradation.

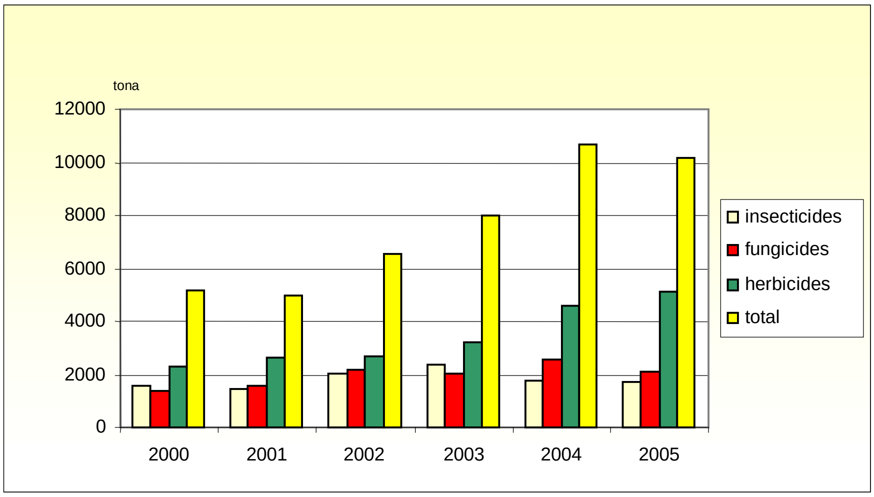


Figure 42

Trend in pesticides consumption in Serbia

Consumption of pesticides in Serbia is presented as a balance between production, import and export, according to categories, in the period 2000 – 2005. Figure 42 presents significant increase of pesticide consumption in this period, with the exemption of fungicides, due to decrease in production. In EU countries, in the period 1992 – 1999, growth of pesticides' sale was 11%, while insecticides' sale decreased 16%.

Irrigation

The effect of agriculture on water regime can be expressed through water demands for irrigation. Relation of irrigation and pollution of the environment can be observed through seemingly separated processes (agriculture land, water, crops, flora and fauna, and air). Increasing of irrigated area leads to increase on water demands.

There are 0.66% of arable land in Serbia irrigated (28072 ha) in 2004, where in Central Serbia this is 3014 ha, and in Vojvodina 25058 ha (Figure 43). Irrigation methods vary: surface method on 4916 ha, artificial rain on 22439 ha, and "drop" method 717 ha. According to statistical data, irrigation is decreasing. It is 10387 ha less then in 2000 (5257 ha less in Central Serbia and 5130 ha less in Vojvodina). As opposed to Serbia, in 12 EU countries there is increase of irrigation in the period 1990 – 2000 (France, Greece and Spain of approximately 30%). Introduction of new irrigation technologies it is possible to improve efficiency in irrigation and decrease water consumption).

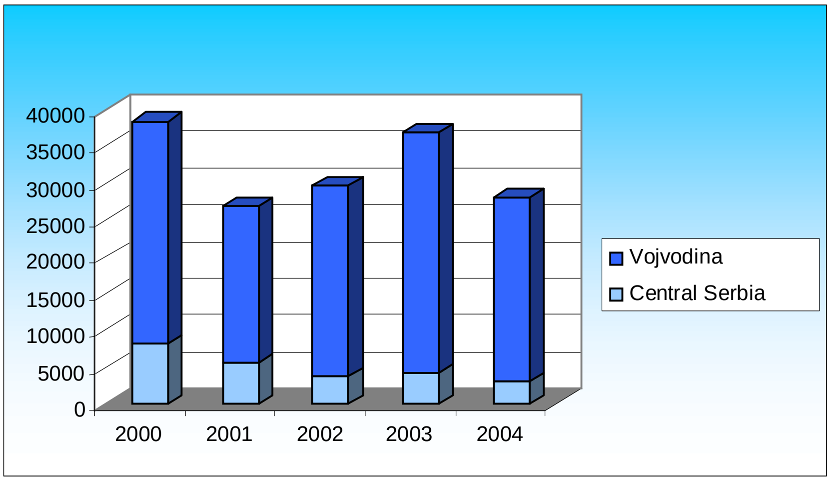


Figure 43

Irrigation in Serbia

Organic agriculture in Serbia

Contemporary agriculture practice is one of the main causes of land degradation, especially challenging ecological regulatory function of the soil, and therefore calls for greatest interventions. The main objective of organic agriculture, as a part of sustainable agriculture, is to improve the health and productivity of associations, soil, plants, animals and humans. Organic agriculture in Serbia is regulated by Law on organic agriculture and organic products.

Total area under organic production in Serbia in 2004 is 200550.12 ha, including wild fruit on 200008.60 ha. The total surface under organic production is 3.92 % of total agricultural area.

Table 1. Total surface under organic production in Serbia

Main product	Certified organic area (ha)	Main product	Certified organic area (ha)
Maize	8.30	Pea	0.10
Wheat	7.50	Grape	6.00
Oats	1.50	Apple	135.40
Rye	2.50	Sour cherry	20.16
Triticale	1.25	Plum	4.10
Barley	1.90	Raspberry	64.76
Oil squash	110.00	Blackberry	8.58
Oil seed rape	60.00	Strawberry	57.16
Sunflower	44.21	Blueberry	20,000
Cabbage	1.00	Wild blackberry	20,000
Pepper	1.50	Wild strawberry	10,000
Savoy cabbage	0.05	Wild apples	150008.60
Brussels sprouts	0.10	Chamomile	5.00
Parsley	0.25	**Total**	**200550.12**
Carrot	0.20	**Wild fruit**	**200008.60**

Participation of organic agriculture in 15 EU countries and EFTA is 4% of the total production. Some EU countries are increasing organic agriculture 10-20% till 2010, relying on quality of production and decrease of negative impacts on environment. It is necessary to stimulate organic agriculture in Serbia, for the same reasons.

FORESTRY

Forests make a significant resource for economic and social development. They are also the habitats of diverse flora and fauna. Their role in conserving soil, water, wildlife, as well as plant and animal genetic pool and diversity is of vital importance.

According to the 1979 forest census, some 2,313,000 ha or 26.2% of total area of the Republic of Serbia was under forests at the time. Overall increase in forest area in Serbia since 1979 has been 53,671 ha, of which 44,604 ha in Vojvodina and 9,157 ha in Central Serbia. The current average annual increase in forest area is 2,333 ha, or 1,939 ha in Vojvodina and 400 ha in Central Serbia.

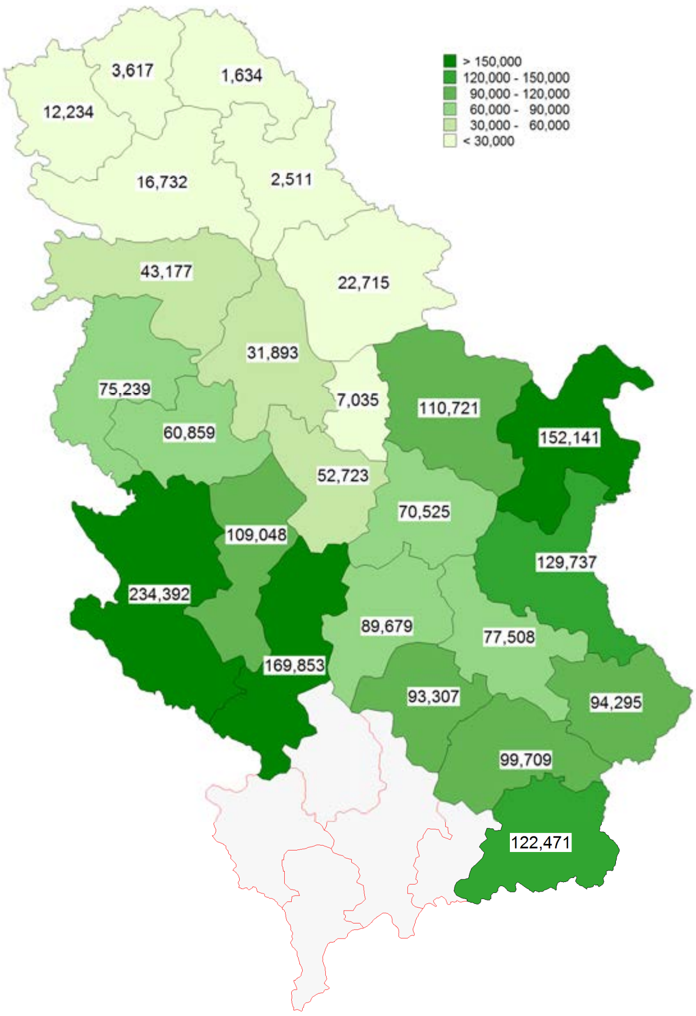


Figure 44

Forest coverage in Serbia

Total wood volume in Serbian forests is approximately 225 million m^3 and most of it (70.1%) forms old-growth forests, while young forests account for 28.3%. Some 54% of total wood volume is in state-owned and 46% in private forests.

Current total volume increment in Serbian forests is approximately 6.2 million m^3 (2.6% of total volume) and it is higher in state-owned forests (3.8 m^3/ha) than in private ones (2.13 m^3/ha) due to a better structure of state-owned than private forests. The highest volume increment in the state-owned forests has been achieved in natural old-growth forests (5.3 m^3/ha), planted old-growth forests (3.9 m^3/ha) and young forests (3.4 m^3/ha).

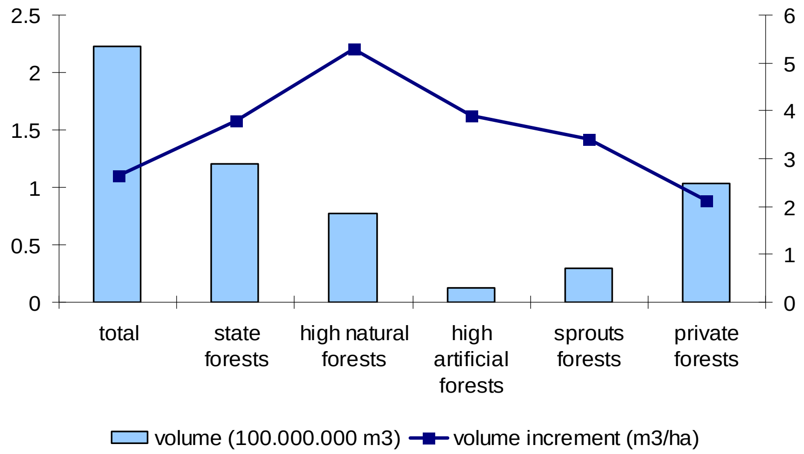


Figure 45

Wood volume in Serbian forests

Serbian forests are managed by public enterprises. Most of the state-owned forest area is managed by Srbijašume, Vojvodinašume, Borjak – Vrnjačka Banja and national parks. The public enterprise Srbijašume comprises 17 forest holdings, while Vojvodinašume has four.

State-owned forests that have been entrusted to forest holdings, and privately owned ones outside areas under conservation are generally considered as commercial forests. Total area under commercial forests in Serbia is around 1,700,000 ha, or some 90% of total forest area.

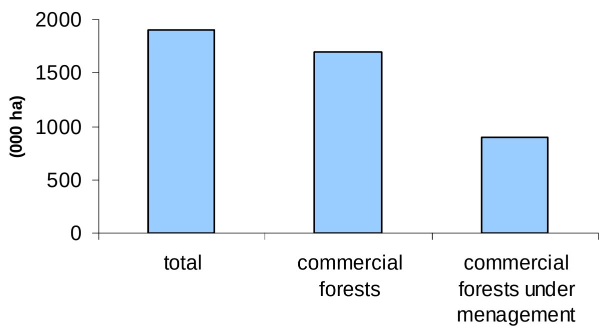


Figure 46

Commercial forests and management-run commercial forests in Serbia

Every 10 years, the Directorate for Forests of the Ministry of Agriculture, Forestry and Water Management approves special management guidebooks for state-owned forests and forest land (over 1,100,000 ha) that have been assigned to public enterprises. The area of forests that are subject to planned management documents is about 900,000 ha, which is around 48% of total forest area or 53% of total area of commercial forests.

Forest exploitation

The total amount of timber in Serbian forests was 2,718,606 m^3 in 2004, which is some 5% more than in 2003. In 2005, the total volume of cut timber exceeded 2,100,000 m^3.

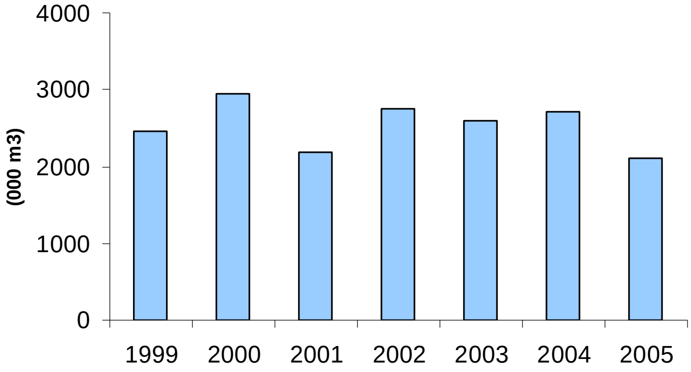


Figure 47

Volume of timber in Serbia

The structure of timber cut in 2004 shows that 7.9% were conifer trees, which coincides with their overall share in Serbian forests (8%). It leads to a further conclusion that there is no pressure for increasing the amount of cut conifers considering their percentage in Serbian forests.

Considering different products of state-owned forestry (industrial, construction and firewood), there is an evident trend of production increase in 2003 and 2004. The 2003 increase resulted primarily from a significant rise in firewood production (14% more than in 2002), while in 2004 it was caused by a surge in the production of construction timber (17% more than in 2003) and industrial timber (7% more than in 2003). In 2005, the rising production trend of industrial timber continued (30% up against 2004), but the amount of firewood decreased (6% against 2004), as well as industrial timber (4.5% against 2004).

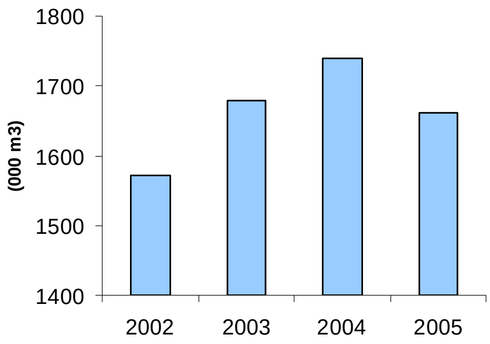


Figure 48

Aggregate output of forestry products in state-owned forests in 2005

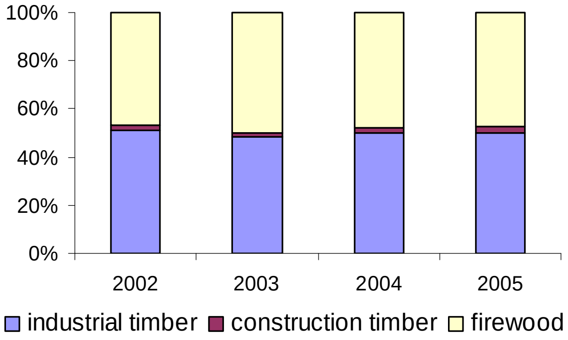


Figure 49

Structure of products of state-owned forestry in 2005

In 2004, according to data collected by the Statistical Office of Serbia, firewood output was 1,431,220 m^3, and only 58% of that amount was cut in state-owned forests. The remaining 42% of firewood came from private forests. On the other hand, as much as 90% of industrial and construction timber was produced in state-owned forests in 2004.

Per capita firewood consumption in Serbia was 0.21 m^3 in 2000, 0.16 m^3 in 2002 and again reached some 0.2 m^3 in 2004.

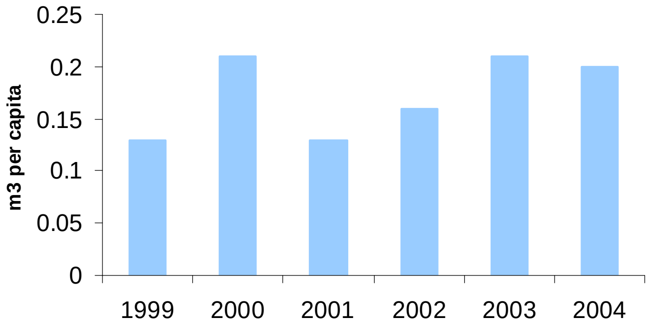


Figure 50

Per capita firewood consumption in Serbia

The rising trend of firewood consumption (0.13 m^3) after the year 2001 is attributed by experts primarily to a rise in electricity prices.

Forest-based industries traditionally play an important role in Serbia's economic development. Serbian forests are both state- and privately-owned, the former accounting for a little over 47% and being mostly managed by Srbijašume (85%). The remaining state-owned forests are managed by Vojvodinašume (7.5%), national parks (6.5%) and educational and research institutions (1%). Srbijašume and Vojvodinašume are state-founded public enterprises in charge of managing state-owned forests, promoting silviculture, maintaining and regenerating forests, managing plantations, reconstructing and reclaiming forests and brushland, producing forest seeds and nursery stock, establishing new forests and forest plantations, etc. The remaining 53% of forest area is owned and managed by private owners.

Forest-based industries, which make an important part of the Serbian economy, account for a relatively high share in the GDP (1.24%) and industrial production (3.63%). This segment of the economy, based on domestic raw materials, has maintained a constant positive foreign trade balance since World War II. Today, there are 2,365 companies engaged in wood processing and a majority of them produce sawn wood (1,491) and furniture (402). Most companies are privately owned (about 96%).

Alternating increases and declines in the production of paper and paperboard were typical in Serbia between 1996 and 2004. There are 11 producers of paper and paperboard in Serbia. Three major producers are still state-run, while the rest are small-scale private enterprises. Annual production of pulp, paper and paperboard is about 330,000 metric tons. Pulp production is mainly used to satisfy the domestic needs in paper, and only small quantities are being exported. Of the overall volume produced, printing paper is the most dominant product. Despite the existing production potentials, most pulp and paper producers are only operating at about 40% of their full capacity, and Serbia continues to import significant amounts of paper. Wood pulp production amounts to approximately 76,000 metric tons per year, while production capacities are twice the amount. Domestic wood pulp production is mainly used to satisfy the needs of Serbian paper producers and only a small portion is being exported.

Plantations occur throughout the country and they are usually monospecific stands where species depend on landscape and ecosystem characteristics. Plantations located in Central Serbia predominately grow coniferous species, especially pines (mainly *Pinus nigra*) and spruce (*Picea abies*), and cover two-thirds of all land under plantations. Only a third of all plantations grow broadleaves, and those are located in northern parts of Serbia. The flat and fertile soil of Vojvodina, veined by rivers, creates a perfect environment for poplar trees (Euro-American black poplar clone) and approximately 95% of all plantations found here indeed are poplars. The other tree species grown there include oak and other hardwood trees.

PROGRESS IN ENVIRONMENTAL MANAGEMENT IN SERBIA

The legal/legislative and institutional framework is founded in the Constitution of the Republic of Serbia, stipulating the right to a healthy environment and the duty of all, in line with the law, to protect and enhance the environment. Environmental legislation in Serbia consists of large number of laws and regulations (approximately 100). Legislative, executive and judicial powers are mostly practiced through the legally prescribed scope of competences of republic authorities. According to the law, certain competences are delegated to the autonomous province and the local government.

The new legal framework for environmental protection was introduced in 2004 in the Republic of Serbia by the Law on Environmental Protection, the Law on Strategic Environmental Assessment, the Law on Environmental Impact Assessment, and the Law on Integrated Prevention and Pollution Control.

The most significant issues covered by the Law on Environmental Protection include fundamental principles of environmental protection; management and protection of natural resources; measures and conditions of environmental protection; environmental programmes and plans; industrial accidents; public participation; a monitoring and information system; clearly identified competences of the Environmental Protection Agency; reporting; financing environmental protection; and inspection services and fines. The new laws are harmonised with the EU Directives on Environmental Impact Assessment (85/337/EEC), Strategic Impact Assessment (2001/43/EC), IPPC (96/61/EC) and Public Participation (2003/35/EC). The Ministry of Science and Environmental Protection Directorate for Environmental Protection (DEP) has the key responsibility in environmental protection.

Within the Programme on Environmental Capacity Building 2003, which was financed by the European Union (EU), and was managed by the European Agency for Reconstruction, the National Environmental Action Plan (NEAP) of the Republic of Serbia was designed.

Local Environmental Action Plans (LEAP) have been designed in several municipalities, where a part referring to implementation of sustainable development at the municipal territory has been integrated into those Action Plans. These parts have also been worked on in Municipal Development Strategies, Municipal Physical Plans, as well as in monitoring plans. There is a network of towns and municipalities having started the sustainable development and Agenda 21 strategic planning process.

Law on Environmental Protection predicted several types of economic instruments within financing and fulfilment of the environmental protection objectives: charges for utilization of natural resources, charges for environmental pollution, budget resources and international financial aid, fund for environmental protection and economic incentives.

Fund for Environmental Protection was registered in May 2005 and it has a status of a legal entity. Currently, the Fund has 10 employees, but the plans are to employ more people in the forthcoming period. The Fund's financial means are mainly based on the budget earmarked funds, income from the charges for utilization of wild flora and fauna, charges for motor vehicles, charges for the import of the materials which deplete ozone layer, charges for gases emission and for produced and disposed waste.

Law on Environmental Protection also predicted economic incentives for legal and private entities which apply technologies and place on the market the products which directly serve to environmental protection, as well as for those manufacturers and consumers who mitigate adverse effects of their activities towards the environment.

CLIMATE CHANGE

CLIMATE SYSTEM
BASIC CLIMATE CHARACTERISTICS
NATURAL AND HUMAN-INDUCED CLIMATE CHANGES
VARIABILITY OF THE ANNUAL TEMPERATURE AVERAGES
VARIABILITY OF THE ANNUAL PRECIPITATION AVERAGES

CLIMATE SYSTEM

Weather and *climate* have a profound influence on all species, including humans. The term "weather" refers to the fluctuating state of atmosphere characterised by changing temperature, wind, precipitation, clouds and other elements. On the other hand, "climate" refers to the average weather in terms of the mean and its variability over a certain time span in a certain area (IPCC, 1996).

The climate system consists of five interacting components: atmosphere, hydrosphere, cryosphere, land surface and biosphere. It is influenced by various external forces, the most important of which is solar radiation. *Atmosphere* is the most unstable and rapidly changing element of the climate system.

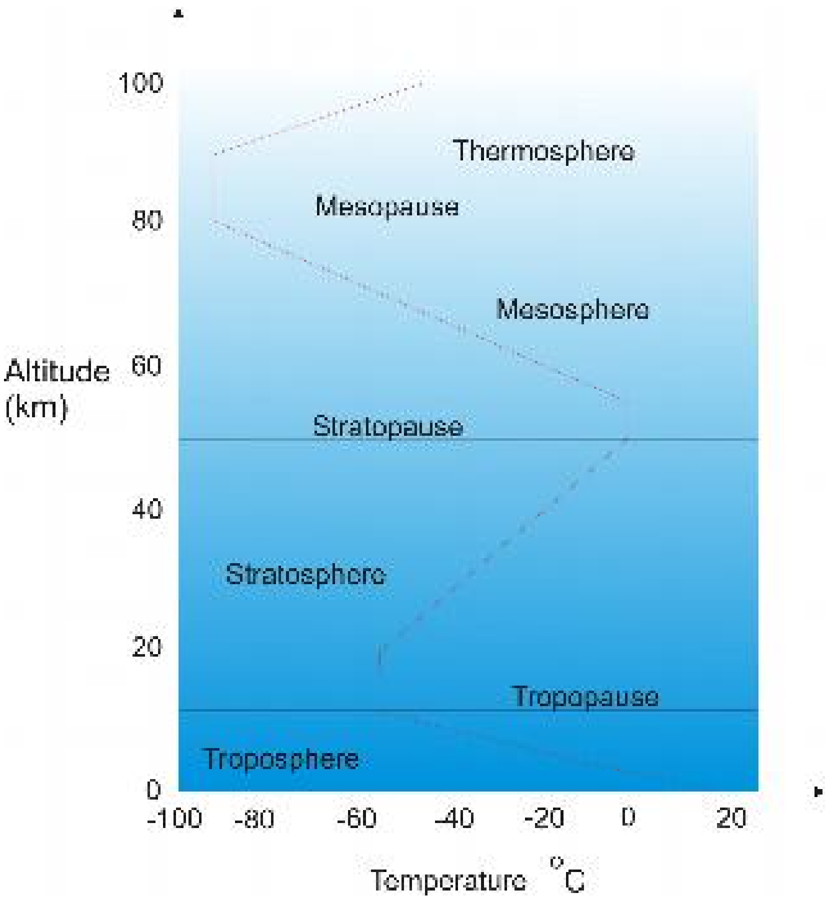


Figure 51

Structure of the atmosphere. Its chemical composition varies with altitude. Atmosphere temperature also changes. Source: Neiburger et al., 1982

Temperature, pressure and chemical composition of atmosphere vary with altitude. The ICAO (International Civil Aviation Organization) has designed the ISA (International Standard Atmosphere), an atmosphere model that describes variations in pressure, density and temperature with altitudes. According to that model (Fig 51), the *troposphere* is the lowest layer of the atmosphere starting at the surface and going up to between 7 km at the poles and 17 km at the equator with some variation due to weather factors. The troposphere has a great deal of vertical mixing due to solar heating at the surface. From that 7–17 km range up to about 50 km, temperature is increasing with height. That atmosphere layer is termed the *stratosphere*. The ozone-rich stratum of the atmosphere (around 10-50 km above Earth's surface) is often referred to as the "ozone layer". The *thermosphere* extends from the mesopause to about 690 km above Earth's surface. This layer is also known as the upper atmosphere (Neiburger *et al.,* 1982). Atmospheric density at sea level is about 1.2 kg/m^3 and it decreases as the altitude increases.

BASIC CLIMATE CHARACTERISTICS IN SERBIA

According to the Report prepared by Republic Hydrometeorological Service (http://www.hidmet.sr.gov.yu), the climate of Serbia is *moderately continental*. Spatial distribution of climate parameters is determined by geographical position (latitude and longitude), orography (altitude, terrain exposure, and inclination), presence of river systems, vegetation, urbanisation, etc. The prevailing meridional direction of rivers and plains in the northern area of the country makes possible a deep southward intrusion of polar air masses.

Average annual *air temperatures* over the 1961-1990 period varied with altitude. Areas at altitudes between 300 and 500 m had an average annual temperature of around 10.0ºC, and those of over 1000 m altitude around 6.0ºC. Absolute temperature maxima during the 1961-1990 period were measured in July and they ranged between 37.1 and 42.3ºC in lower regions, and 27.6 and 34.0 ºC in mountainous areas. July was the warmest month of the year with mean monthly temperatures in the interval from 11.0 to 22.0ºC. Lowland areas (up to 300 m a.s.l.) had mean July temperature between 20.0 and 22.0ºC. The mean July temperature ranged between 11.0 and 16.0°C at altitudes above 1000 m. The lowest temperatures over the 1961-1990 period were recorded in January, ranging between –35.6 (Sjenica) and –21.0 °C (Belgrade). The highest temperature of +44.3ºC was measured in Kraljevo on July 22, 1939. The lowest temperature of –39.0ºC was measured at Karajukica Bunari on the Pešter plateau on January 26, 2006.

Precipitation is one of the most important elements of climate. The annual precipitation during the 1961 – 1990 period, averaged for whole country amounted to 896 mm. Precipitation generally increase with altitude. Dry areas with precipitation below 600 mm are situated in the north-eastern parts of the country, in the South Morava valley and part of Kosovo. Average annual precipitation at the Pešter plateau and Mt. Kopaonik was much higher (up to 1000 mm), and some mountainous summits in the south-west of Serbia had even heavier precipitation of over 1000 mm. Serbia has a predominantly *continental pattern of precipitation* with higher amounts in the warmer period of the year. Most rains fell in June and May, while February and October had the least precipitation. South-western Serbia has a *Mediterranean precipitation pattern* with maximums in November, December and January, and minimums in August. Snow cover was characteristic of the period between November and March, and sometimes even April and October, but snowfall also occurred in other months of the year in mountainous areas exceeding 1000 m altitude. January had the highest number of days with snow cover, accounting for an average of 30-40% of the total number of snowy days.

Considering precipitation records since the beginning of measuring, the driest year was 2000 when precipitation measured merely 223.1 mm in Kikinda. Rainfall was heaviest in 1937 with as much as 1,324.5 mm measured in Loznica. The highest monthly precipitation of 308.9 mm was recorded in Sremska Mitrovica in June 1954, and the highest daily precipitation of 211.1 mm in Negotin on October 10th, 1955.

Annual solar radiation ranges between 1500 and 2200 hours annually.

Surface air circulation is mostly the result of orographic factors. In the warmer part of the year, winds from north-west and west prevail, while easterly and south-easterly winds, the so-called “košava”, predominate in the colder period of the year. Winds from the south-western direction prevail in the mountainous parts of south-western Serbia.

NATURAL AND HUMAN INDUCED CLIMATE CHANGE

Each square metre of the Earth's spherical surface outside the atmosphere receives an average of 342 Watts of solar radiation throughout the year, 31% of which is immediately reflected back into space by clouds, atmosphere and the Earth's surface. The remaining 235 Wm^{-2} are partly absorbed by the atmosphere, but most (168 Wm^{-2}) warm the Earth's surface: the land and the oceans. The Earth's surface returns that heat to the atmosphere, partly as infrared radiation, and partly as sensible heat and water vapour that releases heat after condensing higher up in the atmosphere.

Natural and human-induced greenhouse effects

The atmosphere contains several trace gases, primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3), which absorb the infrared radiation emitted by the Earth's surface. The quanta of absorbed infrared radiation increase the rotation and vibration of these molecules, thus increasing air temperature. Heated molecules re-emit infrared radiation in all directions, including downward to the Earth's surface. Thus greenhouse gases trap heat within the atmosphere. Vaporized water molecules also have the natural greenhouse effect. Clouds absorb and emit infrared radiation and thus contribute to warming the Earth's surface, just like the greenhouse gases. The average temperature in troposphere is approximately 14°C. Without the natural greenhouse effect, air temperature would be much lower.

Human activities involving the combustion of fossil fuels for industrial or domestic usage, and biomass burning, produce greenhouse gases and aerosols that affect the composition of the atmosphere. Human-induced greenhouse effect is caused by development of industry, agriculture and transportation.

Depletion of stratospheric ozone

Depletion of the stratospheric ozone layer, which absorbs significant amounts of high energy UV radiation, additionally increases air temperature. High energy UV wavelengths range from 200 to 400 nm, which may be classified in three categories: UV-a (320-400 nm), UV-b (280-320 nm), and UV-c (200-280 nm). Ultraviolet rays are energetic enough to break the bonds of DNA molecules, which leads to cell damages, immune system damages, mutations or dangerous forms of skin cancer (basal, squamous, and melanoma). Ozone is effective at absorbing the extremely harmful UV-c rays (Morrison, 1989, UNEP, 1991, IARC, 1992, Stiling, 1996).

Emission of chlorofluorocarbons (CFCs) and other chlorine and bromine compounds, as well as SF_6, accelerates the stratospheric ozone depletion process (Fisher, 1990, Prather and Watson, 1990, US EPA, 1990, WMO, 1991). Kurylo and Rodriguez, 1999; Prinn and Zander, 1999, Butler *et al.*, 1999 reviewed CFC compounds and their effects on stratospheric ozone depletion.

The consumption of ozone depleting substances (ODS) in Serbia has sharply decreased since the 1990s. Such trend clearly shows Serbia's contribution to global efforts to protect the stratospheric ozone layer. Serbia has no ODS production.

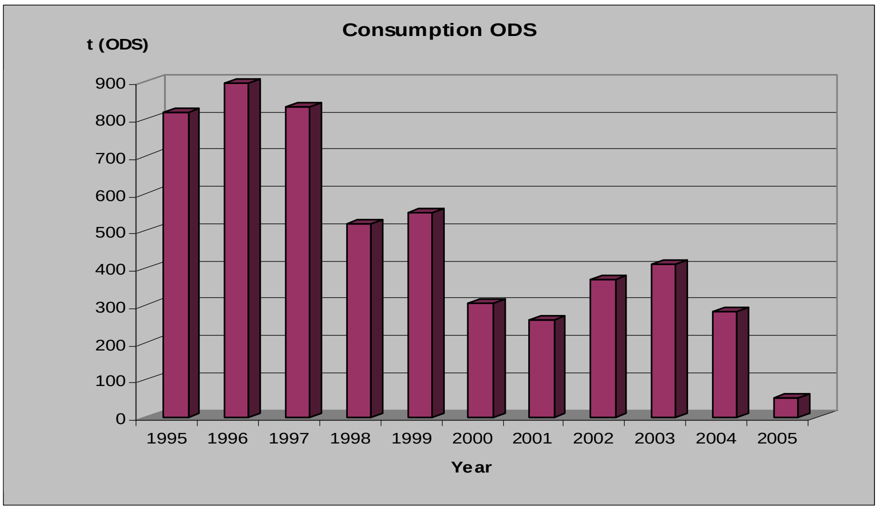


Figure 52

Consumption of ODS in Serbia

ODS production and consumption in Europe is dominated by 15 EU members, which account for 80-100% of total production and consumption. An overall decline of ODS production and consumption is in accordance with international regulations and agreed schedule. Production and consumption of halons have been banned in developed countries since 1994, and CFCs, carbon tetrachloride and methyl chloroform since 1995.

Following the Vienna Convention (1985), and the Montreal protocol (1987) and its amendments and adjustments, policy measures have been taken to limit or phase-out production and consumption of ozone depleting substances in order to protect the stratospheric ozone layer against depletion.

The rapid CFCs consumption cut in Serbia in 2005 has two explanations: certain measures taken to substitute CFCs with more environment-friendly substances, and the methodology employed to calculate CFCs consumption.

VARIABILITY OF THE ANNUAL TEMPERATURE AVERAGES IN SERBIA

As a consequence of human-induced greenhouse effect and depletion of stratospheric ozone, climate changes are observed globally. The average global surface temperature has increased by approximately 0.6°C since late 19th century, with 95% confidence limits of close to 0.4 and 0.8°C. Most of this increase occurred in two periods, from about 1910 to 1945 and since 1976 onwards, and the largest recent warming is in the winter extratropical northern hemisphere (Folland and Karl, 2005). A trend of temperature increase has also been observed in the Serbian territory. Climate varies naturally on all time-scales.

Measurements for several successive years show considerable variance. Total variability of data reflects a trend (a tendency to consistent growth or decrease regarding any given climatic element) and coincidence.

A temperature trend is discernible by analysing a time series of average annual air temperatures. Deviation from a long-term average is a reliable indicator of a changing climatic tendency (Popović and Jovanović, 1994; Jovanović and Popović, 1999; Popović, 2002).

A normalized departures from mean annual air temperature in Serbia for the 1951-2005 period is shown in Figure 53.

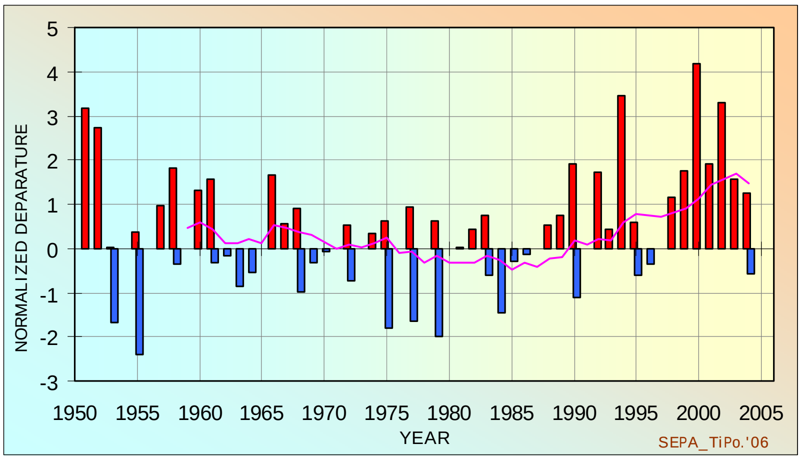


Figure 53

Normalized departures of mean annual air temperature in Serbia in 1951-2005

Higher annual temperatures than the 1961-1990 normal_were recorded in 14 of the past 19 years (since 1985) - 9 years were warmer than normal, 3 were significantly warmer and the year 2000 was extremely warmer than normal.

The annual air temperature trend in Serbia, according to data for the 1951-2005 period, varies between –0.7ºC/100 years (Leskovac) and +1.7ºC/100 years (Palić). The region of Leskovac, Dimitrovgrad and Vranje in south-eastern Serbia is the only area with a negative trend of annual air temperature. An area off that region that runs along the Southern and Great Morava valley northwards to the lower Danube basin and south-eastern Banat has the mean annual air temperature trend of +0.7 oC/100 years. Parts of Serbia to the west and east of that area have higher positive trends of annual air temperature. The most intensive trends have been recorded in the north of Vojvodina, the City of Belgrade environ, and the regions of Negotin and Loznica. Over the past 55 years, annual air temperature in those areas has been rising at a rate of more than 1.4 ºC/100 years.

Spatial distribution of annual air temperature trends in Serbia, according to data for the period 1991-2005, indicates that all of Serbia has a perceptible trend of rising annual air temperatures. The intensity of that temperature increase over the period 1991-2005 was several times higher than it was in the 1951-2005 period.

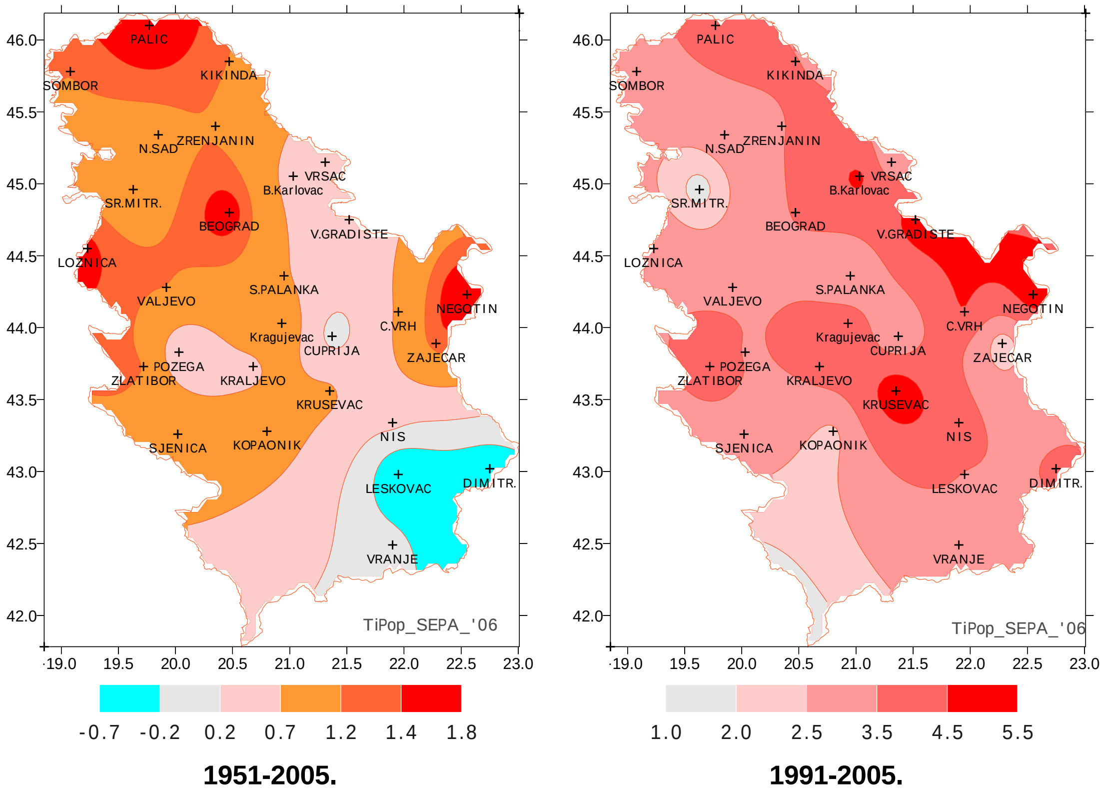


Figure 54

Spatial distribution of annual air temperature trends in Serbia (º C/100 years)

VARIABILITY OF THE ANNUAL PRECIPITATION AVERAGES IN SERBIA

In 2003, the normalized departure of annual precipitation in Serbia was negative and below -1 (Figure 55), suggesting that precipitation amount in 2003 was lower than the average for Serbia.

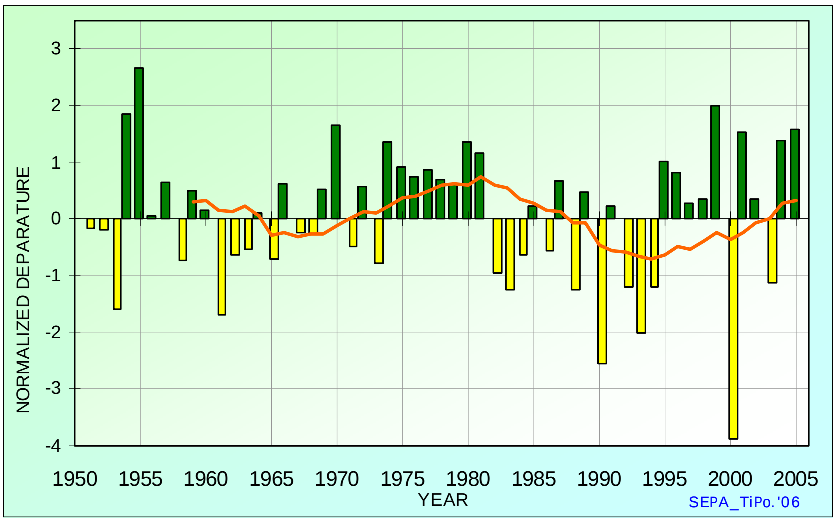


Figure 55

Normalized departures of annual precipitation in Serbia in 1951-2005

The negative variation is below -1 standard deviation, which indicates that annual precipitation in Serbia in 2003 was below the normal range. It further shows that 2003 was a year of drought in Serbia. Applying the same procedure of precipitation assessment in 2005, it turned out that 2005 was a rainy year in Serbia.

Over the past 24 years (period after 1981), 12 years had lower annual precipitation than the average, 8 years were droughty, 3 exceptionally droughty and one, the year 2000, was extremely droughty. In the same period, 12 years had total precipitation exceeding the average, and 4 of those can be described as rainy years.

It is noteworthy that the beginning of a period of decreasing annual precipitation coincides with the beginning of a period of rising annual air temperatures. However, unlike the positive temperature trend, which is continuing, the negative precipitation trend has stopped.

Spatial distribution of annual precipitation trends in the territory of Serbia, according to data for the periods 1951-2005 and 1991-2005, is shown in Figure 56.

A negative trend of annual precipitation is characteristic of most of Serbia. Its intensity is higher in eastern parts of the country and climaxing in the region of Negotin. A positive precipitation trend characterizes areas of Mt. Zlatibor, Pešter plateau, a part of Mt. Kopaonik and, slightly less, the region of Bačka. In other words, annual precipitation is decreasing in most of Serbia, particularly the central parts, since 1951.

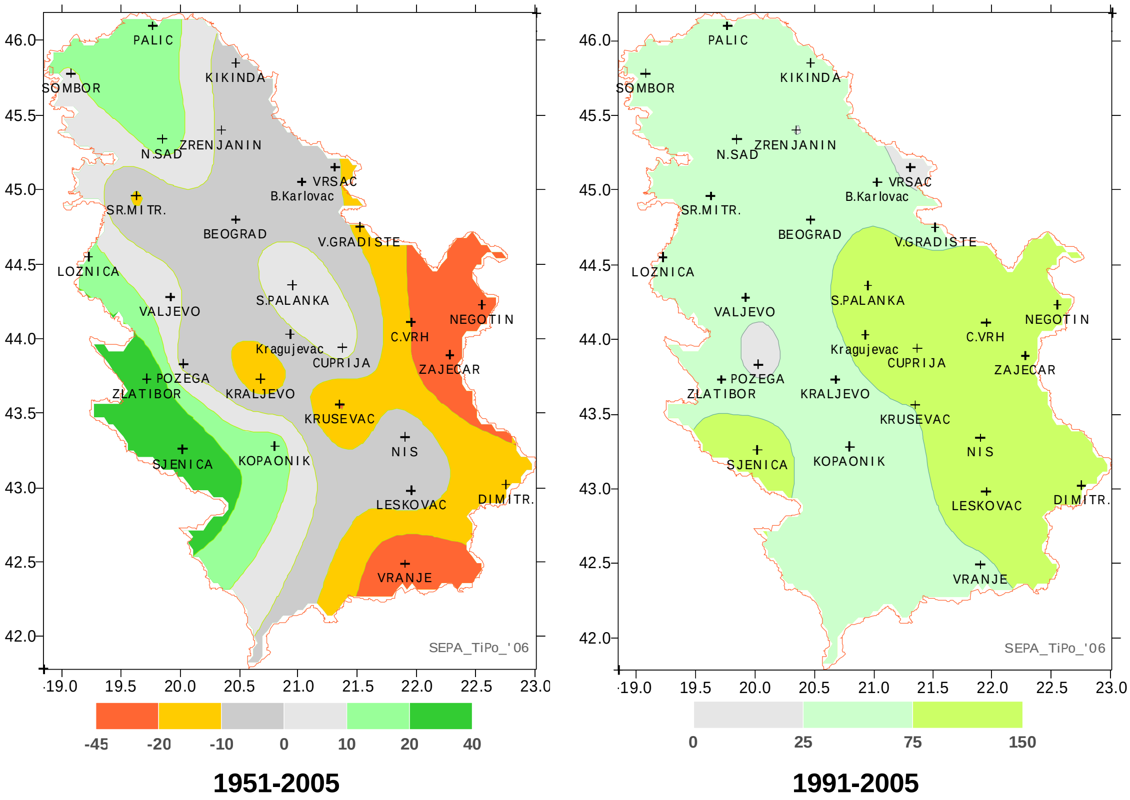


Figure 56

Annual precipitation trend in Serbia in % of 1961-1990 normal

Spatial distribution and intensity of annual precipitation trends in Serbia in the period 1991-2005 are shown in Figure 56 - right. The precipitation trend for that period is presented as a percentage 1961-1990 normal for fifteen years. The minimum of +0.9 % was recorded in Vršac and the maximum of +45.2% in Cuprija. According to the 1991-2005 data, all of Serbia had a rising trend of annual precipitation.

The observed trend of climate change has a number of undesirable effects, beginning with economic damage caused by periodic climatic events (floods, drought) to decreasing agricultural yields, threat to species preferring cold temperature climates, etc.

Two severe floods occurred in Serbia in 1979 and 1999. According to Hoyois and Guha-Sapir (2003), 12,000 and more than 70,000 inhabitants were affected by the floods in 1979 and 1999, respectively. More recently the frequency of floods in Serbia (and also neighbouring regions) significantly increased. Severe floods occurred during two successive years (2005 and 2006).

Secanj and Zitiste, two municipalities in Serbia's northern province of Vojvodina were flooded by the Tamiš River during the April 2005, due to a flood wave from Romania, after dams had yielded under pressure from high tides caused by heavy rains. This flood affected 25 000 inhabitants of the municipalities of Plandiste, Zitiste, Nova Crnja, Secanj, Alibunar and Vrsac. The village of Jasa Tomic (3,500 people) in Secanj was struck first and most severely. More than 600 houses were submerged and more than 250 have been completely destroyed. Agricultural machinery was trapped under the mud. Bridges and electricity supply have been damaged.

The Zapadna Morava overwhelmed in the region of Požega more than 1000 hectares of fertile land during the March 2006. At the same day period, thousends of hectares were overwhelmed because of overgrowing of rivers Kolubara, Jadar and some smaller rivers. More than 600 hectares near the city of Smederevo were destroyed by water from so called Red Water Canal. Due to heavy rains and rising of water levels of all rivers, mainly in the middle flow of rivers, a number of new lands sliding grew up, so on the March 27th in many regions, the statement of natural disasters was proclaimed. Subterranean waters soaked fields and cities.

Number of landslides appeared in the central and western part of Serbia. In the region of Čačak there were evident more than 70 landslides, in Požega 17, Aranđelovac 30, Valjevo 158. Hundreds of families lost their homes.

Subsequently (during the April 2006), another wave of floods occurred in Serbia. Two weeks of flooding in large swaths of central Europe, caused by melting snow and heavy rains, have swelled tributaries draining into the Danube.

The Serbian government declared a state of emergency in nine municipalities. More than 240 000 hectares of land in northern Serbia were flooded, or threatened by underground waters and landslides; out of the 240 000 hectares, more than 122 000 hectares are flooded, more than 112 000 hectares were threatened by underground waters and landslides threatened more than 5 500 hectares of arable land. The most threatened areas were the district of southern Backa with more than 50 000 hectares and central Banat with 42 000 hectares under water. The 35 million EUR, allocated from the budget to compensate damage from floods, had been spent in the April and that the real damage would be known when the water withdrew and later (Čekerevac, 2004).

Republic of Serbia has signed and ratified a number of international agreements focusing on the treatment of global warming. Many of those agreements outline the principles and legal and economic instruments that could slow down climate change. By adopting the Law on Ratification of the Vienna Convention for the Protection of the Ozone Layer (Official Gazette of the SFRY, International agreements 1-90) and the Law on Ratification of the Montreal Protocol on Substances That Deplete the Ozone Layer (Official Gazette of the SFRY, International agreements 16/90, and 24/04), our state was actively involved in programmes aimed at protecting the stratospheric ozone. The Law on Endorsing the United Nations Framework Convention on Climate Change was also adopted (Official Gazette of the SRY, International agreements 2/97).

AIR

AIR QUALITY MONITORING
SULPHUR DIOXIDE (SO_2)
NITROGEN DIOXIDE (NO_2)
PARTICULATE POLLUTANTS
TROPOSPHERIC OZONE
ALLERGENIC POLLEN

AIR QUALITY MONITORING

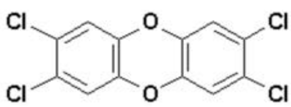
Dominant gasses in dry atmosphere are nitrogen (78.084%), oxygen (20.946%), argon (0.934%), carbon dioxide (0.035%) and trace gasses such as neon, methane, helium and hydrogen. The content of water vapour in the atmosphere is highly variable (within 1-4% range). Such composition is characteristic of ideally clean air. However, the atmosphere is usually contaminated by various gases, liquid or solid pollutants.

Human exposure to air pollutants may cause a variety of health effects, depending on the type of pollutant, the magnitude, duration and frequency of exposure and toxicity of any specific pollutant. Excessive exposure to air pollutants may cause a wide range of disorders in children and adults, leading to their disability and a significant reduction in life expectancy (WHO, 2005, 2006). Besides human population, polluted air may also have adverse effect on all other organisms sharing the ecosystems (US EPA, 2003, EEA, 2003).

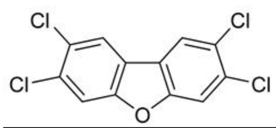
The most prominent air pollutants include: sulfur dioxide, nitrogen oxides, ozone, suspended particles, persistent organic pollutants and allergenic pollen (WHO, 2005).

Compounds such as *sulfur dioxyde, nitrogen oxides* are precursors of strong acids that may damage cell membranes and proteins. *Ozone* is strong oxidizing agents that may disturb physiological processes in cells.

Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food chain, and pose a risk of causing adverse effects to human health and the environment (Stockholm Convention on Persistent Organic Pollutants, 1997). The most important POPs are: certain insecticides, such as DDT, chlordane, aldrin etc., which were once commonly used to control pests in agriculture; polychlorinated biphenyls (PCBs) that were used in hundreds of commercial applications, including electrical, heat transfer and hydraulic equipment, and as plasticizers in paints, plastics and rubber products; and certain chemical by-products, such as dioxins and furans produced unintentionally from most forms of combustion, including municipal and medical waste incinerators, open burning of trash, and industrial processes (WHO, 1998).



2,3,7,8- tetrachlorodibenzo-p-dioxin



2,3,7,8-tetrachlorodibenzofuran

These compounds are characterized by: *persistence* (their half-life is more than two months in water or more than six months in soil), *bioaccumulation* [fat soluble (lipophilic) substances cannot be excreted in urine, a water-based medium, and so accumulate in fatty tissues of an organism if it lacks enzymes to degrade them], and *biomagnification* (concentration of an element or compound increases in the food chain as a consequence of slow excretion or degradation of pollutants from food or pray tissues), and *toxicity*.

Polycyclic (or polynuclear) *aromatic hydrocarbons* (PAH) are complex mixtures of hundreds of chemicals. PAHs are semivolatile, which means that they are transported in the atmosphere both in the gas phase and bound to particles.

Several PAHs may induce a number of adverse effects, such as immunotoxicity, genotoxicity, carcinogenicity and reproductive toxicity (affecting both male and female offspring). Benzo[*a*]pyrene (BaP) is the PAH most widely studied, and most information on the toxicity and occurrence of PAHs is related to this compound. The WHO has recommended no specific guideline value for PAHs in the air.

PAHs are frequently found in ambient air. They are formed during incomplete combustion of organic matter, so that important PAH sources are transport and electricity and heating generation (Sander and Wise, 1997).

Some elements belonging to the group of *heavy metals* (metals with specific gravities greater than 4.0), including cobalt, copper, manganese, molybdenum, vanadium, strontium, and zinc are, in trace concentrations, required for normal metabolic processes of living organisms. However, excessive levels of these elements can be detrimental to the organism. Other heavy metals such as mercury, lead and cadmium have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of mammals can cause serious illness. Chronic exposure to excessive levels of heavy metals may induce higher incidence of kidney, liver, neurological and developmental disorders.

Natural sources of air pollution include gaseous emissions from trees, animals and lightning, and gaseous and particulate emissions from volcanic eruptions, soil erosion, wind-blown dust and forest fires. *Anthropogenic* sources of air pollution involve combustion of fossil fuels (thermoelectric power plants, motor vehicles, communal and household heating installations), mining operations (sources of fugitive dust emissions), manufacturing processes (metallurgical plants, chemical plants, oil refineries), agricultural activities (crop spraying, crop-residue burning), etc.

Protection from air pollution is regulated in Serbia by the Law on Environmental Protection (Official Gazette of the Republic of Serbia No. 135/04), Bylaw on Limit Values, Methods of Imission Measurements, Criteria for Posting Measuring Stations and Collecting Data (Official Gazette of the Republic of Serbia No 54/92), Bylaw on Emission Limit Values, Methods and Deadlines for Measurements and Data Collecting (Official Gazette of the Republic of Serbia No. 30/97) and Bylaw on Detailed Requirements for Expert Organisations Measuring Emissions and Imissions (Official Gazette of the Republic of Serbia No. 5/2002).

The Air Quality Control Programme in Serbia (Official Gazette of the Republic of Serbia No. 48/2004) is aimed to achieve several objectives:

- to determine levels of air pollution;
- to monitor trends in air pollution over several successive years;
- to assess air quality based on data comparison with guideline values;
- to determine measures to be taken to improve air quality;
- to identify critical and alarming situations with a purpose of warning the public and taking appropriate steps;

- to assess effects of air pollution on human health, climate and forest ecosystems.

Network of monitoring stations

Systematic measurements of air quality in Serbia are performing in several observation networks falling under the competency of different state-run organizations and institutions. Those are:

- the main network of meteorological stations and main network of urban meteorological stations
- local network of urban stations for measuring concentrations of main pollutants and local network of urban stations for measuring concentrations_of specific pollutants.

Territorial distribution of stations under the Programme of Air Quality Control in the Republic of Serbia is shown in Figure 57.

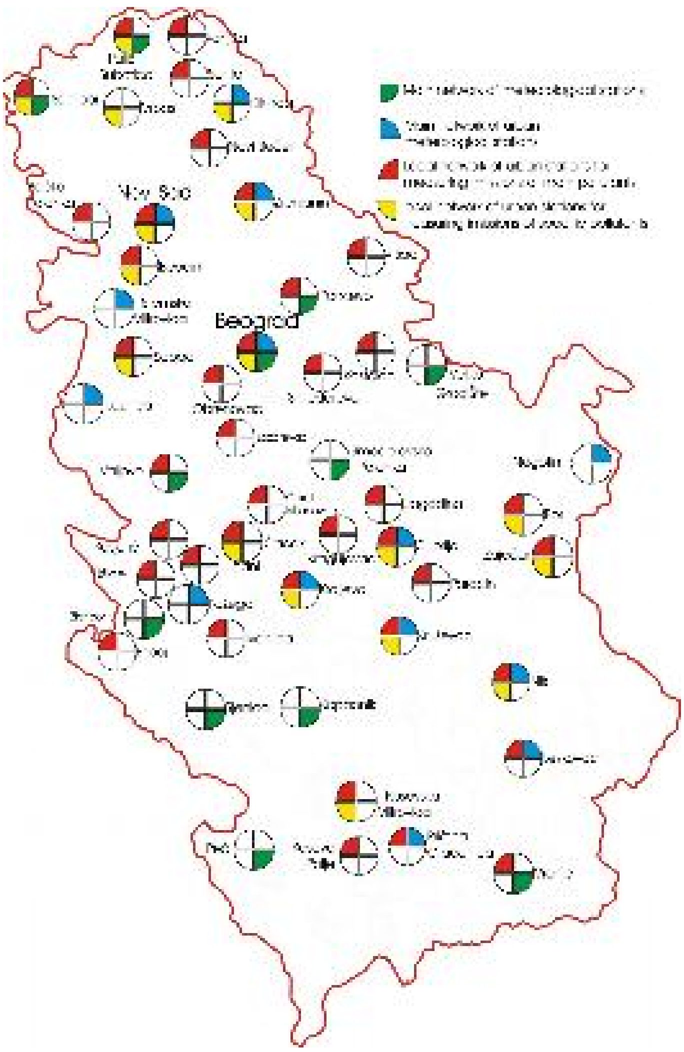


Figure 57

Network of air quality measuring stations

SULPHUR DIOXIDE (SO_2)

Sulphur dioxide (SO_2) is an irritating gas that is associated with deteriorated lung functioning and increased risk of mortality and morbidity. Adverse health effects of SO_2 include coughing, phlegm, chest discomfort and bronchitis. A range of chronic and acute health disorders may result from human exposure to sulphur dioxide.

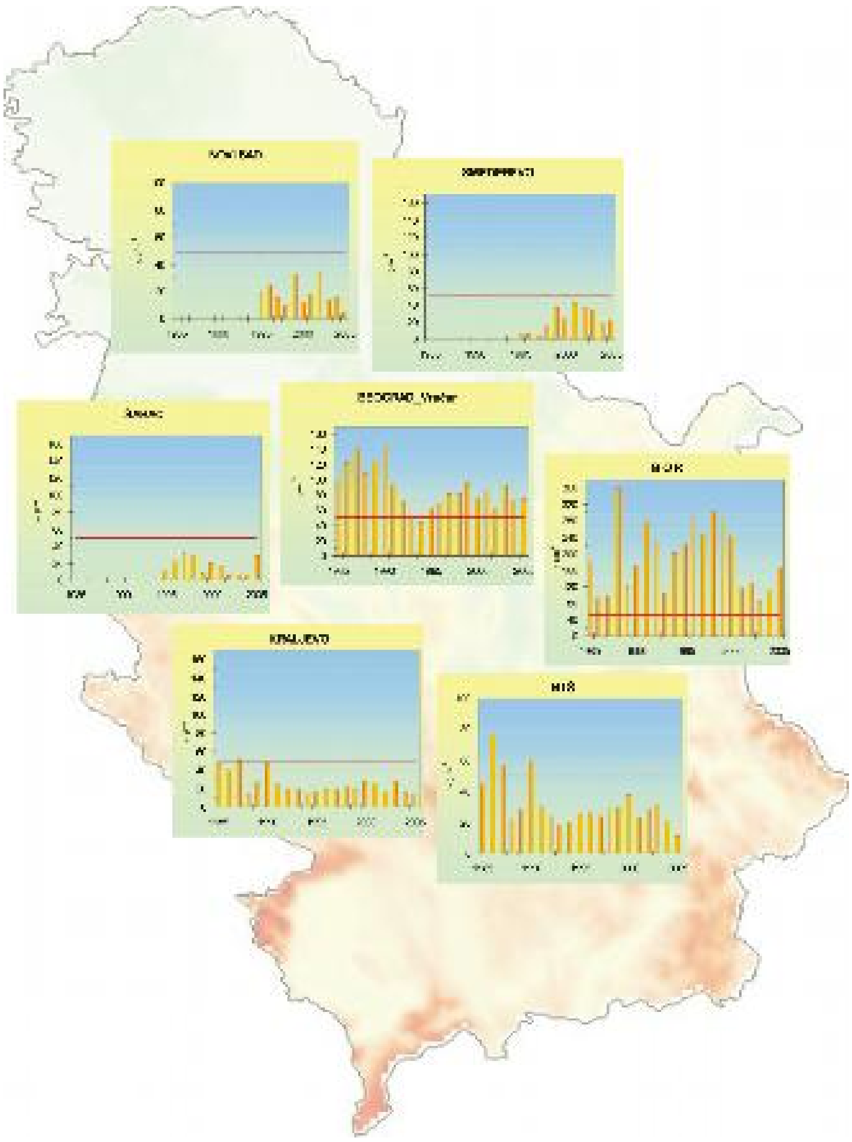


Figure 58

Annual average of SO_2 concentrations ($\mu g/m^3$) in Serbia during 1985 – 2005 period. The horizontal line on histograms denotes the permitted limit of 50 $\mu g/m^3$.

In the gaseous phase, SO_2 can irritate the respiratory system, and reversible effects on the lungs may occur during brief exposures to high concentrations (Kotlik & Bower, 1999). Further oxidation of SO_2 forms extremely harmful sulphuric acid (H_2SO_4),

The air quality guideline values, proposed by WHO for SO_2 are:

- 500 μg/m³ for 10 minute exposure
- 125 μg/m³ for 24 hour average exposure
- 50 μg/m³ for annual average exposure

Considering Serbian legislative (By Law on Limit Values, Methods of Imission Measurements, Criteria for Posting Measuring Stations and Collecting Data -Official Gazette of the Republic of Serbia No 54/92), the *permitted limits* of SO_2 for urban areas are:

- 350 μg/m³ for hour average exposure
- 150 μg/m³. for daily average exposure
- 50 μg/m³.for annual average exposure

Annual average of SO_2 concentration in Serbian industrial towns is represented in Fig. 59.

According to the available data for 2005, annual SO_2 values exceeded the permissible limit of 50 μg/m³ at two locations: Bor - 169 μg/m³, and Belgrade-Vračar - 73 μg/m³ . Close to the limit value were two other locations in Belgrade: Č. Čaplina– 48 μg/m³, and B.D. Stefana Str. - 43 μg/m³, and following them were the towns of Užice – 39 μg/m³, Loznica – 34 μg/m³, Kosovska Mitrovica – 30 μg/m³, and Pančevo and Šabac - 29 μg/m³ each (Figure 59) .

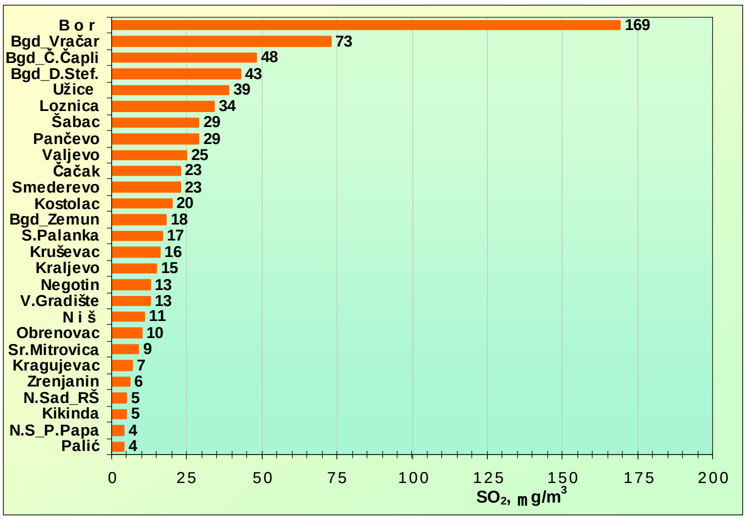


Figure 59

Mean annual concentrations of SO_2 (μg/m³) at selected measurement stations in Serbia in 2005

The highest daily concentration of sulphur dioxide in 2005 was detected in Bor - 1567 μg/m³. Maximum daily concentrations at other stations were lower: in Šabac 693μg/m³, Belgrade-Vračar 378μg/m³, Belgrade-B.D.Stefana - 269μg/m³, Belgrade-Č.Čaplina 247 μg/m³ and Belgrade-Košutnjak 185 μg/m³, etc. In 2005, exceedance of the permitted average *daily* limit of 150 μg/m³ occurred most frequently in Bor - 119 days, and Belgrade-Vračar followed with 51 days, Užice 24, Belgrade-B.D.Stefana with 9 and Šabac 5 days.

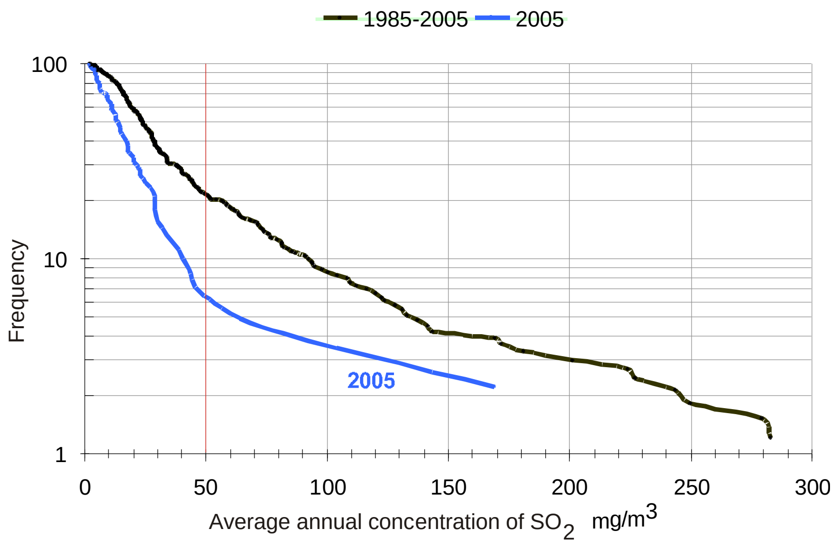


Figure 60

Distribution of ranked annual SO_2 concentrations in Serbia (2005 data collected from stations covering area with 18% Serbian population)

Rank histograms may increase probability of forecast (Hamill, 2001). We used rank histograms to detect the trends of data variability. Let i=0, 1, 2, ...n are ranked values of a measured variable, in our case the concentration of SO_2. Frequency for each of n+1 ranks may be calculated easily. The frequency of the greatest (n-th) SO_2 value is $f_{(n)} = 1/(n+1)$. The frequency of preceding SO_2 value is $f_{(n-1)} = 2/(n+1)$. This SO_2 level is included in the greatest (n-th) SO_2 concentration, so it is observed twice. In general, the frequency of i-th SO_2 concentration is:

$$f_{(i)} = 1 - i/(n+1).$$

Rank histograms of SO_2 concentrations over the 1985-2005 period showed 20% exceedance of the *annual* permitted limit, while in 2005 it was 6%, Figure 60.

The available data series for the period 1985-2005 were used to compute episodes of *daily* permitted limit exceedences that created load on the population. Daily limit was assumed to be 125 $\mu g/m^3$, the value used by the European Environment Agency to identify exceedance of daily concentrations of sulphur dioxide. It is more restrictive than the relevant domestic regulation setting the limit at 150 $\mu g/m^3$.

The measurement stations from which data were collected cover only a part of the population. The 2005 data for SO_2 were taken from stations covering an area with 18% population of Serbia (1985 data covered 8%, those for 1993 - 10%, and data for 2000 - 16% population).

The average number of days with daily SO_2 concentrations exceeding 125 $\mu g/m^3$ per capita (per 1 million citizens) is shown in Figure 61. The distribution shown here suggests three characteristic periods. From mid-1980s until the beginning of 1990s, the average number of days with exceedances of permissible daily concentrations of sulphur dioxide was growing. From that point until 1993, the average number of exceedances per capita dropped. After 1993, it stabilized, and such trend has continued.

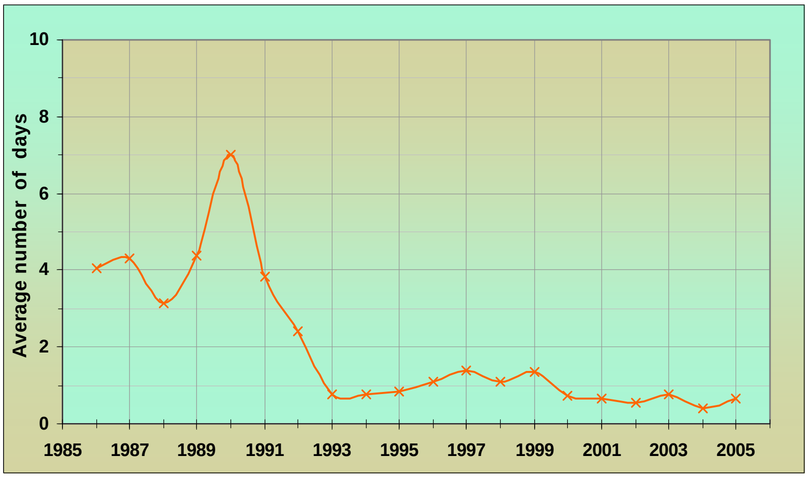


Figure 61

Average number of days with daily SO_2 concentrations exceeding 125 μg/m³ per capita (per 1 million citizens, 2005 data were collected from stations covering area with 18% population of Serbia)

Data on the average frequency of daily SO_2 concentrations exceeding 125 μg/m³ per capita (per 1 million citizens) are shown in Figure 62 Until 1993, average exceedances for 6 or more days were predominating, except in 1988. Since 1993, however, the average number of exceedance days was predominantly either zero or 1-3 days. The analysis also showed that maximum average number of exceedance days of >6 over the past 9 years covered more than 20% population (residing in areas covered by measuring stations).

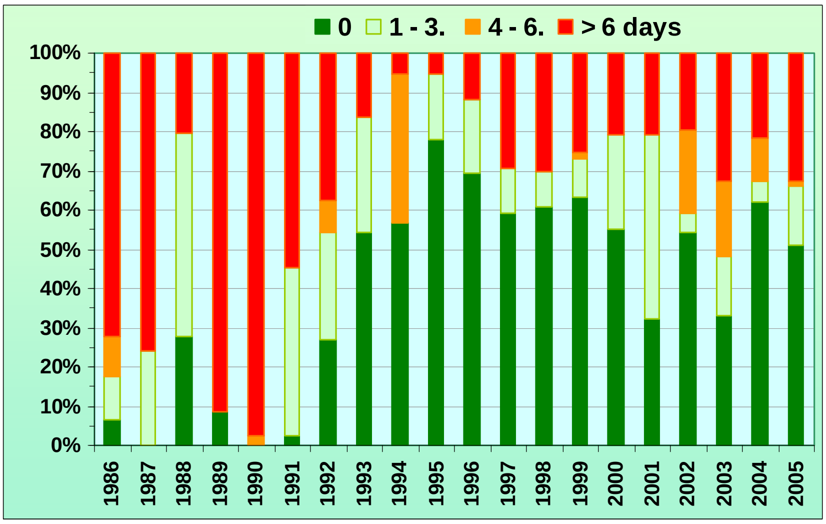


Figure 62

Frequency of daily SO_2 concentrations exceeding 125 μg/m³ per capita (2005 data collected from stations covering area with 18% of Serbian population)

NITROGEN DIOXIDE (NO_2)

Nitrogen dioxide (NO_2) is an air pollutant produced in combustion processes. Whenever nitrogen dioxide is present, nitric oxide (NO) is also found and the sum of NO and NO_2 is collectively referred to as nitrogen oxides (NOx). At very high concentrations, which may only be encountered in major industrial accidents, NO_2 exposure can result in rapid and severe lung damage.

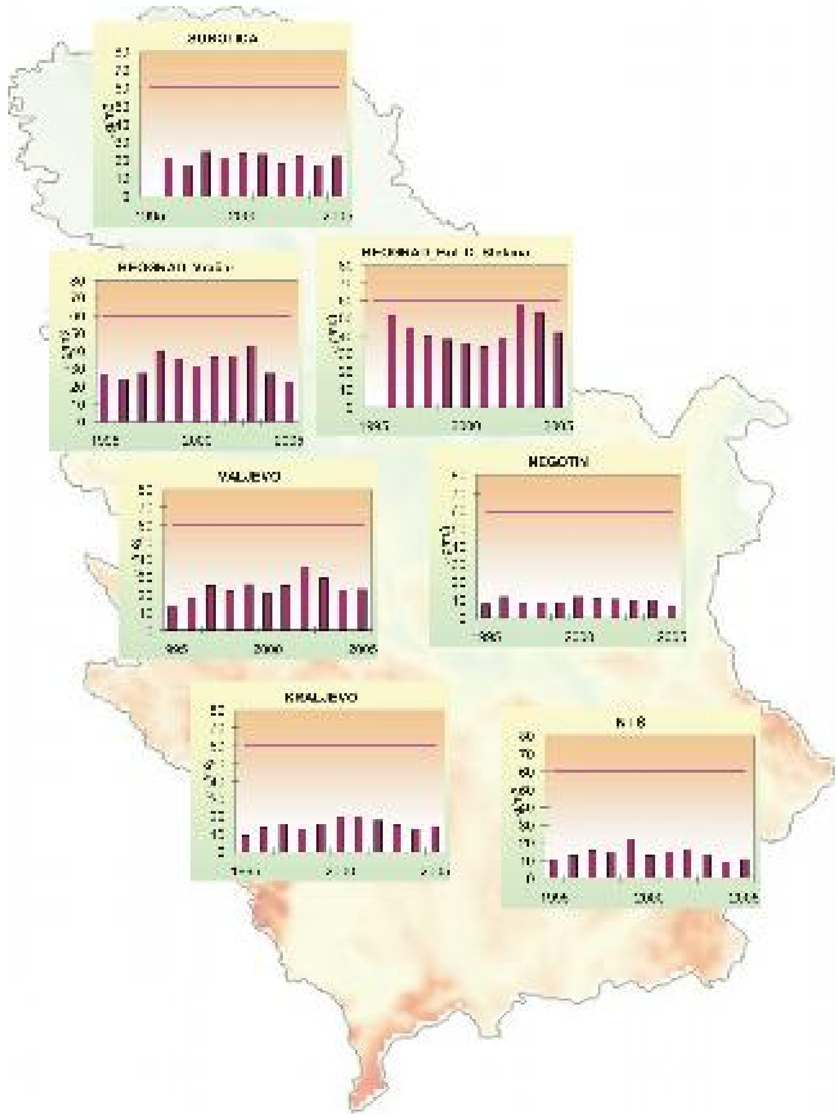


Figure 63

Annual mean concentration of NO_2 ($\mu g/m^3$) at selected stations in Serbia in 1985 – 2005. The horizontal line on histograms indicates the annual upper limit of 60 $\mu g/m^3$.

NO_2 primarily acts as an oxidizing agent able to damage cell membranes and proteins. At high concentrations, the airways may become acutely inflamed. In addition, short-term exposure may predispose towards an increased risk of respiratory infection.

To protect the public at large from such chronic effects, an *annual average* limit value of 40 μg/m³ has been set [*Update and revision of the air quality guidelines for Europe: Meeting of the Working Group on Classical Air Pollutants*. Copenhagen, WHO Regional Office for Europe, 1995 (document EUR/ICP/EHAZ 94 05/PB01)].

Considering Serbian legislative (Bylaw on Limit Values, Methods of Imission Measurements, Criteria for Posting Measuring Stations and Collecting Data -Official Gazette of the Republic of Serbia No 54/92), the permitted *limits* of NO_2 are:

- 150 μg/m³ for hour average exposure
- 85 μg/m³ for daily average exposure
- 60 μg/m³ for annual average exposure

During the long term survey (1985-2005), the annual average of NO_2 was not exceeded the permitted limits in main industrial centres of Serbia (Figure 63).

According to data available for the year 2005, the annual nitrogen dioxide was not exceeding at any measuring station. The highest annual average value was measured in Belgrade-B.D. Stefana - 45 μg/m³, while values below this one were measured in Belgrade-Zemun Trg JNA – 35 μg/m³; Sombor, Belgrade-Vračar and Valjevo – 23 μg/m³; Pančevo – 22 μg/m³ and Subotica - 21 μg/m³. Exceedance of the maximum permissible *daily average* of 85 μg/m³ was measured in 2005 only in Belgrade-B.D. Stefana five times, and once in Belgrade-Vračar.

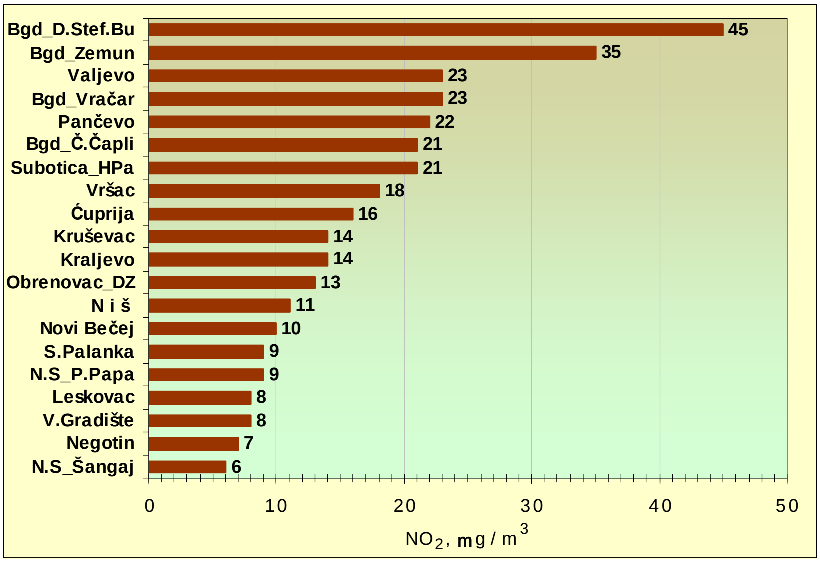


Figure 64

Annual average concentration of NO_2 (μg/m³) at several measuring stations across Serbia in 2005

The highest daily concentrations of nitrogen dioxide in 2005 were measured in Belgrade: Belgrade-Vračar - 142 μg/m³, Belgrade-B.D. Stefana - 140μg/m³, Belgrade-Zemun Trg JNA – 84 μg/m³, Belgrade-Č.Čaplina – 82 μg/m³. Following them in declining order were: Kraljevo – 82 μg/m³, Subotica and Loznica – 80 μg/m³, Valjevo 77 μg/m³, Novi Sad (P.Papa Str.) – 72 μg/m³, Kruševac – 69 μg/m³, Pančevo 65 μg/m³, and Niš – 60 μg/m³.

Rank histograms of annual average concentrations of NO_2 over the 1995-2005 indicate that there were no exceedances of the annual allowable limit of 60 μg/m³ (Fig. 65).

The available data series for the period 1995-2005 were used to calculate episodes of daily allowable limit exceedences that created a load on the population. The daily limit was set at 40 μg/m³, the value used by the European Environment Agency to identify exceedance in daily concentrations of nitrogen dioxide. It is more restrictive than the domestic regulation, which sets the limit at 85 μg/m³.

The measurement stations from which data were collected represent areas covering only a part of the Serbian population. The 2005 data on NO_2 were collected from area covering 15% Serbian population (1996 data covered 14% population).

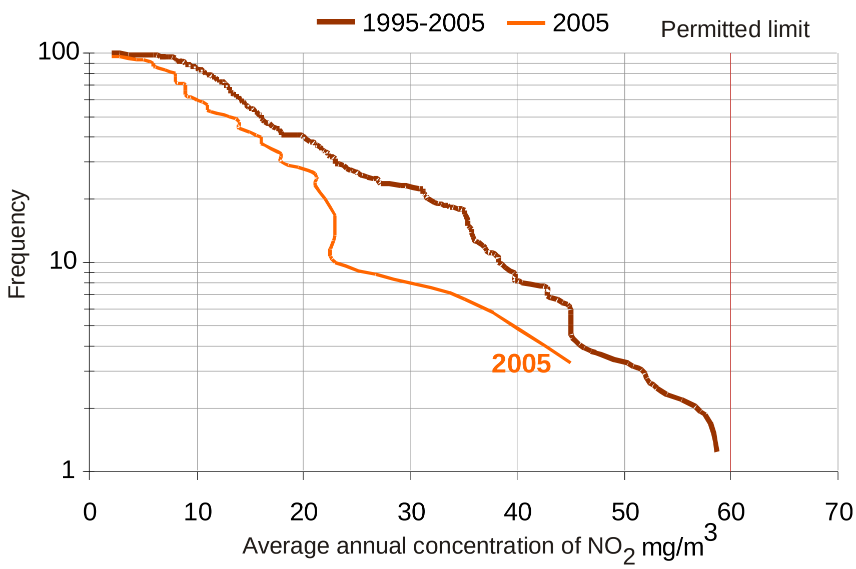


Figure 65

Annual NO_2 concentrations in Serbia (2005 measurements covered 15% Serbian population)

The average number of days with daily NO_2 concentration exceeding 40μg/m³ per capita (per 1 million citizens) is shown in Figure 66. It shows that the highest average per capita load was in 2003, with a declining trend to follow.

Figure 67 shows per capita (per 1 million citizens) average frequency of daily concentrations of nitrogen dioxide over the 1995-2005 period. It indicates a decrease in the frequency of daily concentrations ranging from 0 to 20 μg/m³ in the period 1995-2001 and a declining frequency of measurements exceeding 31 μg/m³ after 2002.

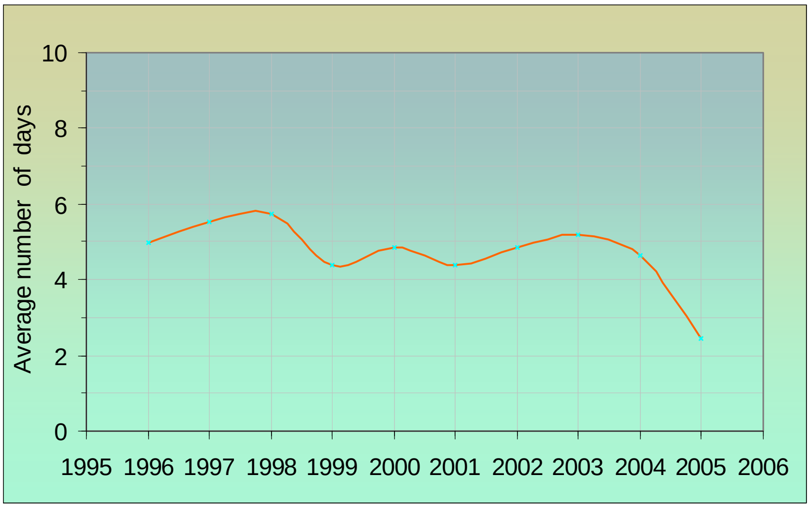


Figure 66

Per capita (per 1 million citizens) average number of days with daily NO_2 imission concentrations exceeding 40 µg/m³ (2005 data collected from stations covering 15% Serbian population)

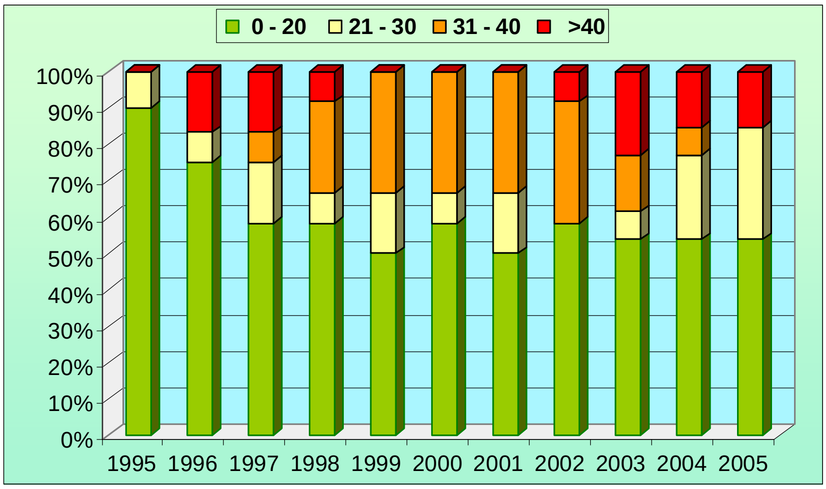


Figure 67

Per capita frequency of daily concentrations of NO_2, µg/m³ (2005 data collected from stations covering 15% Serbian population)

PARTICULATE POLLUTANTS

Particulate matter (PM) is an air pollutant consisting of a mixture of solid and liquid particles suspended in the air. These suspended particles vary in size, composition and origin. In size, they vary from newly-formed ultra-fine particles of a few nanometers aerodynamic diameter to coarse particles of 10-50 micrometers.

Very fine and coarse particles both have short lifetimes in the atmosphere and are generally not transported to long distances. Smaller particles contain secondary aerosols (gas-to-particle conversion), combustion particles and recondensed organic and metal vapours. Important parts of the "secondary aerosols" are sulphate particles (important in terms of acid deposition and visibility reduction on a regional scale), and organics-containing particles resulting from photochemical reactions (important in large urban areas with photochemical pollution). Larger particles usually contain earth, crystal matter and fugitive dust from roads and industries.

The most common size fractions are:

- TSP (total suspended particulates) comprising all airborne particles.
- PM10 particles with aerodynamic diameter <10 µm.
- PM2.5 particles with aerodynamic diameter <2.5 µm.
- coarse fraction comprising particles with aerodynamic diameter between 2.5 µm and 10 µm.
- ultra-fine particles with aerodynamic diameter <0.1 µm.
- BS (black smoke), used widely as an indicator of aerosol “blackness” (and therefore a surrogate for soot).

Particles are emitted to the atmosphere, but they also form via oxidation or reaction between gases. Major sources of primary particles are industrial processes, road traffic, power plants, domestic burning (coal, wood, etc.), incineration, and resuspension of road and construction dusts. Particulate matter is removed from the atmosphere by wet and dry deposition.

Short-term health effects of exposure to combined SO_2, black smoke and particulates include increased mortality, morbidity and pulmonary disfunctions. Other environmental effects include the soiling of exposed surfaces, impaired visibility, possible modification of climate and contribution to acid deposition.

Total suspended particulates

Important sources of air suspended particles are the oil refineries in Pancevo and Novi Sad, the cement factories in Popovac, Kosjeric and Beocin, and chemical plants and metallurgical complexes located in Pancevo, Krusevac, Sabac and Smederevo. Old vehicles, many of which were recently imported, still use leaded or low quality fuel. No plans to introduce systems of vehicle control in traffic to improve maintenance and reduce the discharge of leaded fuel are in place.

Continuous measurement of PM10 in Serbia started since 2003. At this moment there are several PM_{10} measuring stations that cover Belgrade, Obrenovac, Smederevo, Pancevo, Beocin and Zrenjanin. High concentrations of PM10 in Belgrade (as well in other urban agglomerations in Serbia) frequently occur during heating season (Fig. 68).

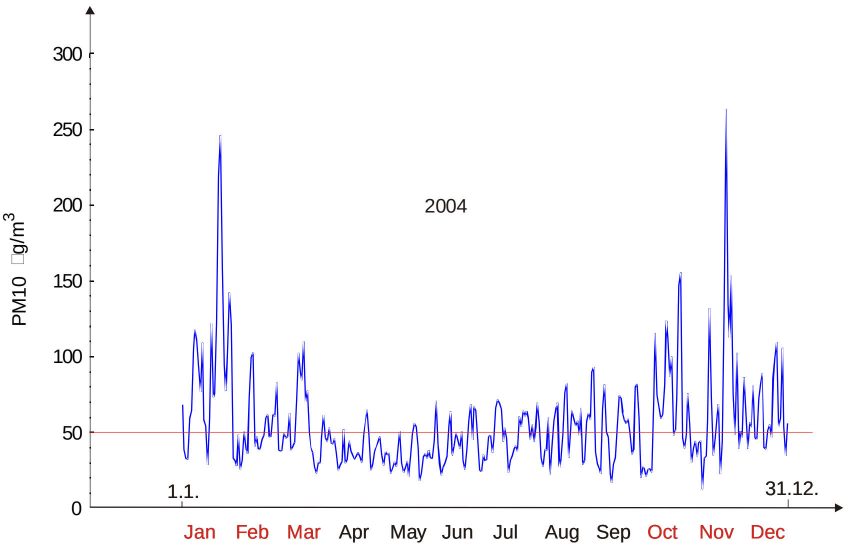


Figure 68

Daily PM10 concentration in Belgrade during 2004. The heating season is marked by red letters

Replacement of heating systems that are based on solid and liquid fossile fuels with the natural gas based systems may significantly reduce the level of suspended particles in urban air. The increased natural gas consumption is one of the most important strategic goals defined in Serbian energy strategy paper. The Serbia Natural Gas Network development and Underground Gas Storage Banatski Dvor construction will have a positive impact on: investments activities, gas consumers, environmental protection, increase in standard of living and reliability of energy supply.

Completion of project for Belgrade – high priority – due to high level of pollution and need for environmental protection, extremely high consumption of electrical energy for heating purposes, and further development of the city. Preparation of General urban documentation and technical documentation is underway, and will be finished in few phases by the end of the year 2006. Cost estimate is 64,5 million Euros (Republic of Serbia Ministry of Mining and Energy, 2005).

The most important capital investment in natural gas sector is construction of main gas pipeline Niš- Dimitrovgrad. This project worth about 60 million $, would ensure another direction of supply connecting Serbian gas pipeline system with the Bulgarian system. Although at the beginning the source of supply would still be Russia, the same source as we now import gas from, across the territory of Hungary, this project would significantly increase security and quality of supply, transit costs would be lower, and systematic gasification of Central Serbia would be possible.

Black Smoke

Black smoke is a dark powdery deposit of unburned fuel residues. As other inorganic PM's, the black smoke can harm the lungs and general health.

According to data available for the year 2005, annual average value of black smoke exceeded the permissible limit of 50 μg/m³ only in Užice - 62 μg/m³. Following in a declining order were: Zemun-Trg JNA, Belgrad-Č.Čaplina, Belgrade-B.D. Stefana (Belgrade Health Protection Institute), Ivanjica and Belgrade-Vračar.

In 2005, Užice and Zemun had the highest number of exceedances of the daily smoke permitted limit of 50 μg/m³ – 133 and 125, respectively. Following were: Belgrade-Č.Čaplina, Loznica, Ivanjica, Valjevo, Pančevo and Belgrade-B.D.Stefana , Figure 69. The highest daily smoke concentrations in 2005 were recorded in Užice- 663 μg/m³, Belgrade-Č.Čaplina – 455 μg/m³, Valjevo - 369 μg/m³, Zemun - 341 μg/m³, Belgrade- Vračar – 297 μg/m³ and Pančevo - 288 μg/m³ .

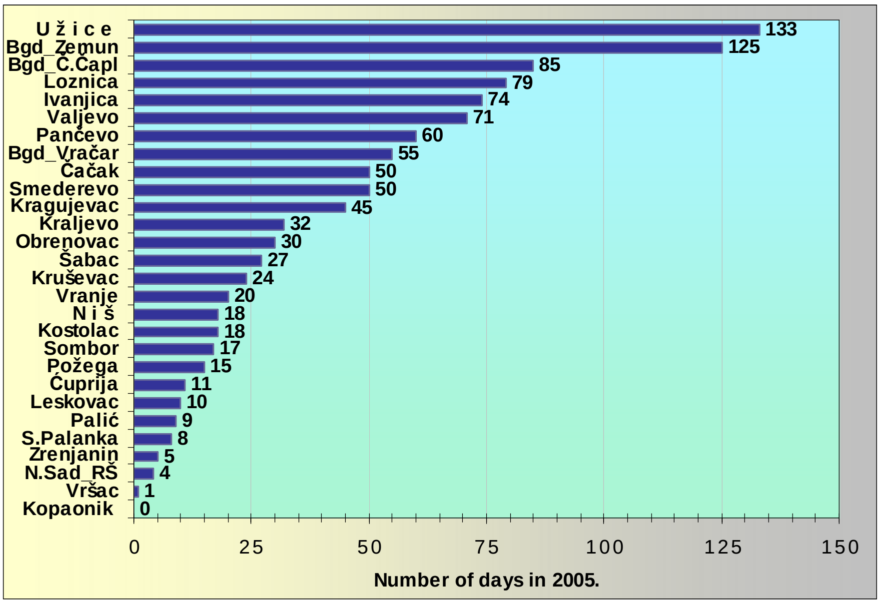


Figure 69

Number of days in 2005 with daily concentrations of smoke above permitted limits Data sources RHMS, DEP; Health Protection Institute "Dr M. J. Batut", Provincial Secretariat for EPSD, Belgrade Health Protection Institute, Secretariat for EP, Pančevo

Variation in the number of days with concentrations of smoke exceeding the permitted limits at selected measuring stations in Serbia over the 1985 – 2005 period is presented in Figure 70. Over the past ten years approximately, annual limit for concentrations of smoke was exceeded in Belgrade and Užice, while Loznica and Valjevo had the next worse rates.

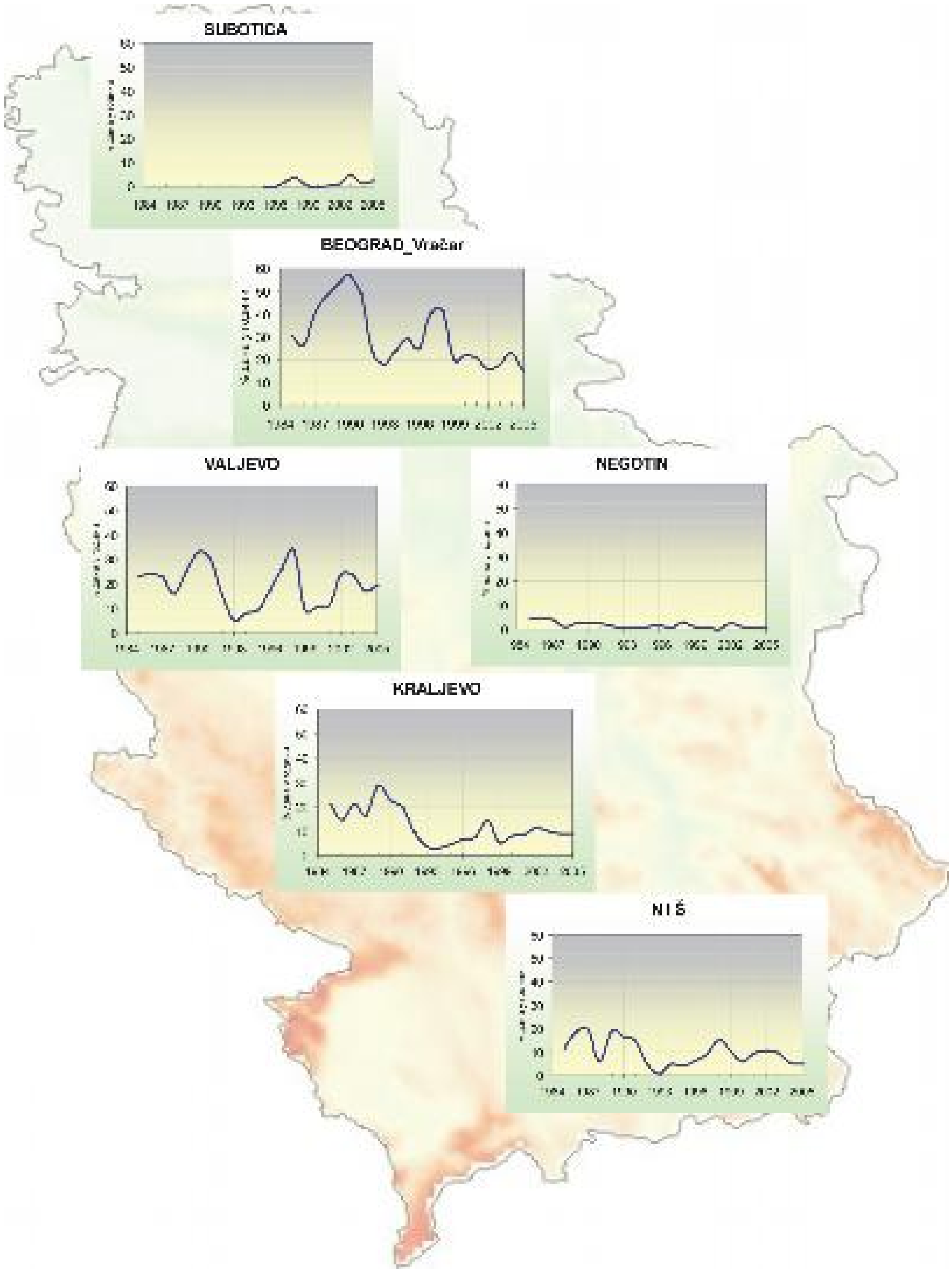


Figure 70

Number of exceedance days of black smoke at selected stations in Serbia in 1985-2005

Total sedimented particles

Sedimented particles include parts of solid fuels, ashes, street dusts and other material that have diameter size >20 µm and, due to their weight, settle on the uppermost layer of soil and all exposed surfaces in urban environment. Their activity in human organism depends on their origin, chemical composition, size, shape, infectedness with microorganisms and tolerance of any individual organism that is exposed to them.

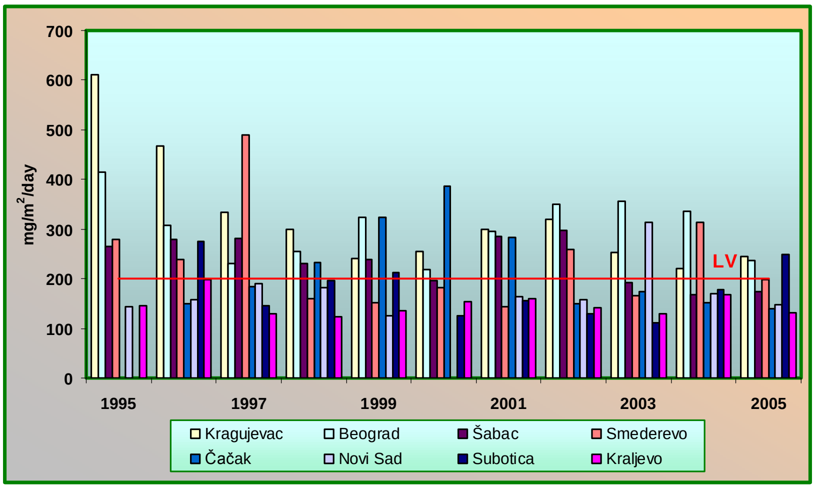


Figure 71

Annual mean concentrations of sedimented particles (mg/m²/day) in major Serbian cities in 1995 – 2005

Specific pollutants

"Specific pollutants" is a group of polluting material emitted from various industrial processes that are specifically bound to industrial environs. They can appropriately be classified according to: their origin (*primary* – emitted immediately from the source of air pollution and *secondary* – as an effect of physico-chemical reactions caused by primary pollutants in the air) and source of emission (*stationary* – industrial facilities, heating plants, etc. and *mobile* sources – motor vehicles).

Several types of pollutants were monitored in 2003, 2004 and 2005:

- inorganic pollutants (ammonia, hydrogen chloride, hydrogen fluoride, nitrogen dioxide, hydrogen sulphide, suspended particles, mercury)
- organic pollutants (acrolein, benzene, benzo[a]pyrene, toluene, carbon disulphide, formaldehyde, phenol*)*
- heavy metals (lead, cadmium, zinc, arsenic, manganese, nickel, chromium, mercury) in sedimented matter/suspended particles/soot.

Benzene

Benzene is toxic hazardous compound. This pollutant is one of the main environmental problems in Pančevo, an industrial town, located 20 kilometers northeast of the capital of Belgrade. The industrial complex covers about 290 hectares and lies to the south and southeast of Vojlovica, a major residential area in Pancevo. The complex involves the HIP Azotara chemical fertilizer factory, the HIP Petrohemija petrochemical plant, and the NIS Oil Refinery.

Pančevo industrial complex was bombed by NATO forces several times between April 4th and June 7th 1999. As a consequence, all three factories were damaged and hazardous substances were released to environment. (UNEP, 1999). The main environmental concerns identified at Pančevo petrochemical plant were serious spills of ethylene dichloride (EDC) and mercury. These had contaminated soil, groundwater and the complex's wastewater canal, which leads to the Danube River. The wastewater treatment plant, though not directly hit during the air strikes, was also damaged, causing untreated wastewater from various units of the petrochemical plant and oil refinery to flow into the canal.

At the heavily targeted Pančevo oil refinery approximately 80,000 tonnes of oil products and crude oil burned, releasing sulphur dioxide and other noxious gases. In addition, an estimated 5,000 tonnes of oil and oil products leaked into the soil and the sewer system, aggravating pre-existing soil and groundwater contamination at the refinery.

At Pancevo fertilizer plant the nitrogen-phosphorous- potassium (NPK) plant and fuel-oil tanks were destroyed, and the ammonia plant was damaged. Large quantities of hazardous substances from the whole complex reached the wastewater canal and the Danube River.

The petrochemical complex has undergone repairs after heavily bombarded during the 1999 NATO air attacks on Serbia, but it still lacks sophisticated safeguards. The concentrations of benzene in Pancevo are presented in figures 72 and 73.

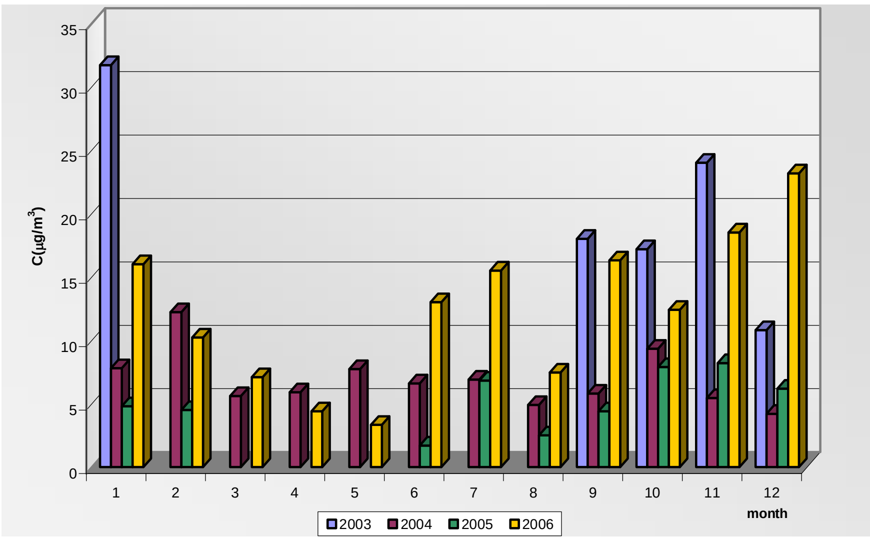


Figure 72

Monthly averages of benzene concentration (µg/m³) in Pančevo in 2003-2006

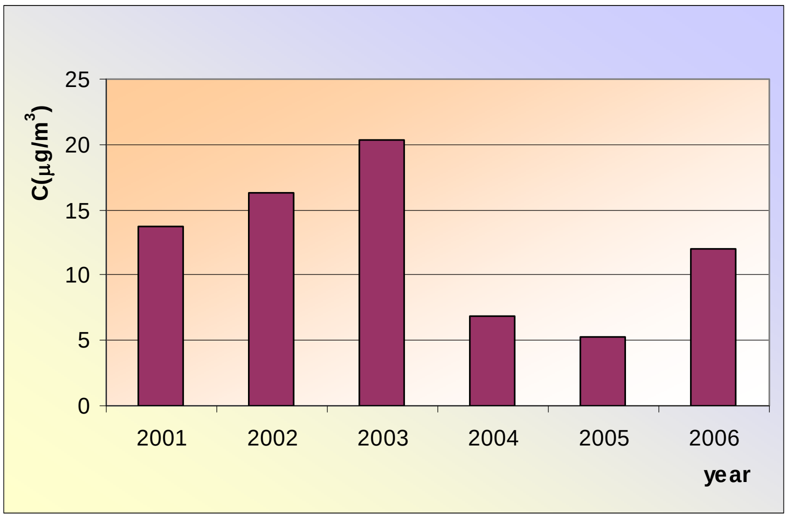


Figure 73

Annual averages of benzene concentration (µg/m³) in Pančevo in 2001-2006

Beside Pančevo, the most severely attacked cities were Novi Sad, Kragujevac and Bor. Various storage and production tanks containing toxic chemicals were damaged or destroyed. These accidents resulted in release of many hazardous chemical substances including polychlorinated biphenyls (Adamov et al, 2002).

During the conflict, several storage tanks and pipelines at *Novi Sad oil refinery* were damaged and in excess of 70,000 tonnes of crude oil and oil products reportedly burned or leaked into the wastewater collection system and the ground, causing contamination of soil and groundwater. In spite of the spills of Pyralene oils from the transformers in the Oil Refinery in Novi Sad in 1999, content of total PCBs was not significantly raised compared to the pre-war values.

Repeated bombing heavily damaged *Zastava industrial complex in Kragujevac*, especially the power plant's transformer station. Approximately 2,500 kg of PCB oil had leaked from damaged transformers.

At *the Bor mining and smelting complex*, which had also been targeted by air strikes, the UNEP identified localized PCB contamination at the site of a destroyed transformer station (UNEP, 2004).

Lead

Lead (Pb) toxicity works through interaction with different enzymes, which is why almost all organs can be considered as potential targets for lead. A wide range of biological effects has been evidenced experimentally, including effects on biosynthesis, nervous system, kidneys, reproductive organs, cardiovascular system, immune system, liver, endocrine system and gastrointestinal tract.

In assessing the risks of human exposure, lead concentration in blood is used as a reliable biomarker. The most susceptible people are young children, especially their nervous system. In this group, effects on the central nervous system, as assessed by neurobehavioral endpoints, appear to occur at blood concentrations below 200 μg/l. Consistent effects have been reported for global measures of cognitive functioning, such as psychometric IQ, to be associated with blood lead concentrations between 100 and 150 μg/l. Some epidemiological studies have indicated effects at blood lead concentrations below 100 μg/l. Based on this information and on the modelled relationship between blood lead concentrations and the long-term average concentration of lead in ambient air, the revised WHO air quality guidelines for Europe recommend that the annual average air lead concentration not exceed 0.5 $\mu g/m^3$.

The main sources of lead pollution are lead ore extraction and processing. Other sources are industrial production (lead is present as a secondary constituent in many minerals and sediments) and coal combustion (household combustion and heating, and electricity plants). Motor vehicles (alkyl-lead additives in petrol) are an important mobile source of lead released into the air in countries where leaded petrol is used. As this source is near the population and widely distributed, road traffic is a major source of exposure. Besides exposure through the air from point sources (industry), mobile sources (motor vehicles) and long-range transport of air pollution, lead sedimented on soil can also contribute to total exposure through food or through direct contact, especially in children. Another important exposure medium is paint containing lead or drinking-water delivered by lead-coated pipes.

Lead is characteristic omnipresent heavy metal that penetrates the organism by the respiratory and digestive tracts. Excessive doses of lead will cause serious disorders, primarily of blood and nervous cells. Children are especially susceptible to its harmful effects as they breathe faster and deeper. The primary source of lead contamination of air in our major cities is exhaust fumes from motor vehicles (which mostly use leaded fuels). Studies of lead contents in sedimented particles have showed permissible concentrations at all measurement sites.

Annual average of lead in sedimented particles over the 1998-2005 period is presented in Figure 74 and it shows that there was no exceedance of the annual allowable limit of 250 µg/m³.

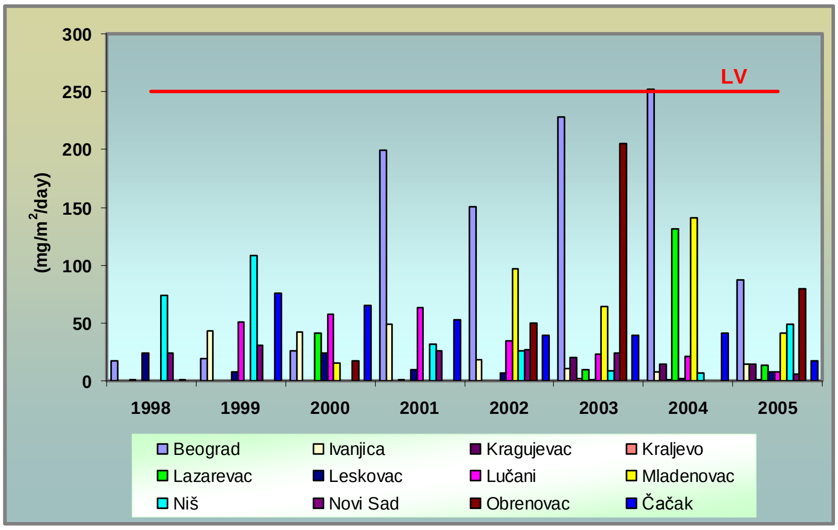


Figure 74

Annual mean lead concentration (mg/m²/day) in sedimented particles in 1995-2005.

It is noteworthy that annual average of lead, originating from exhaust fumes from motor vehicles were monitored only in Belgrade, Niš and Novi Sad. In Belgrade alone, the permitted limit for urban environs was exceeded at all of the ten measurement stations.

TROPOSPHERIC OZONE

Ozone (O_3) is a secondary photochemical pollutant formed from the precursor volatile organic compounds NOx and CO in the presence of short wavelength (λ<400nm) solar radiation. Ozone can enter the respiratory system in a body by inhalation as it is not very soluble in water. Acute exposure to high ozone concentrations can induce changes in lung functioning, airway inflammation and increased airway responsiveness to bronchoconstrictors. Ozone exposure has also been associated with an increased number of hospital admissions from respiratory diseases, including asthma. Data from field studies and controlled exposure studies have provided a basis for choosing the recommended guideline value of 120 μg/m^3 as an 8-hour mean value. Besides providing the guideline values, the updated air quality guidelines for Europe specify a risk of various health outcomes at certain exposure levels close to the guideline concentration.

Measurement data collected by the EMEP [Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (http://projects.dnmi.no/~emep/index.html) and the European Topic Centre on Air Quality indicate that this WHO air quality guideline is currently exceeded in almost every European country.

Increased concentrations of tropospheric ozone result from the rising concentrations of nitrogen dioxide in the atmosphere, and those are caused by exhaust fumes from motor vehicles, which is especially characteristic of urban environs.

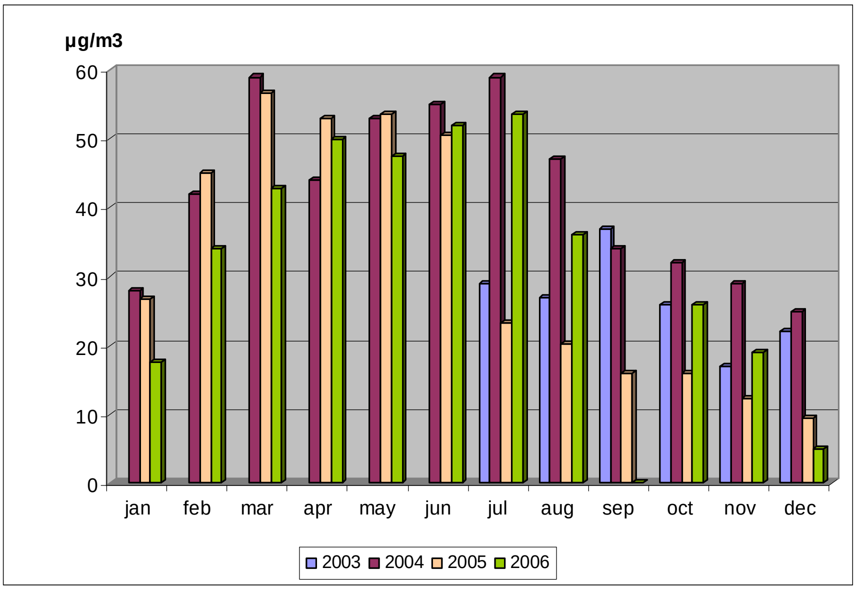


Figure 75

Monthly average concentrations of tropospheric ozone in Belgrade

The alarming limit value is a concentration whose exceedance over a brief period of exposure would cause health hazard, and it has been set at 240 μg/m^3 for an one-hour mean. The level requiring public warning is one above which more sensitive population would be exposed to risk, so that information is needed when one-hour mean exceeds 180 μg/m^3 .

Mean monthly concentrations of tropospheric ozone in 2003, 2004 and 2005, provided by the Belgrade Health Protection Institute, are presented in Figure 76 These concentrations show a typical model of ozone levels with maximums in the summer and minimums over the winter. Seasonal variation depends on many factors, including mean temperature, solar radiation, frequency of overnight temperature inversions and concentrations of OH radicals and NOx.

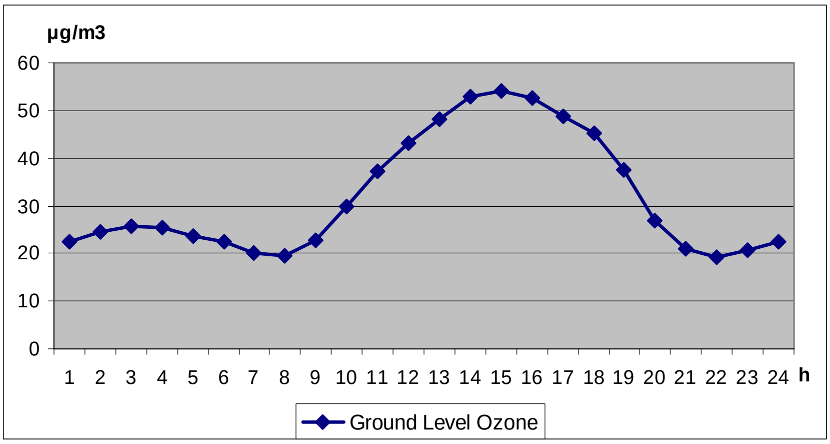


Figure 76

Daily average variation in concentrations of tropospheric ozone in Belgrade in2005

The figure clearly shows maximum concentrations of tropospheric ozone in the afternoon hours, after ozone has interacted with UV radiation and exhaust fumes from intensive afternoon traffic. The figure 77 confirms that increased NO_2 concentration is a precondition for rising tropospheric ozone concentration as the former starts chemical reaction with O_2 and decreases, while O_3 concentration simultaneously increases.

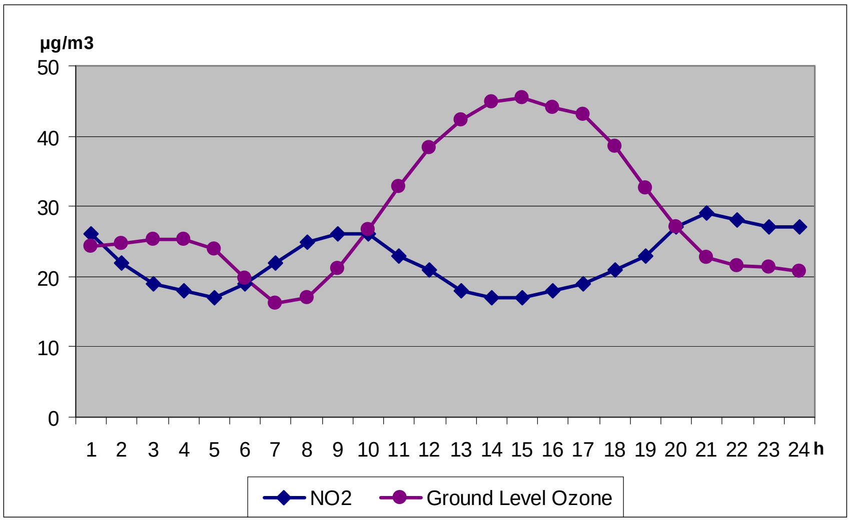


Figure 77

Daily average variations in NO_2 and tropospheric O_3 concentrations in Pančevo in 2005

The figure confirms that increased NO_2 concentration is a precondition for rising tropospheric ozone concentration as the former starts chemical reaction with O_2 and decreases, while O_3 concentration simultaneously increases.

ALLERGENIC POLLEN

Pollen is one of the major allergens in the air and easily transported to considerable distances. Due to their specific chemical composition, pollen grains cause allergic reactions (bronchitis, conjunctivitis, asthma) in great many people. Roughly, between 20 and 25% population suffer from effects of these allergens. Plant pollen may therefore be considered an air polluting material from the aspect of human health.

A number of studies have indicated a correlation between high pollen concentrations in the atmosphere and initiation of symptoms in allergic people. Allergic response sometimes occurs simultaneously as concentration of pollen grains in the air increases, or 24-48 hours after concentration of a certain pollen type has reached its peak. This late-phase response occurs because it takes some time for the body to identify allergens.

Regular monitoring of pollen concentrations in the atmosphere is very important to doctors specializing in allergic disorders both in terms of correct diagnosis and therapy adjustment. For that reason, systematic monitoring of pollen concentrations has been organized in Serbia using the method of continuous sampling defined by the International Association for Aerobiology (IAA).

Under our climate conditions, a critical period begins around February 1 (when hazelnut and alder start flowering) and terminates in early November (at the end of wormwood and ambrosia flowering). Monitoring includes identification and quantification of pollen grains of 24 species: hazelnut, alder, yew, cypress, alm, poplar, maple, willow, ash, birch, hornbeam, plane, walnut, oak, pine, hemp, grasses, linden, plantain, sorrel, nettle, amaranth, wormwood, Common Ragweed. and mulberry).

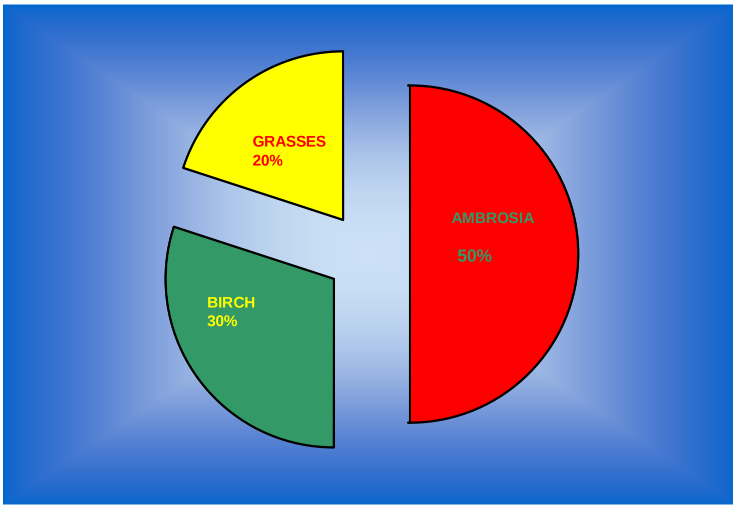


Figure 78

Percentages of allergic reactions caused by various plant species

Ambrosia artemisiifolia L. (Common Ragweed) is the most important weed allergen. Owing to its considerable adaptability, ambrosia occurs in very diverse habitats (Mitrović-Josipović, Dedijer and Karadžić, 2007). It can be described as a species favouring habitats that are moderately humid, neutrophilous, rich in nitrogen but with low amounts of organic matter, uncompacted, illuminated and very warm, and it bears well with acidified biotopes. Regarding life-form, it is a therophyte, meaning that it survives the unfavourable period of the year as a seed. It flowers from July until October.

Figure 79

Pollen grain of ambrosia (Ambrosia artemisiifolia)

Germination starts when soil is warm enough and lasts until wheat harvest, although it is sometimes found to germinate as late as end of September in uncultivated stubble fields. Regarding its biochemistry, *Ambrosia artemisiifolia* contains lactonic sesquiterpenes, flavonoids, monoterpenes and bitter flavonoids. Allergenic properties generally come from:

- chemical compounds that constitute the cytoplasm, inner intine and exine walls
- pollen grain morphology
- biological and ecophysiological properties of particular species

Permanent monitoring of pollen allergens in Serbia started in 2002. Concentration of allergenic pollen in the air depend on meteorological parameters (Figure 80)

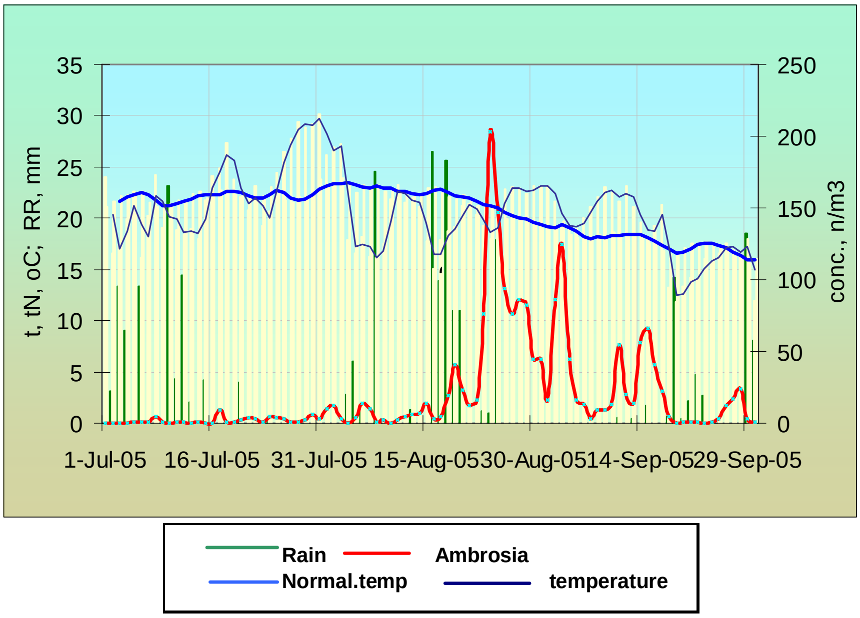


Figure 80

Seasonal variation in ambrosia pollen concentrations in Belgrade in 2005

Concentrations of ambrosia pollen in Belgrade, Novi Sad, Ruma and Subotica in 2005 are shown in Figure 81.

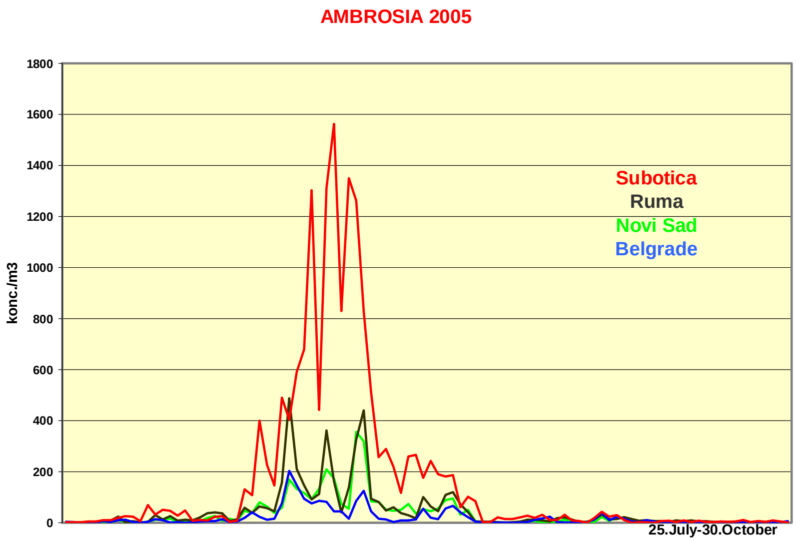


Figure 81

Concentrations of ambrosia pollen in Belgrade, Novi Sad, Ruma and Subotica in 2005

Regional phytogeographic characteristics of vegetation (presence of many aeroallergen species, strong-reaction aeroallergens, strong allergens throughout the pollination period, high concentrations and long periods of pollination) as well as local climate characteristics put Serbia in the line of countries where risk of allergic reactions is running high, especially of respiratory disorders. Over the past several years, a growing number of people have developed symptoms of allergies worldwide, and the situation is similar in this country. Apart from more admissions for allergy treatment after intensive or long exposure to inhalable allergens (pollen), there is also a growing number of patients with bronchitis, asthmatic episodes and chronic asthma.

The Ministry of Agriculture, Forestry and Water Management in 2006 adopted a decree on measures to be taken to control the weed species *Ambrosia artemisiifolia* in order to prevent damage that it causes to agricultural and forest land, construction sites and marshes.

WATER

WATER RESOURCES AND WATER QUALITY
USE OF FRESHWATER RESOURCES
BOD AND CONCENTRATION OF AMMONIUM IN RIVERS
NUTRIENTS IN FRESHWATER
BATHING WATER QUALITY
URBAN WASTEWATER TREATMENT

WATER RESOURCES AND WATER QUALITY

Water is an essential compound for life. Humans use drinking water to maintain basic metabolic functions in arid, terrestrial environment. However, humans additionally require water for use in industry, agriculture, transportation, and electrical power generation. As the world's human population and industrial activity increase, so does the need for water. Water demand that rose during last few decades created a general conclusion that the access to the water resources will be the main limiting factor for social and economic growth in the future (Baumgartner, and Reichel, 1975, UNESCO, 1978). The concept of sustainable use of fresh water resources has been established as the main tool for solving water related problems resulting from the population growth, increased need for drinking water and food, development of the industry and lack of space for the industrial and residential infrastructure.

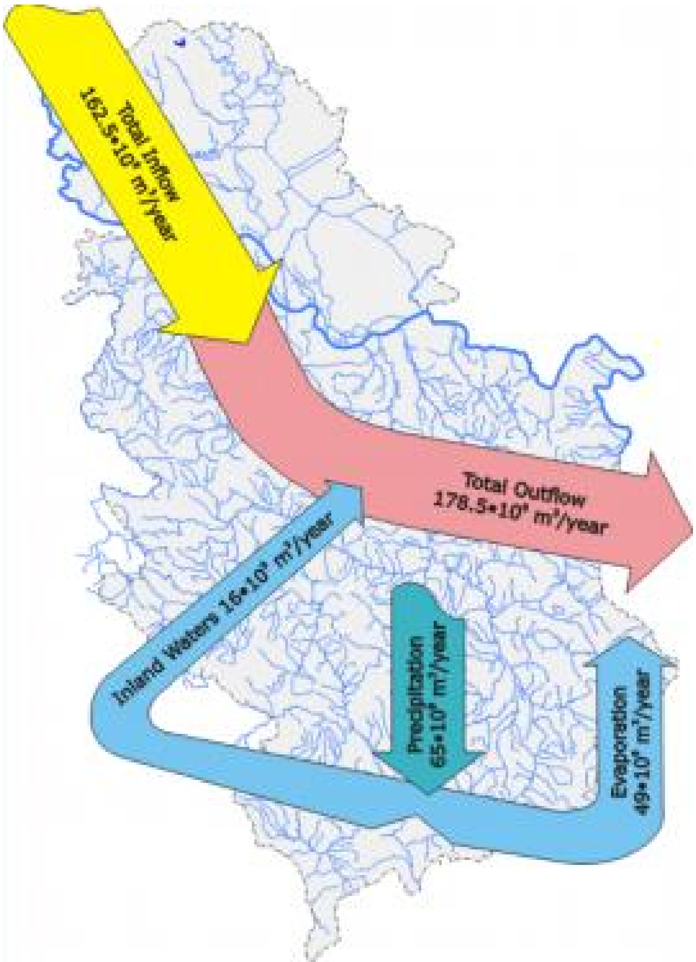


Figure 82

Average water balance for the territory of Republic of Serbia

Already established plans and strategies for water resources use and management in the Republic of Serbia are based on the concept of the sustainable development.

However, during last 15 years the overall political and economical situation was the main obstacle for strategic approach in the field of water resources. International experiences in this field reveal that the same problems appeared in all the countries where the policy implementation in the field of water resources protection strongly depended on the general state of the country development and internal social, economical and political situation. The final success of the integral water management approach can be evaluated using internationally established set of indicators that indicate the quantity and quality of available water resources. Quantity of available water depends on the natural conditions (hydrologic cycle and its conditions for particular area/region, seasonal precipitations distribution and water inflow) as well as on the anthropogenic influence (changes in water flow regime - reservoirs and use of water for irrigation).

Figure 82 shows an average water balance for the territory of Republic of Serbia. Climatic changes have a major influence on the water cycle characteristics, provoking occasional floods or droughts. The disturbed hydrological cycle can be seen as a result of deterioration of natural ecosystems - forests in the first place. In the past, these systems were the main stabilizing factor which reduced the negative influence of climatic change by absorbing a large portion of rainfall, diminishing the direct runoff while controlling evaporation and air humidity with their large transpiration area.

The territory of Serbia is drained into three seas. The entire territory of the Vojvodina Province (21,506 km2) and most parts of Central Serbia is drained by the Danube into the Black Sea, Only 2.17% of the territory of Central Serbia (or 1,215 km2) is drained by the Pčinja and Dragovištica Rivers into the Aegean Sea. Due to specific geographical position and characteristics of its relief, the territory of the Kosovo Province is drained into all three seas: 50.74 (or 5,524.61 km2) into the Black Sea; 42.85 (or 4,665 km2) into the Adriatic Sea; and 6.41 (or 697.4 km2) into the Aegean Sea. A hydrographic hub in which all three marine watersheds converge is located at the peak Drmanska Glava (1363 m a.s.l.) in the Crnoljeva Mountains above the Kosovo Basin. It represents a unique geomorphological and hydrological phenomenon not only in Serbia, but throughout Southern Europe.

Danube is most important river in Serbia (Table 2).

Table 2. Lengths of main rivers in Serbia

River	Length
Danube	588 km (total 2783 km)
Zapadna Morava	308 km (308 km)
Juzna Morava	295 km (295 km)
Ibar	272 km (272 km)
Drina	220 km (346 km)
Sava	206 km (945 km)
Timok	202 km (202 km)
Velika Morava	185 km (185 km)
Tisa	168 km (966 km)
Nisava	151 km (218 km)
Tamis	118 km (359 km)
Begej	75 km (244 km)

Water quality is determined by a set of natural processes (precipitation, geological and pedolocigal characteristics, rinsing level of mineral and organic material, level of organic production in aquatic ecosystems, etc.). The permanent development of energy production, mining, industry, agriculture and urban areas deteriorates the water quality at the local and regional level.

The most important changes in the water ecosystems resulting from an anthropogenic factor are eutrophication, acidification, pollution with organic and non-organic polluters (oil, heavy metals, pesticides, etc.) as well as increased level of radioactivity.

The enrichment of waters by inorganic plant nutrients is called *eutrophication*. This phenomenon can be caused by various sources, both artificial and natural. Eutrophication has relevant effects on water bodies: the main are algal blooming, excessive aquatic macrophyte growth and oxygen depletion. Further consequences for human activities are: the decrease of water quality, aesthetic flow and navigation water problems and extinction in some water bodies of some oxygen depending organisms or animals (OECD, 1982, EEA, 1999, 2003a).

Eutrophication is a process in which water is enriched with organic matter and/or nutrients (mineral matter - principally nitrates and phosphates that increases the production of phitoplanctons and other aquatic flora). The increased amount of biomass in water then activates the process of decomposing of organic matter which uses large amounts of dissolved oxygen. Periodic anaerobic conditions created as a result of this process can be lethal for fishes and other aquatic organisms. Another direct result of eutrophication is an enormous increase in the algae population. Their metabolic products are also toxic for both aquatic world and human population. The eutrophication of aquatic ecosystems can be natural but also provoked by human activities.

Acidification of freshwater ecosystems provided some of the earliest evidence of the damage caused by sulphur emissions. There are several causes of acidification, and various mechanisms by which it may occur (atmosphere deposits of NOx and SO_2, acid wastewater from mining and industry, draining of organic soils). Acid rain falling on water bodies has a direct effect. Environmental impacts involve aluminium acidity and reduction of pH buffering capacity that may be harmful for water biota (Cresser and Edwards, 1987). The acidification problem is insignificant in Serbia due to both favourable climate conditions and the presence of calcareous soils.

Urbanization, industrial and agricultural development led to the pollution of water ecosystems with communal waste (sewages), industrial and agricultural waste. Detergents enriched with phosphates significantly accelerate the eutrophication process of aquatic ecosystems. Point sources of pollution (discharge of urban and industrial waste water) are not the only cause of eutrophication provoked by humans. The diffuse source of pollution resulting form an extended use of fertilizers - phosphates and nitrates rinsed from the agricultural surfaces is another major source of pollution of aquatic ecosystems.

USE OF FRESHWATER RESOURCES

This indicator is presented through the Water exploitation index – WEI, which is given as an averaged annual water abstraction divided by the amount of renewable water resources at the national level, in percents.

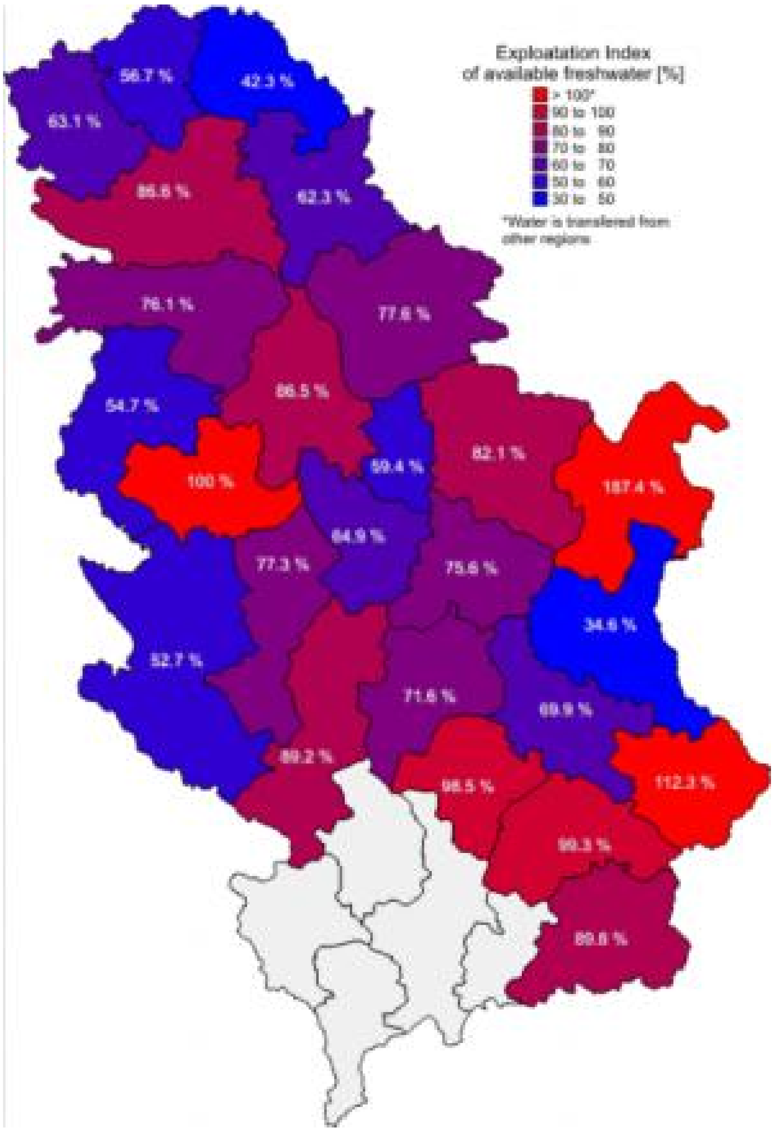


Figure 83

The relation between abstracted amount of water and capacity of already existing surface and groundwater sources as presented in the Republic of Serbia Water Resources Development Master Plan.

Monitoring of water use, performed by the various economical bodies and organizations at the national, regional and local level is one of the main resources for establishing a long term sustainable use of freshwater resources. The percentage of abstracted water in relation to the total available freshwater resources in a simple and easily understandable way indicates the pressure on water resources. At the same time, when the time series data is available, it can illustrate the change in water resources use during the observed period indicating the need of change in water resources management. The indicator can be also applied on the sub-national level, identifying the regions in the country in which the water abstraction level reaches values above the threshold defined as a sustainable limit. When combined with other water quality and quantity parameters the WEI can also give a general overview on the state of water resources, showing a possible cause for increased pressure on surface and groundwater resources.

Figure 84 shows the relation between *abstracted amount of water* and *capacity of already existing surface and groundwater sources* as presented in the Republic of Serbia Water Resources Development Master Plan.

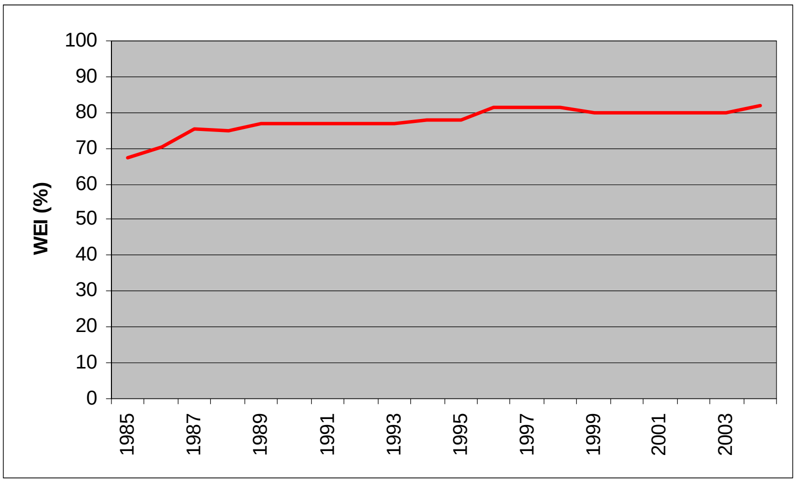


Figure 84

Average Water Exploitation Index (for drinking water resources) in Serbia

It is easy to conclude that the use of water resources varies on a regional level. In some of the regions with low level of available freshwater (Kolubarski, Toplički, Jablanički, etc.) the exploitation index reaches 100%. At the same time, data on water resources abstracted from their own sources was not included in this analysis, meaning that in some cases the realistic estimation of water exploitation index will go beyond 100 percents. At the national level the average exploitation index (for drinking water resources) steadily increases during last twenty years.

In the last decade this index varies around 80% which can be seen as an alarming value, specially having in mind that according to the EEA methodology the threshold value for extreme pressure on water resources is defined as 40%.

BIOCHEMICAL OXYGEN DEMAND AND CONCENTRATION OF AMMONIUM IN RIVERS

The indicator provides a measure of the state of rivers in terms of biodegradable organic load and ammonium. Level of oxygen concentration in water bodies expressed in BOD (biochemical oxygen demand) which is the demand for oxygen resulting from organisms that consume oxidiseable organic matter and concentrations of ammonium (NH4) in rivers.

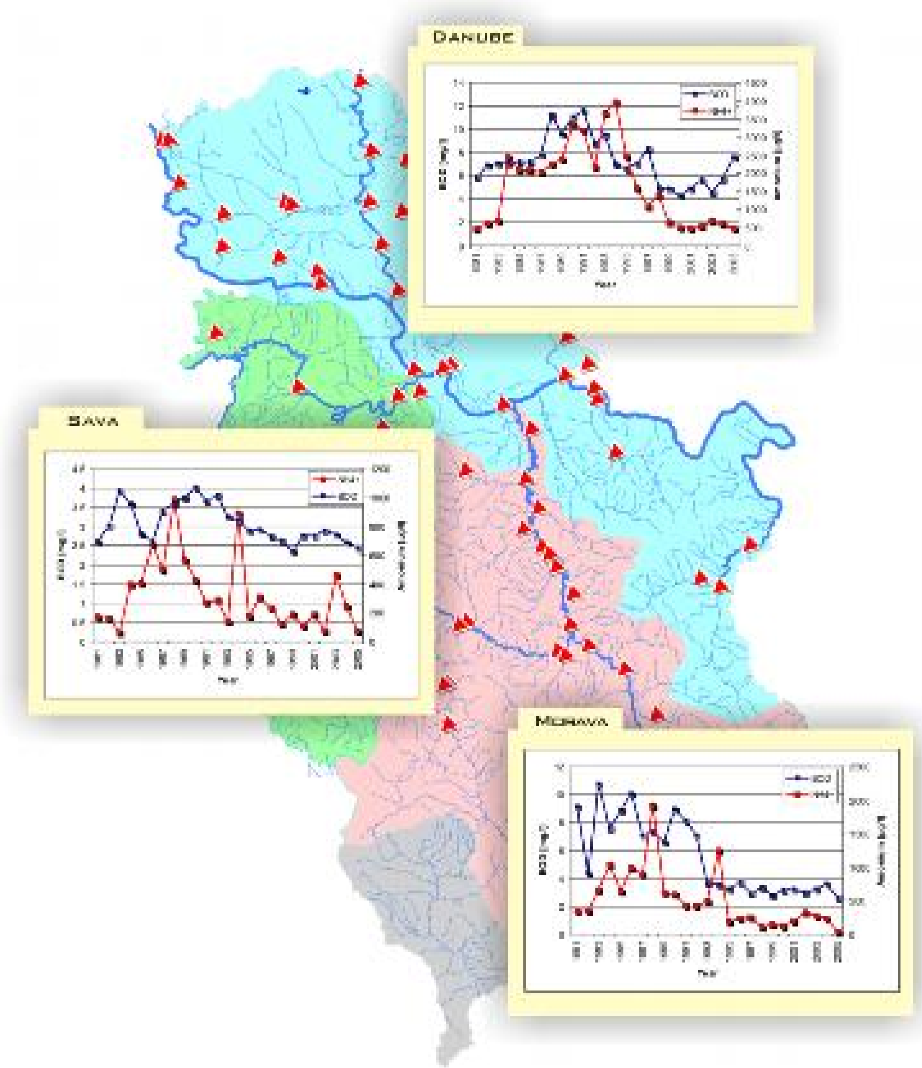


Figure 85

Average values of BOD and ammonium concentration for three main catchments in Serbia

Large quantities of organic matter (microbes and decaying organic waste) can reduce the chemical and biological quality of river water and result in impaired biodiversity of aquatic communities and microbiological contamination that can affect the quality of drinking and bathing water. Sources of organic matter include discharges from wastewater treatment plants, industrial effluents and agricultural run-off. Organic pollution leads to higher rates of metabolic processes that demand oxygen. This could result in the lack of oxygen (anaerobic conditions). The transformation of nitrogen into reduced forms under anaerobic conditions in turn leads to increased concentrations of ammonium, which is toxic to aquatic life above certain concentrations, depending on water temperature, salinity and pH.

The charts with time series of averaged BOD and concentrations of ammonium for three main catchments in Republic of Serbia are presented in Fig 85. State of the rivers in sense of BOD at the catchments of Sava River (with sub-catchments of Drina and Kolubara rivers) and Morava (Velika Morava, Južna Morava, Zapadna Morava) has a positive trend within last 25 years. It is clear that the economical crisis during the last decade of the twentieth century had a positive impact on the overall state of water resources. At both catchments the BOD values are steadily within the II class of water quality (<4 mg/l) with a stagnating trend during last ten years. Average concentrations of ammonium also have a stabile trend within the observed period (1980-2005). Except during few episodes in the nineties the average value stabilized around 500 µg/l NH4, value that classified these rivers and catchments within the I and II class of water quality (according to the current law on water).

At the catchment of Danube River (Danube, Tisa and smaller tributaries in province of Vojvodina and in the eastern Serbia) it is easy to conclude that the state of water resources deteriorates during last couple of years with the increasing trend of BOD, reaching values from the middle of eighties of last century. The averaged BOD valued during the period 1997-2002 classified this catchment in the III class of water quality while the value for the last year for which the data is included in this report (2005) is in the domain of IV class of quality. The main reason for such deterioration can be found in possible increase of waste water discharge in the upper parts of the catchment. When evaluated using the concentration of ammonium, during last seven years the rivers at the catchment of Danube were classified within I or II class of water quality, an obvious improvement from the period before 1997 when the concentration of ammonium reached very high values, even the levels of 4000 µg/l.

NUTRIENTS IN FRESHWATER

The indicator provides a measure of the state of freshwater (rivers, lakes and groundwater) in terms of nutrient concentration through the measurements of concentrations of phosphates and nitrates in rivers, total phosphorus and nitrate in lakes and nitrate in groundwater.

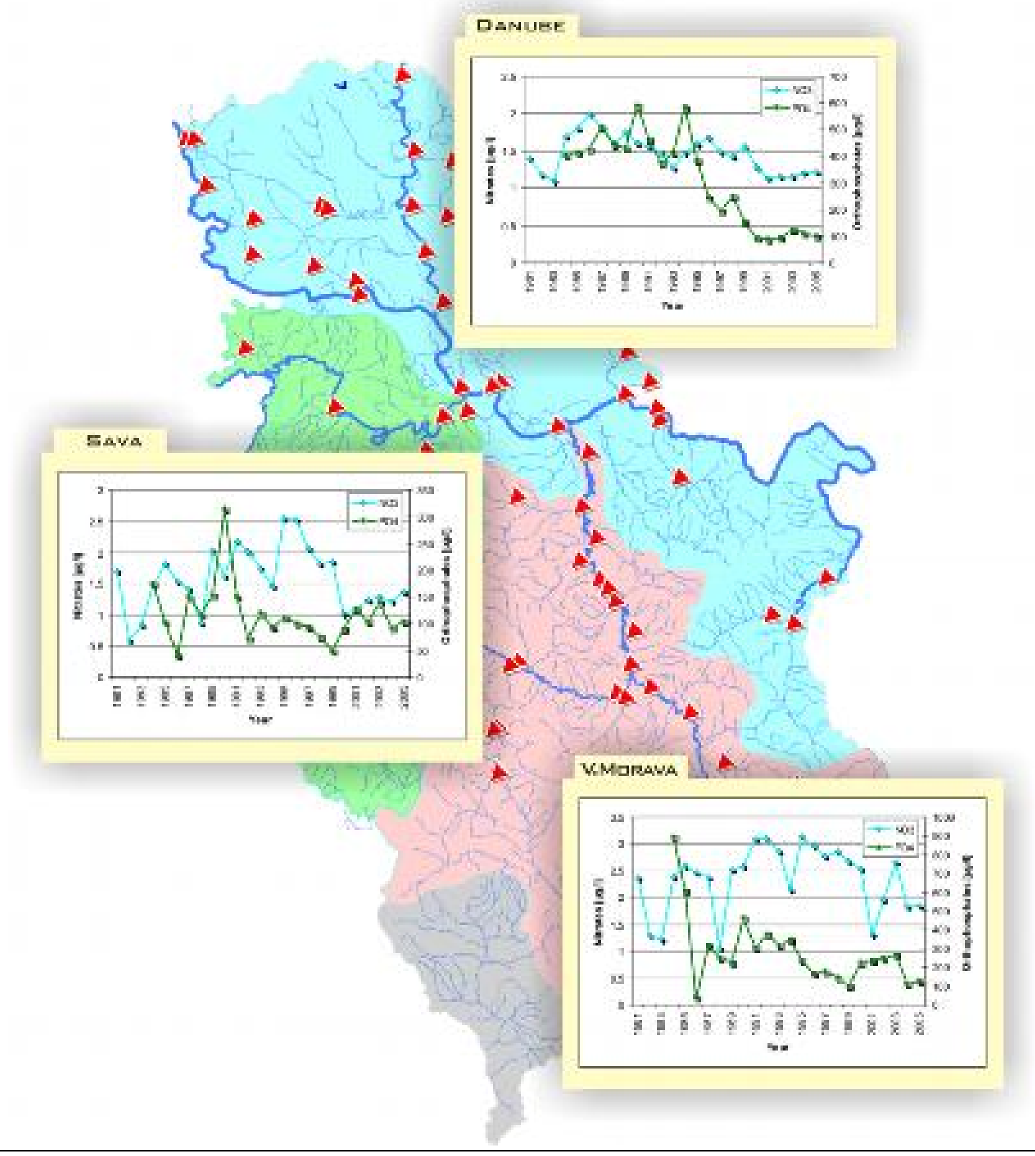


Figure 86

Average concentration of orthophosphates and nitrates in the rivers at the three main catchments in Republic of Serbia

Large inputs of nutrients to freshwater bodies from urban areas, industry and agricultural areas can lead to eutrophication of water bodies. This causes ecological changes that can result in a loss of plant and fish species (reduction in ecological status) and have negative impacts on the use of water for human consumption and other purposes.

The indicator can be used to illustrate current geographical variations in nutrient concentrations and long-term trends. Environmental quality of surface waters with respect to eutrophication and nutrient concentrations is an objective of several documents: The Drinking Water Directive, The Surface Water for Drinking Directive, The Nitrates Directive, The Urban Waste Water Treatment Directive.

The upper picture shows the averaged concentrations of orthophosphates and nitrates for the rivers at the three main catchments in Republic of Serbia (Danube, Sava and Morava) while the picture on the left displays the level of nutrients in the lakes (total phosphorus and nitrate).

The amount of nitrates varies during the observed period with a trend of slight decrease and stabilization in the range between 1.5 and 2 mg/l for rivers and around 0.5 mg/l for lakes.

The level of orthophosphates in rivers also has a decreasing tendency comparing to the period before the year 1995. When compared to the European standards in this field, the averaged values of total phosphorus and orthophosphates for lakes in Serbia are within requested range for these parameters (recommended value of 400 μg/l).

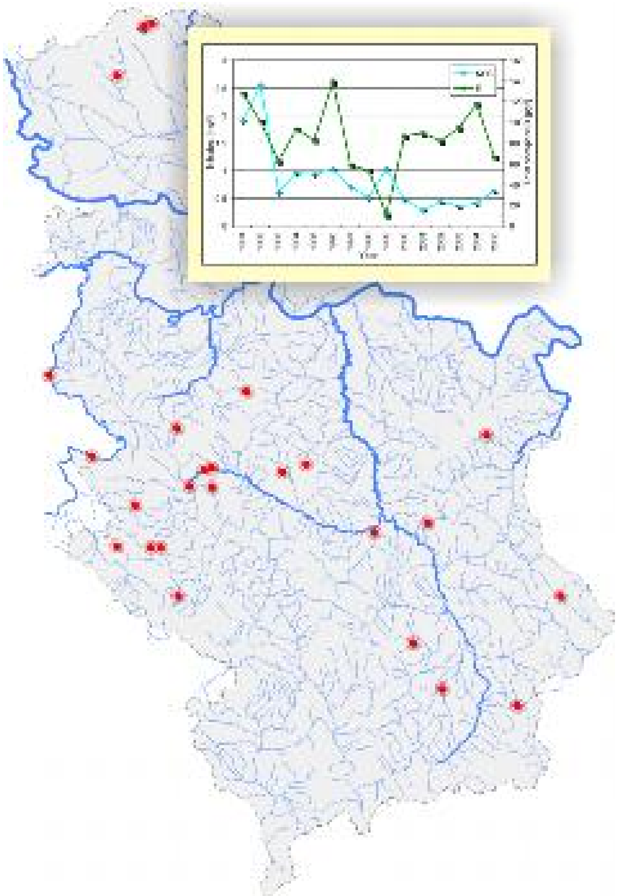


Figure 87

Average concentration of total phosphorus and nitrates in lakes

BATHING WATER QUALITY

The indicator describes the changes over time in the quality of designated bathing waters (inland and marine) in EU Member States in terms of compliance with standards for microbiological parameters (total coliforms and faecal coliforms) and physicochemical parameters (mineral oils, surface-active substances and phenols) introduced by the EU Bathing Water Directive (76/160/EEC).

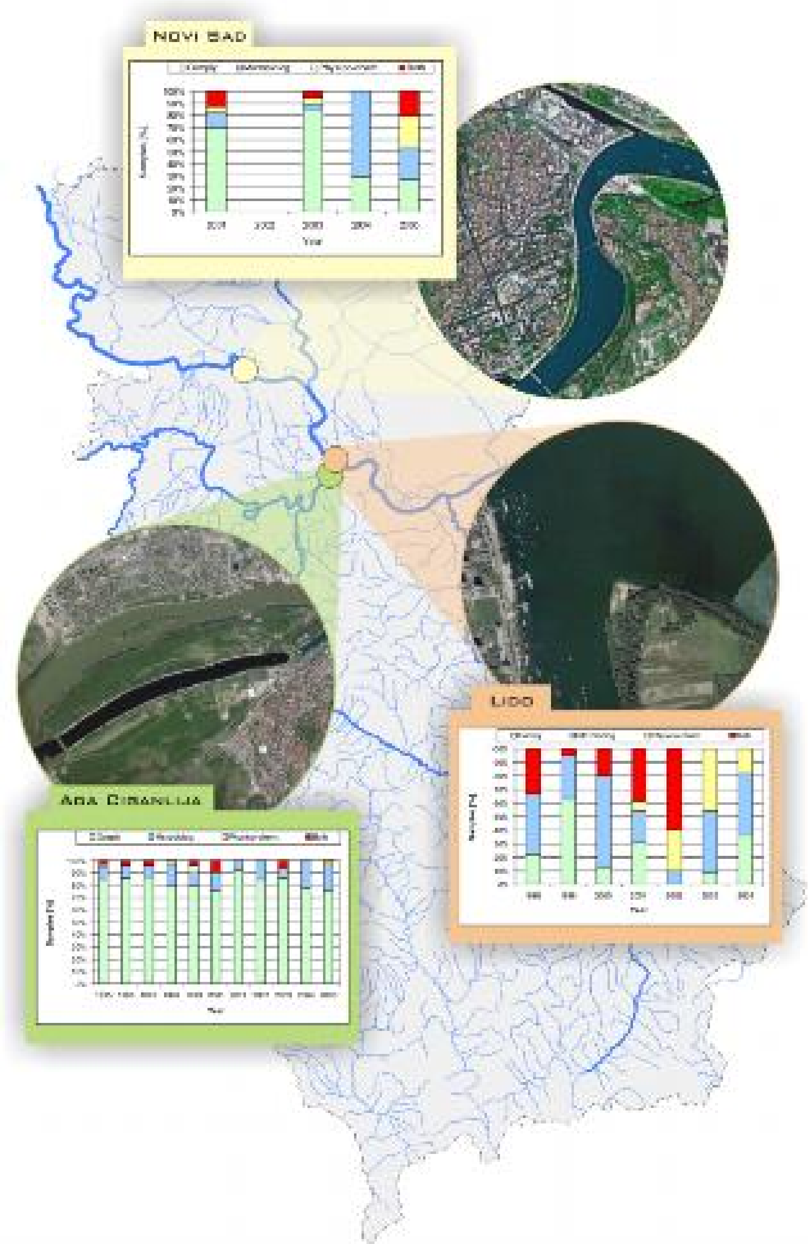


Figure 88

Bathing water quality in Belgrade and Novi Sad

The Bathing Water Directive (76/160/EEC) was designed to protect the public from accidental and chronic pollution incidents, which could cause illness from recreational water use. Examining compliance with the directive therefore indicates the status of bathing water quality in terms of public health and also the effectiveness of the directive

The Bathing Water Directive is one of the oldest pieces of environmental legislation in Europe and data on compliance goes back to the 1970s. Under the directive Member States are required to designate coastal and inland bathing waters and to monitor the quality of the water throughout the bathing season. The directive sets both minimum standards (mandatory) and optimum standards (guide). For compliance with the directive, 95% of the samples must comply with the mandatory standards. To be classified as achieving guide values, 80% of the samples must comply with the total and faecal coliform standards and 90% with the standards for the other parameters.

As a result of the control of the bathing water quality it is possible to propose and to take measures that will lead to the better quality of surface water, to the protection of the environment an after all to the protection of health of bathing facilities users. Sampling, microbiological, physical and chemical analysis and reporting on bathing water quality in the area of two largest cities in Republic of Serbia, Belgrade and Novi Sad is performed by the Health Protection Institutes in both cities according to the current legislative.

Control of bathing water quality in Belgrade's area is performed for two main bathing facilities - Ada Ciganlija on the Sava River and Veliko Ratno Ostrvo on the Danube River having a main objective to protect health of public users of these facilities. At the same time, the control of the Savsko Lake (Ada Ciganlija) also aims the protection of one of the main resources of drinking water for the capital of Serbia. During the bathing season (June - September) the Savsko Lake has about 150000 daily visitors, reaching 200000 during the weekends. The other bathing facility on Danube River, Lido, has about 10000 daily visitors due to the limited area available at the beach and its surroundings. The results of performed analysis show that the Savsko Lake has a decreasing level of water quality in sense of microbiological aspects while the physical and chemical quality remains stable during the observed period (2000-2005). The overall situation puts pressure on the sanitation issues while the water abstraction for drinking water production is still not endangered. On the other hand the water quality at the second Belgrade's main bathing facility strongly depends on the hydrological and meteorological conditions and industrial activities in the municipality of Zemun especially because the sewerage system discharge point is upstream of the bathing facility. The results of analysis show the increased health risk because of the permanent presence of faecal bacteria during the observed period.

Bathing facilities around city of Novi Sad have several thousands of daily visitors. Water quality analysis made in these areas through monitoring of microbiological and physico-chemical parameters during the pervious three years classified the water quality of Danube River bellow the requested II class of water quality.

Different sanitary measures have to be undertaken aiming improvement of water quality in above mentioned areas. In case of Savsko Lake the most important is to provide conditions for permanent water flow through the lake during the bathing season. Lido bathing facility requires different measures, solving of problem of upstream waste water discharges above all. For facilities around city of Novi Sad it is necessary to create a cadastre of upstream polluters that will lead to the implementation of already existing legislative measures on the main polluters in the area.

URBAN WASTE WATER TREATMENT

Percentage of population connected to primary, secondary and tertiary wastewater treatment plants. The indicator illustrates: changes in wastewater treatment in the regions of Europe since the 1980s, conformity (in terms of providing tertiary treatment) by Member States with the requirement to provide stringent treatment for agglomerations with population equivalent (p.e.) more than 10 000 that discharge into sensitive areas, levels of urban wastewater treatment in large cities (>150 000 p.e.) in the European Union.

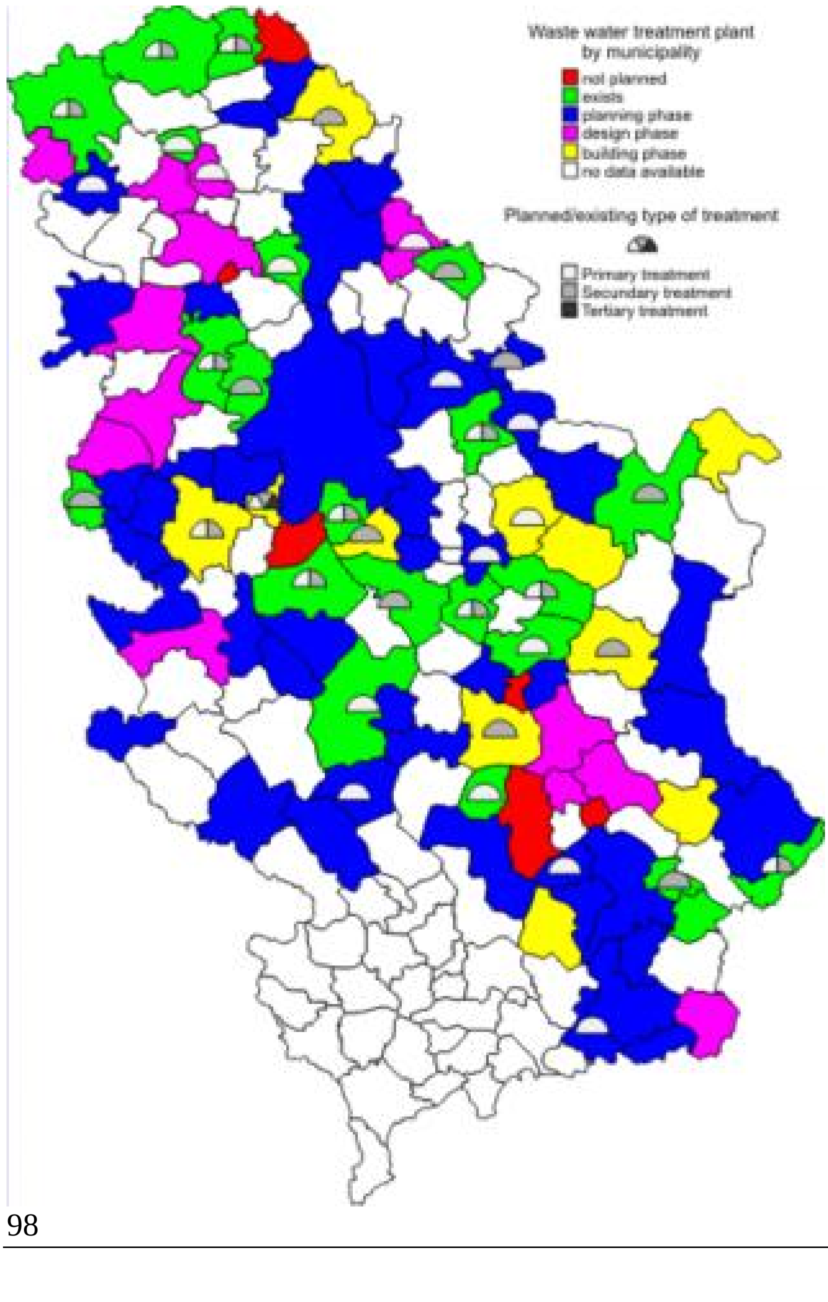


Figure 89

Wastewater treatments in Serbia

Wastewater from households and industry represents a significant pressure on the water environment because of the loads of organic matter and nutrients as well as hazardous substances. With high levels of the population in EEA member countries living in urban agglomerations, a significant fraction of wastewater is collected by sewers connected to public wastewater treatment plants. The level of treatment before discharge and the sensitivity of the receiving waters determine the scale of impacts on aquatic ecosystems. The types of treatments and conformity with the directive are seen as proxy indicators for the level of purification and the potential improvement of the water environment. Primary (mechanical) treatment removes part of the suspended solids, while secondary (biological) treatment uses aerobic or anaerobic micro-organisms to decompose most of the organic matter and retain some of the nutrients (around 20 - 30 %). Tertiary (advanced) treatment removes the organic matter even more efficiently. It generally includes phosphorus retention and in some cases nitrogen removal. Primary treatment alone removes no ammonium whereas secondary (biological) treatment removes around 75 %. The indicator tracks the success of policies to reduce pollution from wastewater by describing the trends in the percentage of the population connected to public wastewater treatment plants with different levels of purification.

In most European cities the percentage of households connected to the sewerage system varies around 95% while in Belgrade this number reaches only 85%. At the national level these indicators show even worse situation, for example in Province of Vojvodina the same indicator is around 45% while in the central Serbia it goes even lower, around 37% of population is connected to the sewerage system. The picture above displays the current situation in the field of waste water treatment showing regions with already existing waste water treatment plants combined with those for which there is an existing plan for building such plants (the type of existing/planned type of treatment included).

The results of analysis performed within the project „Global Waste Water Study in Serbia & Pre-feasibility Study for Belgrade Waste Water Management“ show that about 75% of total urban population in Serbia is connected to the public sewerage system while the percentage of rural population connected to such a system remains very low, at the value of about 9%. Only three urban municipalities have a rate higher of 75% - Kragujevac, Novi Sad and Sremski Karlovci, while for 16 local communities this value varies between 50 and 75%. Percentage of urban population connected to the sewerage system in municipalities of Bor, Čačak, Kragujevac, Kruševac, Niš and Novi Sad goes above 90%. Agglomerations with the population smaller then 25000 are usually equipped with the general sewerage system while the municipalities with 25000 to 250000 citizens have a separate storm sewerage system. The city of Novi Sad on the other hand has only one sewerage system while in Belgrade there are both of them with 50% share. In general, the municipalities covered in this study have about 7200 km of sewerage network thus giving a specific length of 2.3m per capita.

According to the survey, there are 19 municipalities in Republic of Serbia with wastewater treatment plants - 14 with biological treatment and 5 with mechanical treatment. Concerning the rest of Serbia, only seven local municipalities already started to build such a plant (6 with biological treatment) while 11 municipalities reported that they are planning the construction in the near future.

The situation looks even worse when we analyze the number of wastewater treatment plants through the population connected to such a system. Namely, only 16% of population in Serbia is connected to the wastewater treatment plant. Taking in account all the municipalities covered in this survey, only 62% of them are planning to build such a system.

This project didn't cover the industrial wastewater. In many cases, especially when the industrial objects are situated within urban areas the industrial wastewater is discharged directly to the local sewerage system without any previous treatment. Larger industrial zones outside of the urban areas usually discharge their wastewater directly to the recipient (river) without any kind of treatment. It is estimated that direct discharge of industrial wastewater reaches a value of 730 millions of cubic meters per year.

SOIL

ECOLOGICAL AND ECONOMIC VALUES OF SOIL
LAND USE IN SERBIA
SOIL CLASSIFICATION AND MAPPING
MONITORING OF SOIL FERTILITY
SOIL CONTAMINATION
SOIL EROSION

ECOLOGICAL AND ECONOMIC VALUES OF SOIL

Soil is a complex and unconsolidated mixture of weathered rocks and minerals, organic matter, water, and air in varying proportions. Soil genesis is continuous process that is determined by chemical composition of parent material (rocks and minerals), climate, orography, vegetation, macro and microorganisms. Parent material specifies the initial state for soil development, climate and organisms determine the rate at which (bio)chemical reactions occur in the soil, and time measures the extent to which a reaction will have proceeded (Jenny, 1980). As a consequence of different intensities of soil-forming processes, multiple layers (soil horizons) differ in depth, texture (from coarse sand to fine clay), organic matter content and chemical composition. Since formation of soil is extremely slow process, soil may be considered as *partialy renewable resource.* Soils have regional patterns, and also differ substantially over short distances.

Weathering of rocks and minerals result in formation of clay particles with a mean diameter less than 2 micrometers, and consequently significant increase of surface/volume ratio of soil. Clay particles are able to retain ions from solution and in exchange process to release ions held at their surface. Moreover, degradation of complex organic compounds results in relatively fast *mineralization* of proteins, fats and low molecular weight hydrocarbons, and *humification* or formation of humus, a relatively stable acid organic compounds of non-constant molecular weight, which involve fulvic acids, humic acids and humins (Flegman and George, 1975). Humus additionally increases water and ion retention capacity of soils. Soil is main pool of mineral nutrients and water that are essential for plant growth. Due to high water storage capacity, soil prevents sudden flooding. Moreover, soil is the most important compartment of ecosystems for filtering and buffering of contaminants.

Agriculture necessarily lowers soil fertility (soil ability to support plant growth) by removing soil nutrients incorporated in the harvested crops. Excessive cropping or grazing can depress soil-nutrient levels and degrade soil structure. Exposure of soils to wind and rain during cultivation encourages erosion of the fertile surface. Soil erosion is a natural process, occurring over geological time, and indeed it is a process that is essential for soil formation (Kirkby et al, 2004). However, human activities (deforestation, agricultural depletion soil nutrients, urban conversion, irrigation, pollution) accelerated natural rate of erosion.

Artificial fertilisation in agriculture contributes to higher yields but it leads to *eutrophication* of aquatic ecosystems. A balance therefore needs to be found for an optimal use of artificial fertilisers.

Mismanagement of soils may lead to *chemical, physical and biological deterioration* of soil. Deteriorating chemical properties of soil include loss of nutrients, soil contamination, acidification and salinisation.

Soil *acidification* inhibits absorption of phosphate ions, increases solubility of toxic ions of manganese, iron and aluminium, and at the same time decreases the rate of humification (Flegman and George, 1975, Kojić, Popović and Karadžić, 1997). These harmful effects significantly decrease the level of primary production.

Soil *salinisation* is a process of accumulation of readily soluble salts in parts of soil profiles. Inadequate irrigation may speed up salinisation, a process that is more evident in Vojvodina than in any other part of this country.

LAND USE IN SERBIA

Serbia has 5,113,307 ha of agricultural land, which is 66% of its total area (Figure 90). Arable land and gardens dominate as a category with by far the greatest areas under agricultural production (3,343,916 ha or 65.4%). In the territory of Central Serbia, of the total agricultural area of 3,321,148 ha, arable land and gardens account for 1,762,094 ha and these amounts to 53.1%, while in the territory of Vojvodina, out of 1,792,159 ha of agricultural area, arable land and gardens account for 1,581,822 ha (88,3%).

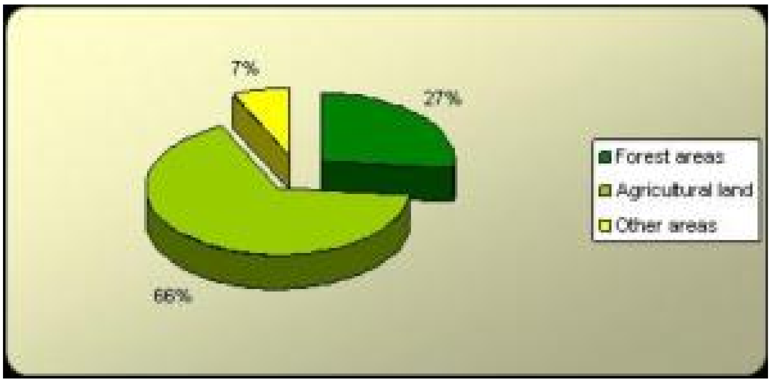


Figure 90

Land use in Serbia

As for agricultural utilization of soils, the potential of Serbian soils is classified into 8 classes, where the first 4 classes are higher-quality soils and classes 5-8 cover soils mainly unfit for agriculture (Table 3). As for the whole of Serbia, the distribution of arable and non-arable land is almost identical. Intensive agricultural production is least restricted in Vojvodina and most restricted in Kosovo and Metohija. The latter territory, similar to that of central Serbia, has a wide range of natural fertility in narrow geomorphological units.

Table 3. Land quality classes in Serbia

Soil class	km^2	%
1	11,650	14.4
2	9,357	11.6
3	10,522	13.0
4	8,682	10.8
Arable	40,211	49.8
5	11,073	13.7
6	20,144	25.0
7	8,069	10.0
8	1,178	1.5
Non-arable	40,464	50.2
Productive	80,675	91.3
Infertile	7,686	8.70
Total	88,361	100

Soil Classification and Mapping

Classification and cartography in Serbia has passed through different phases of development. The first classification of soils of the Kingdom of Yugoslavia, was prepared by Stebut (1927). Other classifications, based on the genetic principles, were published subsequently: Neugebauer et al., 1963, Filipovski et al., 1964.

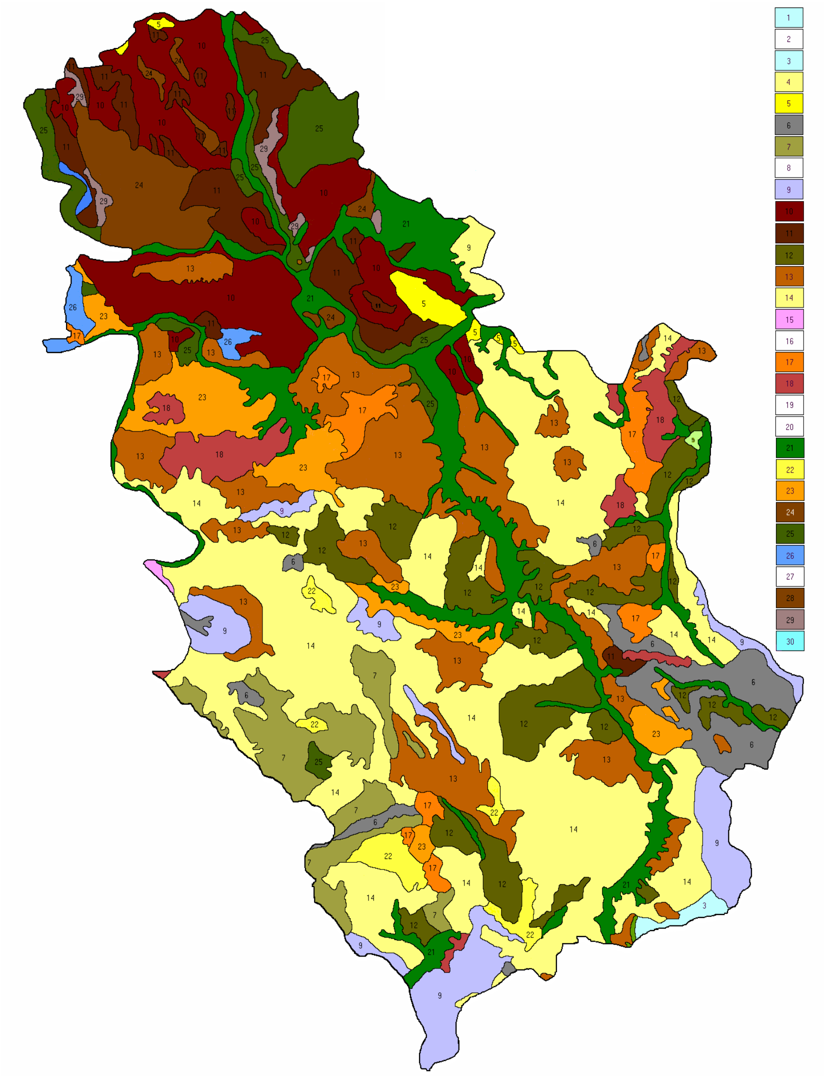


Figure 91

Soil map of Serbia (1:2,000,000)

1. Karst (rocky soil) with spots of terra rossa, brown soil and lithosol 2. Lithosols and eutric cambisol 3. Lithosols on acid rocks and rankers 4. Regosols, rendzinas and eutric cambisols 5. Arenosols and Eutric cambisol on sand 6. Lime dolomite black soisl, lithosols and rendzinas 7. Lime dolomite black soils, cambisols and terra rossa 8. Rendzinas and regosols 9. Rankers and district cambisols 10. Chernozem on loess 11. Chernozem and chernozem-semigley soil 12.Smonitzas 13. Eutric cambisol 14. District cambisols, luvisols and calcocambisols 15. Cambisols, luvisols and calcomelanosols 16. Terra rossa (ilimerized) and calcocambisols 17. Luvisols and eutric cambisols 18. Luvisols 19. Pseudogley soils and rendzinas 20. Acric soil and cambisols on limestone 21. Fluvisols and eugleys 22. Pseudogleys 23. Pseudogleys and ilimerized pseudogley soils 24. Chernozem-semigley soil 25. Humogleys 26. Gley and semigley soils 27. Eugleys 28. Histosols 29. Halomorphic soils

In order to facilitate international communication, the national system of soil classification in Yugoslavia was adapted to the international classification valid at that time in Europe (Škorić et al., 1973; 1985). That classification is still accepted and in use in Serbia, but unfortunately it does not completely correspond to WRB criteria. The first two soil maps of Kingdom of Yugoslavia, at the scale 1:3,500,000 and 1:1,200,000, were compiled by Stebut (1926; 1931). During the period from the late 1970s to mid 1980s, soil mapping in Yugoslavia was intensively conducted resulting in:

- The soil map of Yugoslavia (in a scale 1:1,000,000);
- The soil map of the Vojvodina Province (1:100,000);
- The soil map of Yugoslavia (1:50,000).

Figure 91 shows the soil map of Serbia (1:2,000,000), which was made on the basis of the classification of soils of Yugoslavia (Škorić et al., 1985), by reducing and generalizing the existing soil maps prepared in larger scales.

Proportion of different soil types in Serbia is represented in Table 4,

Table 4. Soil types in Serbia

Soil type	Area (ha)
Lithosol	107.000
Aeolian sands (Arenosol)	86,000
Rendzinas	~ 527,000
Black earth on limestone (Calcomelanosol)	~ 155,000
Humus-siliceous soil (Ranker)	572,000
Chernozem (Phaeozem)	1,200,000
Smonitza (Vertisol)	780,000
Brown soil on limestone (Calcocambisol)	~ 350,000
Eutric brown, typical- brown forest soil (Eutric Cambisol)	560,000
Dystric Cambisol	~ 2,280,000
Illimerised soil (Luvisol)	~510,000
Pseudogley (Planosol)	538,000
Podzol	~ 17,000
Alluvial soil (Fluvisol), Meadow soil (Humofluvisol), Hydromorphic black earth and Marsh-gley (Humogley, Eugley)	~ 760,000
Solonchak and Solonetz	233,000
Peaty soil (Histosol)	~ 3,000
Deposol	~ 50,000

Digitalized soil maps

At present, there is no digital soil map of the whole country; only the soil map of Vojvodina (Figure 92) has been digitalized (Benka and Salvai, 2006).

The basis for constructing the soil map was the Soil Map of Vojvodina published by the Institute of Agricultural Research in Novi Sad in 1971. The map is made in a scale 1:50,000, and the Vojvodina territory is presented on 60 sheets.

The potential application would be the possibility of constructing thematic maps showing the spread of particular parameters related to soil types. In the combination with other GIS layers it is possible to obtain new layers that are the result of the intersection or difference of these layers connected to the corresponding databases.

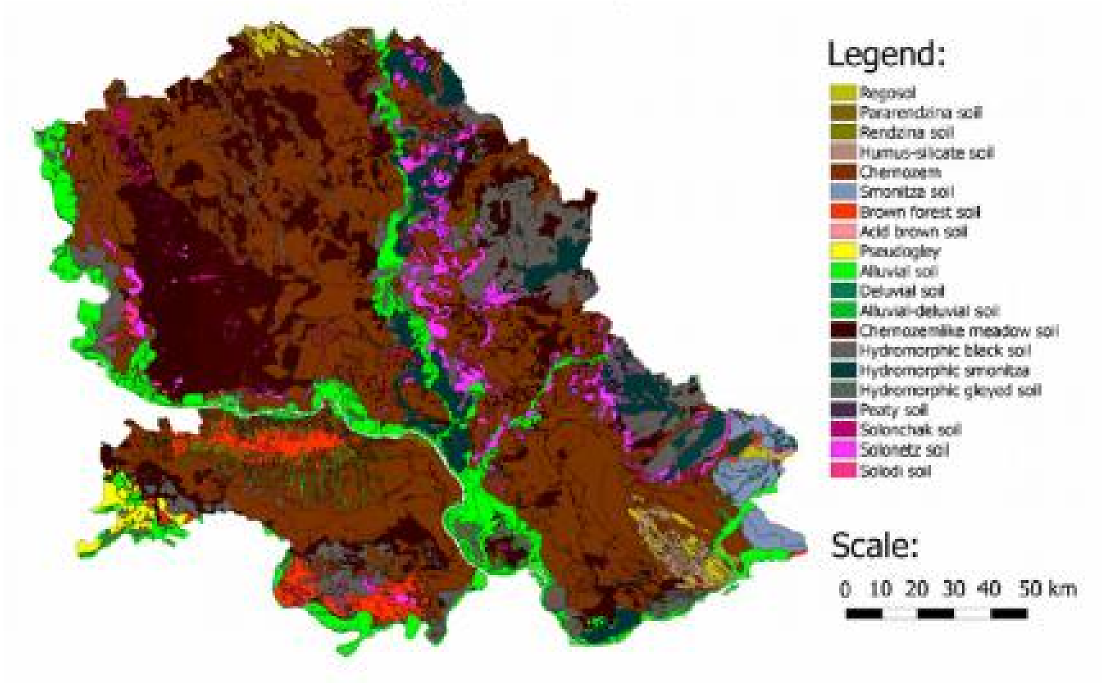


Figure 92

The soil map of Vojvodina based on classical map in scale 1:50,000 (Benka and Salvai, 2006).

MONITORING OF SOIL FERTILITY

Serbia lacks monitoring and integrated soil information system. The state of soil in Serbia has been surveyed through different researches and projects which are implemented in some parts of the country.

The Project "Control of soil fertility and determination of harmful and hazardous substances in soil on the territory of the Republic of Serbia" was carried out on the entire territory of Vojvodina (1.6 mill ha; 1600 samples) in 1993, and in parts of central Serbia in 1997. The implementation of the project was divided mainly between the Institute of Soil Science, Belgrade and Institute of Field and Vegetable Crops, Novi Sad. In 2003, soil monitoring continued in central and western Serbia on another 250 000 ha. Georeferenced soil samples were collected from every 1000 ha (10 km^2), in a grid pattern with precisely determined coordinates. One composite sample, which presents an average sample of 25 soil samples from the depth of 0-30 cm was taken at each location.

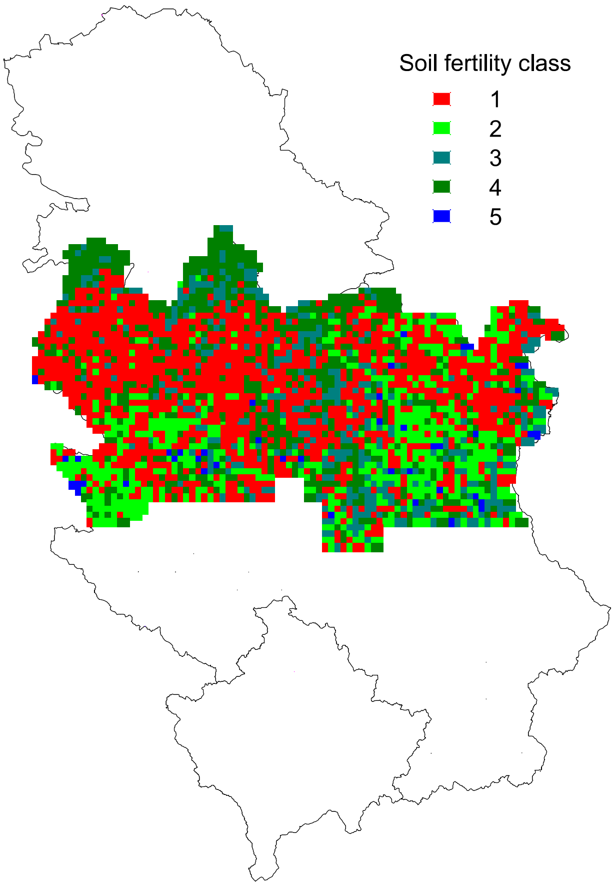


Figure 93

Soil fertility classes in Central Serbia

The program included determination of:

- Acidity (pH_{kcl} in soil), carbonates ($CaCO_3$), quantity of humus and presence of phosphorus and potassium in soil which are easily accessible to plants;
- Microbiological activity of soil (total number of bacteria, dehydrogenic activity of soil, the number of ammonificators, free nitrogen-fixing bacteria, azotobacteria, fungi and actinomycetes);
- Heavy metals and micro-elements concentration (As, B, Cd, Cr, Cu, F, Hg, Ni, Pb, Zn);
- Remains of 17 active ingredients of pesticides in soil (4,4 DDD, 4,4 DDE, 4,4 DDT, Aldrin, alfa HCH, beta HCH, Lindan (gamma HCH), Diazinon, Dieldrin, Endrin, Endrin aldehyde, Heptachlor epoxide, Alachlor, Atrazin, Prometryne, Sinazine, Terbutryn).

Control of the *contents of nutrients (P_2O_5, K_2O), humus and carbonates, and soil acidity* (pH_{KCl}) indicated an unsatisfactory condition regarding soil fertility in Central Serbia. The low fertile soils, with increased acidity, low concentration of easily accessible phosphorus and potassium and smaller quantity of humus include: Eutric Cambisol and Luvisol in Central Sumadia, also partially present in the Kolubara basin where Eutric Planosol dominates whereas Cromic Luvisol, Eutric Planosol and Dystric Cambisol on different substrata dominate in the eastern Serbia.

Soils with increased acidity, low participation of available forms of P and (slightly less of) K, and decreased humus content were found in eutric cambisol illimerised and illimerised soils (luvisol) in central parts of the Šumadija region, in pseudogley soils of the Kolubara basin, as well as illimerised soil and illimerised eutric cambisol to some extent, while acid soils in eastern Serbia mostly occur in illimerised acid soils, pseudogleys and dystric brown soils formed upon different parent materials. The most fertile soils (fertility classes 3 and 4) are located in Mačva, southern Srem, Stig and Velika Morava valley.

Results of the Project indicate that food production can develop with no high degree risks in approximately 93% of researched areas of Serbia. In 13% of researched areas, food production should be organized with a reduced risk (the choice of cultures) and/or periodical /permanent inspections of soil quality and plants along with appropriate agritechnical measures which would cause preventive reduction of potential as well as real risk in the first place.

The research of microbiological characteristics shows that certain parameters have extremely irregular distribution in comparison to the observed data base. It was observed that fungi presence in soil is far more stable than dehydrogenic activity.

No great deviation was observed in the remains of 17 pesticides on soil. The occurrence of DDT and its metabolites and Lindan gHCH is connected to their use in forest protection whereas slightly higher values of the remains of triazine active ingredient were observed in the soils used in farming. According to the recent findings there is no soil pollution from the group of analyzed pesticides remains in almost 99% of examined samples.

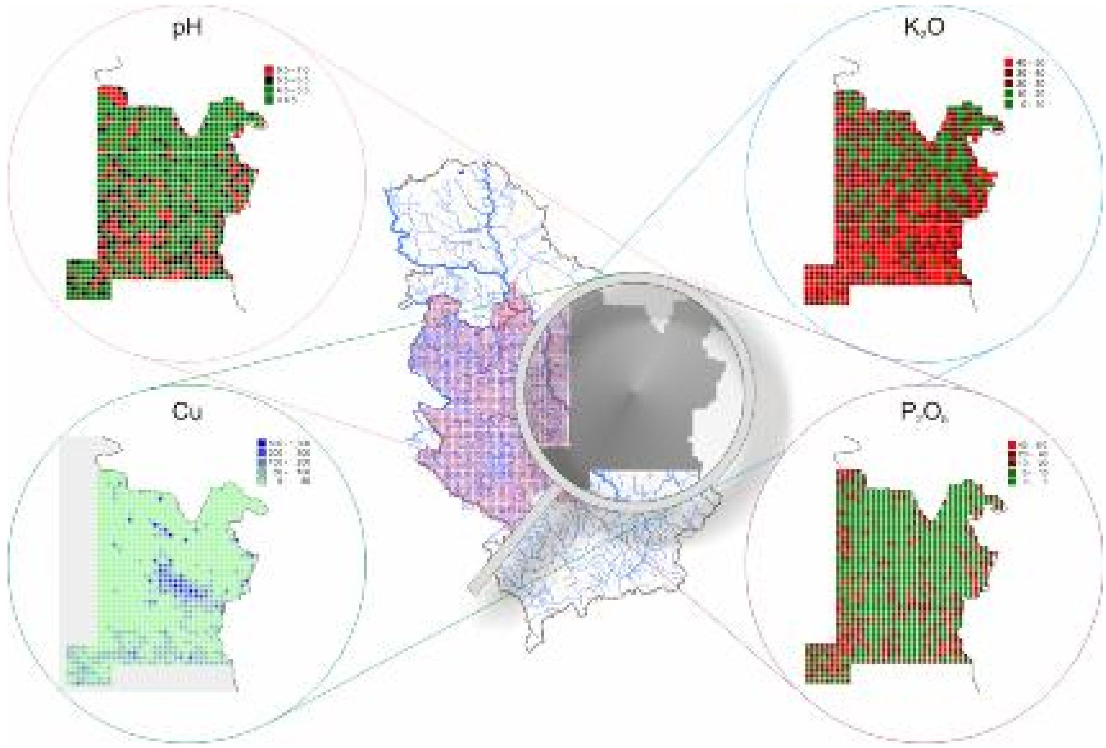


Figure 94

Soil quality of Central Serbia (pH in KCl, K_2O mg/100g, P_2O_5 mg/100g, Cu mg/kg)

There were no surprising findings in the study of residues of 17 pesticides in soils of central Serbia. The occurrence of DDT and its metabolites, and lindane gHCH, is associated with their usage in forest protection, while slightly increased values of triazine residues were recorded in soils used for grain crop cultivation. Nearly 99% of the samples investigated were unpolluted with residues of any of the analysed group of pesticides. The study of pesticide residues in eastern Serbian soils (Figure 95) showed that the mean content of all investigated compounds in soil was below 5 μg/kg. Some pesticide residues, such as β-HCH, alachlor, diazinon and chlordane were not detected at all. Mean α-HCH and heptachlor were low (<1 μg/kg), while DDT and symazine were found to have the highest average content (4.4 and 4.6 μg/kg, respectively).

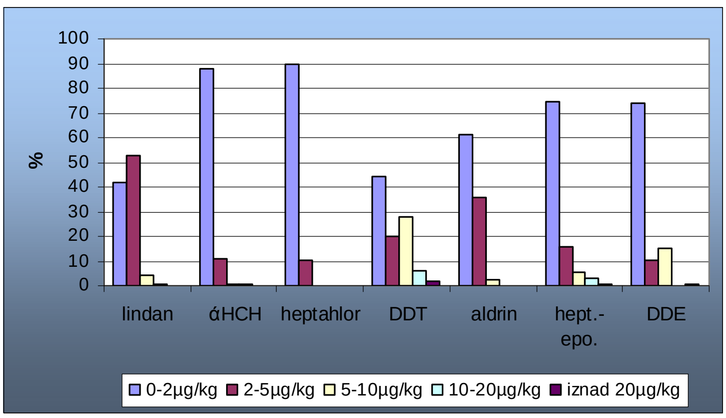


Figure 95

Organochlorine pesticides found in soils of eastern Serbia

Spatial variation of contents was most evident for the organochlorine pesticides DDD, α-HCH and heptachlor epoxide. Some samples collected form forest soils, or meadows close to forests, were found to have increased concentrations of DDT, DDD, α-HCH and heptachlor epoxide, which is associated with their use in forest protection. On the other hand, contents of atrazine and other herbicides were low in most samples. Maximum concentrations of atrazine and symazine, found in some plough-field areas, were below the limit values envisaged by relevant rules (Official Gazette of the Republic of Serbia, 23/94).

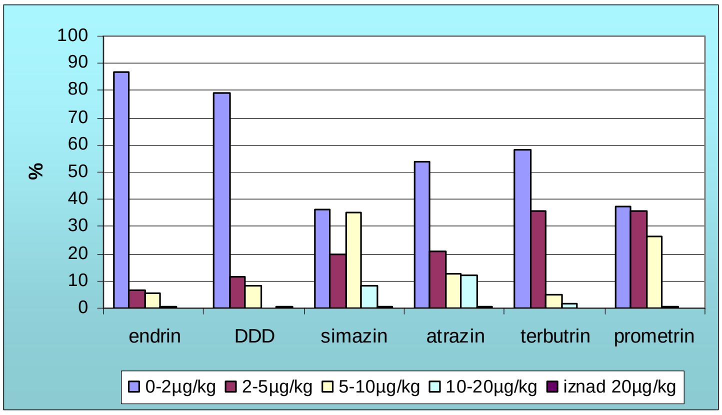


Figure 96

Insecticides and herbicides detected in soils of eastern Serbia

Scientific basis of the Soil Fertility and *Fertilizer Use Control System* was established in 1980 and it was legislated in 1985. The System encompasses the control of all factors that determine soil fertility and fertilizer action, i.e., how soil affects the growth, development and yield of crops and which measures must be undertaken to ensure high, stable and economic yields and adequate protection of the biosphere (Manojlović, 1986). Because of the economic crisis that pestered the country over last 15 years the System was not fully exploited. In 2002, a campaign was launched to conduct soil analyses in the private sector free of charge. In Vojvodina, the campaign was organized by the Secretariat of Agriculture of the Vojvodina Province and the Institute of Field and Vegetable Crops, Novi Sad. In Serbia, the soil monitoring system was realized by agricultural extension service through the project funded by Ministry of agriculture, forestry and water resources of the Republic of Serbia. Since 2002, more than 83,000 samples were collected and analyzed. In 2006 the proportion of georeferenced samples was much higher.

The database contains the following information: Owner, cadastre parcel, land use, crop; pH value in soil suspension with sodium chloride, determined potentiometrically; $CaCO_3$ content; Humus content; Available phosphorus; Available potassium.

At the moment the project "*New technologies in agricultural soil management in Vojvodina*" is being conducted with the general objective of managing soils in Vojvodina, especially agricultural soils. It is of particularly great significance because over 90% of the territory of Serbia is privately owned. The project is based on the most modern technologies (Figure 97) which include remote detection and image processing software, image content classifying software and its distribution to end users. The result of the project is a complex information system which enables managing reforms in space. An information system like this is necessary for documented agricultural production, but it will also enable us to obtain other important information, such as yield estimate, vegetation status, etc.

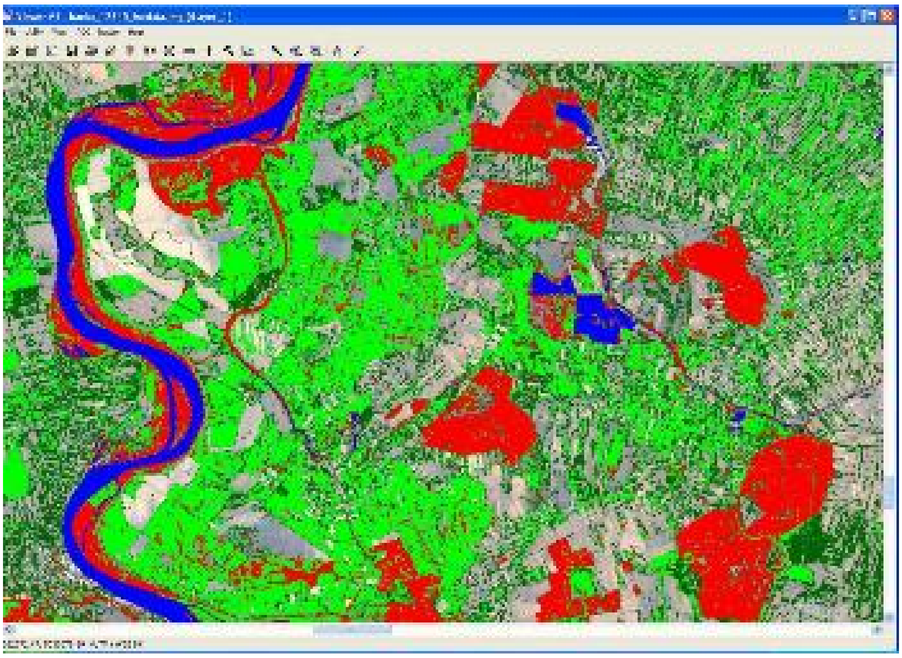


Figure 97

Multispectral satellite image (Provincial Secretariat for Agriculture, Water economy and Forestry & Faculty of Technical Sciences, Novi Sad

The Project "Environmental quality monitoring in the territory of Vojvodina – non-agricultural land" (Figure 98) is a systematic research that is conducted by the Institute of Field and Vegetable Crops in Novi Sad. For monitoring of soil quality in Vojvodina, locations under various kinds of protection were chosen in order to follow the impact of pollution which is a consequence of NATO bombing of industrial complexes in Vojvodina and their state was observed for three years.

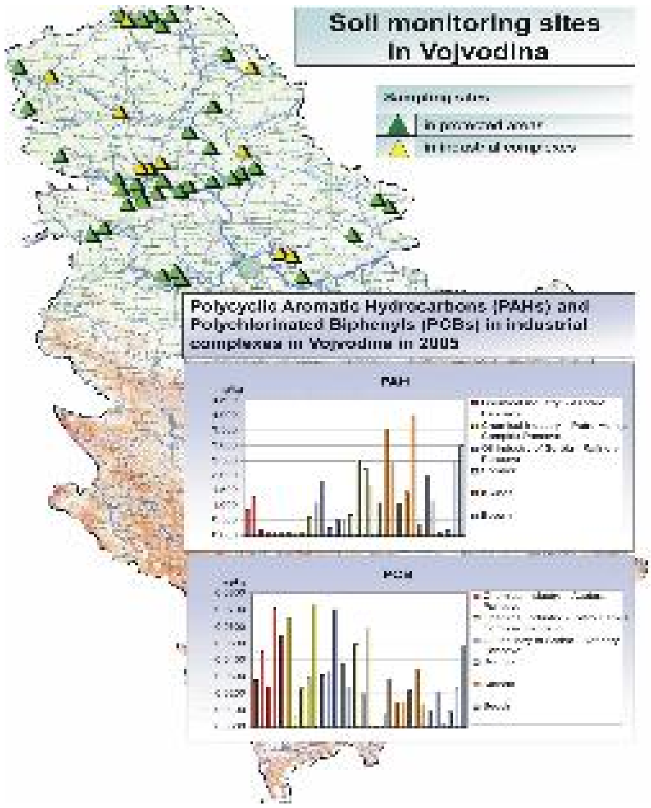


Figure 98

Soil monitoring sites in Vojvodina

The database consists of the findings made by the Project with the georeferenced localities examined in 2002, 2003, and 2004.

Within this Project, the quality of non-agricultural land of larger towns with developed industry was monitored in the territory of Vojvodina, specifically in Pančevo, Sombor, Kikinda, Zrenjanin and Beočin. The results are available in digital format with georeferenced sampling localities.

Examined within the analyses were basic chemical properties (pH, $CaCO_3$ and humus) and soil fertility in the most important biogenic elements (N, P and K), content of heavy metals and microelements, as well as organic pollutants (polychlorinated biphenyls – PCBs, and polycyclic aromatic hydrocarbons - PAHs).

Findings of the examination of heavy metal content in non-agricultural land of industrial zones in 2005 demonstrate that their origin in the soil is primarily geochemical, namely that non-agricultural land of the Vojvodina's industrial zones are not contaminated by heavy metals. At the two localities of cement plant in Beočin, the soil is contaminated by nickel of anthropogenic origin, and the soil in the area of the battery factory in Sombor is contaminated by the lead of anthropogenic origin.

Due to the absence of legislation that governs the MAC for polychlorinated biphenyls and polycyclic aromatic hydrocarbons in soil, the comments on the findings were made applying the German MAC criterion.

PCB contamination is the most intense in the area of Pančevo. Applying the German MAC criterion for PCBs of 0.05 mg/kg, this value is exceeded in 33% samples of soil in Pančevo and only one sample in the vicinity of the battery factory in Sombor.

The average PAH content is highest in the soils of Kikinda and amounts to 2.138 mg/kg of soil. Of the total number of samples, 76.7 % of the examined soil samples were contaminated by PAHs in the quantity that exceeded the MAC. This practically means that the soil can potentially be a source of underground water contamination by polycyclic aromatic hydrocarbons.

Examination of soil quality in *urban zones* is conducted in some of the larger towns and cities and it is mainly associated with accidents. In the area of the City of Belgrade, systematic examination of the soil condition has been conducted since 1999 to determine the contamination level and potential risk to population health. The findings are available in digital format with georeferenced sampling localities.

The laboratory testing of soil contamination in the territory of Belgrade is conducted by the City Institute for Public Health. The processed soil samples are analyzed for the content of following parameters: pH value, humidity, nitrogen, phosphors, sulphates, arsenic, nickel, chrome, zinc, copper, cadmium, lead, quicksilver, pesticides, polycyclic aromatic hydrocarbons (PAH), mineral oils, and polychlorinated biphenyls (PCBs).

The Program of survey of soil pollution on the territory of Belgrade is directed towards:

- Soil in the zone of sanitary protection of drinking water sources;
- Soil in city parks and other facilities;
- Soil in the vicinity of industrial complexes;
- Soil in the vicinity of important motorways.

Within the Project "Monitoring of the health status of forests in the Republic of Serbia", the Faculty of Forestry in Belgrade performed the surveying the soil in the 16 x 16 km grid at 103 bioindication points (Figure 99). In all selected land plots, pedological profiles were opened and soil samples were taken from fixed depths, from the following layers: organic, 0-5 cm, 5-10 cm and 10-20 cm, as well as from the depth of 20-40 cm and further to the holding substrate, with the aim of making the full characterization of soil. As in 2003 the sample plot grid 16x16 km did not cover all the most important forest ecosystems in Serbia, in 2004 another additional plots were installed in 4x4 grid.-

During 2003/2004, in the above network of points, according to the ICP methodology, chemical analyses were conducted for organic and mineral layers of soil. Besides the chemical analyses, also conducted were the analyses of the mechanical composition of soil. The findings of these analyses for deeper layers allowed more precise identification of soil types, both according to the national and FAO classification.

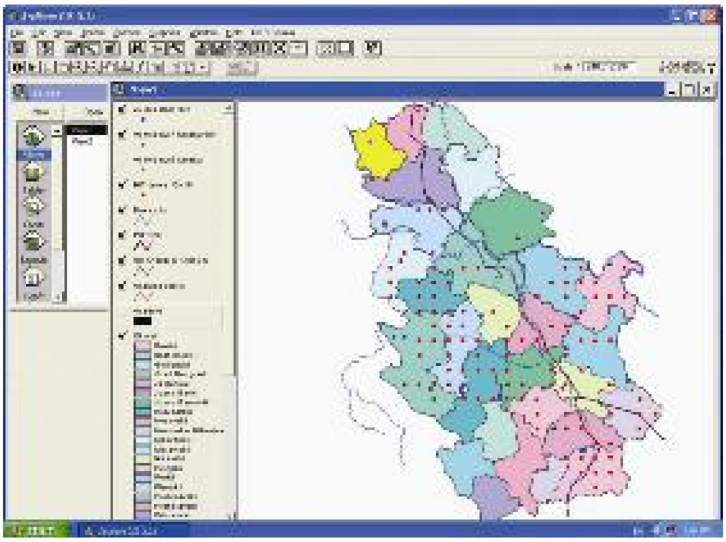


Figure 99

The ICP sample plots in Serbia

SOIL CONTAMINATION

In 2006, the Environmental Protection Agency set up a database of the contaminated areas in the territory of Serbia. The database covers the localities that were identified before 2005 and have not been georeferenced. Large land areas in the vicinity of industrial complexes (Bor, Pančevo, Novi Sad, Smederevo, Belgrade and Kragujevac) are contaminated with various pollutants discharged from industrial facilities.

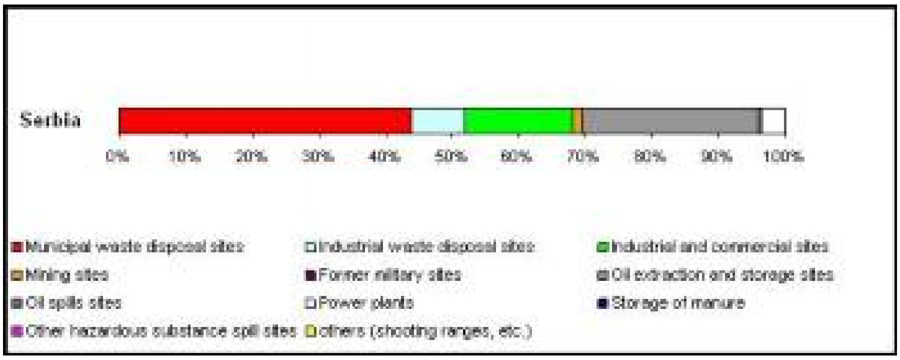


Figure 100

Soil polluting activities from localized sources as % of total sites where site investigation has been completed

Considering the manner in which contaminated areas are managed, the following conclusions can be made:

- Management of contaminated sites in Serbia is not institutionalized and it is not possible to completely quantify the progress in this field at the national level. There is no specific methodology yet that can be used for defining contaminated sites in Serbia. Presented contaminated localities are identified on the basis of laboratory analysis of soil and groundwater in the near vicinity of localized pollution sources and their long term presence.
- Preliminary studies are conducted at most of the identified contaminated sites in Serbia.
- The greatest number of registered sources of localized soil pollution are related to municipal waste disposal sites, oil extraction and storage sites, industrial and commercial sites (Figure 100). The municipal waste disposal site database was updated in 2005. There are 164 municipal waste disposal sites on the territory of Serbia which present a potential source of soil and groundwater pollution.
- The greatest part of the identified polluted soil localities within industry (Figure 101) belongs to the oil industry (59.2%), followed by the chemical industry (15.2%) and the metal working industry (13.3%).
- The database does not include military localities.

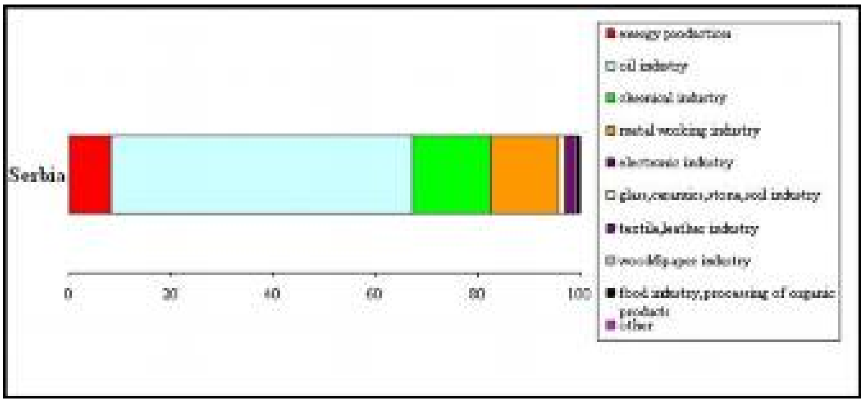


Figure 101

Breakdown industries responsible for local soil contamination as % of total

Sites contaminated by depleted uranium

During the conflict NATO had reportedly deployed weapons containing *depleted uranium* (UNEP, 2002, 2004). Shortly after the NATO actions against Serbia and Montenegro systematic reconnaissance of locations which were under the fire of A-10 planes was organized. According to NATO data 112 locations in Kosovo were contaminated with DU, and 31000 30-mm projectiles, equivalent to 10 tones of DU were fired. According to our military data it must be at least 50000 projectiles, or 15t of DU. Till now nothing has done on decontamination of Kosovo and Metohija locations. The harmful effects of ionising radiation are well documented (UNSCEAR, 1993). Although a higher incidence of Hodgkin's lymphoma among Italian Balkans troops confirmed, the systematic investigation on effects of DU on public health in Serbia is missing.

Outside the borders of Kosovo, 3000-5000 projectiles were fired too, mostly on the south of Serbia. All the locations are marked, co-ordinates of all marked and isolated locations were defined, and the residents informed. Entrance in contaminated locations was forbidden till the end of decontamination

The clean-up of some 5,000 square meters of land in the village of *Bratoselce* near *Bujanovac*, contaminated by depleted uranium during the 1999 NATO bombing of Yugoslavia, was finished on Nov. 9, 2003. During the clean-up, the team performing the task discovered around 100 kilograms of depleted uranium in the soil and stored some 2.5 tons of contaminated earth in the Vinca institute's facilities.

Decontamination of *Pljačkovica (Vranje)* was finished during 2004 year when 48 penetrators and 30 projectile s fragments were found. It was collected and delayed on radioactive waste disposal 1300kg of contaminated soil.

The clean-up of the radioactive pollutants has been completed at a major site in southern Serbia. Approximately 3,468 cubic meters of contaminated soil were removed from the *Borovac* site, hit by 44 depleted uranium shells.

A total of 161 depleted uranium bullets have been recovered in *Reljan near Preševo* in southern Serbia, A total of 2.4 cubic meters of contaminated soil has been collected and removed. The Serbian government has funded the cleanup operation of the Reljan site with 350,000 Euros.

Soil Erosion

The occurrence and progress of erosion processes is one of the major causes of soil degradation and its deteriorated quality. It is estimated that erosion processes (of various degrees) affect up to 80% of agricultural soil in Serbia. While in central regions and the hilly-mountainous regions the predominant type is water erosion, the predominant type in Vojvodina is eolic erosion. Approximately 85% of agricultural soil in Vojvodina is affected by wind erosion with an annual loss of over 0.9 ton material per ha.

Degradation of soil is a process of reduction or loss of its biological or economic productivity and complexity and it occurs as a result of a particular form of land use and certain processes or combinations of processes such as:

- soil erosion caused by winds;
- deterioration of physical, chemical or biological properties of soil
- long-term loss of natural vegetation.

In Serbia, erosion causes immediate annual loss of 20,500 ha of land compared to total annual production of deposits, or 6,000 ha of arable land due to transport of soil deposits.

Research conducted in Serbia (Department of Erosion Protection of the Belgrade Faculty of Forestry) showed that water and aeolian erosion cause, apart from other effects, considerable losses of humus and nutrients (as well as suspended deposits).

Table 5. Amounts of humus and nutrients lost to erosion

Soil component	Amount (t/annually)
Humus	580 327,00
Nitrogen	40 159,00
Phosphorus	3 832,00
Potassium	14 367,00

An erosion map incorporated in the Serbian Water Management Guidebook (Institute of Water Management “Jaroslav Černi”, Belgrade, 1996) shows that different intensities of erosion have been observed on a total area of 88,361.0 km^2, Figure 102.

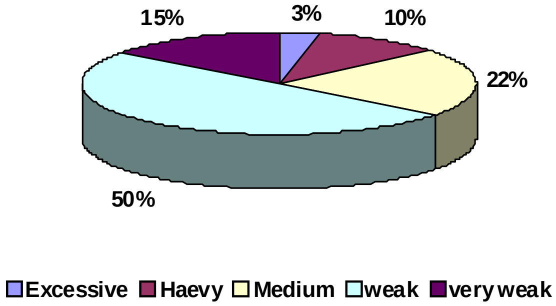


Figure 102

Erosion percentages by category in Serbia

South of the Sava and Danube rivers, the dominant type of erosion is water erosion with devastating torrential streams, while aeolian erosion, or deflation, predominates in the northern region of Vojvodina. Areas undergoing aeolian erosion are found along the main rivers, the Danube and the Tisa in northern parts of the country. The deserts known as Deliblatska, Subotica-Horgoš and Ram-Golubac sands are especially important in this context.

Most endangered areas in Serbia are hilly and mountainous parts where water erosion processes ranked I-III category are most intensive with estimated 12,500 torrential streams. Those areas cover about 2,000,000 ha of existing forests and most of the 1,350,000 ha planned for forestation by the year 2050. Anthropogenic impact on the ecosystem also adds to increasing soil erosion.

Apart from erosion, however, soil can also be degraded by surface mining and tailings near mines and metal processing plants or by communal waste landfills.

Unplanned urban development and unplanned development of transport infrastructure in areas with top-quality soils is a special problem.

Figure 103

Orthophoto image of the Majdanpek surface mining sites.

Figure 104

Orthophoto image of the ash landfill near Obrenovac

WASTE

WASTE MANAGEMENT
UNOFFICIAL AND OLD LANDFILLS AND DUMPS
INTERNAL AND TRANSBOUNDARY MOVEMENT OF WASTE

WASTE MANAGEMENT

Poor standard of waste management has been identified as one of the pressing environmental issues in Serbia, resulting mainly from an inadequate social treatment of this issue so far. High-cost, uneconomical organisation, poor quality of service and inadequate care for the environment are the result of a devastatingly poor organisation of waste management.

The existing relevant legislation in the Republic of Serbia defines local municipalities as the administrative and spatial entities responsible for managing communal waste. Wastes and waste management have been recognised as a major public issue. However, people generally tend to consider wastes as somebody else's problem, rather than their own, so that solutions are expected from the state, its agencies, local governments, industry, etc. Cooperativeness in solving the problem of waste disposal is voiced mostly in moments of crisis and public concern.

The only method of managing waste that is currently practiced in Serbia is disposal in landfills, which mostly fails to meet the most basic requirements of hygiene, as well as technical and technological standards, and some of them are already filled to full capacity.

The National Strategy for Managing Waste, adopted in 2003, provides a basis for an economical and sustainable management of wastes. One of its basic conclusions suggests that regional landfills should be established for communal waste. The Strategy envisages the establishing of 29 regional sanitary landfills, as well as a number of other facilities that are expected to help waste management to become more efficient and effective.

The Environmental Protection Agency, in keeping with its legal competencies, started in 2005 a series of activities to set up a *waste management information system* as part of an integrated environmental protection information system.

In an effort to create a national database on landfills in the Republic of Serbia, two projects were outlined:

- Improvement of the cadastre of waste disposal sites in the Republic of Serbia, and
- Establishment of a cadastre of unofficial and old landfills and dumps in the Republic of Serbia.

The former project aims at upgrading the existing sets of database on official landfills where waste is being brought to and disposed of in an organised fashion. The other one concerns efforts to create a registry of unmanaged and old dumps, and contains data on their location, quantities, type of material disposed of and other information.

Relevant municipal bodies and public utilities are the crucial partners in these projects. Both projects were expected to produce an electronic database of waste disposal sites with a geographic information system (GIS) component included.

Figure 105 shows that 15 of the total number of municipalities have no landfills on their own territory, and therefore use landfills in other municipalities.

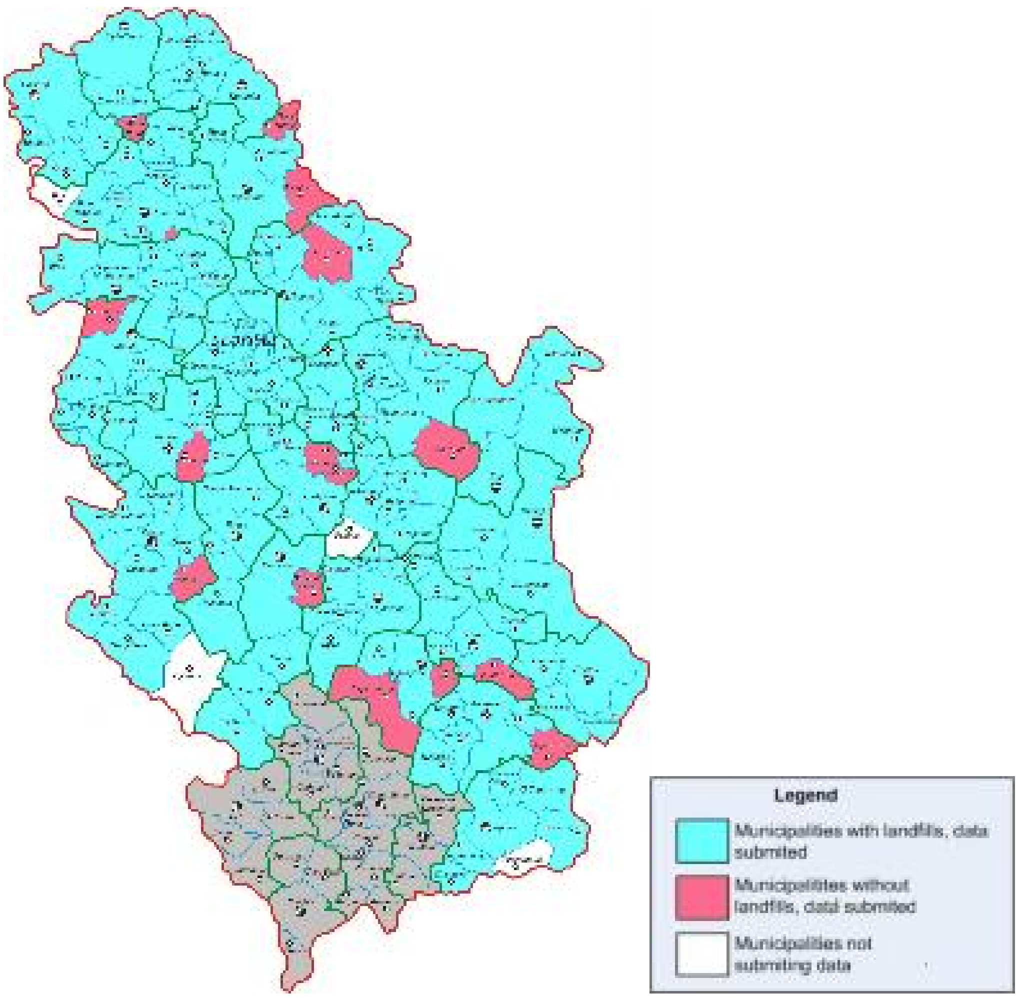


Figure 105

Serbian municipalities with landfills for disposals of waste

According to data provided in this project, Serbia has 164 landfills that are used by local utility companies for disposal of wastes (Figure 106).

The land used for landfills is either the property of the Republic of Serbia, or it is public or company property. Landfill ages vary considerably, ranging from that of five new ones set up in 2005 (Bačka Palanka – Obrovac, Bela Palanka, Malo Crniće, Pančevo and Tutin) to the landfill at Silbaš, the municipality of Bačka Palanka, which was set up in 1956. Data on the sizes and volumes of landfills are not fully reliable as quantification was mostly done based on estimates, which is only understandable as many of them have no appropriate technical documentation.

Waste covering is practiced in 117 landfills or 72%, and it is done mostly with earth or some other inert material. Daily covering is practiced in 15 landfills, monthly covering in one, and it is done occasionally in 101 landfills.

Most municipalities own mechanical equipment and vehicles for collecting waste. Various types of waste collection vehicles are being used from the special Rotopress vehicles with rotating drums and forks for collecting from large containers to common trucks or even tractors with vans. It would be true to say that lack of adequate equipment for waste collection is significant in a great many municipalities.

Figure 106

Distribution of landfills for disposals of waste in Serbia

There is a similar situation concerning mechanised equipment used in landfills. Bulldozers are commonly used for digging up, levelling and compaction of waste, while compactors are being used in no more than 10 landfills. Mechanised equipment is occasionally rented for these operations in several landfills, Figure 107.


Figure 107

Mechanised equipment in landfills (Photo: Hristina Stevanović Čarapina).

Of the total number of landfills, 12 (or 7.3%) are situated within 100 m range of a local settlement. Such data clearly point at the risks undertaken by the local population from being exposed to contaminating emissions and to possible diseases carried by mice, rats and other animals moving about landfills.

Data on the distance between *landfills and water resources* give us a bleak picture as 25 landfills (15.2%) are situated within 50 m from a river, stream, lake or reservoir. Of this number, 14 landfills are practically located on the very bank of a waterway or in its channel. Eleven landfills (or 6.7%) are situated within 500 m from waterworks zones, and another 28 (12.2%) within 1000 m. Data on landfill distances from conserved environments and objects of cultural heritage were submitted only by 63 municipalities. In 3 municipalities, landfills are less than 100 m away from such facilities, while another 8 are situated within 1000 m. Data on landfill equipment include information on the infrastructural systems, installations and facilities used to ensure effective landfill management.

Table 6. Infrastructural systems of landfills.

Description of system, device or facility	Number of landfills
Electricity	34
Fuels (tanks, power units, etc.)	6
Water supply	25
Sewage	10
Weighbridge	6
Internal road network	48
Access to public road	113
Fire-fighting equipment	33
Gas collecting system	12
Car wash platform	18
Working front	22

Table 7. Activities and equipment used to protect the environment

Activity or equipment	Number of landfills
System of rainfall draining canals	30
Leachate collection system - drainage	17
Leachate purification	7
Levelling	124
Compaction	83
Disinfection, pest and rodent control	56
Noise prevention	2
Wind-blown waste prevention	47

Regarding the state of the discharged waste, solids alone are allowed in 163 municipalities, while liquid waste is allowed in addition to solids in 41 landfills.

Table 8. The types of waste material discharged in landfills.

Type of waste material		Number of landfills
Communal waste (households)		163
Metal waste and household appliances		138
Car waste		82
Packaging waste	glass	160
	plastic	159
	paper	158
	paperboard	157
	tins	156
Agricultural waste		82
Construction waste		134
Electronic waste		52
Hazardous waste		60
Medical waste		84
Animal waste (dead animals, slaughterhouse by-products)		83
Waste tyres		117
Green waste from gardens and public parks		134
Forest and wood processing wastes		48
Industrial and mining waste		30
Slimes/sludges/ashes/slags/tailings/muds		95

A large number of municipalities have banned disposal of certain types of wastes in their landfills, primarily hazardous, medical and animal wastes, car tyres, etc.

Organised recycling of waste in Serbian landfills is practically non-existent as 160 of them (97.6%) have no processing of waste developed in any form.

Table 9. Operative status of landfills

Operation status	Number of landfills
Under construction	22
Active	72
Closed down	5
Restored	0
Under reconstruction/restoration	39
Under close-down procedure	19
Landfill planned	18

Table 10 Permissions required for the operation of landfills.

Permit status	Number of landfills
Operating permit	24
Building permit	13
Under environmental assessment	28

Analysing the data on amounts and types of waste discharged in landfills, it is readily apparent that very little care is currently taken of this issue. The fact that only 30 landfills (18.3%) have records of the types and quantities of waste is suggestive enough.

Monitoring of the state of local environment and possible effects of landfills and their disposed materials on the environment is sporadic.

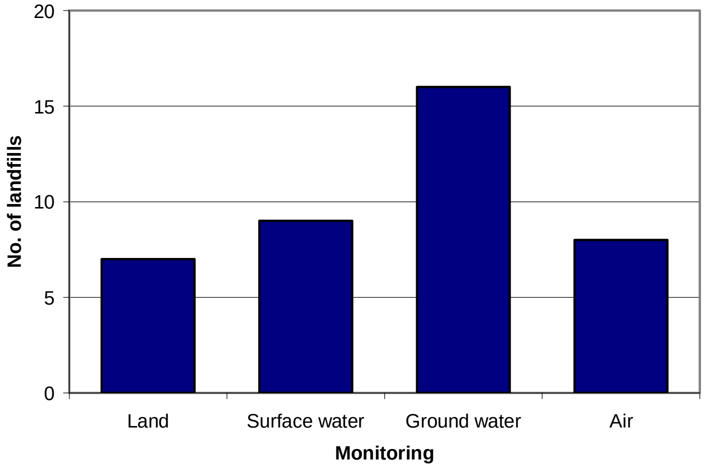


Figure 108

Number of monitoring programs

Figure 108 clearly indicates that monitoring of the impact of landfills on environment is scarce. In the European Union, on the other hand, it constitutes one of the main principles of waste management.

UNOFFICIAL AND OLD LANDFILLS AND DUMPS

Over 800 questionnaires were sent out within the project "Establishment of a cadastre of unofficial and old landfills and dumps in the Republic of Serbia". Some local governments reported unofficial landfills in their territories but without going into detail, explaining that those are being removed regularly and therefore have temporary character.

In most cases, unofficial landfills are found in rural environments and they are mostly the outcome of meagre funds allocated for improving the quality of the waste collecting system, as well as poor organisation of waste management at local level.

Figure 109

Unofficial landfills. Photo curtsey of the Environment Protection Inspection in Čačak

Unofficial landfills also occur along thoroughfares, primarily on slopes and road fills, where wastes are simply being unloaded from trucks. There is mostly a difficulty involved in collecting such wastes due to their inaccessibility.

Natural depressions, cavities and pits that are virtually inaccessible are also being used for waste disposal.

Data on the bulks of unofficial and old landfills, and estimates as to the amounts of disposed waste indicate that some of them have been used for several years, which raises concern over their possible effect on the environment. All kinds of waste are being disposed of in these landfills in an unrestrained fashion – communal, medical, animal corpses, hazardous waste, etc.

INTERNAL AND TRANSBOUNDARY MOVEMENT OF WASTE

The amounts of imported and exported waste are determined based on import and export permits and customs declarations. Such documents enable controlled monitoring of waste transport in the country. Besides, they show whether the waste transported could possibly be recycled in domestic industry as a secondary raw material. The Recycling Agency has a database on transboundary movement of waste.

The established Waste Database is being updated to include fresh data on transboundary movement of waste based on import and export permits, issued by the Environmental Protection Directorate, and the uniform customs document verifying the amounts of imported/exported waste with the idea of monitoring operation of a national control system of imports, exports and transit of waste.

Import of hazardous waste is prohibited. Hazardous waste is exported to EU approved facilities for further treatment. The Ministry of Capital Investments enforces the Republic's laws related to transport of hazardous waste. In addition to safety measures related to hazardous substances, the Traffic Authority currently applies and enforces the European Agreement on International Road Transportation of Hazardous Substances (ADR) and the International Rulebook concerning Railway Transport of Hazardous Substances (RID).

There are neither reliable data on the total number of sources generating hazardous wastes nor the total number of sources generating waste that could be recycled as secondary raw materials.

There is no facility for treatment of hazardous waste, or one for treatment of car waste and other specific types of waste, or indeed any permanent disposal site for hazardous waste complying with relevant legal provisions, so that temporary disposal is mostly done inside the company fence, and very often inadequately. For all these reasons, hazardous waste is being stored temporarily prior to export for further treatment.

BIODIVERSITY

SPECIES DIVERSITY
ECOSYSTEM DIVERSITY
AREAS DESIGNATED FOR NATURE PROTECTION
PROGRAMS OF BIODIVERSITY MONITORING
REINTRODUCTION PROGRAMS AND
EX SITU CONSERVATION OF BIODIVERSITY

SPECIES DIVERSITY

Biological diversity represents the variability of life at all levels of biological organization (Gaston and Spicer, 2004). Such, general definition requires further elaboration since biological diversity involves *itraspecific* (population) and *interspecific* (community) variability. Population or intraspecific diversity depends on genetic variability and variability induced by environment. On the other hand, community diversity involves within community *(alpha) diversity*, species diversity between ecosystems (*beta diversity*) and *gamma diversity* or overall biodiversity within a region (Whittaker, 1972).

Investigations of biological diversity have a long and very rich tradition in Serbia. In a series of articles and monographs, Pančić (1860, 1867, 1869, 1874, 1883) initially described Serbian flora and fauna. His classical work "*Flora Principatus Serbiae*", initiated intensive floristic investigations. As a result of accumulated knowledge, the 10 volume edition of "(vascular) Flora of SR Serbia" was published (Josifović, 1970-1977; Sarić, 1986). Numerous vegetation studies in Serbia were integrated in precious monograph *Vegetation Südosteuropas* (Horvat, Glavač, et Ellenberg, 1974). More recently Sarić (1997), Kojić, Popović and Karadžić (1997) reviewed vegetation units in Serbia. Blaženčić, Cvijan and Laušević (1995), Cvijan and Blaženčić (1996) and Cvijan and Subakov-Simić *(2003*) reviewed taxonomy and distribution of algae in Serbia.

Faunistic investigations covering both *Vertebrates* and *Invertebrates* (Radovanović, 1951, 1957, Petrov, 1992: Simonović, 2006, Gasc et al., 1997, Rašajski, 2004, Ćurčić, Dimitrijević and Legakis, 2004, Jakšić, 2003, Matvejev, 1950, Vasić, 1995).

Despite the great diversity of different taxa, the process of biodiversity erosion is marked, not only in Serbia but in wider regions of Balkan peninsula. Many species disappeared from Serbia, and some rare species are endangered to alarming limits. Human induced pressures on habitats (urbanization, development of agriculture, industry, mining, transport infrastructures) resulted in:

- degradation of natural ecosystems to cultivated agroecosystems, sylvicultures or (sub)urban area,
- fragmentation of habitats
- overexploitation of genetic and biological resources
- introduction of alien species from remote areas
- contamination of air, water and soil by toxic, mutagenic or cancerogenig pollutants
- increased level of ionizing and nonionizing radiation
- induced climate changes

Synergy of all these effects resulted in significant biodiversity reduction in Serbia and neighbouring region. According to the Red data book of Flora of Serbia (Stevanović, 1999), four local endemic taxa disappeared from Serbia, and consequently, from the global gene pool (*Althea kragujevaciensis* Pančić, *A. Vranjensis* Diklić & Nikolić, *Scabiosa achatea* Vis. & Pančić and *Trapa annosa* Janković). More than 40 vascular plants disappeared from Serbia, but not from other parts of Balkan peninsula. Populations of numerous plant species permanently declined during past 50 years.

According to the Red data book of Serbian butterflies (Jakšić, 2003), the species *Leptidea morsei* Fenton 1881 disappeared from Serbia, whereas 22 taxa belong to the IUCN category of endangered species. Unfortunately, the Red data book of other faunistic groups of Serbia is not available yet.

Flora

Floristic diversity in Balkan peninsula is much greater than in other parts of Europe. More than 100 endemic taxa are recorded in numerous mountain regions of the Balkans. Therefore, entire Balkan peninsula in general, and particularly the mountain regions from Creta and Peloponnesus to Dinaric Alps westward and eastward to Balkan-Rhodope mountains represents hot spots of plant diversity on regional (European) level.

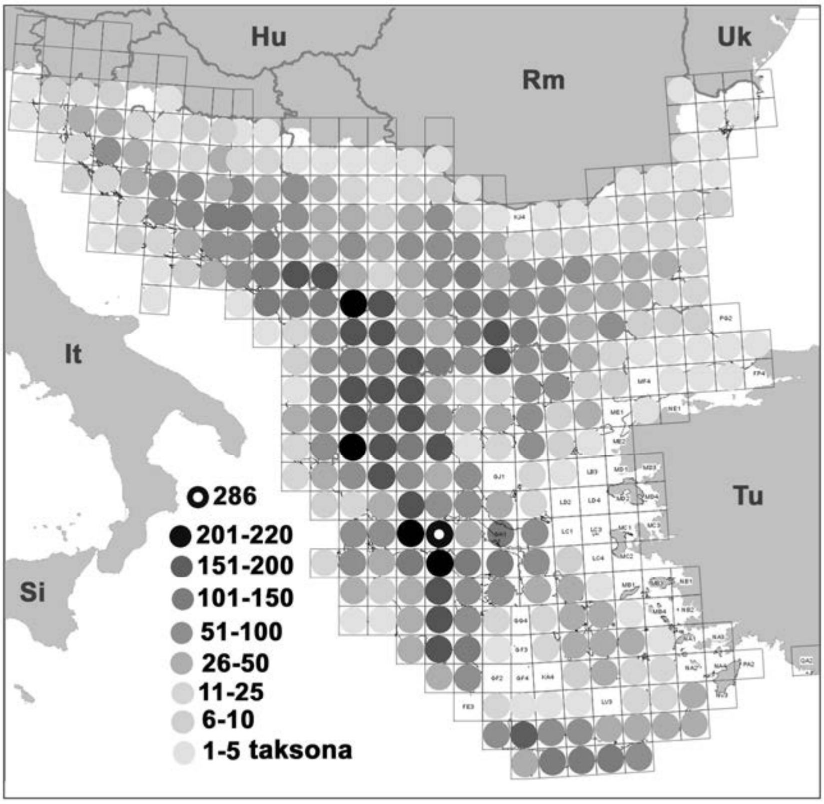


Figure 110

Number of endemic taxa (species and subspecies) in UTM network (50x50 km) on Balkan Peninsula (source: Stevanović, 2005)

Balkan Peninsula is a biodiversity center for 17 mainly monotypic genera, represented by one or only few phylogeneticaly isolated species. Generally, endemic genera, being monotypic, oligotypic or polytypic, indicate age of flora in the specified area and designate this area as a biodiversity center and center of flora diversification. Such monotypic and oligotypic genera, i. e. species belonging to the genera are: *Halacsya sendtneri Boiss., Paramoltkia doerfleri* (Wettst.) Greuter & Burdet, *Paraskevia cesatiana* (Fenzl & Friedr.) W. & G. Sauer, *Petromarula pinnata* (L.) A. DC. *Degenia velebitica* Deg., *Leptoplax emarginata* (Boiss.) O.E. Schultz, *Haberlea rhodopensis* Friv., *Jankaea heldreichii* (Boiss.) Boiss., *Wagenitzia lancifolia* Sieber ex Sprengel (Dostal), *Hymenonema laconicum* Boiss. & Heldr. & *Hymenonema graecum (L.) DC., Thamnosciadium junceum* (Sm.) Hartvig, *Pancicia serbica* Vis., *Horstrissea dolinicola* Greuter , Gertsberger & Egli, *Petteria ramentacea* (Sieber) C. Presl, *Festucopsis sancta* (Janka) Melderis, *Festucopsis serpentini* (C.E. Hubbard) Melderis , *Lutzia cretica* (L.) Greuter & Burdet and *Phitosia crocifolia* Kamari & Greuter.

According to the latest researches, there are over 2600 endemic plant species on Balkan. Territory of Serbia is significant biodiversity center of endemic flora on Balkan Peninsula (Fig. 110). There are 287 *Balkan endemic* species and subspecies in Serbia, which is 8.06% of Serbian flora. The number of Balkan endemics increases from lowland regions in Vojvodina towards high mountain areas. The basic type of endemism in Serbia, like in the entire Balkan Peninsula, is highmountain endemism. Biodiversity centers of endemic flora are primary high mountains (Shar Mt., Prokletije Mt., Koritnik Mt., Pastrik Mt., Kopaonik Mt., Balkan Mt. and Suva Mt.). Besides *highmountain endemis* in Serbia, there exists *edaphic endemism*, as well. Special features are representatives of ophylotic endemic flora on serpentine habitats in west and central Serbia, and in Metohija. Highmountain and edaphic endemism is often combined. In the same time, limestone massifs are richer in endemic species compared to siliceous soils in Serbia. *Local endemics* are of special importance, as specific biological resources globally significant for preservation of gene fund and biodiversity. There are 59 local floristic endemics in Serbia (1,5% of total flora in Serbia), mostly Tertiary relics. Shar Mt., with 19, and Prokletije Mt. with 15 local endemics are mountains with highest local endemism in Serbia.

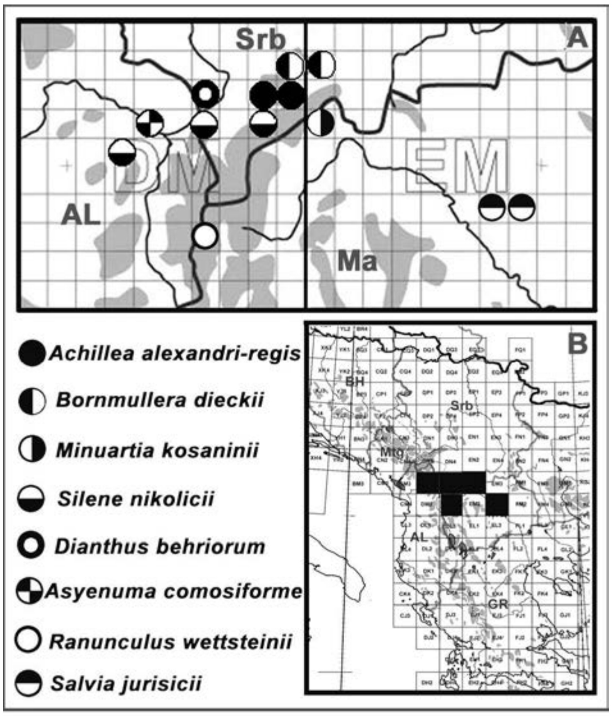


Figure 111

A) Distribution of several local endemics represented at UTM squares 10 x 10 km inside of selected UTM squares 50 x 50 km DM1, DM3, DM4, EM1 and EM4 (orig.); B) selected UTM squares are represented at the map of the C.Balkans (black). (source: Stevanović, 2005)

Unique remains of the (sub)tropic flora in Europe are paleo-endemic species that belong to the *Gesneriaceae* [Rich. & Juss. ex] DC. family. This family is is represented by three genera (*Ramonda* Rich., *Jankaea* Boiss. and *Haberlea* Friv.) in Balkan peninsula. Species of this family are mainly distributed in the tropics and subtropics of the Old and the New World, with transgressions to the north (Europe: Pyrenees, Balkan Peninsula; Asia: Himalayas, China) and the south (SE Australia, New Zealand, S Chile).

Figure 112

Ramonda nathaliae, endemic and relic species of Balkan Peninsula Photo: D. Mišić

Both in Asia-Malesia and in America there are around 60 genera; in Africa there are 9 genera (c. 160 spp.), in Europe 3 genera (6 species). Such disjuncted distribution clearly indicates that endemic representatives of *Ramonda, Haberlea* and *Jankaea* are relics of old flora. *Ramonda myconi* (L.) Rchb is distributed in Spain, whereas other European *Gesneriaceae (Jankaea heldreichii* (Boiss.) Boiss, *Ramonda serbica* Panc. *R. nathaliae*

Panc. & Petr. *Haberlea rhodopensis* Friv. and *H. ferdinandi-coburgii* Urum.) are restricted to Balkan peninsula (Serbia, Montenegro, Albania, Greece and Bulgaria). Two *Gesneriaceae* species (*Ramonda serbica* Panc. and *R. nathaliae* Panc. & Petr.) are distributed in Serbia.

Figure 113

Distribution of Gesneriaceae. Adapted from Тахтаджян, 1981.

The most important endemic plant species in Serbia is *Picea omorika* (Pančić) Purkyne 1877. A wide distribution of *P. omorika* during Tertiary was reduced to an ultimate extent. Recently, it is native to the Tara Mountain, the Mileševka river canyon and part of Western Bosnia in the middle course of the Drina River. Serbian spruce is a graceful, beautiful tree with a narrow pyramidal form.

Figure 114

Forest of Serbian spruce-Picea omorika (Pančić) Purkyne 1877 at Tara Mt.

There are 3662 vascular species and subspecies in Serbia. These taxa are grouped in 141 families and 766 genera, which puts Serbia into a group of European countries with highest floristic diversity per area unit.

Figure 115 presents species density (i. e. number of taxa per 20x20 km UTM squares) of vascular plants in Serbia. Vojvodina and areas along large rivers have relatively low species density. Density increases towards south (mountain areas) and the largest is in the area of Prokletije Mt., Shar Mt., Kopaonik Mt., Balkan Mt., and Tara Mt. Gradient of floristic richness is greatly correlated to urban areas and anthropogenic influence to the environment.

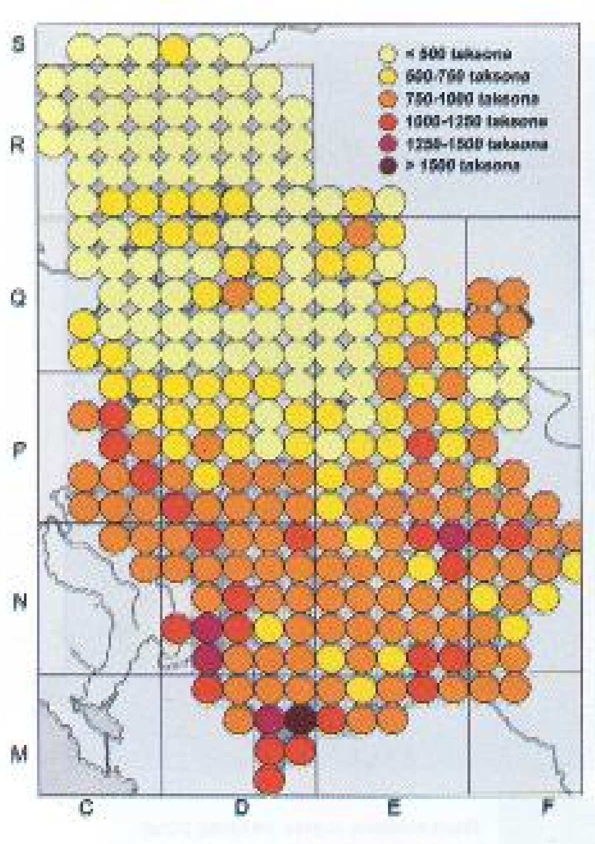


Figure 115

Species density of vascular plants per 20x20 km UTM (Universal Transverse Mercator) squares in Serbia (source: Stevanović et al, 2005)

High floristic diversity in Serbia is consequence of variety of orographic, geological, climate and historical factors, which have been or are still active in this area. Not all groups of flora in Serbia have been equally studied. The best studied groups are vascular plants, where algae are the least studied.

Fungi

Fungi and bacteria are the primary decomposers of organic matter in most terrestrial ecosystems. The term *Macromycetes* or *Macrofungi* denotes the representatives of *Basidiomycotina* and *Ascomycotina*, two phila (major divisions) of the kingdom *Fungi*, that form large macroscopic fruitbodies. Macrofungi are a diverse and ecologically important group of organisms.

According to Ivančević (1995), more then 600 species of Macromycetes are recorded in Serbia. They belong to 232 different families of Fungi. More than 60 species of Macromycetes are endangered to various degree.

Figure 116

Tuber melanosporum. Over 50% of European true truffles are detected in Serbia

Kušan (1953) reviewed lichenized fungi of Yugoslavia, including many species from Serbia. According to the most recent data (Savić and Tibell, 2006), 586 lichens are distributed in Serbia.

Fish diversity

There are 110 *fish species* registered in Serbia, or 51% of all European ichtyofauna. Freshwater ecosystems in Serbia comprise *large basins* (Danube with tributaries), *macroaccumulations* (Djerdap, Vlasina, etc.), *microaccumulations* (larger number of small accumulations for irrigation and other local purposes), *flooded areas and wetlands* (Apatin wetland, Kovilje-Gardinovac wetland, and a series of smaller areas of local significance) and a canal network (Danube – Tisza – Danube, and other smaller networks). There are 4 areas in Serbia with specific ichtyofauna: Danube-Black Sea System, Tara-Piva-Drina, System, Ohrid-Drim-Skadar System and rivers of Aegean basin.

There are 79 fish species in Danube Basin, from 16 families and 3 species of Cyclostomata. Family *Cyprinidae* has 50 species. Specific feature of the Danube-Black Sea system is seasonal presence of 5 species from *Acipenseridae* family and 2 species from *Clupeidae* family, which migrate from the Black Sea to the Danube during spawning season. Hydroelectric power plant cut this migratory path, and they can reach only to Djerdap II plant. There are 12 endemic fish species and subspecies in the Danube basin and one endemic species of *Cyclostomata*. There are also 13 allochthonous species. Populations of some introduced species are rather numerous, and some of them are undesirable in natural ecosystems.

Tara-Piva-Drina System is significant for mountain areas. There are 32 fish species registered in this system

Ohrid-Drim-Skadar System represents very important area for it is a main corridor between riverine, lacustrine and marine ecosystems. It has specific ichtyofauna for the large number of endemic species and subspecies. Metohija area, as a part of this system, has 16 autochthonous (*Salmo trutta* with two subspecies) and 9 allochthonous species.

Aegean Basin rivers comprise rather small area in Serbia and there are no precise data on ichtyofauna.

Aquatic ecosystems enable fast spreading of introduced or non-indigenous species that are rapidly expanding outside of their native range. Introduced species can alter ecological relationships among native species and can affect ecosystem function, economic value of ecosystems, and human health. More than 15 fish species in Serbia are introduced from other regions (Janković and Krpo-Ćetković, 1995). The newest case of introduction was recorded in 2006. A specimen of the North American paddlefish, *Polyodon* spathula was caught near Prahovo in the Serbian part of the Danube River (Lenhardt et al., 2006).

Figure 117

Polyodon spathula WALBAUM, 1792, an introduced fish species in Serbia

Amphibians and reptiles

Balkan Peninsula has 95 amphibian and reptile species, of which 45 are endemics, and therefore represents very significant area of European herpetofauna. Considering Serbian territory only, 44 amphibian and reptile species were recorder (55 subspecies in total), within 19 genera and 14 families, which clearly indicates large diversity in herpetofauna in this area. Some of these species are important from biogeographic point of view. The Alpine salamander, *Salamandra atra* (LAURENTI, 1768), is a completely terrestrial, and viviparous amphibian. It is an endemic species to the Alpine arc from Switzerland to Austria with some geographically isolated areas in the Dinaric Alps (Slovenia to Albania). There are two currently recognized subspecies: *S. a. atra* and the yellow spotted *S. a. aurorae* which is restricted to an extremely small area in the Asiago plateau in NE Italy (Grossenbacher, 1997).

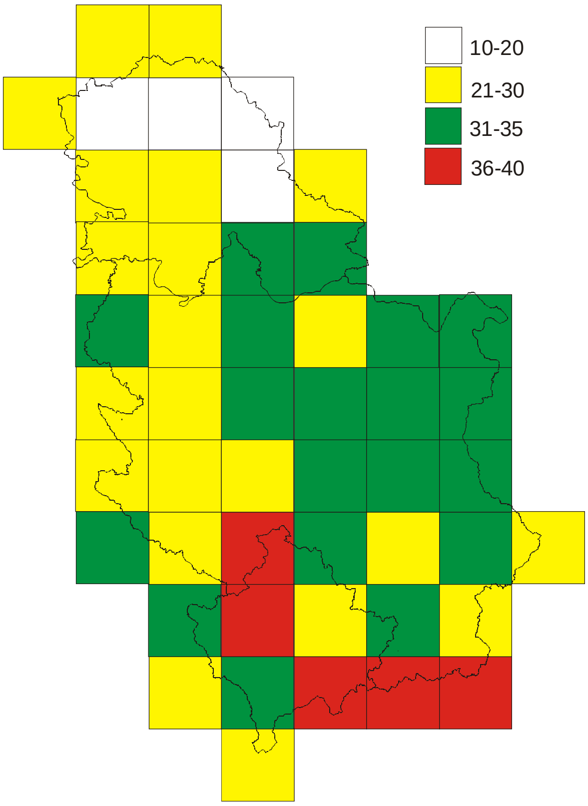


Figure 118

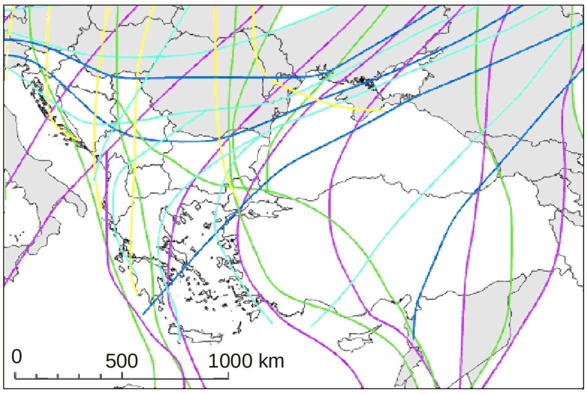
Species density of Amphibians and Reptiles per 50x50 km UTM squares in Serbia (source: Džukić, 1995.)

There is a general trend in decreasing of amphibian and reptile populations in the world, where causes are related to human influence, above all. Such trends are visible in Serbia, as well. The main causes are alterations of autochthonous landscapes, degradation, fragmentation and isolation of habitats, pollution of water, air and soil, transportation and hunting.

Birds

There are 345 bird species in Serbia registered so far, which presents 74% of European species. This richness is, above all, represented in the number of *nesting bird species*. There are approximately 300 nesting species on the Balkans, where 253 are in Serbia (84%). Migratory species are wintering in Serbia, or continue migration to the south. Serbian south provinces are the richest in bird species inhabiting dry habitats, as opposed to the lowland areas of north-east Serbia, along the Danube. Including waterfowls, south part of Serbia is, after Macedonia, the largest center of bird diversity on the Balkans.

The most important bird migration routes in South-Eastern Europe are the Bosfor strait (a west-easter route) and a north-south route in the Caucasus region (EUCC, 1999). However, there are several other migration routes over South-Easter Europe (Fig 119) and some routes over Serbia are of global importance (Biro, Bouwma and Grobelnik, 2006).



General direction of autumn migrating W Siberian Waterfofl from summer mounting places in Wetlands of N Caspian Sea

Autumn migrating W Siberian wetland birds looking for scarce wetlands in W Balkans

Scandinavian and Baltic Cormorants

NE European and Wsiberian Passerines, Herons and small Raptors Quails etc.

N European and C European (partim) Passerines, Storchs, large and medium Raptores etc.

Figure 119

Bird migration routes in Balkan peninsula. Source: Vasić, in: Biro, Bouwma and Grobelnik, 2006.

Decrease of number of species is consequence of synergistic effect of unfavourable factors, and the most prominent are land use alterations (agriculture), loss of habitats, pollution, changes in forestry practice, pressure from hunting and chasing, overexploitation of birds which are not usually hunted and climate changes.

Figure 120

Mergus merganser. Photo: S. Marinković

Table 11 presents the number of nesting species in Serbia. All species taken into account, and not only nesting ones, shows that diversity per regions is somewhat equalized in relation to the north-south distribution (Vasić, 1995).

Table 11. Number of nesting species in different regions in Serbia

Territory	All bird species	Dry habitat bird species	Waterfowls
Vojvodina	188	131	57
west Serbia	183	101	82
central Serbia	188	131	57
Carpathian Serbia	174	143	31
Balkan Serbia	153	144	9
south Serbia	189	169	20
South-west Serbia	191	165	26

Mammals

Mammals have specific position and role in functioning of natural ecosystems. There are 94 terrestrial mammal species in Serbia, within 6 orders (Fig 121). They inhabit preferably deciduous forests, and less open or semi-open habitats. Endemism is not characteristic for European mammals. However, Martino's snow vole (*Dinaromys bogdanovi* (Martino, 1922) *is* an ancient member of the rodent subfamily *Arvicolinae*, with a small range on the karstic bedrock of the Western Balkans.

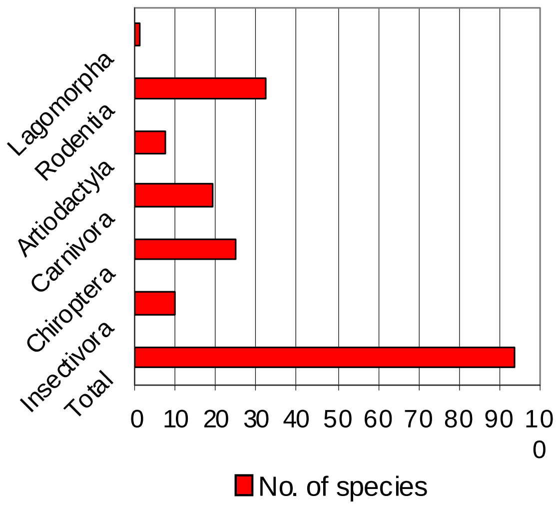


Figure 121

Diversity of mammalian fauna in Serbia

There are two areas of high diversity: east area of south Banat, Carpathian and Balkan Serbia and Sumadija, and west area of Backa, Srem and Drina River valley. The lowest diversity is in north Banat and Sava River valley.

Table 12. Distribution of mammalian fauna in Serbia according to regions/provinces

Region	*Insectivora*	*Chiroptera*	*Carnivora*	*Artiodactylia*	*Rodentia+ Lagomorpha*	Total
Bačka	7	7	9	6	21	50
Srem	7	17	11	5	20	60
N.Banat	7	1	7	2	15	32
S.Banat	7	6	13	3	22	51
Sava valley	5	2	7	3	14	31
Drina valley	9	16	10	3	15	53
Šumadija	7	15	6	2	21	52
W.Morava valley	5	6	7	2	16	36
G.Morava valley	6	13	9	2	17	47
Carpathian Serb.	8	20	15	5	19	67
Balkan Serbia	7	9	13	3	18	50
S. Morava valley	4	2	10	2	17	35
Vlasina and Krajište	5	0	6	2	13	26
Toplica and Jablanica	5	3	9	2	14	33
Raška	7	9	12	3	15	46
Ibar and Kopaonik	7	2	11	2	14	36
Kosovo	7	4	13	3	17	44
Metohija	9	8	12	5	16	50

Table 12 presents distribution of mammals according to more strict biogeographic zoning of Serbia (Savić et al., 1995). Compiled data on mammalian diversity are presented in order to present diversity centers in more realistic way.

Certain species are globally or regionally distributed into different categories of endangered species. Most of them are low risk (LR) and its sub-categories. Main factors are degradation of natural habitats, overexploitation and pollution of habitats.

ECOSYSTEM DIVERSITY

The term ecosystem denotes the entire assemblage of organisms (a biotic community or biocoenosis) living together in a certain space (biotope) and interacting with their environment. Similar ecosystems may be grouped and classified into ecosystem types. In general, there are two approaches of ecosystem classifications. Habitat-oriented approach groups ecosystems which are similar with respect to environmental conditions (climate, hydrology, geology, soil) within their biotopes. On the other hand, community-oriented approach groups ecosystems which are similar with respect to physiognomy or floristic (faunistic) composition of biotic communities.

Habitat-oriented classifications of ecosystems are specified by Directive on Wild Birds (EEC/79/409 directive) and Habitat Directive EEC/92/43. More elaborated classification system involves CORINE biotopes. EUNIS in Paneuropean classification system of ecosystems, which is based on climate, soil, water quality, vegetation, physiographic elements and characteristic or dominant plant and animal species.

Some countries have developed their national classifications of ecosystems in order to emphasize the both landscape and biological diversity of their territory. Most of national classification systems are based on the classification of vegetation, since vegetation is most important structural (and functional) part of ecosystems.

The vegetation of Serbia is extremely diverse. More than 700 associations, up to 500 subassociations may be grouped in higher phytosociological units (242 alliances, 114 orders and 59 vegetational classes). This fact points out in the best way that the territory of present Serbia is characterized by a high diversity of habitats, and due to that fact, by a diverse plant communities which single out this region as one of the most significant European centers of diversity of vegetation and ecosystems. Polydominant forest vegetation in Serbian (and more generally Balkan) canyons represents a valuable pool of species diversity. A great heterogeneity of environmental conditions and specific history of biota in the canyons resulted with complex communities that represent significant resource of rare and endangered taxa (Karadžić et al., 1996, 2001).

The number of species in various types of vegetation on the territory of Serbia has shown that the deciduous forests (*Querco-Fagetea*) with 1,498 recorded species and secondary xero- and xero-mesophilic grasslands (*Festuco-Brometea*) with 1,194 of species, have the highest alpha diversity. The lowest number of species has been recorded in a water environment, within the zone of a floating and submersed vegetation (*Lemnetea, Charetea, Ruppietea maritimae* - between 19 and 37 species).

The highest species diversity is recorded in the inland herbaceous xerophytic and mesophytic ecosystems (2,399 species and subspecies, which make 84 % of the plants of the complete flora of Serbia). Contrary to this type of ecosystem, within the water environment only 74 species have been registered, making just 2.59 % of the analyzed vascular flora of Serbia. Analysis of the changes of the alpha diversity in the ecological gradients has shown that a decrease of habitats' temperature provokes the statistically significant decrease in the number of species (Lakušić, 2005).

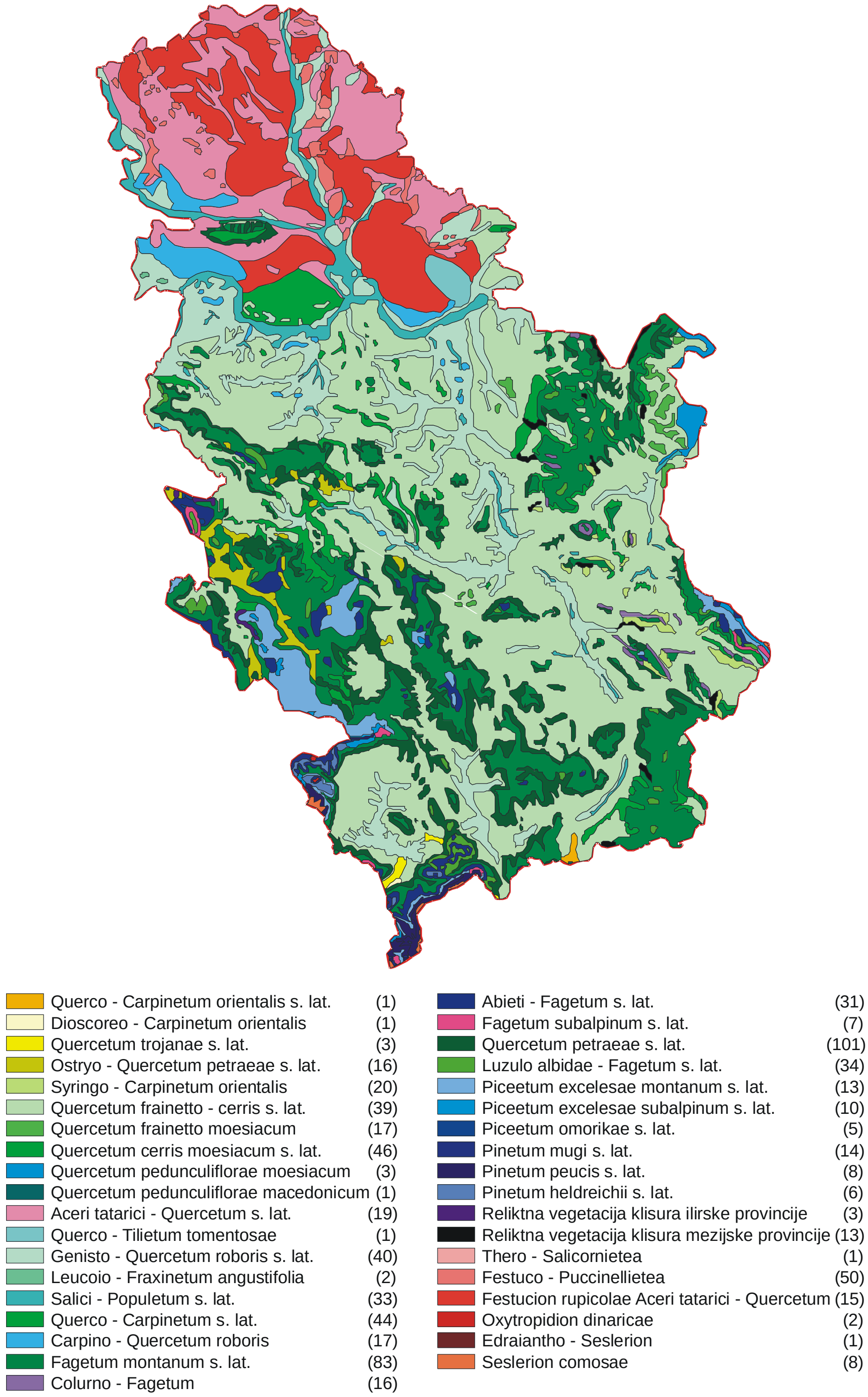


Figure 122

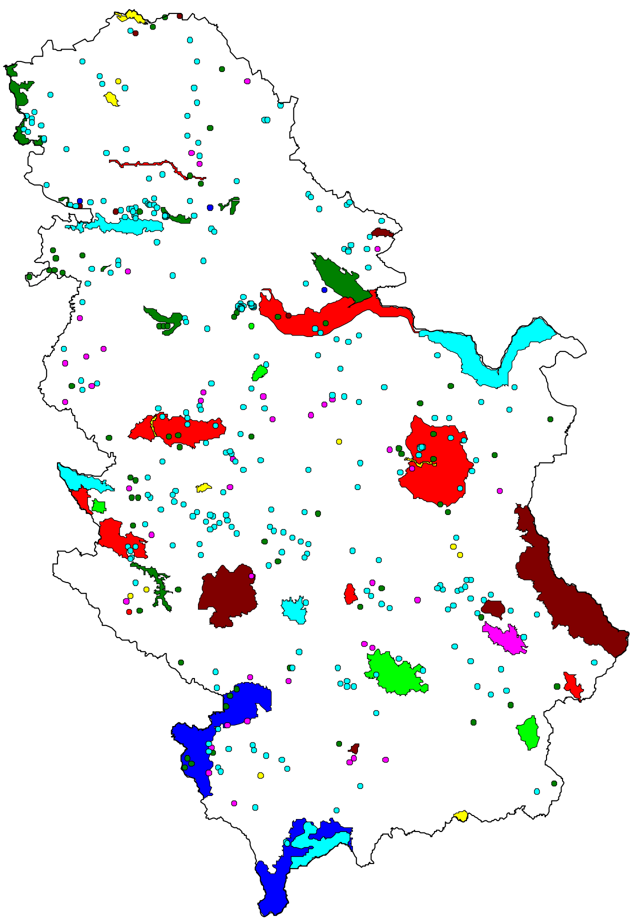
Vegetation heterogeneity in Serbia (source: Stevanović, Jovanović and Lakušić, 1995).

Table 13. Number of species (alpha diversity) in various vegetation types in Serbia (source: Lakušić, 2005)

Vegetation classes	No of species	% species
Querco-Fagetea Br.-Bl. et Vilieger 1937	1498	52.49
Festuco-Brometea Br.-Bl. et R. Tx. 1943	1194	41.84
Molinio-Arrhenatheretea R. Tx. 1937	895	31.36
Vaccinio-Piceetea Br.-Bl. 1939 emend. Zupančić 1976	703	24.63
Erico-Pinetea Ht. 1959	683	23.93
Festucetea vaginatae Soó 1968 emend. Vicherek 1972	681	23.86
Festuco-Seslerietea Barbero et Bonim 1969	673	23.58
Asplenietea trichomanis Br.-Bl. 1934 corr. Oberd. 1977	568	19.90
Artemisietea vulgaris Lohm., Prsg. et R. Tx. 1950	524	18.36
Juncetea trifidi Hadač 1944	441	15.45
Betulo-Adenostyletea Br.-Bl. et R. Tx. 1943	357	12.51
Nardo-Callunetea Preising 1949	333	11.67
Bidentetea tripartitii Tx., Lohm. et Prsg. 1950	327	11.46
Chenopodietea Br.- Bl.1951 em. Lohm. J. et R. Tx.1961	301	10.55
Stellarietea mediae Tx., Lohm. et Prsg. 1950	292	10.23
Epilobietea angustifolii R. Tx. Et Preising 1950	291	10.20
Phragmitetea communis R. Tx. et Preising 1942	290	10.16
Festuco-Puccinellietea Soó 1968	246	8.62
Plantaginetea majoris Tx. et Prsg. 1950	242	8.48
Scheuchzerio-Caricetea fuscae (Nordhagen 1936) R. Tx. 1937	238	8.34
Alnetea glutinosae Br.-Bl. et R. Tx. 1943	220	7.71
Drypetea spinosae Quezel 1967	211	7.39
Isoeto-Nanojuncetea Br.-Bl. Et Tx. 1943	148	5.19
Agropyretea repentis Oberd., Th. Muller et Gors 1967	148	5.19
Thero-Brachypodietea Br.-Bl. 1947	112	3.92
Paliuretea Trinajstić 1978	85	2.98
Thero-Salicornietea Pignatti 1953 emend. R. Tx. 1955	77	2.70
Thlaspietea rotundifolii Br.-Bl. et al. 1947	72	2.52
Potametea R. Tx. et Preising 1942	66	2.31
Salicetea purpureae Moor 1958	52	1.82
Salicetea herbaceae Br.-Bl. et al .1947	46	1.61
Montio-Cardaminetea Br.-Bl. Et Tx. 1943	40	1.40
Charetea Fukarek 1961 ex Krauch 1964	37	1.30
Lemnetea W. Koch et R. Tx. 1954	36	1.26
Ruppietea maritimae J. Tüxen 1960	19	0.67
Total	2854	100.00

AREAS DESIGNATED FOR NATURE PROTECTION

Total protected areas in Serbia are 6.6% of the country's territory. There are 5 national parks, 14 parks of nature, 72 natural reserves, 17 protected landscapes, 43 cultural-historical landscapes and 312 monuments of nature. The largest share in protected areas goes to national parks and nature parks, as presented in Figure 123.



Area envisaged for protection
Area in the procedure to be protected Landscape of outstanding qualities
Area in the procedure to be protected National Park
Area in the procedure to be protected Nature Reserve - Special Nature Reserve
Landscape of outstanding qualities
National Park
Nature Park
Nature Reserve - Special Nature Reserve
Area of cultural and historical importance
Natural monument (botanical, geological, hydrological)

Figure 123

Review of designated areas in Serbia (source: Institute for nature conservation of Serbia)

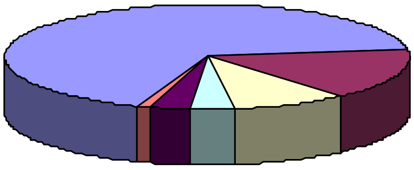


Figure 124

Structure of protected areas in Serbia

Serbian legislative system for the protection of natural resources is governed by a number of international conventions, directives and resolutions — including bilateral and multilateral treaties through which countries systematically regulate the protection of biological and landscape diversity. Serbia ratified:

- The Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971), which it ratified in 1977;
- The Convention on Biological Diversity (1992), which it ratified in 2001;
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979) (CITES), which it ratified in 2001.

Like in any European country, there are two categories of designation. Internationally designated areas involve:

- Bern Convention's Emerald Network
- Ramsar sites and
- UNESCO MAB sites.

Nationally designated areas involve:

- Natural Monument Wildlife reserve
- Natural Monuments and Landmarks
- Nature Landscape Reserve
- Nature Park
- Landscape (of outstanding value) Special Reserve

Internationally acknowledged areas

Ramsar sites are wetlands of international importance designated under the Ramsar Convention. Initial Ramsar sites in Serbia were designated in 1977. Since then, many more have been designated (Figure 125).

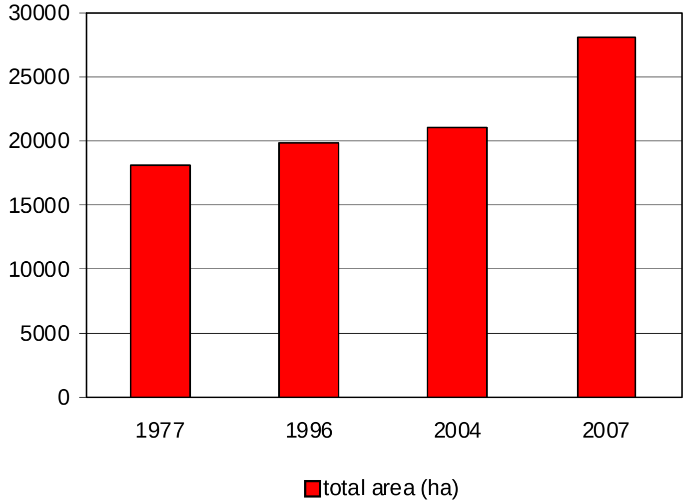


Figure 125

Cumulative area of international importance wetlands in Serbia

Golija-Studenica MAB (UNESCO's Man and the Biosphere Programme) reserve covers 53 804 hectares. The biosphere reserve includes the Studenica Monastery, which is a cultural World Heritage site and a popular tourist attraction. In the area, many non-governmental organizations are interested in the protection of the natural environment and in the implementation of sustainable development principles. With the establishment of a biosphere reserve, these organizations will be able to carry out their programmes and contribute to the functions of the Golija-Studenica Biosphere Reserve, based on a rich history of scientific research and observations.

Emerald Network sites

The Emerald Network is a network of areas of special conservation interest (ASCIs), which is to be established in the territory of the contracting parties and observer states to the Bern Convention, including, among others, Central and Eastern European countries and the EU Member States. For EU Member States, Emerald Network sites are those of the Natura 2000 network. The Natura 2000 is a network of protected areas under the EU Habitat and Bird Directives. The network consists of Special Protection Areas (SPAs) and Sites of Community Interest (SCIs). *Emerald network* of Areas of Special Conservation Interest – ASCI are designated by countries – observers of Bern Convention, which is still not ratified in Serbia. A pilot project which is aimed at preparation of *Emerald network* of ASCIs started in 2005. Six ASCIs have been designated initially (Kopaonik NP, Obedska bara, Gornje podunavlje, Deliblatska peščara SNRs, Prokletije Mt. and Vlasina Lake). However, potential Emerald ASCIs in Serbia cover more than 60 sites.

Prime Butterfly Areas (PBA)

Prime Butterfly Areas are an initial selection of important butterfly areas in Europe, focussing on target species that are conservation priorities across a large and diverse region. Protection and proper management of these areas will help to conserve not only these target species, but also the many other characteristic butterflies they contain. There are 13 PBA in Serbia.

Important Bird Areas (IBA)

BirdLife International provided data on IBAs. A site is recognized as an IBA only if it meets certain criteria, based on the occurrence of key bird species that are vulnerable to global extinction or whose populations are otherwise irreplaceable. An IBA must be amenable to conservation action and management. The IBA criteria are internationally agreed, standardized, quantitative and scientifically defensible. Ideally, each IBA should be large enough to support self-sustaining populations of as many as possible of the key bird species for which it was identified or, in the case of migrants, fulfil their requirements for the duration of their presence. By definition, an IBA is an internationally agreed priority for conservation action. According to the Bird Life International criteria, there are 35 Important Bird Areas (IBA) in Serbia.

Important Plant Areas (IPA)

IPAs are natural or semi-natural sites exhibiting exceptional botanical richness and/or supporting an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanical value. The mapping of IPAs in Serbia is still in preparation. Initial assessments indicated that 222 potential IPAs and 12 cross border IPA sites may be delimited within Serbia (Boteva et al., 2004). At the moment, there are 59 IPAs in Serbia (Stevanović, 2005).

Figure 126

Chlidonias hybridus. Photo: S. Marinkovic.

Nationally acknowledged areas

According to existing legislative, there are 12 categories of nationally designed areas. The National Assembly establishes national parks. The Government proclaims nature reserves and other protected areas of national importance. Local authorities (municipalities) may decide on protected areas of local importance. The Institute for the Protection of Nature prepares the documents necessary for the establishment of protected areas. Five national parks are the most important nationally designed areas in Serbia (Table 14, Fig 124).

Table 14. National parks in Serbia

National park	Area (ha)
Djerdap	64 000
Tara	19 200
Kopaonik	12 000
Fruška Gora	25 400
Šar planina	39 000

Djerdap National Park is situated in the northeast and borders Romania. It is characterized by the Danube canyon and the huge Djerdap gorge. Vegetation consists of about 60 forest and shrub community types that provide habitats. The *Djerdap* National Park stretches along the right bank of the Danube River from Golubacki grad to the dam near Sip.

Fruska Gora is a 539 m high mountain in northern Serbia, with 90% of it forested. About 1100 plant species have been identified, 12% of which are relict or endemic. In addition to 200 bird species, wildcat, badger, marten, dormouse, bat and other species can be found.

Kopaonik National Park is situated in the central part of Serbia, on the highest parts of Mount Kopaonik. Due to altitude and climate zone differences, the area is characterized by a rich biodiversity, especially of endemic and rare species. Beside biodiversity, its main feature is a very attractive landscape. National Park *Kopaonik* was founded and proclaimed in 1981. It covers an area of 11.800 ha, and has a protecting belt of 19.986 ha. The wildlife refuges that are under special protection cover 689 ha. The park is placed on the highest parts of the mountain. The base of the park represents mountainous, relatively levelled region of the medium height above sea - level about 1700 m. The upermost point is *Pancicev Vrh* (Pancic Peak) (2017 m a. s. l.).

Mount Shara National Park is in the very south of Serbia, where 20 endemic species are to be found. Beside diverse vegetation, many animals live there, among them lynx, bear, eagle and the griffon vulture. The *Šar Planina* National Park is in the territory of the Autonomous Province of Kosovo and Metohija. It spreads on 380 square kilometres, on the northern slopes of the Šar Mt. What this national park boasts in particular are the endemic pine relict species *Pinus heldreichii* H.Christ and *Pinus peuce* Griseb.

Tara National Park comprises a mountain chain intersected by river valleys and crags. Its peculiarity is endemic and relict spruce (*Picea omorica*). Forests, pastures, peat sites and riverbank vegetation serve as habitats to many animal species and are the main features of the attractive landscape. Tara National Park was established in 1981 and it encompasses Tara and Zvijezda mountains, in vicinity of the Drina River. The park covers approximately 220 square kilometers with altitudes varying from 250 to 1,500 meters a.s.l. Habitats with endemic and stenotopic Serbian spruce are important.

Serbia's current spatial plan provides some guidelines for natural heritage protection, including: (1) the enlargement of current protected areas up to 10% by 2010; (2) the development of protection regimes for protected areas; (3) regional priority areas for protection; and (4) new Ramsar sites.

ENDANGERED AND PROTECTED SPECIES

Decree on protection of natural rarities has been enacted in 1993 in Serbia, aiming to protect and enhance biodiversity and gene fund. Decree comprises 215 plant and 427 animal species. Also, Decree on putting under control trade and collection of wild flora and fauna has been enacted.

Majority of endangered species (IUCN List) are part of the Decree, as presented in Fig. 127. It is necessary to include globally endangered species into international mechanisms of protection.

There are significant differences between lists of nationally and globally endangered species, as it is in Serbia, as well. Large number of animal species which are extinct, endangered or vulnerable according to national experts (SRB), are not on global lists (Figure 10). Even more drastic example is in Red Data Book of Flora in Serbia, where 171 species and subspecies are classified as extinct (EX, EX-Srb) and critically endangered taxa (CR, CR-Srb), while on IUCN list only one species is listed as extinct.

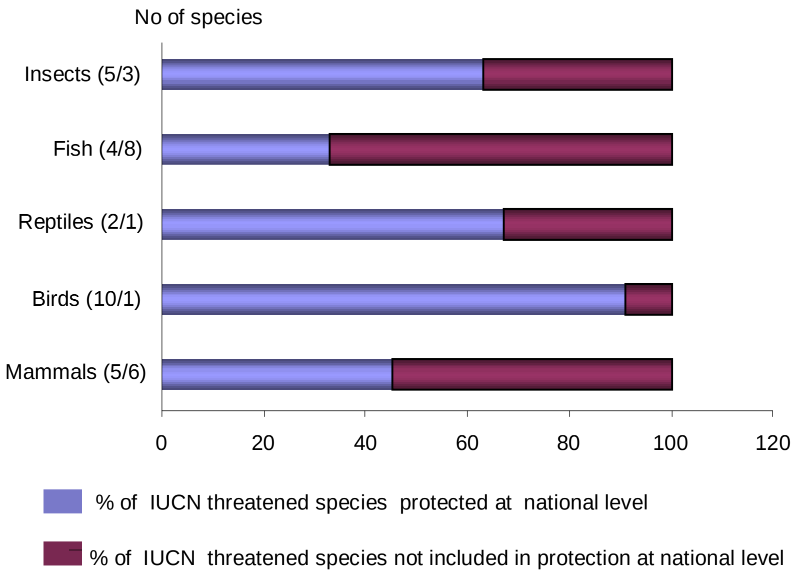


Figure 127

Globally endangered species protected at the national level (Decree on protection of natural rarities)

Having in mind significance and specificities of Balkan and Serbian flora and fauna, it is necessary to expand IUCN list of endangered species with Balkan endemics, above all (Figure 128).

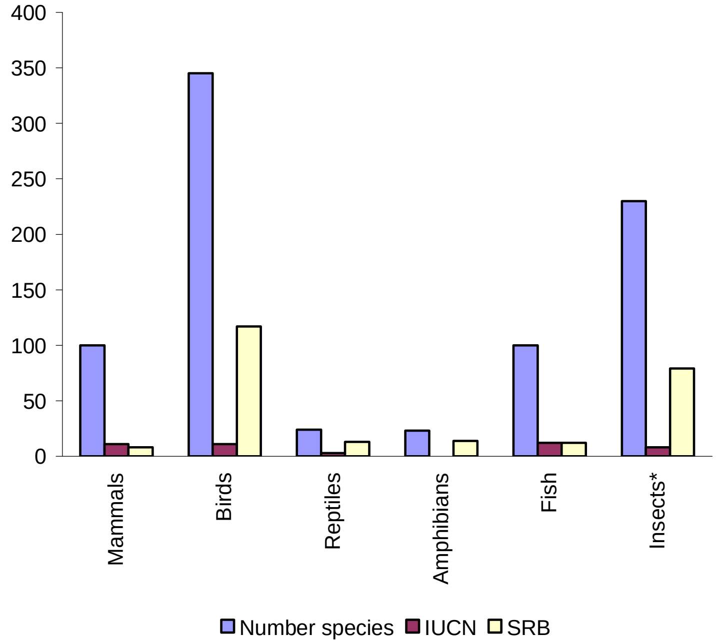


Figure 128

Total number of species per classes and number of threatened species by IUCN and SRB
** The data on Insects are not representative because of insufficient research of this class*

PROGRAMS OF BIODIVERSITY MONITORING

The largest number of biodiversity monitoring projects is related to endangered bird populations (*Gyps fulvus, Otis tarda, Coracias garrulous, Falco cherrug, Aquila heliaca, Phalacrocorax pygmaeus).* There are also monitoring programs of *Testudo hermanni, Rana synklepton esculenta, Cerambycidae, Syrphidae* and *Pyrgomorphulla serbica.*

Figure 129

Gyps fulvus. Protection measures and construction of feeding spots increased the number of nesting pairs in Serbia. Photo: S. Marinkovic.

Monitoring programs are focused not only on rare and endangered species, but also on *alien invasive species*, that are introduced deliberately or unintentionally outside their natural habitats where they have the ability to establish themselves, invade, outcompete natives and take over the new environments. Plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments. (www.biodiv.org/programmes/cross-cutting/alien/default.asp).

The Western Corn Rootworm, *Diabrotica virgifera* Le Conte, (Coleoptera: Chrysomelidae), was introduced in the 1990s into Serbia (Yugoslavia). This is an important pest of maize occurring in North America, whose soil-inhabiting larvae can seriously damage roots of maize *(Zea mays*) and lead to yield losses. *D. virgifera* was first detected in July 1992 in the locality of Surcin near the Belgrade International Airport. The origin of this introduction remains unknown (European and Mediterranean Plant Protection Organization (EPPO), www.eppo.org).

The pest multiplied and spread during 1993 and 1994. The main direction of spread was towards the north-west. In general, the main movement of the populations follows the prevailing winds. Monitoring of the pest populations has continued in 1995, by visual inspections and use of cucurbitacin traps.

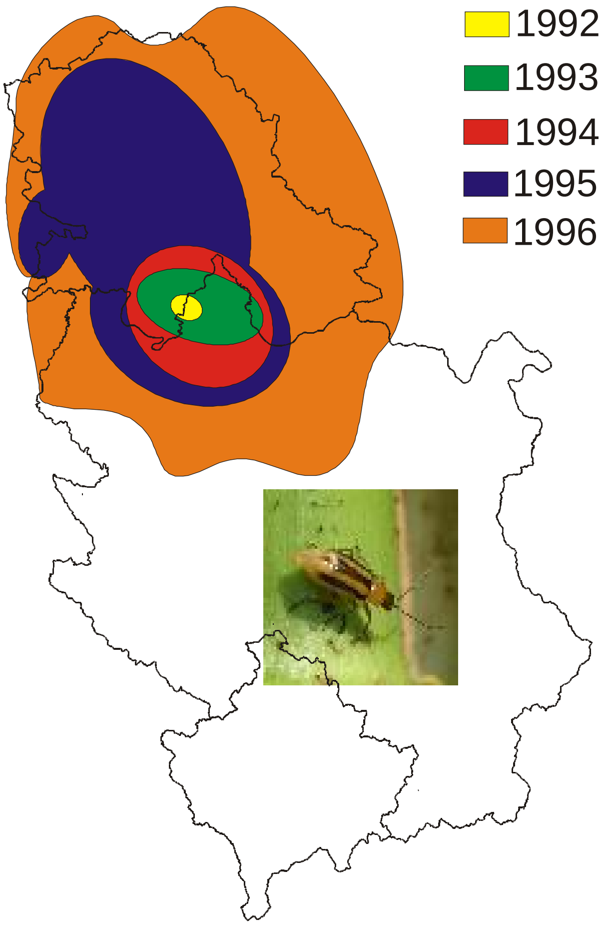


Figure 130

Dynamics of the spread of Diabrotica virgifera Le Conte in Serbia From Camrag, 1995

REINTRODUCTION PROGRAMS AND *EX SITU* CONSERVATION OF BIODIVERSITY

Reintroduction is rather efficient way for protection of species in their natural habitats. Directorate for environmental protection initiated several (very successful) reintroduction projects.

The data from paleontological and archaeological excavations show the continual presence of European beaver (*Castor fiber* L. 1758) in Serbia, from Pleistocene through prehistory to its complete extinction from this area at the beginning of the 20th century. During the first half of the 19th century beaver was relatively widely spread along the river beds and swamp areas along our big rivers (the Danube, Sava, Morava). The project of European beaver reintroduction in Serbia has been realized in association with Ministry of Science and Environmental Protection - Directorate for Environmental Protection, Biology Faculty in Belgrade, the Association from Bavaria and SNR Zasavica. Several beaver families were reintroduced in Obedska swamp and Zasavica special nature reserve.

Figure 131

Beaver (Castor fiber L.). Photo: S. Marinkovic

Micropropagation and reintroduction of *Nepeta rtanjensis* Diklić & Milojević, an endemic and critically endangered perennial of Serbia is successful ongoing project that is financed by the Ministry of Science and Environmental Protection - Directorate for Environmental Protection. This species was recorded for the first time in 1974 in the territory of Serbia, in the locality Greda on the southern slopes of Mt Rtanj (eastern Serbia). During the field investigations in 1996, the species was found on southeastern slopes of Mt Rtanj as well, in the locality Javor. By its restricted distribution the plant is *stenoendemite* (local endemic species) of Serbia. At the same time it is the relict one being geographically isolated in relation to the other species of the same *Nepeta sibthorpii* - complex..*N.*

rtanjensis is aromatic, potentially medicinal plant, protected by law in Serbia as local endemic species of international importance (Diklić,1999).

Figure 132

Nepeta rtanjensis Diklić & Milojević, rare and endemic species. Photo D. Mišić

REFERENCES

A statistical view of environmental issues, EUROSTAT, 2005.

Adamov, J., S. Jovetic, D. Buzarov, M. Vojinovic-Miloradov 2002. Content of PCBs in food of animal and plant origin in Vojvodina (Serbia) after industrial disasters in 1999. In: Book of abstracts of the 6th International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Prague, Czech Republic, September 01-04, 187.

Antić, M., Avdalović, V., Jović, N.1982. Pedologija, Naučna knjiga, Beograd.

Baumgartner, A and Reichel, E (1975) The World Water Balance. R. Oldenburg Verlag, Munich.

Benka, P., Salvai, A., 2006. GIS Soil Maps of Vojvodina for Integrated Water Resources Management. Conference on Water Observation and Information System for Decision Support BALWOIS, Section 8: Information systems, CD of proceedings, Ohrid - Rep. of Macedonia.

Biro, E., Bouwma, I. and Grobelnik, V. 2006. Indicative map of the Pan-European Ecological Network in South-Eastern Europe - Technical Background document. (ECNC Technical Report Series).ECNC, Tilburg, the Netherlands.

Blaženčić, J., Cvijan, M. and Laušević, R. 1995. Diverzitet slatkovodnih algi Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović, V. And Vasić, V. (eds): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Boteva, D., I. Apostolova, L. Melovski, D. Petrovic, Z. Kaneva, T. Meshinev, J. Spiridonov, D. Lakusic, T. Nikolic, S. Tzoneva, V. Matevski, D. Peev, N. Valjovska and A. Petrova 2004. Potential Important Plant Areas in selected South Eastern European countries. The Regional Environmental Center for Central and Eastern Europe.

Čuvardić (Manojlović), M., Hadžić, V., Sekulić, P., Kastori, R., Belić, M., Govedarica, M., Nešić, Lj., Pucarević, M., Vasin, J., 2004. Quality Control of Agricultural Soils and Irrigation Water in Vojvodina Province (in Serbian). Zbornik radova. A Periodical of Scientific Research of Field and Vegetable Crops. Institute of Field and Vegetable Crops, Novi Sad, 40: 115-127.

Hoyois, P., Guha-Sapir, D. 2003. Three decades of floods in Europe: a preliminary analysis of EMDAT data. WHO collaborating Centre for Research on the Epidemiology of Disasters (CRED), Catholique University of Louvain.

Chevreuil, M, Chesterikoff, A and Letolle, R (1987) PCB pollution behaviour in the river Seine. Water Research 21, 42734.

Council of Europe.1998. The EMERALD Network - a network of Areas of Special Conservation Interest for Europe. Document T-PVS(98)13, Council of Europe, Strasbourg.

Cresser, M and Edwards, A (1987) Acidification of freshwaters. Cambridge University Press, Cambridge.

Cvijan M. and Subakov-Simić *G.* 2003. Flora algi Srbije tom II *Rhodophyta*. NNK international Beograd

Cvijan, M and Blaženčić, J 1996. Flora of algae of Serbia (Flora algi Srbije). Volume 1. *Cyanophyta*. Naučna knjiga, Beograd, 290 pp.

Davies C.E. & Moss, D. 1999. EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Conservation, European Environment Agency. October 1999. 256pp.

Davies C.E. & Moss, D. 2002. EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Protection and Biodiversity, European Environment Agency. February 2002. 125pp.

Davies, C.E. and Moss, D. 2000. The EUNIS Habitat Classification. 2000 ICES Annual Science Conference; Theme session on Classification and Mapping of Marine Habitats. ICES CM2000/T:04. Brugge, Belgium, 27-30 September 2000

Devillers, P. & Devillers-Terschuren, J. 1996. A classification of Palaearctic habitats. Council of Europe, Strasbourg: Nature and environment, No 78.

Diklić, N. 1999. Nepeta rtanjensis Diklić & Milojević. In: Stevanović, V. (ed):The Red Data Book of Flora of Serbia 1. Extinct and Critically Endangered Taxa. Ministarstvo za životnu sredinu Republike Srbije, Biološki fakultet Univerziteta u Beogradu, Zavod za zaštitu prirode Republike Srbije.

Directive on the promotion of electricity from renewable energy sources in the internal electricity market (2001/77/EC).

Džukić, G. 1995. Diverzitet vodozemaca (Amphibia) I gmizavaca (Reptilia) Jugoslavije sa pregledom vrsta od medjunarodnog značaja. In Stevanović, V, Vasić, V. (eds) Biodiverzitet Jugoslavije sa pregledom vrsta od medjunarodnog značaja. Pp. 447-470. Biološki fakultet, I Ecolibri, Beograd.

EEA 1995. Europe’s environment. The Dobris assessment. Office for Official Publications of the European Communities. Luxembourg.

EEA 1998. Europe's Environment: The Second Assessment. Copenhagen: European Environment Agency.

EEA 1999. Nutrients in European ecosystems. Office for Official Publications of the European Communities. Luxembourg.

EEA 2001. Towards agri-environmental indicators. Office for Official Publications of the European Communities. Luxembourg.

EEA 2002 Environmental signals 2002. Office for Official Publications of the European Communities. Luxembourg.

EEA 2003. Europe’s environment the third assessment. Office for Official Publications of the European Communities. Luxembourg.

EEA 2003 a. Europe’s water: An indicator-based assessment. Office for Official Publications of the European Communities. Luxembourg.

EEA 2005. Climate change and a European low-carbon energy system. Office for Official Publications of the European Communities. Luxembourg.

Energetski bilans Republike Srbije za 2006. godinu, Sl. glasnik broj 11/06

Environmental Protection Expenditure in Europe by public sector and specialised producers 1995-2002., Nancy Olsson, Eurostat, 11.2005

European Communities. 1991. Habitats of the European Community. CORINE biotopes manual, Volume 2. Luxembourg: Commission of the European Communities.

European Communities. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities, L206.

Fisher, D A et al 1990. Model calculations of the relative effects of CFCs and their replacements on global warming. *Nature* 344, 51316.

Flegman, A. W. and George, R. A. T. 1975. *Soils and other growth media.* The MacMillan Press, London.

Folland, C.K., Karl, T.R., Christy, R., Clarke, R.A., Gruza, G.V., Jouzel, J., Mann, M.E., Oerlemans, J., Salinger, M.J. and Wang, S.W. (2001): Observed climate variability and change; in Climate Change 2001: The Scientific Basis, (ed.) J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson, contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, p. 99–182.

Gasc J.P., Cabela A., Crnobrnja-Isailovic J., Dolmen D., Grossenbacher K., Haffner P., Lescure J., Martens H., Martínez Rica J.P., Maurin H., Oliveira M.E., Sofianidou T.S., Veith M. & Zuiderwijk A. (eds), 1997. *Atlas of amphibians and reptiles in Europe.* Collection Patrimoines Naturels, 29, Paris, SPN / IEGB / MNHN, 496 pp.

Gaston, K. J. and Spicer, J. I.. 2004. "Biodiversity: an introduction", Blackwell Publishing.

Grossenbacher K. 1997. Salamandra atra. In: Atlas of Amphibians and Reptiles in Europe. Societas Europaea Herpetologica & Muséum National d'Histoire Naturelle, pp. 68-69. (IEGB/SPN), Paris.

Horvat I., Glavač V. et Ellenberg H. (1974): *Vegetation Südosteuropas*. - G. Fischer, Jena, 768 p.

http://www.hidmet.sr.gov.yu/podaci/meteorologija/ciril/2004.pdf, 2004. Osnovne klimatske karakteristike na teritoriji Srbije u periodu januar-decembar 2004 godine, Beograd

IARC 1992. Solar and ultraviolet radiation. IARC Monographs on the evaluation of carcinogenic risks to humans, 55. International Agency for Research on Cancer (IARC), WHO, Geneva.

Institute for Soil Science, 2005. Report on project ″Fertility inspection and detecting presence of dangerous and harmful substances in the soil of the Republic of Serbia″, Belgrade.

IPCC, 1996: *Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.)]. Cambridge University Press, Cambridge.

Ivančevič, B. 1995. Diverzitet makromiceta u Jugoslaviji sa pregledom vrsta od međunarodnog značaja. In V. Stevanović and V. Vasić (eds.): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Jakšić, P. 2003. Red Data Book of Serbian Butterflies, Lepidoptera: Hesperioidea and Papillionoidea. Institute for Nature Conservation of Serbia, Belgrade.

Janković, D., Krpo-Ćetković, J. 1995. Diverzitet slatkovodnih riba (Osteichthyes) i kolousta (Cephalaspidomorpha) Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović, V. And Vasić, V. (eds): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Jenny H., 1980. The Soil Resource, Origin and Behaviour, Springer-Verlag, New York

Josifović, M. 1970-1977 Flora SR Srbije, SANU, Beograd

Karadžić B., Mijović A., Popović R., Perišić, S., Marinković, S. 2001. Forest vegetation in West-Serbian canyons: Biodiversity hotspots. In: Ragodlou, K (*ed*.) *Forest Research: A Challenge for an Integrated European Approach.* NAGREF-Forest Research Institute, Thessaloniki, Greece.pp. 513-518.

Karadžić, B., Marinković, S., Mijović, A. 1996. Canyons in western Serbia: Significant refuge areas for rare species and centers of a great biodiversity. Balkan conference "National parks and their role biodiversity protection on Balkan Peninsula", Ohrid, 177-183.

Kirkby, M.J., Jones, R.J.A., Irvine, B., Gobin, A, Govers, G., Cerdan, O., Van Rompaey, A.J.J., Le Bissonnais, Y., Daroussin, J., King, D., Montanarella, L., Grimm, M., Vieillefont, V., Puigdefabregas, J., Boer, M., Kosmas, C., Yassoglou, N., Tsara, M., Mantel, S., Van

Lynden, G.J. and Huting, J. (2004). Pan-European Soil Erosion Risk Assessment: The PESERA Map, Version 1 October 2003. Explanation of Special Publication Ispra 2004 No.73 (S.P.I.04.73). European Soil Bureau Research Report No.16, EUR 21176, 18pp. and 1 map in ISO B1 format. Office for Official Publications of the European Communities, Luxembourg.

Kojić, M., Popović, R., Karadžić, B. 1997. *Vaskularne biljke Srbije kao indikatori staništa*. IZP "Srbija", IBISS, Beograd.

Kojić, M., Popović, R., Karadžić, B. 1998. *Sintaksonomski pregled vegetacije Srbije.* IBISS, Beograd.

Kurylo, M.J. and J.M. Rodriguez, 1999: Chapter 2, Short-lived Ozone-Related Compounds. In: Scientific Assessment of Ozone Depletion: 1998. Global Ozone Research and Monitoring Project - Report No. 44, World Meteorological Organization, Geneva, Switzerland, pp 2.1-56.

Kušan, F.1953. Prodromus flore lišaja Jugoslavije. JAZU, Zagreb.

Lakušić, D. 2005. Odnos specijskog i ekosistemskog diverziteta. In: Andjelković, M. (ed.) Biodiverzitet na početku novog milenijuma. SANU, Beograd, pp. 75-105.

Law on Agricultural Soils, 2004. Off. Jour. of the Republic of Serbia 62/2006, Belgrade.

Law on Environmental Impact Assessment, 2004.Off. Jour. of Republic of Serbia, No. 135/04, Belgrade.

Law on Environmental Protection, 2004. Off. Jour. of Republic of Serbia, No. 135/04, Belgrade.

Law on integrated pollution prevention and pollution control of the environment, 2004. Off. Jour. Republic of Serbia No. 135/04, Belgrade.

Law on Organic Production and Organic products, 2006. Off. Jour. of the Republic of Serbia 62/2006, Belgrade.

Law on Strategic Environmental Impact Assessment, 2004. Off. Jour. of Republic of Serbia, No. 135/04, Belgrade.

Lenhardt, M., A. Hegediš, B. Mićković, Ž. Višnjic Jeftić, M. Smederevac, I. Jarić, G. Cvijanović, and Z. Gačić. 2006. First record of the North American Paddlefish (*Polypodon spathula* WALBAUM, 1792) in the Serbian part of the Danube river. Arch. Biol. Sci., Belgrade, 58 (3), 27P-28P.

Lenhinger, A. L. 1983. Principles of Biochemistry. Freeman.

Lopatin, I.K., Matvejev, S.D. (1995). Kratka zoogeografija sa osnovama biogeografije i ekologije bioma Balkanskog poluostrva. Knjiga 1, Univerzitetski udžbenik, Ljubljana.

Matvejev, S. 1950. Rasprostranjenje i život ptica u Srbiji. SANU, Beograd, 161 pp.

Memorandum on Budget and Economic and Fiscal Policy for 2006, Ministry of Finance

Ministry for the Protection of Natural Resources and the Environment, Republic of Serbia, 2003. Report on the State of the Environment and Natural Resources in 2002, Belgrade.

Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia-Directorate for Forests, 2004. Forest condition monitoring in the Republic of Serbia, Annual report ICP Forests 2003 Level I, Belgrade, 20-54.

Ministry of Health and Environment of the Republic of Serbia-Directorate for Environmental Protection, 2001. Report on the State of the Environment for 2000 with Priority Tasks for 2001, Belgrade.

Ministry of Science and Environmental Protection, Environmental Protection Agency, Republic of Serbia, 2005. Report on the State of the Environment and Natural Resource in 2003, 2004 and 2005, Belgrade.

Mišić, V. (1981): Šumska vegetacija klisura i kanjona istočne Srbije . - Institut za biološka istraživanja "Siniša Stanković", Beograd.

Mišić, V. (1982): Reliktne polidominantne šumske zajednice Srbije. - Matica Srpska, Novi Sad

Mitrović-Josipović, M., Dedijer, A. and Karadžić, B. 2007. Dinamika cvetanja i produkcija polena ambrozije In: Janjić, V. And Vrbičanin, S. (eds.) Ambrozija. Herbolološko društvo Srbije, Beograd, 47-59 pp.

Morrison, W L (1989) Effects of ultraviolet radiation on the immune system in humans. Journal of Photochemistry and Photobiology 50. 51524.

National Programme of Environmental Protection in Serbia, Ministry of Science and Environmental Protection, 2005

Neiburger M., Edinger J.G. and Bonner W.D. 1982. *Understanding Our Atmospheric Environment* (second edition). W.H. Freeman and Company, San Francisco.

OECD (1982) Eutrophication of waters. Monitoring, assessment and control. OECD, Paris.

Pančić, J. 1883 *Ortoptere u Srbiji*. Glasnik Srpskog Ucenog Društva, Beograd, 1883, drugo odelenje, knjiga XV, str. V-X, 1-172

Pančić, J. 1860 *Ribe u Srbiji (Pisces Serbiae)*. Glasnik društva Srbske Slovesnosti, Beograd, knjiga XII, str. 500-667.

Pančić, J. 1874. *Flora Principatus Serbiae*. - Drzavna štamparija, Beograd, XXXIV+798 str.

Pančić, J. 1867 *Ptice u Srbiji*. Drzavna štamparija, Beograd, 80 str.

Petrov, M. B, 1992: Mamals of Yugoslavia, Insectivores and Rodents.Natural history museum in Belgrade.Supplementa Special issues. Vol 37. st 185.

Popović T. 2002. Is it already warm? -Temperature trend on the territory of FR Yugoslavia. *18th International Conference on Carpathian Meteorology*, CD, Belgrade

Popović T., Jovanović O. 1994. Procena klimatskih promena na području SR Jugoslavije do 2020. godine, *11. Savetovanje hidrauličara i hidrologa*; str. 571 -578, JDHI i JDH, Beograd pp. 143-146, Visegrad, Hungary

Prather, M J and Watson, R T (1990) Stratospheric ozone depletion and future levels of atmospheric chlorine and bromine. Nature 344, 72934.

Prostorni plan Republike Srbije, Institute of Architecture and Regional & Urbanplaning of Serbia

Protic, N., Martinovic, Lj., Milicic, B., Stevanovic, D., Mojasevic, M., 2005. The Status of Soil Surveys in Serbia and Montenegro. In: *Soil Resources of Europe, second edition*. R.J.A. Jones, B. Houšková, P. Bullock and L. Montanarella (eds). European Soil Bureau Research Report No.9, EUR 20559 EN. Office for Official Publications of the European Communities, Luxembourg, pp. 297-315.

Radovanović, M. 1951. Vodozemci i gmizavci naše zemlje. Naučna knjiga, Beograd.

Radovanović, M. 1957. Die Verbreitung der Ampohibien und Reptilien in Jugoslawien. Senck. Biol. 45, 553-561.

Rašajski J. *2004. Birds of Serbia with distribution maps.* Izdavač: Triton public Vršac 2004.

Regulations on permitted amounts of hazardous and harmful substances in soil and water for irrigation and methods for their testing, 1994. Off. Jour. of Republic of Serbia, No. 23/94, Belgrade.

Report on the Transition Process in Serbia and Montenegro, G17 Institute, 2004.

Republic Hidrometeorological Service of Serbia, Meteorological Yearbook 3, Air Quality.

Republic Hidrometeorological Service of Serbia, Hydrological Yearbook 3, Water Quality.

Republic of Serbia Ministry of Mining and Energy, 2005. Guidelines for Bational Action Plan for Serbia gasification.

Republic of Serbia, 1996. Prostorni plan Republike Srbije, Planska i analitičko-dokumentaciona osnova, Belgrade.

Sander, L. C. and Wise, S. A. 1997. Polycyclic Aromatic Hydrocarbon Structure Index, NIST Special Publication 922. Government Printing Office, Washington.

Sarić, M. (ed). 1997. *Vegetacija Srbije II1*.-SANU, Beograd.

Sarić,M. (ed.) (1986) *Flora SR Srbije,10*,SANU, Beograd

Sarić,M. (ed.) (1992) *Flora Srbije 1*,SANU, Beograd

Savić, S. and Tibell, L. 2006. Cheklist of the lichens of Serbia. *Mycologia Balkanica* 3, 187-215.

Savić, R.I., Paunović, M., Milenković, M., Stamenković, S. 1995. Diverzitet faune sisara (Mammalia) Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović, V. And Vasić, V. (eds): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Stevanović, V.2005. Procena biodiverziteta – od interpretacije do konzervacije. In: Andjelković, M. (ed): Biodiverzitet na početku novog milenijuma. Zbornik radova SANU.

Stevanović, V.2005. IPAs in Serbia. In: Important plant areas in Central and Eastern Europe. Plant life International.

Stevanović, V., Jovanović, S. And Lakušić, D. 1995. Diverzitet vegetacije Jugoslavije. In V. Stevanović and V. Vasić (eds.): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Stevanović, V., Kit Tan and Petrova, A. 2005. Size, distribution and phytogeographical position of the Balkan endemic flora. XII International Botanical Congress, Vienna.

Simonović P. 2006. *Ribe Srbije.* NNK international Beograd.

Škorić, A., Filipovski, G., Ćirić, M., 1973. Klasifikacija tala Jugoslavije (Classification of Soils of Yugoslavia) .

Škorić, A, Filipovski, G., Ćirić, M., 1985. Klasifikacija zemljišta Jugoslavije (Classification of Soils of Yugoslavia), Akademija nauka i umjetnosti Bosne i Hercegovine, Posebna izdanja, knjiga LXXVIII, Sarajevo.

Stiling, P. 1996. *Ecology: Theories and Applications.* Prentice Hall, Inc., New Jersey.

Тахтаджян, А. Л.1981. *Жизнь растений.* Просвещение, Москва.

The Convention on Wetlands of International Importance, especially as Waterfowl Habitat.

The Strategy of Development of the Energy Sector, Ministry of Mining and Energy, 2003.

U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C., 1976.

UNEP 1991. Environmental effects of ozone depletion: 1991 update. United Nations Environment Programme, Nairobi.

UNEP 2002. Depleted uranium in Serbia and Montenegro. Post-conflict environmental assessment in FRY", United. Nations Environment Programme, Geneva.

UNEP. 2004. From Conflict to Sustainable Development Assessment and Clean-up in Serbia and Montenegro. SRO-Kundig SA, Switzerland.

UNESCO (1978) World Water Balance and Water Resources of the Earth. UNESCO Series Studies and Reports, No 25, UNESCO, Paris.

UNSCEAR (1993) Sources and effects of ionising radiation. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), United Nations, New York.

US EPA 1990 Hydrofluorocarbons and hydrochlorofluorocarbons: interim report. Office of Toxic Substances, US Environmental Protection Agency, Washington DC.

US EPA, 2003. Air Quality Index. Air Quality and a Guide to Your Health. United States Environmental Protection Agency.

Vasić, V. 1995. Diverzitet ptica Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović, V. And Vasić, V. (eds): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Voet, D. and Voet, J. G. 1995. *Biochemistry*. John Wiley, New York.

Whittaker, R. H. 1965. Dominance and diversity in land plant communities. *Science* 147, 250-260.

Whittaker, R. H. 1972. *Communities and Ecosystems*. Macmillan, New York,

WHO, 1998. Assessment of the health risk of dioxins: re-evaluation of the Tolerable Daily Intake (TDI) WHO Consultation May 25-29 1998, Geneva.

WHO, 2005. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005 Summary of risk assessment. WHO Press, Geneva

WHO, 2006. *Health risks of particulate matter from long-range transboundary air pollution* European Centre for Environment and Health Bonn Office

Živković, B., Nejgebauer, K.V., Tanasijević, Đ., Miljković, N., Stojković, L., Drezgić, P. (1972): Zemljišta Vojvodine (Soils of Vojvodina), Institut za poljoprivredna istraživanja, Novi Sad.

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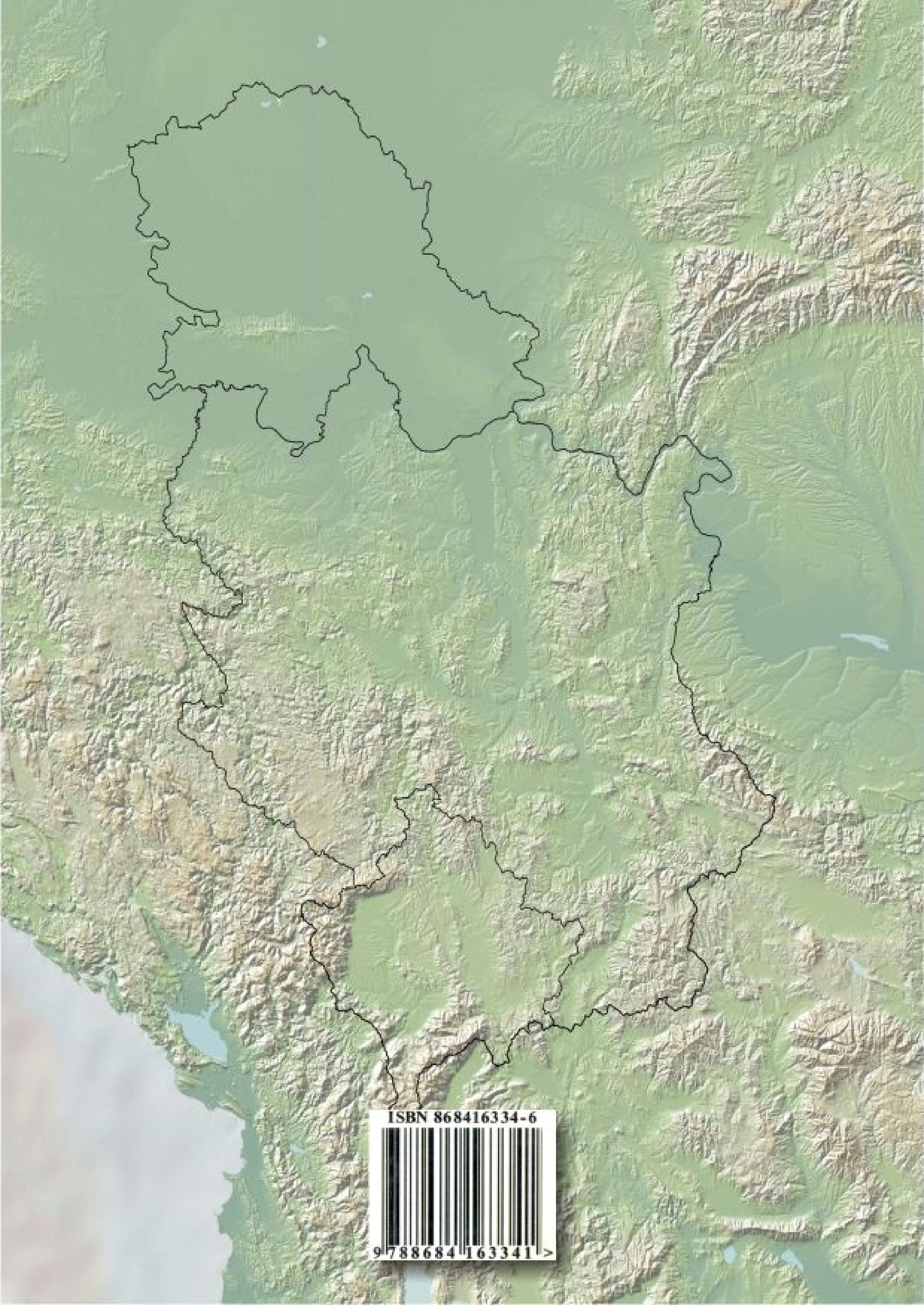

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